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The Canon of Potato Science:
35. Seed and Ware Potato Storage

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What is it?

Potatoes will sustain losses during their post-harvest life as they are living organisms with an active metabolism. Depending on storage conditions potato tubers will – to a lesser or greater extent – respire and transpire and thus lose fresh weight. Maintenance and metabolic processes require energy, and potato tubers use part of their dry matter (mainly starch) for necessary energy supply resulting in dry matter loss. Tubers therefore always show a weight loss due to transpiration (water loss) and respiration (dry matter loss). Moreover, potato tubers show changes in their chemical position during the period of storage. Finally, total weight losses can be increased substantially by storage diseases and pests. Nevertheless potato is a commodity that can be stored successfully for up to 10 months provided the right initial product is loaded, the right storage conditions are created and the right treatments are applied.

Two types of storage losses can be distinguished: weight losses and losses in quality. The major factors causing weight and quality losses are:

- Evaporation of water from tubers and sprouts;
- Respiration;
- Sprouting;
- Changes in the chemical composition;
- Damage by extreme (too low, too high) temperatures;
- Spread of diseases.

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Potato tubers lose water through evaporation. Water loss from stored potato tubers is a physical process. Lower water vapour pressure in the store environment will lead to water loss from potato tubers. Tubers with severe water loss are more susceptible to bruising and black spot during handling and will have increased peeling losses during processing. So water loss itself may be considered an economic gain (less transportation costs); its consequence is an, often larger, economic loss. Water loss can be reduced through:

- Maintaining a high relative humidity (RH) of at least 95%;
- Using ventilation air with a similar RH level;
- Restricted ventilation time;
- Avoidance of silver scurf.

Respiration in healthy tubers shows a minimum at about 5 °C. Respiration rate is higher at temperatures lower than about 5 °C and is also higher at temperatures above about 5 °C. The respiration rate increases very rapidly with an increase in temperature when temperatures become higher than about 15 °C. The absolute weight loss of healthy tubers caused by respiration is rather low. It amounts to about 10% of the total weight loss during a storage period of 6 – 8 months. The remaining portion, about 90%, of the absolute weight losses is caused by water loss, i.e., transpiration. Silver scurf caused by the fungus *Helminthosporium solani* makes the skin of potato tubers porous and inadequate control leads to higher losses by transpiration.

Sprouting of the stored tubers results in an increase in weight losses. The sprout itself constitutes a loss. Respiration of the entire tuber also increases when sprouting starts due to the strong increase in metabolic activity and growth. But the increase in evaporative water loss caused by sprouting is much larger than the effects of sprouting on dry matter losses.

The chemical composition of potato tubers is affected by storage conditions. This especially regards the conversion of starch into reducing sugars and *vice versa*. The processing suitability of potatoes is affected by storage temperature both negatively (too high reducing sugar levels at too low storage temperatures) and positively (reducing the amounts of reducing sugars through reconditioning). Prolonged periods of storage at relatively high temperatures, however, are inductive to the phenomenon of senescence sweetening.

Potato tubers can become damaged either at too low or too high storage temperatures. Freezing of potatoes occurs at temperatures below −1 to −2 °C. Frozen tubers lose water and will start rotting thereby negatively affecting neighbouring tubers. Storage temperatures below about 2 °C will cause chilling injury, negatively affecting the internal and external appearance of the tubers. High temperatures cause increased respiration rates and these may be associated with damage as well. Cells in the tuber heart suffer from insufficient oxygen supply caused by high respiration rates and will eventually die. This will show as tissue discolouration resulting in black hearts.

Diseases in the stored product can increase storage losses substantially. Major storage diseases are discussed in contribution number 21 in this Canon of Potato Science.

