What is Suberization Anyway?

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Suberization is a complex subject that can lead to much discussion. However the basic concept of Suberization, and its effect on potatoes in storage, is easy enough to grasp. Most important, though, is the effect Suberization has on potatoes in storage. This article is an introduction to the practical aspects of Suberization; techniques for achieving good Suberization also will be discussed.

So what is Suberization, anyway?

The potato industry refers to Suberization almost synonymously with wound-healing. Specifically, (and properly) though, Suberization, as related to potatoes, is the process of sealing off wounds, cuts, and general skin damage that occurs during harvest. The digging and potato handling operations at harvest always cause some skin damage. These injuries to the tuber cause, among other things, an increase in respiration of the damaged portion; and this leads to other concerns. Dr. Bill Dean, WSU professor, suggests Suberization simply be considered:

1. The deposit of suberin, a waxy, fatty substance, into tuber cells adjacent a wound, and
2. Transforming the surface of the damaged area and skin into corklike tissue.

Prior to the formation of suberin, the exposed potato cells are permeable to water, which allows moisture to escape from the potato. So the waxy suberin deposit helps to prevent moisture loss, along with other important benefits.

For the sake of keeping this subject as practical as possible, and since the wound-healing period for potatoes in storage is mainly the Suberization process, we can consider the terms "suberization" and "wound-healing" to have the same useful meaning. This wound-healing period is normally complete after the first few (2 to 4) weeks a potato is in storage. However, since potato harvest for a grower may span a month to possibly six weeks or more, the woundhealing period *for the storage* is the period beginning with the date the first potatoes enter storage until suberization is complete for the last potatoes placed in storage. Therefore the wound-healing period usually is considered to be the first two months or so of storage.

That's a quick introduction to the suberization process, which leads us to the effects suberization has on potatoes in storage. Results of potato research conducted at Washington State University, The University of Idaho, and other facilities have been published in abundance. All stress the importance of good suberization. And the reason is simply that proper suberization is the key to minimum losses in storage. Weight loss can be dramatically minimized, and quality losses can be even more significantly minimized if the suberization process is optimum. In addition, good suberization has a direct positive effect on the disease resistance of potatoes in storage. So the benefits of good suberization include:

1. Minimum weight loss.
2. Minimum quality losses.
3. Maximum disease resistance.

Note that other factors also effect the above three items, such as pathogen infestation in the field, for example. But it is important to realize that during this initial storage period the effectiveness of the suberization process actually sets the stage for how well the potatoes will store.

How then is optimum suberization best achieved? And what storage conditions affect suberization? Several factors have significant influence on the wound-healing process, and include:

1. Potato temperature in storage.
2. Oxygen and CO_2 levels in the supply air.
3. Relative humidity of supply air.
4. Potato maturity at harvest.
5. Potato variety.
6. Magnitude of bruise and wound damage during harvest.

Storage conditions control the first three factors

Let's examine the influence of these factors.

Regarding Temperature

The air system's primary task, of course, is to maintain the pile temperature. But what temperature should be used for suberization?

Studies conducted by Bill Dean at Washington State University suggest that the suberization process is completed fastest when the tuber temperature is about 68 degrees F. A rapid suberization process is important to minimize weight loss. However, Dr. Willie Iritani, professor of horticulture at Washington State University, recommends lower temperatures for wound-healing for several reasons.

Since one of the primary benefits of the suberization process is development of general resistance to disease with an associated reduction of bacterial infection, a temperature for suberization that also addresses rot development during the wound-healing process must be considered. Research by Iritani concludes that rot can be effectively controlled at temperatures below 48-50 degrees F and that the best compromise temperature during suberization seems to be 50 degrees F. Rot organisms, on the other hand can get out of hand when potatoes are stored for extended periods at above 55 degrees F. In addition, Iritani indicates that higher temperatures (55-60 degrees F) during suberization can cause a greater quantity of reducing sugars after the storage set point is lowered to the long-term holding temperature. Consequently, a storage set point of 50 degrees F for suberization is recommended.

Oxygen and CO2

Potatoes in storage are a living organism and require oxygen. This combustion process continues all the time the spuds are in storage. So another task for the air system is to supply oxygen and eliminate the carbon dioxide generated by respiration. Since respiration is very high during wound-healing, an adequate supply of oxygen is vital to promote good suberization. Therefore the air system must distribute the supply air uniformly throughout the storage. Several factors contribute to a uniformly distributed, adequate air supply:

- Good storage design with a well-engineered air system.
- Careful alignment of air-duct sections with attention to orientation of the discharge holes.
- Taped duct-section joints to minimize leakage.
- End caps in place.
- Elimination of dirt and weeds.
- Piling potatoes so the top of the pile is level.

Relative Humidity of Supply Air

Research conclusions on relative humidity requirements of supply air during suberization agree that high relative humidity promotes good wound-healing and enhances the suberization process. However, relative humidity is very much a function of heat load.

