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POTATO EYES

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Wounding During Harvest

In the first issue of Nebraska Potato Eyes this year, articles discussed the advantages of cutting tubers for planting and the need to heal the wounded, cut surface. Wound healing of seed-pieces was outlined and the factors affecting this process. In the second issue, the wound healing process was reviewed in more detail with descriptions of cutting, shatter and skinning bruises. This issue includes descriptions of internal black spot and pressure bruising. So, now we have come full circle to bruising at harvest and wound healing in storage.

There are a number of factors that affect susceptibility to bruising during harvest. The physical condition of the soil such as type is important, but the key controllable factor is soil moisture. For minimum risk of bruising, soil moisture at harvest should be between 60 and 80% of field capacity (FC). Possibly the most critical factors in the tendency to bruise and type of bruising are tuber hydration and maturity. Hydrated tubers (turgid) are firm and less susceptible to black spot but more susceptible to shatter and cracking while dehydrated tubers (flaccid) susceptibilities are the reverse. Tuber temperature as well as soil moisture affects tuber dehydration, so it is best to harvest when tubers are between 45 and 65^{o} F with 50 to 60^{o} F being optimal. The temperature as discussed in earlier issues is the key factor affecting wound healing as well. Immature tubers easily show skinning. And, different potato cultivars show differing propensities to bruising and the type of bruising that occurs.

Another and obvious major factor for bruising is the harvesting and piling operations themselves, such as chain speeds and heights. For the discussion on these influences, I recommend the videos listed in the references section and "Bruise-Free Potatoes: Our Goal" edited by Kleinschmidt and Thornton, 1991.

For a brief review, note that a break in the skin allows tubers to lose water or dehydrate, and entry of pathogens into the tuber causing storage rots. The wound healing process involves the formation and cross-linking of lignin and pectin between the cells below the damage and slow water loss. This is followed by suberization in cell walls thereby inhibiting bacterial rots. Finally, a new skin, the phellogen layer, is formed via cell division and this inhibits fungal rots and controls movement through the skin. This process is highly affected by temperature, and additionally affected by relative humidity and air quality.

Wound Healing in Storage

After tubers are harvested, it is best to assume and would be expected that some bruising occurred during the harvest and piling operation. The initial storage period should be a 'curing period' which is used for healing the wounds of the harvested tubers. Curing is a short storage period after harvest and before tubers enter the 'holding period' which is the normal storage for the off-season.

Recommendations for curing are:

a. one to three weeks

b. temperatures between 50 and 60^{o} F (If temperature is lower the wound healing process becomes too slow and takes much too long and if the temperature is higher than pathogen populations increase and rots increase).

c. relative humidity between 90 and 95%

d. air movement at 10 to 30 cfm/20 cwt or per ton (US)

e. NO free water, that is condensate, wash etc. Free water blocks oxygen intake, stopping healing and promoting rots.

After the curing period, the storage temperature can be altered to the desired holding temperature. Temperature changes should be fairly rapid, about 0.5^{o} F per day. The holding temperature depends on the market for the tubers. For seed tuber storage, the holding temperature is low, between 34 and 38^{o} F unless they will leave storage early and dormancy needs to be overcome. Fresh market potatoes are stored nearly as cold, between 36 and 40^{o} F; they may be

Continued on Page 2

Inside this issue...

Wound Healing in Storage

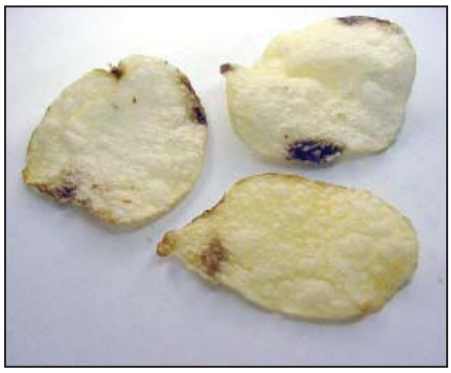
Continued from page 1

stored slightly higher and longer if a sprout inhibitor is used. Tubers going for processing as french fries may be stored at 44 to 48^{o} F and sprout inhibition practices are required. For most chip processing cultivars, holding temperature remains in the region of curing, 50 to 55^{o} F. Sprout inhibition is required. Note that for chipping, growers may expose tubers to higher temperatures between 55 and 65^{o} F for a short period called 'conditioning' or 'pre-conditioning' in order to lower reducing sugars in the tubers; this would replace the curing period. The higher temperatures for tubers to be processed by frying are needed to keep the sugar levels down and thereby minimize browning during frying, the Mallard Reaction.

