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Variation in Corn Grain Starch Availability

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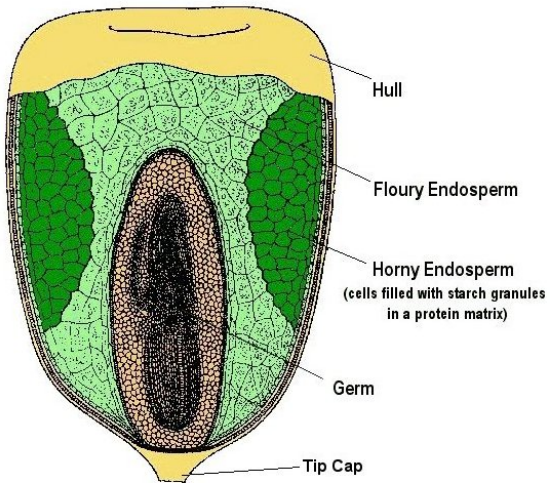
Corn kernel composition is shown in the diagram. Different corn varieties and types result in different kernel starch and protein makeup. A review by Knowlton from Va Tech summarized that waxy corn types contain only amylopectin starch and digest faster than non-waxy which have both amylase and amylopectin. Non-waxy varieties with predominantly floury starch texture digest faster than those with more vitreous (horny) endosperm. High lysine varieties may have more available starch, and dent varieties (normally more floury) have more starch availability than flint varieties. In addition, application of heat, moisture and pressure (high moisture or steam flaking) alter rumen fermentation and starch availability. Increased starch digestion is achieved by disrupting the protein matrix surrounding starch granules and destroying crystalline structure. Several trials comparing corn starch endosperm type are reviewed below.



French Researchers Phillipeau et al in 1999 compared 8 dent and 6 flint varieties and reported that dent corn averaged 51% vitreousness vs. 72% for flint corn. Effective ruminal degradability averaged 62% for dent vs. 46% for flint.

Vitreous endosperm has a more extensive, harder to degrade protein matrix and typically higher protein content in the grain. Floury endosperm has a thinner protein matrix around the starch granules. The starch matrix in floury endosperm has more empty spaces and is less dense. This makes it easier for rumen bugs to attack and break down the starch more readily. In the Phillipeau trial the CP% of the corn was directly related to the starch vitreousness. Other measures more closely related to degradability were apparent density and 1000 grain weight.

A 1997 trial by the same French group reported 61% vs 40% starch degradability for dent and flint corn, respectively. Dent had 48% vitreous starch vs. 72% for flint at maturity. Starch availability was lower at greater maturity and the drop was greater for flint types. However, even at silage stage (30% DM) there was a large difference between types. They concluded silage starch availability can be modified by genetic selection.

The Shaver group at Wisconsin (2002) compared 14 U.S. hybrids (dent) at ½ milk line (38% Moisture), black layer (25.7% Moisture) and +21 days later (13% Moisture). Growing conditions and location of kernel on the ear affects vitreousness and were controlled. On average, vitreousness increased from 42% to 46% to 48% as time passed. Within each stage of maturity, earlier maturing hybrids had higher vitreousness. They also compared 5 Brazilian varieties (flint) at maturity and found 74% average vitreousness. The results were similar to the French comparisons of flint and dent corn. Across maturity and type vitreousness ranged from 35 to 80% and corresponding ruminal starch availability ranged from 80% to 45%.

The table shows a range in vitreousness within US dent hybrids and Brazilian flints. Notice the highest U.S. dent variety had similar vitreousness to the lowest Brazilian flint variety. Within U.S. dent varieties, as vitreousness increased with increasing maturity, starch availability decreased for both a low and high vitreous variety. Note the

starch availability decline with advancing maturity was greater for the more vitreous variety. The WI group also measured kernel density and found a good relationship with vitreousness and starch availability. In their work, relationship with 1000 kernel wt wasn't as high.

	U.S.Dent			Brazilian Flint		
	Lo Hybrid 1	Mid Hybrid 2	Hi Hybrid 3	Lo Hybrid 4	Mid Hybrid 5	Hi Hybrid 6
Vitreousness %	35	44	62	64	76	80
	Lo Vitreous (36%) Dent Variety			Hi Vitreous (55%) Dent Variety		
Stage	1/2 milk	Black Layer	BL +21 day	1/2 milk	Black Layer	BL +21 day
Kernel Moisture %	37	24	12	37	30	15
Vitreousness %	33	35	41	50	56	60
In Situ degadability	78	79	76	71	69	63

US Grains council data from the 2001/2002 Value Enhanced Grain Report shows heavier bushel test weights and vitreousness from 1997 to 2001 for hard endosperm selected corn. Waxy was heavier than commodity corn in #/bu but lighter in gms/1000 kernels. Density differences are apparent.

	#/bu	1000 kernel wt.	vitreousness
Hard Endosperm Corn	60.5 to 61.5	330 to 355	87 to 91
Waxy Corn	58 to 60.5	315 to 325	
Commodity Corn	57 to 58.5	320 to 345	81 to 82.5

Michigan researchers in Allen's group (2005) fed floury or vitreous corn grain along with either standard or BMR corn silage. As expected, the floury corn was more ruminally available (62% vs 46%) and was available faster (22 vs 13 %/hr). Floury corn was also more available in the small intestine (91% vs 84%) and within the total GI tract (97% vs 92%). Because of its softer texture, floury corn ground significantly finer. Vitreous corn passed from the rumen faster because it was denser. In addition, interactions occurred with starch types and the rest of the diet. When floury corn was fed with BMR corn silage, intake was 0.7 lbs higher and milk was 4.6 lbs higher. However intakes were 4.2 lbs lower when floury was fed with standard corn silage and production was 2.6 lbs lower. Ruminal fermentation rates and patterns affected meal size and frequency.

In another report from the MI group (2005), when floury endosperm corn was fed dry ground it improved milk production efficiency, but efficiency decreased when floury was fed as high moisture corn. Brazilian researchers (2005) reported more digestibility, higher milk production, and milk protein with a dent vs. flint variety.

Allen and the MI group summarize by saying it's unlikely that optimal starch digestion amount and rate is constant across all diets, depends on a variety of factors and is difficult to predict. Response of animals will probably depend on energy balance, stage of lactation, hormone response, and nutritional balance.

As indicated by Knowlton, processing of corn also affects the endosperm type availability and creates further interactions. Grinding (fineness of grind), HM vs. dry, rolling vs. flaking must be coordinated with the endosperm starch type to provide the best combination for animal performance.

Several groups are working on determining rates and extents of starch availability for individual ingredients and in TMRs using chemical, NIR, in-vitro, enzymatic and gas release techniques. Renaissance is working with these groups using both currently available tests as well as new procedures available only to Renaissance nutritionists. The area of starch availability is being intensively investigated. All corn is not alike.