Sugar: Good for Tuber Survival, Not So Good for French Fries!

A tuber's complicated sugar storage mechanism is designed to maximize survival through dormancy and support successful growth the following spring. To translate that mechanism into something that best suits potato production priorities, producers must first understand how sugars develop and change through tuber growth and dormancy.

Potato plants produce sucrose via photosynthesis. This sucrose is transported to tubers where it is converted into fructose and glucose and eventually into starch.

The process reverses to feed respiration. If conversion back to sugars exceeds respiration's consumption, however, sugars accumulate in the tuber. This accumulation is problematic because, at high frying temperatures, monosaccharide, reducing sugars like glucose and fructose can react with the tuber's amino acids. This chemical reaction, called the Maillard reaction, results in an undesirable darkening of processed products including chips and fries. Sucrose – a polysaccharide or non-reducing sugar – is believed not to contribute to a Maillard reaction.

The levels of glucose, fructose and sucrose are dependent on tuber maturity at harvest, storage temperature and variety.

Sucrose is a good indicator of maturity at harvest. Glucose, on the other hand, is the best indicator of processing quality. The two forms of sugar correlate: sucrose levels at harvest correspond with glucose accumulation levels during storage.

Low storage temperatures will result in an accumulation of reducing sugars, an effect known as 'cold sweetening'. Because the temperature at which cold sweetening occurs is variety dependent, ask your processor or variety breeder for temperature recommendations. Typically, processing potatoes should not be stored below 7ºC/ 44ºF. That said, breeders are attempting to develop varieties that can withstand lower storage temperatures without accumulating sugar.

Tubers that enter storage with high sucrose levels or that accumulate high reducing sugar levels in storage can be improved via careful management. Tubers that have excessive sugar at harvest can be preconditioned by extending the early stage, higher temperature (approximately 13ºC/55ºF) suberization period until sugar levels drop into an acceptable range. The higher temperature allows tubers to convert some of the sugars into starch, while some of the rest of the sugar is consumed via respiration. Typically, producers test samples for fry colour to determine when the temperature can be lowered.

Tubers that have sustained cold sweetening in storage can be reconditioned at least partially by increasing storage temperature to the suberization temperature until acceptable fry colour can be achieved.

Sugar also accumulates due to stress. Cold temperatures at harvest and/or in storage, physical damage, oxygen deficit and dormancy break can all contribute to elevated sugar levels.

While sugar accumulation is the most common cause of processed product darkening, it should be noted that prolonged exposure to high CO_2 concentrations (over 2500 ppm for most varieties, though some varieties and end uses can be more sensitive) can also negatively affect fry colour. Though the correlation between fry colour and $C0_2$ was first identified almost 60 years ago, scientists have yet to fully understand the relationship between the two.

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