THE POTATO IN STORAGE

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In any coverage of this topic, there are a few basic fundamentals which should be declared. First, the potato is living in storage; it has the ability to manufacture new skin in wounded areas if the right environment is provided; it respires; there is a constant natural attempt for equilibrium to become established between the potato and the environment around it, thus it is affected by temperature, humidity and rot organisms.

TEMPERATURE

What effect does temperature have on the potato in storage? The potato freezes around 28°F. Chilling injury and discoloration can be encountered at temperatures as high as 34°F if kept at these temperatures long enough. At temperatures under 35° to 36°F, the carbohydrates in the potato change to a form which give a sweet flavor, undesirable to some consumers. Most varieties of potatoes start to accumulate sugars which affect deep fat frying operations at temperatures under 50°F and tend to lose these sugars at temperatures above 55°F. These figures will vary somewhat, dependent on the variety, the location and the season. As the temperature is increased above 40°F, there is a marked increase in speed of multiplication of rot organisms, respiration rises sharply, and transpiration potential is increased. Thus, unless there is some specific quality reason such as processing color which requires a higher temperature, the potato can best be kept for long periods at temperatures around 40°F.

HUMIDITY

The greatest part of the potato is water. Consequently, for practical purposes we can say that the inside of the potato is 100% relative humidity. We could also expect that whenever the air surrounding the potato is less than 100% relative humidity, there would be a constant atempt for the two to establish equilibrium and thus the potato could be expected to constantly be losing water in dry storage areas. The loss is not as great as it might appear to be expected, however, because of several reasons. First is the excellent moisture barrier provided by a well-matured skin of a potato; second is the fact that the salts in the water of the potato prevent loss of moisture until the outside humidity is down around 90% instead of 100%. This will vary slightly with variety and the cultural and climatic conditions which may affect the concentration of the cell sap. For practical storage purposes we can expect that whenever the humidity in storage is at 88% or higher, the moisture loss from the potato will only be from normal life processes and not from equilibrium establishment due to vapor pressure differences. In general, the storage rot organisms have the most favorable growth environment under high humidity conditions. There is some indication that humidity conditions which leave the surface of the potatoes wet for a prolonged period are detrimental to good color of certain types of potato processing.

The Effect of Storage Environment on Important Storage Defects

1) STORAGE ROT ORGANISMS:

In general, the higher the temperature and the higher the humidity, the faster the incidence of infection and growth of the common storage rot organisms, as indicated in the previous discussion on temperature and humidity.

2) SPROUTING:

This is clearly a storage defect if it takes place in storage. Sprout growth at temperatures of 40°F and lower is very slow. Areas which can obtain 40°F quickly after the wound healing period may be able to control sprouting in storage by temperature control alone. Whenever climate does not allow quick cooling to 40°F or whenever potatoes must be held for any length at temperatures higher than 40°F due to processing color problems, sprout inhibitors should be used to control this defect. If potatoes have been held at 40°F and sprouting thus controlled in storage, if in the marketing program they are shipped long distances and held in transit and store conditions at higher temperatures, inhibitors should be used to control sprouting in market channels.

3) BLACK SPOT: (Pressure Bruise)

This has been one of the most serious defects in storage areas such as Long Island for many years. As temperature requirements in storage were raised with no humidity adjustments, this defect has been recognized in every major area. The only control for this defect in storage is to keep the potato firm by controlling shrinkage and moisture loss. This requires proper management of air movement, humidity adjustment, sprout control, and cultural techniques during the growing and storing periods which may affect tuber firmness and skin development.

With all three important varieties, Katahdin, Kennebec and Russet Burbank, research has clearly indicated complete control of black spot from an October to June storage, if shrinkage was controlled. The four storage variables which must be adjusted to control shrinkage are temperature, humidity, air movement and use of sprout inhibitors. Areas which do not have a cold climate after storing so that temperatures can be reduced quickly by little air movement, may find that they should only try to cool to 50°F for the early storage period and use an inhibitor. Then after cold temperatures are available, cool on down as close to 40°F as possible without impairing quality. A considerable amount of air can be moved without shrinkage of the potato if the humidity of the air can be maintained at levels about 85 to 88%. With the air necessary for cooling, however, in areas like Long Island, there is no equipment presently available which will adequately humidify the air. The desired temperature must be sacrificed in order to control shrinkage for the early cooling period.

