Rethinking Scales for Measuring Peanut Quality

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ABSTRACT

Peanut quality is influenced by a complex web of factors with scales ranging from the molecular to global weather patterns impacting climate. In some cases these quality factors are well understood, measured and controlled. In others, due to time, technological or resource limitations, this is not the case. Success in current and future markets will depend on the capacity of a supply base to reliably deliver the most important quality factors, which must be well defined for a given application and cost balanced. New technologies and systems are needed to more efficiently provide data across the relevant quality scales, which will allow for better predictive tools, drive more differentiation/value in the supply base, and catalyze new market applications.

Key Words: peanut quality, peanut safety, single kernel measurements, single kernel distributions

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"You can't beat quality" -Wil Parker. Mr. Parker has served the peanut industry for 40 plus years, many with JLA, and his technical knowledge and industry wisdom are deep. This simple but powerful message sums up Wil's philosophy on peanuts, drives his work and is the core of this presentation.

"Uncontrolled Variation is the Enemy of Quality" - W. E. Deming. Dr. Edwards Deming was an American statistician and engineer. This quote certainly applies to our industry. Consistency with no surprises is critical to peanut ingredient performance and safety. On the flip side of Deming's quote, it seems fair to say that "controlled variation is a source of value." That is, if we can more effectively measure and capture the natural variation present in the peanut supply, we can deliver ever more functional, healthy and excellent tasting ingredients.

Given the fifty year anniversary of APRES, my charge was to present thoughts on challenges facing the peanut industry over the next fifty years from a food science perspective. First, let us call these challenges opportunities. Second, let us not forget that peanuts are food ingredients. Third, while no one can predict the future, if we embrace new, better, and more efficient ways to predict, measure and deliver quality, I predict our industry will grow ever more viable over the next fifty years.

Market success depends on delivering raw materials with well defined quality parameters at a fair price. Depending on grade, market type, etc., a shelled 20 MT lot contains roughly 10 to 100 million peanut kernels. Despite large peanut kernel counts, lot quality are often defined with single kernel (SK) resolution. For example, the frequency of contaminants in a high oleic lot, frequency of kernels with aflatoxin, or the frequency of kernels not a meeting a defined oil content (maturity), could all result in finished product quality that limits ingredient performance at best, or results in food safety (excessive aflatoxin) concerns at worst. Despite the inherently understood importance of SK chemical data on incoming lots, this data has been historically limited, due to technological, time and/or cost constraints.

Currently, how do manufacturers sourcing raw peanuts control and/or measure quality? Three considerations are presented next. The first is institutional knowledge and trust. Institutional knowledge is how well that manufacturing organization collectively understands its processes; that accrued knowledge and wisdom over time. This institutional knowledge is often paired with trust in a supply base, which is best earned over years of collaboration. While institutional knowledge is critical to controlling quality, there must also be a scientific foundation for raw material specifications, or manufacturing organizations will be at increased risk for the extremes (crop failures, quality concerns, etc.) that commonly present when sourcing biological ingredients.

Second, manufacturing organizations procuring peanuts typically specify market types (runner, virginia, spanish or valencia) and then a subsequent grade. While there's certainly overlap in the chemistry, physical properties, and sensory properties of these market types, they are specialized ingredients that have been developed over years to best serve certain applications. The industry has essentially captured variation naturally present in the germplasm to generate specialized ingredients, and by grading we are now making ever more specialized ingredients. Grade standards define

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controls for important factors like damage that correlate with chemistries that can cause havoc from a free fatty acid or aflatoxin perspective, for example. Importantly, peanut grades also have standardized sizes, which in turn indirectly promotes similar chemistry among kernels. All other factors being equivalent, peanuts of equivalent size, tend to be of similar maturity, which in turn tend to have more consistent chemistry among peanut kernels; however, the size/maturity/chemistry relationship is indirect, so a more direct measurement of a sample's SK chemical distributions would be high value for subsequent processing of that ingredient.

Third, manufacturers can measure and control incoming ingredient quality by direct chemical measurements of samples representing lots of interest. For example, various industry standardized oil chemistry measurements provide information on the ingredient's overall oil content, fatty acid composition, free fatty acid content, and peroxide value. These are relatively simple but powerful measures that indicate how the peanut ingredients will perform from a sensory and shelf life perspective. There are several broad limitations for direct chemical measurements to assess quality. First, there is simply not much time for chemical measurements as the shelled ingredients are often being produced on tight logistical schedules. The most realistic time frames for direct quality measurements of lot samples is in the range of hours, typically not multiple days. A second limitation is cost, as the economic margins in the peanut business are often small, any testing must be high value/high impact. Closely related to time and money, another limitation for most chemical measurements for assessing shelled lot quality, is that these measurements consider kernel *averages*. While averages are important, the SK chemical distribution is often more important than the average value itself. This is true for sugar distributions and roast consistency, aflatoxin management, and high oleic lot purity, to name a few. This leads to a final limitation/constraint of chemical measurements to assess lot quality: sample size. Shelled lots are often 20 MT but due to time/cost constraints the industry often evaluates sample sizes on the order of 10 to a 1000 grams, so anytime we can effectively increase sample size, it allows for a better understanding of the lot's true chemistry. This is especially true for skewed distributions, such as what's typically encountered for lots contaminated with aflatoxin where only a relatively small frequency of kernels can cause the problem.