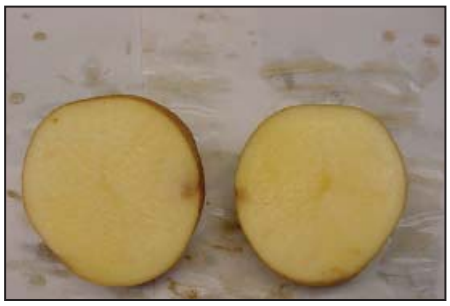
Internal Blackspot

In addition to the impact-caused, external bruises discussed previously, there is an impact-caused internal bruise, that is unseen by looking at the tuber surface, called IBS, internal blackspot or just blackspot. It occurs under the skin surface and can only be seen by removing the skin or cutting into the tuber where the discoloration exists. IBS appears as a small, dark, oval area just under the skin. When potatoes are fried, these dark spots appear deep dark near the edge of the tuber surface. For instance in a potato chip, IBS areas appear along the chip's rim.

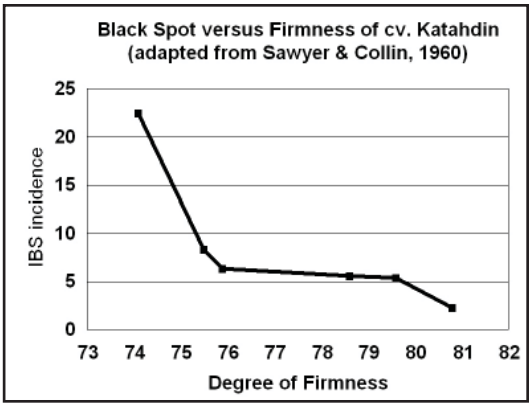
IBS forms as a result of an impact of the tuber against a hard surface such as the sides of the harvester or piler. The discoloration under the skin appears one to two days after the impact. As with pressure bruising, it results from a phenolic reaction in the wounded cells. Cells collapse; ethylene is released, and further cell wall breakdown occurs resulting in more cell death. The dark discoloration identifying IBS and pressure bruising is from a pigment, melanin, formed in the phenolic reaction. (Note, this is the same pigment that darkens skin in people.) As with pressure bruising, susceptibility to IBS is related to tuber dehydration or firmness. Tuber firmness may be inversely related to specific gravity thereby making tubers with higher solids more susceptible to IBS than those with lower solids (Sawyer and Collins, 1960). Tubers should be harvested when their internal temperature is above 45^{o} F and less than 65^{o} F. Also, harvesting when the soil is not dry helps minimize the occurrence of damage.



Internal blackspot on potato chips.



Internal blackspot in a tuber.



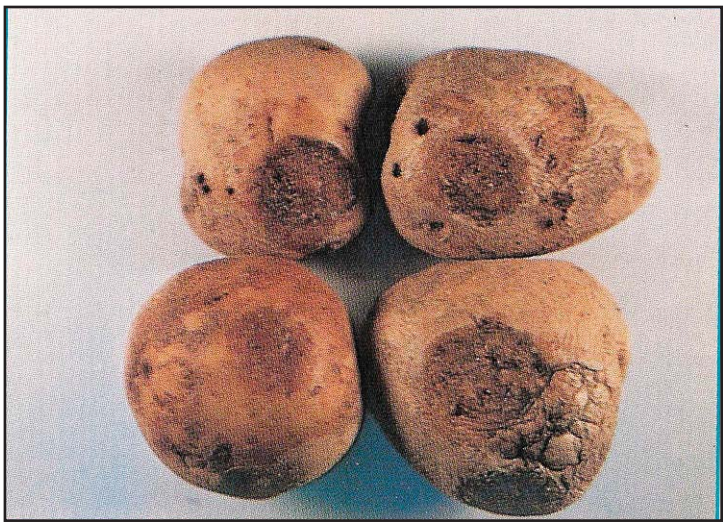
Examples of Blackspot Bruise Susceptibility of Cultivars (adapted from Corsini, 1997). (scale: 1 = resistant, 2 = some tolerance, 3 = intermediate, 4 = some sensitivity, 5 = susceptible).

