A Guide to Understanding Vitreousness and Prolamins in Corn

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Corn is a Seed: The corn seed is comprised of three basic morphological parts, pericarp, germ, and endosperm. The endosperm represents 75-80 percent of the corn kernel and contains primarily starch and protein. The endosperm of corn is virtually devoid of fiber (ADF or NDF) but contains abundant proteins (albumins, globulins, prolamins, and glutelins) of which prolamins are of primary importance in ruminant nutrition.

Prolamins Make Corn Vitreous: The word vitreous means "glass like" and prolamins are proteins associated with starch in all cereal grains. In corn, prolamin proteins are named zein and comprise 50-60 % of the protein in whole corn. Prolamin proteins cross-link encapsulating starch into a water tight (hydrophobic) matrix. Although less common, floury or opaque endosperm corn types have lower prolamin content as compared to flint or normal dent corn hybrids. Differences in starch encapsulation by prolamins can be seen using scanning electron microscopy Figure 1. Prolamins define differences in the chemical composition between vitreous dry corn (glassy, translucent) and floury or opaque corns although the relationship is not absolute. Starch in vitreous dry corn is more extensively encapsulated by prolamins and is less degradable in the rumen as compared to floury or opaque corns.

Vitreousness or Prolamins Decrease Starch Digestion: Research studies have observed negative relationship between the vitreousness (prolamin) of a feed grain and starch degradability or digestibility. In a University of Wisconsin study total tract starch digestibility was decreased 0.86 percentage units for each percentage unit increase in the grain prolamin content when prolamin was expressed as a percentage of starch.

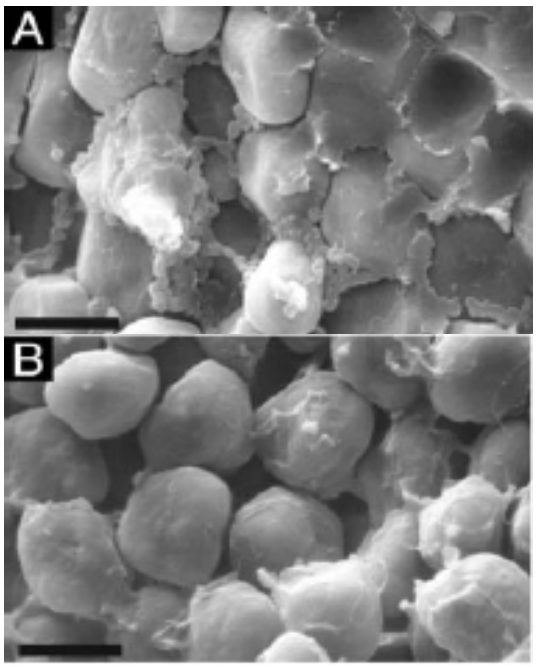

Figure 1. Scanning electron microscopy of starch granules in corn: A) starch granules heavily imbedded in prolamin-protein matrix, B) starch granules in opaque corn with less extensive encapsulation by prolamin-proteins (Gibbon et. al., 2003). Published with permission: *Copyright (2003) National Academy of Sciences, U.S.A.*

Nitrogen Fertility Effects Vitreousness & Prolamins: The nitrogen fertility status of the corn crop during the growing season can affect the prolamin content of the grain. Excessive rainfall can result in N losses from leaching and denitrification. Likewise, lack of moisture during the pollination can result in poor N status. When corn is deficient in N, yield is reduced because the nitrogen sink, which facilitates starch accumulation and increased kernel weight, is altered. Corn kernels from normal hybrids grown under nitrogen deficient conditions may be more opaque and may contain only one-half of their normal prolamin concentration.

Fermentation Degrades Prolamins: Improved starch digestion in high moisture corn or corn silage kernels is dependent on the degradation of prolamins via fermentation. Prolamin degradation is dependent on the length of the ensiling time and the intensity of fermentation. Prolamin degradation is difficult to measure in the laboratory but soluble protein and or ammonia concentration are excellent markers of prolamin degradation in high moisture corn. Prolamin proteins in high moisture corn containing

45-65 % soluble protein or 4-6 % ammonia (% of total N) have likely been extensively degraded. Dry corn or unfermented high moisture corn has no ammonia and soluble protein concentrations are typically less than 30 % of total protein.

Evaluating Vitreousness and Prolamins in Corn: Determination of vitreousness requires manual dissection of whole corn kernels and is not routinely performed by commercial feed and forage testing laboratories. Likewise, vitreousness is not viably measureable in ground dry corn or high moisture corn. Vitreousness of mature corn kernels can be indexed on farm by laying mature corn kernels on a background light source and observing translucence (Figure 2).

A commercial test is available to determine the concentration of hydrophobic prolamin proteins that encapsulate corn starch. The prolamin protein assay is available at a number of commercial feed and forage testing laboratories. The prolamin content of dry corns ranges from 2.5-5.5 % of dry matter. Corns > 4.5 % prolamin as a % of DM are likely more vitreous, may contain more flint genes, are short relative maturity hybrids (more flint genes) and had adequate N fertility. Corns with lower prolamin protein < 3.0 % maybe unique opaque-floury hybrids or be grain from N deficient corn. The prolamin assay used in commercial feed and forage testing laboratories is similar to vitreousness in that it indexes corn endosperm characteristics. The prolamin assay does not measure the degradation of prolamin proteins in high moisture corn as induced by fermentation. Degradation of prolamins in high moisture corn should be evaluated using soluble protein or ammonia as markers of prolamin degradation.

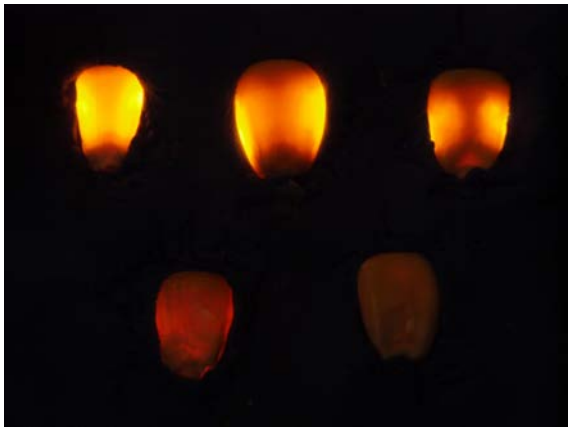

Figure 2. Differing translucence (vitreousness) of corn endosperm types as defined by a light box. Brighter corn endosperms are an index of greater vitreousness and potentially greater prolamin protein concentrations. Corn endosperm types which transmit minimal light are considered opaque.