



Postharvest loss

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POSTHARVEST LOSS

Weight loss

At seven days after packaging, the weight of packed potatoes must still be equivalent to the weight indicated on the packaging. Potatoes South Africa conducted surveys through its Department: Industry Information, which found significant differences in terms of weight loss in the 10 kg bags of different farmers in a particular region, and also between different regions. This factsheet addresses the causes of weight loss, as well as measures that can be taken to reduce such loss.

Weight loss in potato tubers after harvesting is primarily caused by evaporation, and to a lesser extent respiration.

Respiration is a function of all living tissue and is the physiological process whereby oxygen and glucose are converted into energy, carbon dioxide and water.

- Although respiration is responsible for a relatively small percentage of weight loss the rate of respiration increases with a rise in temperature, with the respiration rate generally doubling with every 10oC rise in temperature. Where tubers are harvested at 30oC, weight loss due to respiration can be twice that at 20oC.
- When tubers are damaged the rate of respiration increases, because the wound-healing process uses energy.
- Where harvesting occurs at a high temperature the respiration rate is relatively high, particularly when tubers are damaged by mechanical means.
- When tubers are transported from the warm conditions in the field to the cool conditions in the pack house, the respiration rate decreases as the tuber temperature drops.

Evaporation is the major cause of weight loss occurring in tubers postharvest. Water evaporates from the surface of the tuber due to a difference in the moisture content of the tuber and the moisture content of the air (relative humidity) surrounding the tuber. When tubers are harvested after full skin-set, the corky cells of the skin help to limit evaporation. Factors that can increase weight loss due to evaporation are:

- **Thin, immature skin.** Research in the USA has found that an immature tuber with intact skin loses approximately 28 times more moisture from evaporation than a mature tuber with full skin-set.
- **Loose skin.** When the skin of an immature tuber is abraded, weight loss due to evaporation can be up to 250-1000 times more than when the immature skin remains intact.
- **Mechanical damage** leaves the tuber tissue unprotected and leads to an increase in respiration and evaporation.
- **The rate of evaporation is influenced by temperature, relative humidity, and ventilation / wind.** The higher the temperature, the higher the rate of evaporation. The more moisture there is in the air surrounding the tuber, the lower the rate of evaporation. Where the air surrounding the tubers is very dry, weight loss increases due to evaporation. Ventilation or wind increases evaporation and weight loss.

Postharvest decay

Wet bags can lead to crop losses since the affected consignments could be rejected at the market. Wet bags result when tubers infected with soft rot decay into a watery mass. Postharvest decay is generally caused by soft rot pathogens, with *Pectobacterium* being the most common pathogen in South Africa.

MANAGE THE RISK OF POSTHARVEST LOSS

PLANTING TIME

RISK	MANAGEMENT
The crop matures during hot, wet conditions	<p>Conditions of high moisture and high temperature are conducive to soft rot.</p> <ul style="list-style-type: none"> • Avoid excessive irrigation. • Maintain high levels of sanitation during the harvesting and handling of crops.

CHOICE OF LAND

RISK	MANAGEMENT
Stony soils	<ul style="list-style-type: none"> • Remove stones where practical as they can cause mechanical damage to tubers during harvesting. Alternatively all possible measures must be taken to avoid damage and postharvest decay. • Harvesting should take place when the soil contain 60-65% of the plant available water which helps to reduce damage. Irrigate a few days prior to harvesting, if necessary.
Waterlogged areas or poor drainage	<ul style="list-style-type: none"> • Avoid such fields where possible, since crops planted in waterlogged soil are susceptible to soft rot, nematodes, powdery scab and enlarged lenticels. • Manage irrigation to prevent wet soil and waterlogging, thus reducing the risk of enlarged lenticels and tuber borne diseases. • Tubers from waterlogged soils must be harvested and handled separately from other tubers, and all machinery must be thoroughly disinfected to avoid infecting other tubers with soft rot.
Nematode and powdery scab infections cause knobs and lesions on tubers	<ul style="list-style-type: none"> • Knobs and lesions are easily damaged, while the skin is prone to abrasion with brushing. • Ensure that tubers with these symptoms are removed during sorting, especially when harvesting during warm weather conditions, and where wet bags are a recurring problem. • Pathogens must be properly managed, and all possible measures must be taken to prevent damage and postharvest decay.
Soil contaminated with pathogens that cause black dot	<ul style="list-style-type: none"> • Black dot is a disease that can survive in the soil for long periods of time and causes loosening of the skin. Where a particular field has a history of black dot, the potatoes must be harvested as soon as skin is properly set. The longer the potatoes remain in the soil, the more serious the symptoms of black dot will become.