Although black spot had been the most serious storage disorder for many years and a major research project for over twenty years with several Masters and Doctorate theses written on the subject, the results on controlling black spot by controlling shrinkage have been so conclusive that the project was closed out last year. There is a continuing storage research program to best produce the environment which will eliminate black spot. New varieties and cultural techniques will continue to be screened for their effect on black spot.

In order to have black spot, the tuber must have the chemical potential, the physical susceptibility, and a mechanical triggering of the reaction. A firm potato is not physically susceptible and thus a bruise will not produce the chemical reaction.

MANAGING A STORAGE ENVIRONMENT

An ideal storage environment cannot take the place of poor cultural practices or poor harvesting and storing practices which leave a potato very susceptible to rot organisms and moisture loss once it is in storage. At least 50% of the problems in storage are normally brought in from the field. A good air distribution system is of little value in a pile of potatoes with a lot of dirt. None of the undersized, unsaleable potatoes and trash should go into storage.

The temperature of a given area will indicate the early storage management. Make sure potatoes are cured to give a good skin, since this skin is going to determine markedly the ability of the potato to lose water over the whole storage period. Best curing is obtained by holding at temperatures of 60 to 65°F for seven to ten days with high humidity and good ventilation. If there is rot going into storage bring the temperature down to the low 50's and use a longer curing period. Once curing is over, cool as rapidly as possible to the desired holding temperature, taking into consideration the basic temperature, humidity pattern of your area and adjusting accordingly to keep shrinkage at a minimum. Once the holding temperature has been reached, move no more air than necessary for maintaining temperature.

The amount of air recommended for cooling varies greatly amongst storage areas. The variation is mainly due to differences in climate. Regardless of the area, however, cooling is only one of the factors which should be considered in determing air rate. Air systems can provide excellent insurance for containing storage rots which even the best storage manager frequently encounters. An air rate which may be completely adequate for cooling in a cold production area may be insufficient for containing rot organisms, particularly if held at processing temperatures. The lower the humidity of the area, the lower the air rate required to dry out a rot problem.

On Long Island, .8CFM per CWT. is the level recommended for ventilation. We want this amount of air available for rapid cooling; also we know this level will contain all of our serious rot organisms. Because the systems are designed for this level does not mean that these levels are recommended at all times. The basic philosophy should be -- move as little air as possible to get the desired temperature and maintain it. The interaction of air and humidity is very important. If the humidity can be kept high, large amounts of air are not harmful. If humidities are very low, very little air movement can be harmful. Thus, it is very difficult and dangerous for you as an area to take the information from one area, be it Maine, New York or Idaho, and apply it to your area unless you understand the basic principles involved, and recognize the differences in climates.

When a rot problem develops in storage, follow the following rules:

(a) bring the temperature as far down as possible without freezing injury or cold temperature discoloration;
(b) continuously move the air through the pile to keep the rot contained to the individual potatoes breaking down;
(c) temporarily forget about the harmful effects of dehydration;
(d) move potatoes as fast as possible into market channels;
(e) if the storage is being held at chipping temperatures with heat available, warm up cold air to increase its water holding capacity, bring the air through the pile and then exhaust it;
(f) after rot is contained, resume normal storage procedures and practices.

The same general principles hold true for chipping stock, however minimum temperatures should be around 50°F. Temperature should be adjusted as low as possible without sugars accumulating past the point that they cannot be cured out, in two to four week period.

POTATO SPROUT INHIBITORS

Sprout inhibitors in the past five years have become a part of sound storage management for almost every area. They are no longer limited to the processor and the warm areas of production and storage. As the necessity and use has developed, so also have new and better techniques been developed. Some of the inhibitors which were available ten years ago are no longer available.

