GRAIN QUALITY Task Force

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Quality Grain Needs TLC

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Breeding efforts in the specialty grain area continue to increase especially as they relate to the milling and snack food industries. Corn and soybeans are no longer just “commodities”. Specific traits have been genetically developed for specific end use purposes, such as corn dry and wet milling, snack food manufacturing, soybean oil extraction, peroxidase recovery, and livestock feeding. However, a desirable attribute for one application might be a negative one for another. It appears that commodity markets may become a spectrum of multiple “niche” markets, with some niches larger than others, and some more demanding about quality than others.

Grain Quality

Grain quality is a nebulous term that means different things to different people. Grain quality largely depends on the grain type and its end use. It includes a range of properties that can be defined in terms of **physical** (moisture content, test weight, kernel size, total damaged kernels, heat damage, broken kernels, stress cracking, breakage susceptibility), **sanitary** (fungi and mycotoxin count, insects and insect fragments, rodent excrements, foreign material, toxic seeds, pesticide residue, odor, dust), and **intrinsic** (milling yield, oil content, protein content, hardness, density, starch content, feed value, viability, storability) quality characteristics. The quality properties of a grain are affected by its genetic traits, the growing period, timing of harvest, grain harvesting and handling equipment, drying system, storage management practices, and transportation procedures.

Only a few of these quality factors are actually part of the official U.S. grain standards used for grading grains and oilseeds. Often contracts between processors and producers will specify specific varieties, quantities, and quality criteria. Some processors offer premiums for high quality grain as a function of how far within the maximum or minimum specifications farmers deliver their crops. Thus, it is important to understand how these quality characteristics are affected so that producers can maintain and deliver these grain quality attributes, and receive deserved premiums.

Corn Quality for End Use Processing

Corn dry milling, for example, results in a range of degermed corn products from flaking grits to corn flour. These products may be used in breakfast cereals, snack foods, prepared mixes, batter and breading mixes, and low calories/high fiber foods. In order for the processor to supply the end user with prime products of high quality, he needs corn that in addition to the “universally” desired attributes (minimum FM, BC, damage, and moisture) has special ones, such as high test weight, maximum hard endosperm, minimum stress cracks, no mold, and large uniform kernels.

Corn-based snack foods, such as corn and tortilla chips, represent one of the fastest growing segments of the nearly 10 billion dollar salty snack food market. White corn products are in particularly high demand. Before grinding corn into masa needed for chip production, each kernel’s hull must be removed during the cooling, soaking, and washing process. Some corn hybrids have thick hulls, which are more difficult to remove. Thus, hybrids with thin hulls are preferred by processors. Stress cracked, broken and damaged kernels take up moisture more rapidly and disintegrate during the cooking, soaking, and washing process. Typical snack food corn specifications may include less than 20 parts per billion of aflatoxin, and maximum values of 20% moisture at harvest, 10% defects, 30% stress cracks, and 5% dead germ.

The wet milling industry is the largest industrial user of corn, consuming over 12% of the annual crop. Wet milling separates corn kernels into their basic components (starch, protein, germ, fiber) with the principle one being purified starch. Simply put, corn is softened and ground. Then the individual components are separated based upon their different densities in water. Each fraction is marketed for its highest value. Corn starch can be converted to sweeteners such as dextrose and high fructose corn syrup. Optimum quality of incoming corn is critical for maximum processing yield. The official grading factors provide a minimum acceptable corn quality for wet milling. Economically significant are compositional differences and structural attributes. Both of these are influenced by genetics and handling, which in turn are primarily controlled by the producer. The general quality goals for the four wet milling products are: less than 0.3% protein in the starch, 70% protein in the gluten, minimum bound starch in the fiber, and more than 45% oil in the germ. The wet miller prefers a soft endosperm because it has a shorter steeping time, which increases throughput, and its starch fraction separates more easily from the protein. High stress-cracked corn increases the amount of broken kernels, and reduces oil and starch recovery. Additionally, in order to optimize starch yield, corn kernel temperatures must be kept below 140°F during drying.