MANAGE THE RISK OF POSTHARVEST LOSS

CHOICE OF CULTIVAR

RISK	MANAGEMENT
Cultivars susceptible to soft rot	<ul style="list-style-type: none"> • Consideration should be given to planting alternative cultivars in cases where soft rot is a regular occurrence and cannot be managed successfully.
Cultivars with a tendency to crack	<ul style="list-style-type: none"> • Plant cultivars that do not have a tendency to crack in regions where harvesting occurs in cold weather conditions. • Cultivars suitable for processing have a greater tendency to crack and should be treated as such: <ul style="list-style-type: none"> • avoid harvesting at the coldest times of the day; • reduce the drop height; and • do not allow workers to walk on the tubers.

SEED POTATOES

RISK	MANAGEMENT
Seed potatoes infect-ed with silver scurf and / or black dot	<ul style="list-style-type: none"> • Plant only certified seed potatoes. • If infected seed is planted, every effort should be made to avoid conditions of stress and delayed emergence. • Harvest such plantings as soon as the skin has set.

CROP MAINTENANCE

RISK	MANAGEMENT
Wet soil and waterlogged conditions	<ul style="list-style-type: none"> • Manage irrigation to prevent wet soil and waterlogging, thus reducing the risk of enlarged lenticels and soft rot. • Where the soil has remained wet due to ongoing rainfall, all possible measures must be taken to prevent the occurrence of soft rot.
Indiscriminate fertilization	<p>Unbalanced fertilization can lead to poor skin-set and greater susceptibility to soft rot.</p> <ul style="list-style-type: none"> • Sufficient calcium must be available during tuber formation and approximately four weeks thereafter. • N should not be applied late in the season, as it delays skin-set.

MANAGE THE RISK OF POSTHARVEST LOSS

CROP MAINTENANCE

RISK	MANAGEMENT
Haulms are not allowed to fully die-off before harvesting	<ul style="list-style-type: none"> • Should growth be halted by suspending irrigation, harvesting should take place only after the haulms have fully dried and proper skin-set has occurred. • Where herbicide is used to kill plants, but regrowth occurs, the haulms can be pulled. <p>Sufficient time should still be allowed for skin-set to occur prior to harvesting.</p>

HARVESTING

RISK	MANAGEMENT
Loose skin due to silver scurf / black dot	<ul style="list-style-type: none"> • Where a particular field has a history of black dot, the potatoes must be harvested as soon as possible after skin-set has occurred to reduce the incidence of loose skin.
Extremely hot conditions	<ul style="list-style-type: none"> • Tubers should be lifted and harvested at cooler times of the day so as to reduce evaporation. • Tubers should not be left to lie on top of the hot soil.
Cold conditions	<ul style="list-style-type: none"> • Harvesting should be avoided when the soil and tuber temperature is <10oC. At low temperatures, tubers have a greater tendency to crack than at higher temperatures. • Tubers should not be lifted from the soil and then left to lie on the cold ground. It should be gathered as soon as possible and transported to the pack house.
Mechanical damage during lifting	<ul style="list-style-type: none"> • Immature, loose skin is easily damaged. • Harvesting should take place when the groundwater content is at 60-65% of the plant available water. This prevents clod formation in soil that is too dry, as well as smearing with soil that is too wet. • Ensure that the harvester is set correctly so that the blade is deep enough to sever the roots below the tubers. The ground speed of the harvester must match the chain speed to cushion the tubers on a layer of soil as they move along the chain bars.
Tuber infection due to soft rot pathogens	<ul style="list-style-type: none"> • Soil that is contaminated with soft rot pathogens may cling to the tubers during harvesting. Such fields must be harvested and handled separately from those not affected by soft rot. • Implements must be cleaned daily with a high pressure hose to prevent the spread of the disease.

MANAGE THE RISK OF POSTHARVEST LOSS

WASHING AND SORTING

RISK	MANAGEMENT
Soft rot pathogens are spread from contaminated tubers to those not yet affected	<ul style="list-style-type: none"> • See to it that the wash water is replaced regularly, since soil particles and plant debris in dirty wash water not only absorbs disinfectants, but also serves as a growth medium for softrot pathogens to multiply. • Consider using a system whereby disinfectants are applied to washed tubers by means of a low-volume application method. • Maintain a temperature of <25oC during washing and packaging, especially in regions where harvesting takes place in the summer. This will help to reduce the activity of pathogens.
Damage to tubers	<ul style="list-style-type: none"> • Prevent mechanical damage to tubers as far as possible during the washing and sorting process: <ul style="list-style-type: none"> • cover hard surfaces with shock-absorbent material; • see to it that conveyor belts are operating at maximum speed to prevent tubers from rolling; • reduce the drop height; and • contact your PSA regional manager to identify those places in the washing and sorting line where tubers are exposed to impact by making use of the Impact Recording Device.
Elongated tubers and those with lesions are easily damaged	<ul style="list-style-type: none"> • The tuber skin must be properly set, and effective disinfection must be ensured after washing.

