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Drying of High Oil Corn for Quality

Dirk E. Maier and Adam E. Watkins
Agricultural and Biological Engineering Department

High quality, high oil corn (HOC) should be low in stress cracks (brittleness) and other damages (heat, mold, insects, BCFM) and high in feed value and other desirable end-use attributes (oil, protein, starch, test weight). Stress cracks increase the breakage susceptibility of corn during storage and handling. Corn with a high number of stress cracks generates more dust during grinding, and is more vulnerable to insect and microbial attack during storage. A low feed value results in undesirable feed/gain ratios for HOC.

Stress Cracking

Small numbers of stress cracks occur naturally in all corn (usually less than 3% due to field drying). However, this background level of stress cracking is greatly increased during post-harvest handling. High drying and cooling rates are the major factor in stress crack development. When moisture is removed from the kernel too quickly, the structure of the kernel fails and stress cracks form. In order to maintain quality and therefore maximize premiums, producers must strive to minimize the increase in the number of stress cracks caused by drying and cooling.

Stress cracks in corn kernels can be broken down into four categories (Figure 1).

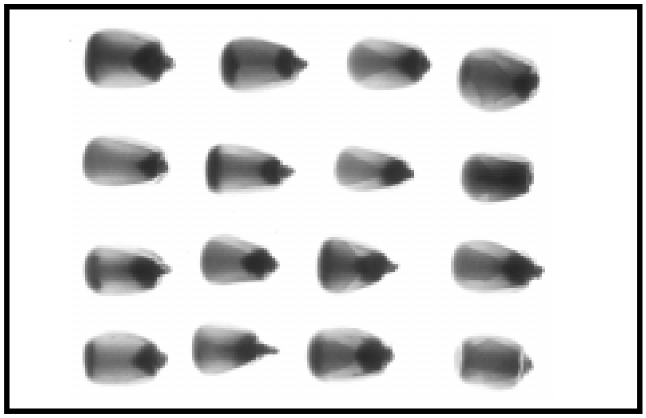

Figure 1: Zero, single, double, and multiple stress cracks in yellow corn kernels.

The first stress crack category includes kernels with zero stress cracks. This is obviously the most desirable category and the goal producers should strive for. The second stress crack category includes kernels with a single stress crack. Kernels with a single stress crack are often acceptable to corn processors. The third stress crack category includes kernels with two stress cracks (double crack). The most severe stress crack category includes kernels with more than two (multiple) stress cracks. These kernels are often referred to as checked or crazed kernels and are least desired by processors.

Stress cracks are easily determined by carefully inspecting kernels that are placed germ-down on a light-board. A sample of 50-100 kernels is usually sufficient to provide a representative indicator of the severity of stress cracks out of a dryer, in a storage bin, or in a truckload.

By counting the number of kernels in each stress crack category, the stress crack index can be calculated. Stress crack index (SCI) is a measure of the severity of damage in the corn and is calculated as follows:

SCI = Single + 3*Double + 5*Multiple

Where single, double, and multiple are the number of kernels with single, double, and multiple cracks, respectively. High oil corn has a larger germ than commodity yellow corn, and thus, less starchy endosperm. Every quality conscious producer should determine the level of stress cracks (and possibly SCI) and other critical quality parameters in their high oil corn before ever marketing or delivering the first load off their farm. Knowing your quality beforehand avoids surprises at the grading station and gives producers an additional marketing tool to maximize value added premiums.

Effect of Kernel Temperature

Thin layer drying tests with five HOC hybrids from the 1997 harvest at Purdue University have demonstrated the relationship between the kernel temperature during drying, the percentage of stress cracked kernels, and the digestibility of high oil corn. In these tests, small samples of high oil corn were dried on a screen one kernel deep from approximately 20% w.b. moisture to 14% w.b. moisture. Drying tests were performed at 100°F, 140°F, 180°F and 220°F. After drying, samples were subjected to either rapid cooling to 40°F or allowed to temper for one hour before being allowed to cool to room temperature. Figure 2 shows the combined results of each drying treatment.

