<u>Improving food corn by trait discovery, association mapping, and GxE of kernel composition</u>

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Food grade corn is the main ingredient in many popular snack foods such as tortilla and corn chips. The food grade corn market makes up 3% of the total US corn market (USDA Feed Yearbook, 2016). Of this 3%, even a smaller fraction of food grade corn is bred specifically for use in corn chip products. Manufacturers have stringent quality standards that need to be met in order to provide high quality products to their consumers. Seed companies work closely with manufacturers to select hybrids that meet these food grade quality specifications. Breeders also select hybrids based on agronomic performance to meet the production needs of growers. Only after a hybrid is selected based on coarse food grade traits and agronomics, does it finally reach the stage of cook testing with the manufacturer.

There are several control points within a corn chip manufacturing operation that are used during cook tests to evaluate the samples for processing and sensory qualities. The first, and most critical control point, is the moisture uptake of kernels during an alkaline cooking process called nixtamalization. Kernel moisture profiles must fall within an acceptable range in order to form a dough with uniform consistency and moisture content. Additionally, moisture content can have an effect on the end oil content of the product. High moisture may result in increased oil content, leading to higher manufacturing costs and is often viewed negatively by consumers concerned about nutritional content. In addition to moisture content, samples are submitted to sensory evaluation when cooking is completed. Hybrids will either pass or fail based off of the observed processing and sensory qualities. Approved hybrids then are added to a list of varieties that contracted growers are allowed to use. Failure in either of these areas results in the hybrid not being used for food production.

Both breeders and manufacturers face challenges within this hybrid approval process. A primary concern is that there are no highly effective proxies for evaluating kernel quality before submission to the cook test. This lack of effective phenotyping and evaluation techniques is due to a poor understanding of the relationship between kernel compositional components and their effect on the end product quality. Breeders do not know which traits control food grade quality, and therefore do not fully understand the underlying genetics of food grade traits. These two factors, lack of effective phenotyping techniques and an unknown genetic architecture, complicate the development process of food grade corn for the corn chip industry. An additional challenge for breeders is that genotype by environment (GxE) effects are not well characterized for food grade traits. Breeders are not able to account for all potential environmental factors during their evaluations, which can lead to unexpected GxE effects that negatively affect quality.

The endosperm tissue is the portion of the kernel that is turned into dough and cooked. The two main biochemical components of kernel endosperm are protein and starch. Their relative effects on moisture uptake during nixtamalization is not well understood. Starch is comprised of two main polysaccharides, amylose and amylopectin. These polysaccharides undergo different reactions with water and heat during nixtamalization including starch granule swelling and crystallization properties (Mondragon et al, 2004). Zeins distributed throughout the endosperm tissue may also affect moisture properties due to their hydrophobic nature (Anderson & Lamsal, 2011; Dombrink-Kurtzman & Knutson, 1993). Previous research has described individual components' biochemical reactions with water, but does not fully account for the interactions between components during the nixtamalization process and the resulting kernel moisture content.

The goal of my research is to develop a base of knowledge for breeders and manufacturers to improve the quality of food grade corn for corn chip production. The three specific objectives are to:

1) Build a phenotypic platform that effectively evaluates compositional traits in raw grain to predict processing quality.
2) Characterize the genetic architecture of processing quality in food grade corn, as well as the causal compositional traits.
3) Classify the type of environmental factors that contribute most to processing quality.

The basis for food grade traits will be explored using a diverse set of 500 inbred lines of corn (Hansey, et al 2011). This diverse panel will be grown in St Paul, MN, and Ames, IA during the 2016 and 2017 growing season. A total of 4000 samples will be harvested from this panel to be used for further compositional analysis. Compositional traits will be analyzed using near infrared spectroscopy (NIR), and moisture uptake will be evaluated using a small scale nixtamalization cooking assay. The compositional and moisture data will be analyzed using a supervised learning approach to elucidate the effects different compositional traits have on processing characteristics. Traits that are found to be highly significant for corn chip processing will be further explored through a Genome Wide Association Study (GWAS). Environmental data collected during these growing seasons will be used to explore the effect that GxE interactions have on compositional traits as well as moisture uptake during nixtamalization.

In summary, the development of food grade corn for corn chip production is difficult for breeders and manufacturers. These difficulties are the result of a poor understanding of how specific kernel compositional traits affect moisture uptake during the nixtamalization cooking process. The development of a base of knowledge around food grade corn entailing the above three objectives will offer a deeper understanding of important food grade traits as well as an understanding of the genetic and environmental effects contributing to processing quality.

References

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