Cultivar	IBS reaction
Russet-skinned types:	
Goldrush	5+
Norgold Russet	3
Ranger Russet	5+
Russet Burbank	4
Russet Norkotah	3
Russet Nugget	2
Round White-skinned types:	
Atlantic	2
Gemchip	5
Monona	3
Norchip	1
Snowden	2
Long White-skinned types:	
Katahdin	3
Kennebec	3
Shepody	3
Red-skinned types:	
Norland(s)	2
Red LaSoda	3
Red Pontiac	2
Viking (Red)	3
Yellow Types:	
Yukon Gold	4

Pressure Bruise

In addition to the external bruises discussed in the previous issue, during storage another external bruise called pressure bruise can occur. Pressure bruising appears as a depressed, dark, softened, and circular area on the tuber surface (picture). It may be small, quarter inch in diameter, to as large as a couple of inches. The depression may be as much as a half inch deep. (At home, you may have noticed apples with pressure bruising since the symptoms are very evident on them.) The bruise enlarges over time once it forms. When the center of the bruise dries, it may collapse and form a cavity. Obviously, this bruise markedly reduces marketability and must be sorted out when tubers leave storage. However, in storage, as cells at the surface break down, an entry portal for pathogens develops and tuber rots in the pile develop.

Pressure bruising occurs on tubers at the bottom of a pile and results from the weight of tubers above. Do not pile tubers higher than 18 feet. It is aggravated under conditions of low relative humidity. Storage humidity should be greater than 90% RH. Dehydrated tubers are especially susceptible. Tuber water loss is not uncommon with immature tubers, wounded tubers, and tubers harvested from soil with low moisture. Potato cultivars having tubers with low solids



Pressure Bruises on tubers (ref. Chase and Silva, 1985)

are most at risk. The condition is a phenolic reaction in the periderm (tuber skin cells) that also produces a gas, ethylene, a growth hormone, which also promotes further cell wall breakdown in an auto-catalytic reaction thereby making the condition increasingly worst.

Catechol and Tetrazolium Tests

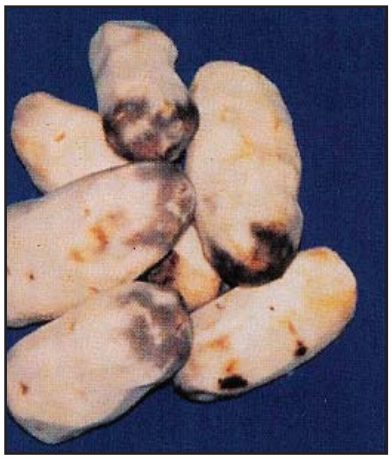
There are three ways of evaluating internal bruises, especially (internal) black (brown) spot: abrasive peeling, homogenization and impact-bruising methods (Dean et al., 1993). The first two give the most consistent results. The most common way growers and processors use is the catechol test in conjunction with peeling. The catechol test is used primarily to detect external and evaluate external bruises: skinning, shatter and depth of cuts. Catechol is a polyphenol that reacts with wound enzymes turning purple to dark red. The following procedure is adapted from Gould, W.A., 1995 and Kleinschmidt, G. and Thornton, M. (Eds.), 1991.

1. Take a 10-tuber sample, three to five pounds, and wash off soil etc.

2. Immerse tubers for one to five minutes in 1.5% catechol or 2 oz catechol per gallon with a bit of soap, detergent or nonionic surfactant to break the water tension.

3. Drain and let stand for one to 10 minutes.

If there are purple or dark red areas, then there are bruises. The severity of the bruises is estimated by the number of strokes with a potato peeler in takes to get below the coloration. One stroke indicates a surface bruise probably skinning or slight shatter. Two strokes indicate a shallow bruise, shatter, deep abrasion or slight cut. If more than two strokes are needed to remove the catechol stain than the bruise is deep and serious.



Tetrazolium results after peeling.

A specific test for (internal) blackspot (or brownspot) or IBS is called the tetrazolium test. The method is:

1. Collect a tuber sample and wash them.

2. Peel the tubers slightly then place them into a solution of 1% 2,3,5-tetrazolium chloride for about 40 minutes. Bruises will appear as dark pink areas in a matter of minutes. The staining is most pronounced when this test is done under sunlight and when the tetrazolium was dissolved in water warmed to room temperature (70 F). Note tetrazolium is toxic to animals including us, so the potatoes and leftover solution need to be disposed of safely.

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Videos available on bruise prevention from the Univ. of Idaho, College of Agriculture:

The Harvester, Tape # 275

Harvester Chain Adjustment, Tape # 471

Handling, Tape # 586

The Nebraska Potato Eyes

is on the World Wide Web at:

www.panhandle.unl.edu/peyes.htm