This data shows a significant step increase in the amount of stress crack damage from 100°F to 140°F. At temperatures above 140°F, the amount of stress cracking decreased. The decrease is more pronounced for the tempered HOC. Drying high oil corn at kernel temperatures of 140°F appears to be the most damaging. This phenomenon of a kernel temperature that maximizes stress crack damage around 130-160°F has been previously shown in the literature. It is thought that as the starch pre-gelatinizes around 140°F, the endosperm actually develops a sort of resistance to stress cracking. Pregelatinizing of starch is undesirable in corn, such as waxy and high amylose corn, that is used by wet millers, because it reduces starch recovery during processing. On the other hand, pregelatinizing of starch can increase the digestibility of corn for livestock feed. Obviously, excessive kernel temperatures can lead to a breakdown in starch, which becomes evident in caramelized kernels (heat damage). However, if HOC feed quality was not negatively affected by higher kernel temperatures, and brittleness (stress cracking) was controlled by tempering, higher drying air temperatures than previously thought could be

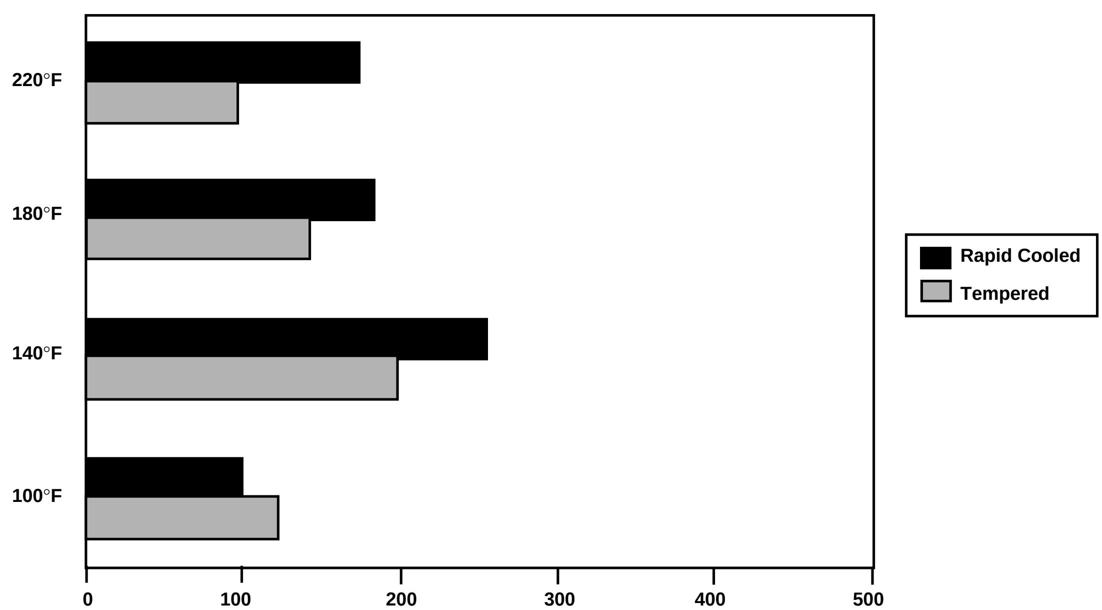

Figure 2: Average stress crack index for all high oil corn hybrids in each drying treatment