PACKING

RISK	MANAGEMENT
Packing of wet tubers	<ul style="list-style-type: none"> • Tubers must be dry when packed, especially in very hot weather, to reduce the risk of soft rot.
Packaging with insufficient ventilation	<ul style="list-style-type: none"> • Insufficient ventilation and high temperatures promote the development of soft rot. Ensure sufficient ventilation, especially when potatoes are packed in plastic bags.

MANAGE THE RISK OF POSTHARVEST LOSS

TRANSPORTATION

RISK	MANAGEMENT
High temperature	<ul style="list-style-type: none"> High temperature leads to weight loss due to evaporation. Potatoes should be transported at cooler times of the day. Where potatoes are transported over long distances in hot weather, cooling to a temperature of <20oC can help to reduce weight loss. Where potatoes must be transported in hot weather, ventilation can reduce the risk of soft rot.
Temperature variations	<ul style="list-style-type: none"> When tubers have reached a high temperature and are then cooled rapidly, condensation can form. Free water creates ideal conditions for the development of soft rot.

REDUCING WEIGHT LOSS

Avoid mechanical damage

Different types of damage and their causes:

- **Loose skin** is a problem when immature tubers are harvested, especially when tubers are exposed to abrasion.
- **Cuts** are caused by allowing tubers to fall and slide against sharp objects or edges.
- **Holes** are caused by allowing tubers to fall onto sharp ends.
- **Surface / thumbnail cracks** commonly occur when tubers fall onto hard surfaces at a temperature of <10°C.
- **Deep cracks / ruptures** are formed when the lifter speed is set too high, tuber temperature is low (<10°C) and tubers are harvested shortly after haulm die-off, and when cold tubers are handled roughly during sorting.
- **Bruised tissue**, appearing black in colour, is caused by pressure damage to tubers, e.g. workers walking on tubers.

Cultivars vary in terms of their tendency to crack:

- In regions where potatoes are harvested from cool soil, new cultivars must be tested for their tendency to crack.
- Cultivars with a high dry weight have a greater tendency to crack than cultivars with a lower dry weight.
- Cultivars with elongated tubers are more susceptible to mechanical damage during handling than tubers with a rounder shape.

Tuber size. The impact suffered by large tubers when falling from a low height makes them more susceptible to cracking than smaller tubers.

The temperature and moisture level of a particular tuber determine the likelihood of cracks forming. Tubers with a high moisture content (high turgor pressure) and low temperature (<10°C) are more likely to crack and suffer mechanical damage.

- During cold winter weather it is advisable to harvest crops only once warmer temperatures have set in. Harvested tubers should not be left outside, and the grading and transportation of potatoes should be avoided under extremely cold conditions.
- The optimal groundwater level is 60-65% of the plant available water. If conditions allow, irrigation should be suspended well in advance. This will not only improve the moisture level of the tuber, but will also allow for proper skin-set.

Harvesting practices employed is the main determinant of the extent of damage that occurs.

- Soil that is too wet (especially clay soils) tends to cling to the tubers, which hinders the washing process and leaves the wash water with increased soil deposits.
- Soil that is too dry can form clods, hampering the harvesting process and leading to the mechanical damage of tubers. Light irrigation 2 to 3 days prior to harvesting can help to resolve this problem.
- See to it that the potato lifter is set correctly. The blade must be set at the correct depth to sever the roots below the tubers. The ground speed of the lifter must match the chain speed so that the tubers move along a cushion of soil across the chain rods. However, do not allow too much soil to pass over the rods along with the tubers, as any stones and gravel in the soil can damage the tubers.
- Harvesting tubers by hand poses less risk of mechanical damage than using automatic lifters.
- Workers should not stand or sit on the potatoes while it is being transported to the pack house, as the tubers could suffer bruising that is invisible, thus preventing such tubers from being removed during the sorting process. Such internal bruising leaves the tubers highly susceptible to decay-causing organisms.

Washing and sorting.