New technologies are needed to overcome these constraints and one platform that shows promise is (NIR) spectroscopy. NIR is actually not new technology, as it has been used in commercial food chemistry measurements for more than 40 yr. Common measurements include total moisture, fat, protein, and sugar. Once calibrated, and the sample presented to the instrument, NIR data is generated near instantaneously. With that said, some challenges include developing and maintaining calibrations across matrices (different market types, processing levels, i.e. raw, blanched, roasted, etc.) and limitations on the chemistries that can be quantified by NIR. Furthermore, traditional NIR has been applied to measuring *averages* and not SK chemical distributions. However, there has been some recent success in the latter, notably in the peanut industry around determining the frequency of SK conventional oleic 'contaminants' in high oleic lots of peanuts (Davis *et al.* 2017). The instrument used in this application is a Luminar 2036 Seedmeister NIR spectrometer (Brimrose Corporation, 19 Loveton Circle Hunt Valley Loveton Center, Sparks, MD 21152) and peanut kernels are loaded onto a conveyor belt, scanned by NIR, and oleic acid content measured on a SK basis at the rate of 1 kernel every few seconds.

High oleic peanuts have a modified fatty acid composition which promotes exceptional resistance to oxidation after roasting. However, this improved value is negated when there is excessive contamination with conventional oleic peanuts in high oleic lots. Beyond unintentional mixing, factors contributing to variation in oleic acid concentration in peanut kernels include cultivar planted, environmental growing conditions, maturity and/or kernel size, to name a few. Using the SK-NIR platform, 24,000 plus individual kernels were scanned from test plots and it was shown that planting date, market type, a novel late season flower termination technology, and/or shelling practices all substantially impacted the number of immature kernels not meeting high oleic status and suggested practical strategies to elevate and deliver more consistent SK distributions in this key chemistry. In this limited study, quality scales ranging from the molecular (cultivar genetic material, chemical constituents, etc.) to global weather patterns after various planting dates, to farming and shelling practices, all impacted the ingredient quality including SK oleic acid distributions. Generally speaking, by better understanding the connectivity among these and other factors, and designing measurement systems across the relevant quality scales, it should be possible to

drive more quality, and hence more value into our industry.

The best NIR tools currently allow for scanning one kernel every few seconds. The SK chemical distributions provided by this technology have proven high value to the industry in truly understanding, predicting and controlling high oleic purity. However, this delivery speed limits many future applications, but it seems NIR (or other relevant wavelength detectors) has potential for being scaled up given the rapid detection (not delivery) speed and nondestructive nature of this technology. With increased delivery speeds and computer processing power, it is readily conceivable to measure more chemistry, on substantially larger sample sizes, and statistically validate the understanding of a peanut lot's SK chemistry distributions (i.e. its fingerprint). If such data were available in real time (in line processing for example), this could lead to algorithms that automatically modify unit operations in shelling plants to generate desired outputs. Likewise, it seems possible that computer algorithms for various SK outputs (fingerprinting) could be tied to smart roasters or other processes that could optimize that input for a very specific output, i.e. roast color, flavor profile, etc.

Thinking ahead fifty years, this paper would be remiss without some commentary on food safety. Ingredient performance is nice, but it does not matter if the food is not safe. The stakes in making safe, wholesome peanut based products are enormous, as witnessed in the 2008-2009 peanut butter salmonella outbreak stemming from one small peanut butter plant in South GA that ultimately sickened folks across 46 states and likely contrib-

uted to nine deaths (Anonymous, 2009). This event was a catalyst for the FDA Food Safety and Modernization Act enacted in 2011, which brought sweeping federal legislation controlling the production and processing of foods. While the salmonella outbreak in 2008-2009 was in many ways the fault of an outlier, the US peanut industry collectively responded with increased emphases and investments to deliver safe, wholesome food. What food safety changes will occur in the next 50 years, no one knows, but the overarching importance of food safety will remain, and it seems the markets will reward enhanced food safety practices, which of course must be balanced against risks and costs.

In conclusion, one could readily argue that today the US peanut supply is consistently the best in the world because of 100+ years of hard work, ingenuity, research coupled with an emphasis on safety and quality. Future means of measuring quality and the scales they represent will surely change, but these should be embraced to grow the industry and deliver ingredients of the future. Remember, "you can't beat quality", and that should still be true in 50 years. At least I hope so.

Literature Cited

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