Screening Soybeans

Genetic engineering has produced new soybean varieties with increased oleic fatty acid, a monounsaturated fat considered a healthier oil due to it having lower saturated fat and offering higher oxidative stability and longer shelf life compared to conventional soybean oils due to the lower amount of polyunsaturated fatty acids (Cahoon, 2003; Lunn and Theobald, 2006; DuPont Pioneer, 2017). Hydrogenation is not needed for this higher stability and trans-fat is not created which is important for the food industry with the banning of partially hydrogenated oils (Food and Drug Administration, 2015).

Genetically modifying soybeans for higher oleic acid composition offers a viable way of increasing the supply of high oleic vegetable oil which is limited in the market (Wilson, 2012). Soybean varieties that accumulate high oleic oil and provides protein quality is a potential sustainable solution to meet nutrition demands in the future (Day, 2013).

With the growing production of new specialty soybean (high oleic) oils and increased regulation of GMO food ingredients, it is key for food companies to be able to monitor incoming soybeans (Ahmed, 2002). However, traditional methods can be time-consuming, labor intensive and require skilled labor, thus, finding a rapid and simple methods for screening ingredients is of importance for food companies to continue efficient production.

Being miniature and low cost, NeoSpectra spectral sensors, can be an ideal candidate to be used as a screening tool for identifying Plenish® GMO high oleic from conventional soybeans.

Reference measurements of Soybeans

Soybean samples were kindly donated by DuPont Pioneer's Plenish® Division that included 15 Plenish® high oleic and 15 conventional soybeans varieties. Plenish® is a GMO high oleic soybean engineered by Dupont Pioneer. Soybeans were homogenized in a Waring blender producing fine particles used for NIR spectral collection. The fat and protein levels of the soybean varieties was determined using the Soxhlet (AOAC #945.16) and Dumas combustion (ICC Standard No. 167) methods, respectively.

Collection of spectra of Soybean samples

Soymeal powders were transferred into a 10 mm diameter glass petri dish and placed onto a rotating stage (Figure 1). The rotation of the stage was continuous throughout spectral collection for 20 seconds with 16 nm intervals. All tests were done in duplicates. The obtained spectral data was evaluated by using multivariate statistical analysis software (Pirouette® version 4.5, Infometrix Inc., Woodville, WA, USA).

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Data Analysis

Plenish® GMO high oleic soybeans (protein=38.2 ± 0.15, fat= 15.5 ± 1.2) and non-GMO conventional soybeans (protein= 37.5 ± 0.22, fat= 16.2 ± 1.4) showed similar levels of protein and oil (p=0.06 and 0.71, respectively), indicating the genetic modification of the Plenish® high oleic varieties did not affect protein and fat content.

Figure 2 shows the NIR spectra of soybean powders corresponding to the overtones and/or combination bands involving highly anharmonic X-H (mainly C-H, N-H, and O-H) stretching modes. Characteristic bands were located as follows:

- O-H stretching were centered at 1,408 nm (7100 cm-1, first overtone) and 1,934 nm (5170 cm-1, combination)
- C-H vibration modes of lipids centered at 1,726 nm (5795 cm-1, first overtone) and 2,347 nm (4260 cm-1, combination)
- N-H vibration band at 2,106 nm (4747 cm-1, combination).

Pattern recognition analysis using soft independent modeling of class analogy (SIMCA) was utilized to statically identify Plenish trait in soybean varieties.

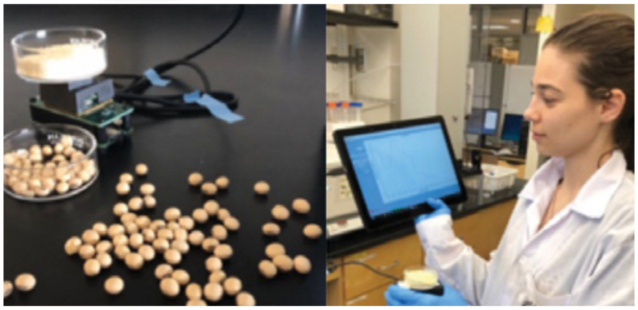

Figure 1: Collecting spectra of soybeans with the NeoSpectra-Micro spectal sensor.