Seven phases are distinguished in potato storage:

1. Field drying;
2. Store loading of healthy tubers;
3. Drying at and during store loading;
4. Wound healing after store loading for about 10 days at 15 °C and high RH;
5. Cooling down to the desired temperature level. For the different end uses the optimal temperature ranges are:
   a. Seed potatoes: 3−4 °C
   b. Ware potatoes:
      i. Table consumption 4−5 °C
      ii. French fry production 6−8 °C
      iii. Crisps production 7−9 °C
      iv. Flakes, granulates 7−10 °C
6. Maintaining the temperature at the desired level;
7. Warming up before unloading.

Delivering large quantities of high quality product to table consumption markets or to processing industries is the sole objective of potato storage. Therefore potato storage managers aim at maintaining quantity and quality at the level as delivered by the grower. Quantity relates directly to profit; when payment is based on quality also quality relates to profit.

Why is it Important in Potato Science?

Research and development of potato has many disciplines, most of them scientists can dedicate themselves to independently such as genetics or virology. The research on potato storage, however is very much interdisciplinary as the aims vary (seed, processing of fresh market) and the tools vary (soft- and hardware) as well as the starting points (health and physiological status of the tubers entering the store).

Seed potatoes require a somewhat different storage approach as compared to ware potatoes. Ware potatoes are considered all potatoes in the human food chain both for fresh consumption and processed products.

The purpose of seed potato storage is to have either sprouted or chitted seed tubers at planting time. Seed potato storage should result in the physiological status desired at time of planting. Seed potato storage duration can be a few months up to 9 months. The longer the storage period, the lower the storage temperature. Short term seed potato storage may need a storage temperature of 10−15 °C, depending on cultivar and growing history. Long-term seed potato storage will require 3−4 °C storage temperature. For short-term seed potato storage at relatively high temperatures rather simple structures will suffice. For long-term storage at low temperatures financial investment to construct cold storage buildings solely used for potato storage will be required.

In ware potato storage sprout inhibition during potato storage is essential to prevent large losses. Therefore sprouting is often controlled chemically. Widely applied sprout inhibition compounds are based on chloro-propham (CIPC).

Management and technology are the best tools to control storage losses. Technology aims at using sufficiently insulated, often purpose-built, structures equipped with a cooling system and an air distribution system in the store. Management is the ultimate tool to reach clever decisions using up-to-date technology. Research and development in potato storage technology has led to the availability of well-designed small and large potato stores commissioned all over the world. Potatoes are successfully stored in areas with freezing ambient air temperatures and in hot tropical climates.

Why is it Important for the Potato Industry?

Potato production (growing, handling, storage) requires a substantial amount of financial investment. Any factor disturbing or hampering quantity and quality of the stored product is undesirable and must therefore be prevented or removed.

The internationally operating potato industry, whether focusing on processing or on fresh consumption, handles large volumes of potato tubers and applies strict rules and regulations with respect to quality. The potato grower needs to have access to the best field production techniques and storage tools in order to produce high yields and maintain high levels of quality during the storage period. Major tools in field production are cultivar, N and K fertilization, disease-free cropping and bruise-free harvesting. Storage tools include careful handling and applying the right storage temperatures with the aims to have low storage losses and sufficiently low reducing sugars content at time of delivery to market parties.

Scientific Developments

Seed potato production requires large amounts of medium sized seed tubers. Carvon (Talent) and ethylene (Restrain) give rise to an increased number of stems per seed tuber resulting in more medium-sized tubers. Both compounds are applied during the entire storage period. Application of sprout growth regulating compounds fine-tuned at cultivar level will further show their potential benefit.

Modern potato breeding programmes have goals directed at specific markets. The globally most relevant market is the potato processing industry. Breeding techniques resulting in potato cultivars with low reducing sugar contents will expand the usability of a cultivar.

Some new developments in the fields of research, techniques and management are:

- New (synthetic and natural) compounds for sprout inhibition and storage disease control, contributing to lower residue levels in stored produce;
- New application techniques for disease and sprout inhibition compounds;
- Sensory techniques for monitoring and predicting sugar and disease levels;
- Increased physiological knowledge at seed potato lot and cultivar level;
- Specific storage regimes for optimizing growth vigour of seed potatoes;
- Further optimization for storage management at store manager level.

Further Reading

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