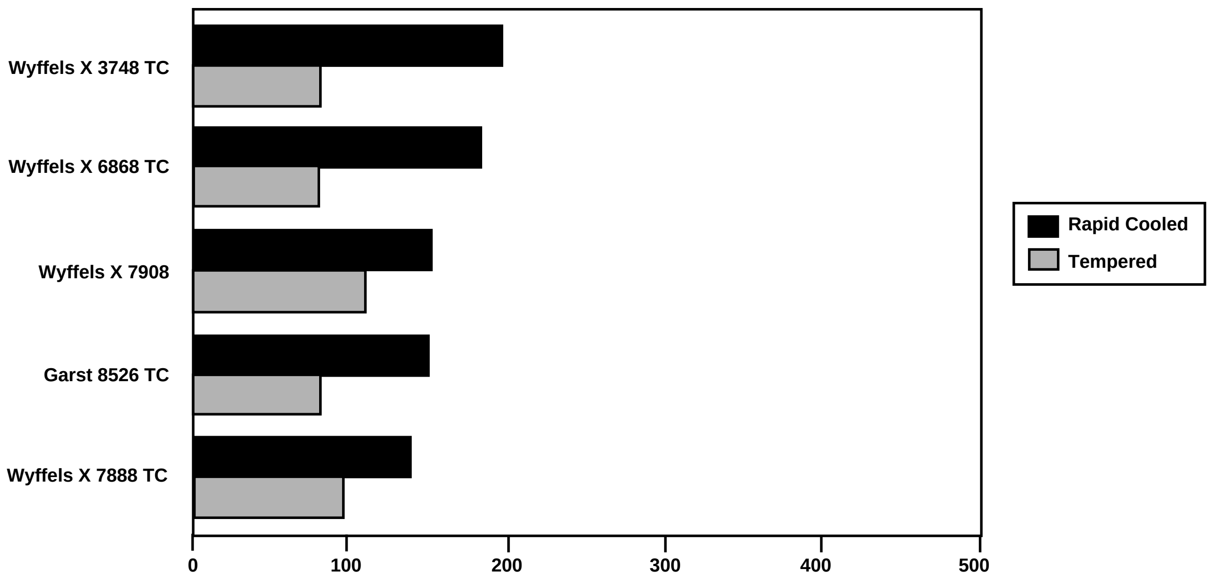

Figure 3: Stress crack index of five hybrids dried at 220 °F

used with HOC. This would be immensely beneficial to producers and elevator managers as higher drying temperatures result in higher drying capacities.

Effect of Tempering

The benefit of tempering hot corn after drying over rapid cooling was significant for high oil corn at kernel temperatures of 140°F and above. The benefit increased as the kernel temperature increased, while for rapid cooled corn the stress crack damage was not significantly different between 180°F and 220°F. It is noted that this data was obtained for HOC dried to 14% w.b. It is presumed that the benefit would be even greater if HOC was dried full heat to 17-18% w.b., then tempered followed by slow cooling in a bin (dryeration, in-bin cooling).

Effect of Hybrid

Figure 3 shows the stress crack index versus five high oil corn hybrids dried at 220°F. The data indicates that variations in stress crack susceptibility of over 30% exist among HOC hybrids cooled rapidly, while this difference was less than 26% for the slow cooled treatment. Minimizing this variability would benefit producers, handlers, and livestock feeders with respect to brittleness and dust generation during handling and grinding.

Drying Rate

This research also investigated the drying rate of high oil corn hybrids. It was shown that the difference between a fast versus a slow drying hybrid was as high as 15 %. This means that when under the same drying conditions the fast drying hybrid reached 14% w.b., while the slow drying hybrid had only reached 15% w.b. This has a significant effect on drying capacity.

Digestibility

The benefit of pre-gelatinization of starch was investigated for the hybrid with the highest oil content in a feeding trial with ducks. Thirty ducks were fed samples of ground corn dried at one of the four drying temperatures. The excrement from the ducks was collected and analyzed for nitrogen, dry matter, and energy content, and the data was compared to data collected from undigested corn. The resulting analysis showed no significant correlation between the maximum kernel temperature during drying and the nitrogen, dry matter, or energy retained by the ducks.

Thus, based on the limited data from this research, it appears that high oil corn does not have to be dried as carefully as other specialty grains in order to preserve feed value. As a matter of fact, producers, handlers and feeders may benefit from reaching kernel temperatures above 140°F during the drying process provided that the HOC is transferred hot and tempered before cooling in order to reduce brittleness (stress cracking). This observation will have to be investigated further before a general recommendation can be made.

Storability

Another concern in preserving HOC end use quality is its allowable storage life. One HOC hybrid (that was not part of the drying study) was investigated with respect to its storability versus white corn and popcorn. This was done by measuring the carbon dioxide released from tubes of corn over a 12 day period. The mass of carbon dioxide released by the high oil corn was much higher than that released from the other corn types. This indicated that respiration was occurring at a higher rate in the high oil corn. This could be due to the fact that high oil corn has a larger germ than other corn types. High oil corn may also have a higher equilibrium moisture content at the same absolute humidity than other types of corn. Thus, based on the limited data available, it appears that high oil corn may respire more and not store as well compared to other corn types. This would be highly undesirable for producers, handlers, feeders, and especially exporters, considering the need to store HOC for feed use from one harvest to the next. This observation will need to be investigated further before a general recommendation for storage management can be made. In the meantime, it may be advisable to consider drying HOC to a lower moisture content for long term storage than regular commodity corn.

For a complete report of this research contact the authors by e-mail (maier@ecn.purdue.edu), phone (765-494-1175), or fax (765-496-1356) and request ASAE paper No. 98-6039 *Thin Layer Drying Rates, Stress Cracking, Digestibility, and Dry Matter Loss of High Oil Corn Hybrids.*

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