Managing Potatoes for Processing Quality

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Introduction
The rapid expansion in the potato processing industry currently underway in Manitoba is an endorsement of the reliability of supply and the quality of locally grown potatoes. But the supply of high quality potatoes for processing comes at a cost and is not always easy to achieve. Production and storage management practices, pest problems, and weather have a significant effect on the suitability of potatoes destined for processing into french fries. Growers and agronomists must understand how the potato tuber responds to its environment and how the physiological characteristics of the tuber influence end-product quality. Failure to provide a top quality raw product to processors may result in financial penalties for poor quality or complete rejection of the load.

Tuber Characteristics
Cultivar selection for french fry production is very limited in Manitoba. There are only two main cultivars used for french fries, Russet Burbank and Shepody. These cultivars produce relatively large, oblong tubers that, when cut, produce the typical long fry. Additionally, the dry matter content, measured as specific gravity or bulk density, must be in a suitable range in order to produce fries with an acceptable texture and which do not take up too much oil during frying. Russet Burbank and Shepody have the specific gravity processors are looking for. Although the specific gravity of cultivars is generally consistent from year to year, growing season, fertility program, and crop maturity at harvest can influence it.

Production Management
Tuber size, uniformity, and yield can be influenced by various management practices. Proper seed piece spacing will help to ensure uniform tuber set and development under each plant. Uniform tuber set will help to ensure more uniformity in tuber sizing and ultimately result in more uniform french fries. Optimal fertility is important in ensuring crop yield but can also reduce tuber susceptibility to certain physiological disorders such as hollow heart. Uniformity of soil moisture assists in uniform tuber development by maximizing yield and by reducing the incidence of tuber disorders such as knobs and tuber splitting. These problems usually arise with irregular water supply to the plant. Irrigation is generally used to provide a constant water supply to potatoes, which in turn ensures uniform growth and subsequently normal development of tubers.

Managing Diseased Tubers
Late blight has, in the past few years, become a major cause for concern for potato growers. Late blight can cause significant crop loss in the field and breakdown of tubers in storage. When late blight is present, a regular fungicide spray program is required to limit disease spread in the field. The spray program must be continued until harvest to reduce the potential for tuber infection during harvest. If the late blight fungus is present on green tops at harvest, it may be transferred to tubers during harvest as tubers and tops make contact during digging. During the first few weeks of storage, temperatures and humidity are high which offers an ideal environment for the development of late blight that subsequently exposes infected tubers to further invasion by soft rot organisms. Depending on the severity of the disease, complete breakdown of the potato pile can occur. Cooler storage temperatures would help reduce the spread of the disease but may also result in lowered tuber quality for processing. It is preferable then to control diseases such as late blight in the field rather than to try to manage diseased tubers in storage.
Vinekilling
Desiccation of the tops of potato plants about two weeks before harvest can serve two purposes: 1) eliminate diseases such as late blight on the foliage since the late blight fungus needs living plant tissue to survive. Transfer of the fungus to tubers during harvest will then of course be prevented. 2) enhance skin set on tubers. Once the tops are dead, no further tuber sizing occurs and tubers will set a heavier skin which in turn reduces the amount of tuber bruising damage during harvest and subsequent handling. Most growers of processing potatoes in Manitoba choose not to vinekill in order to allow the crop to produce as much yield as possible before harvest.

Vinekilling can be accomplished by two methods. Chemicals such as diquat cause a rapid desiccation of the green tops and is the preferred method of vinekilling. Mechanical vinekilling by equipment such as a rotary mower can also be used although rapid removal of green tops on actively growing plants may cause some quality problems for processing.

Harvest
Careful handling of tubers at harvest and during any subsequent handling of the crop is essential to ensure tuber quality for processing. Tubers will bruise or shatter if drop heights are excessive or if tubers are too cold. Tubers should not be dropped more than 15 cm (6 inches) any time they are handled. Metal chains and conveyor belts should be protected with rubber to minimize bruising potential. Bruised tubers are susceptible to subsequent infection by diseases. In addition, the bruised tissue, once fried during processing, will darken resulting in non-uniform colour of the french fries.