First let us consider those materials which are presently available and how they should be used for a storage application. There are three methods presently cleared for use with tolerances established -- Maleic

Hydrazide, Chloro IPC and irradiation, listed according to the order of time that they became available for commercial use. A fourth material, Fusarex, has been available for many years and is presently awaiting the establishment of a permanent tolerance.

Maleic Hydrazide

This material has been around for many years. Some areas are still learning of its limitations and how and when to properly apply it. It is applied to growing foliage. The foliage must be actively translocating to the tubers. The foliage must be relatively similar in all plants. If an uneven come-up, verticillium wilt and other diseases have caused uneven plant development in a field, it is impossible to get a good thorough application to every tuber. Wherever there are storages with poor air distribution MH is the only material presently available for use. The largest proportion of storages by far in the United States today are only satisfactory for a material like Maleic Hydrazide.

Chloro IPC (Sprout Nip)

CIPC (Sprout Nip) has steadily gained in acceptance and use throughout the potato storage world. Some countries are still not recommending its proper use. The early problems of application have been recognized and adjustments made. Although there are still people trying to prove and disprove the relationship of CIPC to internal sprouting, results clearly indicate that CIPC, applied at a sufficient dosage in storages with good air distribution, will control both external and internal sprouts. Now that the problem of internal sprouting has been recognized, some of the worst problems in recent years have been observed in storages holding at processing temperatures where no inhibitor was used or ever had been in the building.

Essential for good storage treatment are 1) good air distribution, 2) relatively tight storages so that the gases will remain inside during treatment and during the 48 hours or longer the fans are shut off after treatment, and 3) proper timing of application (as soon after wound healing as possible, and storage temperatures have been brought down to 55°F or under). The higher the temperature, the tighter the storage must be in order to not lose too much of the chemical before the chemical has effectively stopped the growth cells from dividing.

Treatment should be made to potatoes with well suberized skins. The same physiological mechanism is involved in wound periderm formation as with growing sprouts. If you stop one, you also stop the other.

There is a dust formulation which could be safely used when mature tubers with careful handling are moved from one storage to another, for long term holding. There is also an emulsifiable formulation which can be used to treat potatoes in a grading operation to control sprouting in market channels. This method is very effective in areas with old storage facilities which can, however, keep potatoes at very low storage temperatures until they are packed and on the way to market.

Irradiation

Despite the grandiose claims by glamour research people; despite the work presently being done in some areas which is repetition of work done over ten years ago; despite the pressure of certain government organizations along with equipment people to promote this method, no one has come up with any solution to the deleterious quality problems caused by irradiation. The potato industry cannot afford to consider any practice which is detrimental to quality, particularly when potatoes have such a wide range of competitive products. Irradiation at levels necessary for sprout control have effectively increased after-cooking darkening in cooked potatoes and increased black spot in the uncooked tuber. Maybe the day will come when these quality problems will have been solved. Until they have been solved, in my opinion, there is no place for irradiation in the sprout inhibition field despite its very potent sprout control ability.

Tetra Chloro Nitro Benzene (Fusarex)

Tetra chloro nitro benzene (Fusarex) is the only inhibitor that can be applied to potatoes going into storage. It is a relatively weak inhibitor and consequently does not markedly impair wound periderm formation with this type of application. Since it is a weak inhibitor, it is not satisfactory at high storage temperatures and care must be taken to not ventilate any more than necessary for temperature adjustment. One can expect sprouting on the periphery of a pile where the volatilized product does not build up sufficient concentration for sprout inhibition. This can be compensated for commercially by placing a higher concentration of dust over the surface of the pile.

What can sprout inhibitors do for you and your marketing program? The potato industry must recognize that the public wants quality. Last year during the very high price period, there were few complaints about price but there were many loud complaints about quality, and rightly so. A sprout inhibitor can help maintain quality in storage, spreading out the marketing period, controlling quality in market channels. A sprout inhibitor does more than control sprouting. Sprouting leads to increased moisture loss and shrinkage. This moisture loss and shrinkage may lead to pressure bruise and black spot. All of these are very important to you as growers. They are very important to the consumer who must be presented with quality potatoes, internal and external, raw and after cooking so that the consumer will not turn to competitive foods.