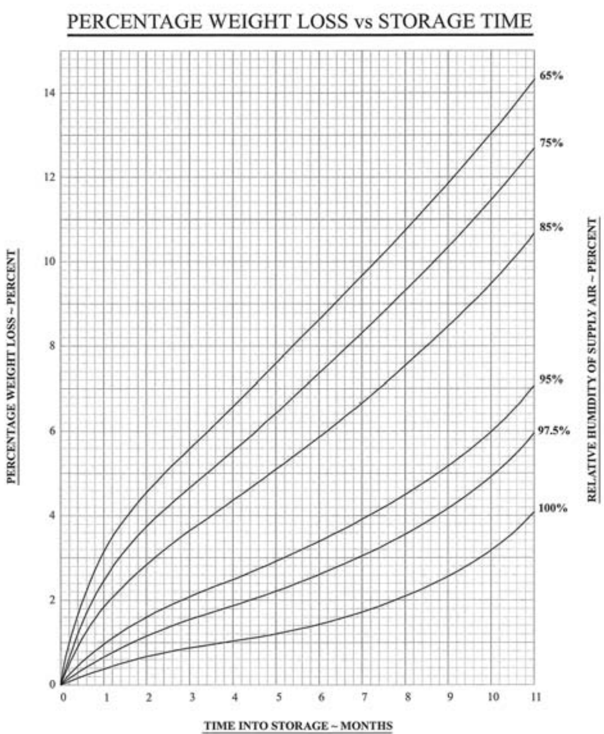
To better understand relative humidity in the storage, a quick look at the heat load which the supply air is trying to control is in order. During the first two months of storage this heat load, the heat in the pile which the air system must remove, is higher than at any other time in the storage season. The total heat load comes mainly from three sources:

1. Heat of Product or Field Heat. This is the heat associated with pulp temperatures at harvest warmer than the desired 50 degrees F storage temperature. The temperature of potatoes brought into storage often is 60 degrees F or higher.
2. Respiration. The requirement for oxygen discussed above is a respiration process that produces relatively large amounts of CO2 and heat during the early storage period. This heat is referred to as "heat of respiration."
3. Mechanical Heat. The heat generated by fans and other equipment in the storage amounts to about 30 percent of the total heat load during suberization. The effects of this mechanical heat will be discussed later.

Effect of Relative Humidity on Weight Loss

Now then, everyone agrees that a supply air relative humidity of 95 percent or greater is desirable, especially during suberization. The figure shown is a plot of weight loss versus time in storage for various supply air relative humidities. For example, with a supply air relative humidity of 95 percent and a storage period of 7 months, note that you could expect a total weight loss of about 4 percent. The actual measured average weight loss, however, for a 7-month storage period is 7 percent. Note in the figure that this falls between the 75 percent and 85 percent RH lines. But doesn't everyone know and say that they have 95 percent RH supply air? Let's take a close look at a few details shown by the various plots in the figure.

First of all, note that the slope of the 75 percent RH curve past 2 months is not that different from the slope of the 95 percent RH curve. But, look at the difference in the slopes of the two plots in the first month. In other words, after the early storage period, weight loss potential is not so drastically affected by supply air relative humidity. Sure, the 75 percent curve is somewhat steeper after 2 months in storage than the 95 percent curve. But hack during the first 6 weeks to two months of storage the rate of weight loss is highly dependent on supply air relative humidity. The stage is clearly set during suberization for weight loss. So, it's much more important to assure maximum relative humidity during the



early storage period.

Factors that Affect Achievement of High Relative Humidity

Well, what affects achieving high relative humidity? Why is it a problem? The following five factors all influence the final relative humidity of the supply air:

First, heat of product, the heat associated with warm harvested spuds, has an influence on relative humidity. The reason is simply that warm air can hold more moisture than cool air. If the air system blows 50 degrees F with 95 percent relative humidity onto warmer spuds, and the air warms to 55 degrees F, the relative humidity of that air drops to 78 percent. And often, spuds are considerably warmer at first . . . pulp temperatures of 60 degrees F and maybe 65 degrees F are common at the start of harvest! This problem only lasts for as long as it takes to drop the pile temperature to set-point, of course. But the effect is dramatic. And moisture removed from the pile during this cool-down period causes the highest rate of weight loss.

Second, the respiration rate is especially high during suberization. This combustion process is a big contributor to pile heat, and consequently respiration lowers the relative humidity.

Third, impingement is a problem. Ideally, we would like to supply saturated air, 100 percent RH would be perfect . . . weight loss would be minimized. But air doesn't want to stay saturated. One of the chief reasons is that when air impinges, bangs off walls, turns corners (which it must to get to the spuds), moisture is wrung out of the air. Air in a plenum is turbulent so there is impingement in the plenum, but the corrugations in ducts assure additional impingement. As the air goes down the ducts, the corrugations ripple the air, and that impingement simply wrings more moisture out of the air.

Fourth, the warm dry air that is usually associated with fall harvest requires special attention to achieve saturation. An air washer designed especially for the high humidity requirements of suberization in potato storage is the optimum solution.

Fifth, since the mechanical heat from fans and other equipment in the storage is such a significant portion of the total heat load, attention must be directed to the effect of this heat on relative humidity. Air moving across the fans will warm up about 1 degree F. If the air entering the fans is at 95 percent RH, the air downstream from the fans will have a relative humidity of 90 percent or less simply due to the mechanical heat added by the fans. Therefore, an air washer placed downstream from the fans prevents this humidity loss. Realizing, again, that the fan heat is such a large portion of the total heat load, a well-designed air washer, located so that the fans blow through the washer, is most desirable.

Suggestions for Optimizing the Relative Humidity of Your Storage

So you can see, measuring supply air relative humidity in the plenum is only an indication of system performance. And the message is clear:

To actually achieve the highest relative humidity possible —

1. Try to place spuds into storage with a pulp temperature close to 50 degrees F.

2. Realizing that heat of product and respiretion lower the relative humidity of the supply air, and that impingement wrings additional moisture out of the air, make certain that micron-sized droplets of water are carried by the supply air to the pile. A fog in the plenum will help to offset the relative humidity losses caused by those factors.

3. Incorporate a well-designed, blow-through air washer in your air system, if possible, to achieve the desired fog and address the five main factors discussed above which directly affect high relative humidity.

Good humidification is simply essential to a good suberization process. And good suberization is the key to minimizing weight loss, minimizing rot, and maintaining quality.

In summary, the suberization process sets the stage for preservation of potato quality during storage, and optimum suberization maximizes profit.

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