- The height from which potatoes are dropped and the surface onto which they are dropped must be monitored at every step of the sorting process. Wood and metal surfaces should be replaced with shock-absorbent material, with the drop height limited to a maximum of 50 cm.
- Conveyor belts must operate at maximum operating capacity to limit the tubers from rolling.
- Tubers with nematode lesions are easily damaged by brushing, especially when the skin is thin.
- Brushing removes powdery scab lesions on tubers, exposing the underlying tissue.
- To determine precisely where in the process, from harvesting to packaging, mechanical damage occurs on a particular farm, contact the Potatoes South Africa regional manager in your area who, with the aid of an Impact Recording Device (IRD), will assist to identify the risk areas.

Preventing silver scurf / black dot

Wherever a field is infected with silver scurf / black dot and harvesting is delayed, there is a high probability that tubers will suffer mechanical damage during harvesting. This is because the pathogen infects the tuber between the skin and the underlying tissue, allowing the skin to loosen easily. The longer the tubers are left in the soil, the higher the number of tubers that will be infected, and the greater the percentage of the surface area infected. In such cases, it is advisable to harvest the tubers as soon as skin set has occurred. For more information, refer to the Potatoes South Africa factsheet: **Silver scurf and black dot** (2015).

Preventing enlarged lenticels

Under normal circumstances, gas is exchanged between the tuber and the surrounding air through the lenticels. Lenticels, which are formed from stomata, are small openings in the skin that are protected by the cork cells. Under oxygen deficient conditions and excessive soil moisture, the cells just beneath the lenticels become swollen and break through the corky cells. Enlarged lenticels manifest as raised white tissue on the surface of the tuber. The size can vary from insignificant to large. When tubers are removed from wet soil, the raised tissue is white, but discolouration occurs when it dries. In warm weather soft rot often starts in enlarged lenticels, and decay is visible as areas of darker tissue surrounding the lenticels. The loose cells of an enlarged lenticel are easily removed when the tubers are brushed, exposing the underlying tissue to moisture loss and infection by softrot pathogens.

Avoid planting in fields that are prone to waterlogging. Avoid over-irrigating two weeks prior to harvesting, by irrigating when 40-50% of the plant-available water has been used. If tubers with enlarged lenticels are harvested, they must be dried as soon as possible. Tubers from waterlogged areas must be harvested separately from tubers in other areas, where possible. Ensure optimum sanitation levels during the washing process, and see to it that tubers are dried as quickly and as thoroughly as possible prior to packing.

Ensure proper skin set

Proper skin set is of cardinal importance, as the corky cells of mature skin serve to prevent evaporation and subsequent moisture loss, thus preventing infection by soft rot pathogens.

Tubers with mature, firm skins are less likely to be damaged during harvesting, washing and sorting than tubers with a thin skin.

Skin set is influenced by the following factors:

- **Plant maturity.** As long as nutrients are being transported from the green leaves to the tubers, the tubers will continue to grow in size. The skin does not thicken, as cell division has to keep up with the growth rate of the tuber surface. It is only once the haulm has completely died-off that the tuber stops growing. The skin then sets when the phelloderm (the cell layer from which cambium cells are formed) stops to divide and is attached to the underlying tuber cells.
- **Temperature.** In warm weather, it takes approximately 10-14 days for the skin to set properly. At low temperatures, more time must be allowed before harvesting the tubers.



REDUCING THE RISK OF WET BAGS

There are no symptoms of the latent contamination of tubers by soft rot pathogens. The bacterial cells are found in the lenticels, vascular tissue or wounds. When conditions are not favourable for disease development, the bacterial cells will survive without causing soft rot. Soft rot can, however, spread rapidly under conditions that are conducive to disease development. This includes warm, wet conditions, especially when coupled with oxygen deficiency. For more information on soft rot, refer to the factsheet **Soft rot - black leg** (2015), available from Potatoes South Africa or www.potatoes.co.za/research/fact-sheets.

Where lenticels are contaminated and the conditions are favourable for soft rot, small watery spots form around the lenticels and are the first sign of soft rot. The affected areas

are usually visible as sunken brown spots. As the decay spreads, these spots melt together and form a slimy wet rot that is cream to brown in colour. The border between decaying and healthy tissue often appears dark brown or black in colour.

Infection can occur in deeper lying wound tissue or vascular tissue, with the decay spreading from there. In such cases, the skin may be unaffected while the deeper lying tissue decays, visible as sunken spots. Handling the affected tuber causes it to break apart into a watery, slimy mass.

Soft rot is initially odourless, but secondary infection usually results in an unpleasant odour. This unpleasant odour is usually an accurate indication of soft rot during storage and transport.





REFERENCES

Labelling requirements for packaged products (pre-packages) and general requirements for the sale of goods subject to legal metrology control. South African National Standards SANS 289:2013. SABS



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