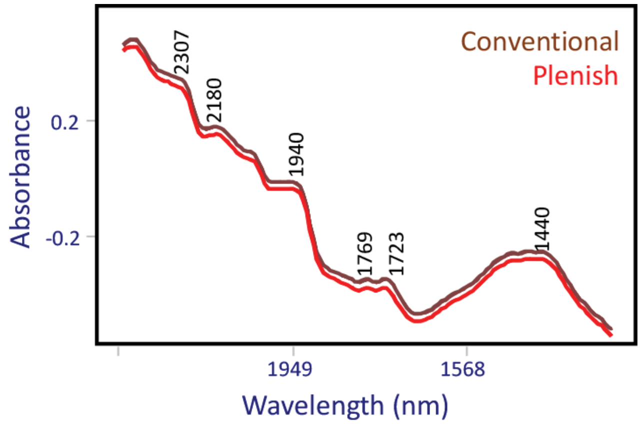

Figure 2: NIR spectra of high-oleic and conventional soybean samples collected by using NeoSpectra sensors.

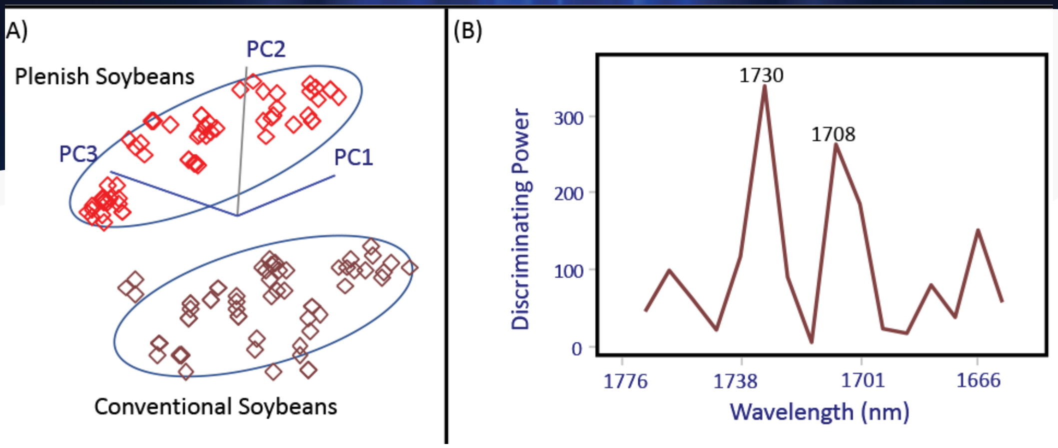

Figure 3: Soft independent modeling of class analogy (SIMCA) 3D projection plots of spectral data collected by NeoSpecta sensors for soymeal samples.

Figure 3 shows the SIMCA projection plot generated from NIR spectra, indicating well-separated classes between Plenish® and conventional groups, proving this technique is effective in screening for the high oleic trait in soybeans. The discriminating power plot indicated that the important bands were associated to the 1st overtone of C-H functional groups 1,724 – 1,786 nm (5800–5600 cm–1) likely associated to differences in the content in oleic acid. Wright and Hagen (2003) reported that the degree of unsaturation affects the magnitude of the olefinic C–H stretching and bending modes as well as the magnitude of the C=C stretch.

Conclusions

The NeoSpectra sensors provide a rapid (20 sec) and cost-effective screening tool for identifying high-oleic soymeal from the conventional varieties. NIR devices have potential to be used for a rapid, in-field, and simple method to identify different varieties of soybeans and screen for specific traits, making this a great alternative to time-consuming analytical reference methods. The palm-size NIR allows rapid phenotyping for the high oleic trait in soybeans without extensive sample processing or the use of chemicals and solvents. Accurate and robust predictions by the NIR method can allow selections of soybean varieties with desirable fatty acid composition to be accomplished efficiently which furthers their applications from breeders to farmers that can get incentives for value-added soybeans, and potentially introduce constituent-based pricing for soy- bean seed, rather than on a dry weight basis (Karn et al., 2017).

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