Curing
Curing, often referred to as ‘suberization’, is the process used for potatoes once they have been loaded into storage. Curing occurs under conditions that encourage the deposition of several layers of cells to form the skin and the production of a waxy-like compound called suberin within these cells. The process of curing actually starts in the field when the tops have been vinekilled or have died naturally. But because the process may not be completed while still in the ground, curing is normally continued in storage during the first few weeks. Temperatures of 16-18°C and a high relative humidity for two to three weeks allow the rapid development of the skin. Wounds that occur during harvest and handling are also healed at this time. Tubers with a well-developed skin are able to resist disease entry and are less susceptible to dehydration which thereby reduces weight loss during storage. Once curing has been completed, storage temperatures are gradually lowered to the desired level.

Because environmental conditions for curing (warm temperatures and high humidity) are also conducive to disease development, tubers with disease or those that have been frosted before harvest can break down quickly during this time. The grower needs to decide whether to forego the curing phase and lower temperatures quickly to minimize losses from disease.

Sprout Inhibition
The moderate temperatures required for storage of potatoes destined for french fry production (7 to 8°C) will cause significant sprouting of tubers within several weeks of being placed in storage. In order to prevent sprouting, growers apply a chemical sprout inhibitor, either to the crop during growth or more commonly to the tubers once they are in storage. Maleic hydrazide is the most common chemical used as an in-field foliar spray mid-season. It is translocated to the tubers where it inhibits subsequent sprouting. Timing of application is critical and depending on the environmental conditions, some detrimental effects on tuber development could occur. Growers generally therefore prefer to use chlorpropham (CIPC) as an in-storage treatment because timing
of application is more flexible and there are no detrimental effects on processing quality. It is generally custom-applied as a vapour in the closed storage during which time the chemical settles on tubers and reduces sprouting.

**Sugars and French Fry Colour**

One of the major determinants of french fry quality is colour after frying. Fries must be light brown in colour and as uniform as possible. The colour is determined by the amount of free sugars, primarily glucose. Under high temperature frying, the free sugars interact with other components in the tuber to produce a browning...the more sugars, the darker the fry.

During plant growth, sucrose resulting from photosynthesis, is transported to tubers. There it breaks down into glucose and fructose that are in turn converted into starch or are utilized for the production of energy through respiration. Sucrose is a good indicator of tuber maturity during growth and is often measured during later stages of development to determine tuber maturity and suitability for harvest (Figure 1). If sucrose is high at harvest, the amount of glucose accumulation within the first few weeks of storage can be excessive. High glucose concentration will cause poor fry colour. It is preferable to harvest with a low sucrose so glucose accumulation is limited. Once sucrose levels drop to a certain low level, the crop is ready to harvest and tubers should be suitable for processing during several months of storage.

![Figure 1. Change in sucrose concentration during potato growth and storage and in glucose concentration in tubers harvested at different sucrose concentrations.](image)

After harvest, sucrose is no longer a good measure of processing quality. Glucose then becomes the best indicator of process colour. Monitoring glucose during storage is a technique used by some processors as an indication of the suitability of specific lots of potatoes for processing or as a signal of storage stress. Several stresses can cause an elevation of sugars that may make tubers
unacceptable for processing including: physical damage, cold temperatures, oxygen deficit, and sprouting. These stresses cause sugars to accumulate due to conversion from starch.

**Lowering tuber sugars**
Sugars that become unacceptably high after harvest can be lowered in storage. ‘Preconditioning’ is the process whereby high storage temperatures are maintained until sugar levels drop. Thereafter storage temperature can be lowered to that for long term storage. ‘Reconditioning’ is the process whereby storage temperature is elevated before shipment of tubers to the processor to again lower the sugar content. These elevated temperatures allow some conversion of free sugars into starch while some are burned off in respiration.

**Summary**
In order for Manitoba french fry processors to remain competitive in the international marketplace, growers must provide a continuous supply of high quality raw product at a competitive price. Proper field production and storage management practices are essential to ensure high yielding, high quality potatoes. Growers and agronomists must understand how management practices affect the physiological activity in tubers that will determine suitability for processing. Agronomic practices, handling techniques, environmental conditions, disease, and the storage environment all affect tuber characteristics and ultimately processing quality.