Effects of Drying on Quality

The drying system can generally have the most detrimental effect on grain quality. Drying of grains and oilseeds can be divided into four broad categories: (1) low temperature drying, which uses unheated air, or air heated by up to 15°F; (2) medium temperature drying with heated air that keeps grain kernel temperatures below 110°F for seed and food grains, and below 140°F for grains to be milled for industrial use; (3) high temperature drying with heated air that keeps kernel temperatures below 180°F for animal feed; and (4) combination drying, which uses both low and high temperature air to optimize capacity, efficiency, and quality. Low temperature and combination drying systems are almost exclusively used on-farm, while medium and high temperature drying systems are used both on- and off-farm.

Grain Kernel Temperature

The operator of a dryer must be aware of the difference between the drying air temperature, which is set at the burner, and the temperature which individual grain kernels may reach as they dry. They are NOT the same! High grain kernel temperatures during drying probably have the most detrimental effect on quality characteristics. High kernel temperatures reduce dry matter in feed grains, increase the amount of stress cracking and breakage susceptibility, reduce the yield of grits during dry milling and of starch during wet milling, diminish the yield and quality of oil from oilseeds, and destroy the germination value in seed grain.

Typically, air temperatures used to dry commodity grains in high-temperature, high-capacity crossflow dryers range from 180 - 230°F. The negative impact of these high values on desirable quality characteristics can be limited by using air temperatures sufficiently low to avoid exceeding the maximum recommended kernel temperatures, or by switching to less detrimental combination drying practices utilizing natural and low temperature air. Regardless of dryer design, grain kernel temperatures must be kept below the maximum values during the entire drying process to minimize undesirable quality losses.

Stress Cracks and Breakage Susceptibility

Stress cracks in corn kernels are due to internal failures in the endosperm and are caused primarily by high drying and cooling rates. Vaporized water inside individual grain kernels can leave a kernel only so fast, and moisture gradients develop. If the moisture is forced out too quickly during drying (or evaporative cooling), the physical structure of a kernel is overloaded and fails. The cracks may or may not reach the surface just beneath the pericarp. Stress cracks are easily detected by candling individual kernels over a light source. They are classified as single, multiple, or checked cracks. Moisture gradients inside the kernels have a greater effect on creating stress failures than temperature gradients. Corn with a high percentage of stress-cracked kernels tends to increase in BCFM as the product moves through a grain handling facility and the marketing channel. The breakage susceptibility of corn is generally related to the average moisture content but likely also depends on the moisture variation among individual kernels. The susceptibility of grain to breaking (brittleness) can be measured with a commercial breakage tester, though the practical usefulness of the resulting number is difficult to correlate.

Years of research and experience have clearly shown that the development of stress cracks (and thus the amount of BCFM) can be minimized by selecting less susceptible hybrids, harvesting and drying at lower initial moisture contents, avoiding overdrying, controlling the amount of moisture removed per drying pass especially between 15 - 18% moisture, minimizing the drying rate to 4 - 5 percentage points per hour, reducing the grain kernel temperature, tempering during drying and before cooling, slow cooling after drying (dryeration and in-bin cooling of hot corn), and controlling the relative humidity of the storage environment.

Summary

Producers and handlers considering opportunities to deliver high quality grains to millers and processors need to carefully weigh the strict physical, sanitary and intrinsic quality requirements set forth in contracts. In order to meet these demands, major changes in current drying practices, such as switching to low and medium temperature systems, are needed especially to minimize stress cracking of kernels. Afterall, quality grain needs tender loving care from the seed bag to the food package.

For more information, obtain a copy of

GQ-3 Costs of Drying High-Moisture Corn,
GQ-5 Low Temperature Drying of the 1992 Indiana Corn Crop,
GQ-14 Proper Use of Moisture Meters,
GQ-15 Optimizing Dryer Operations,
GQ-18 Blue Eye in Corn,
GQ-19 Last Minute Grain Dryer Checks, and
GQ-20 Slow Versus Fast Low-Temperature Bin Drying of Corn from your local CES Office.

Grain Quality Fact Sheets can be accessed on-line through:
World Wide Web (Mosaic or Netscape) URL address:
http://hermes.ecn.purdue.edu:8001/server/purdue/acspub.html

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