Abstract

Rapid, accurate, reliable and cost-effective composition analysis of soybeans is important for the agricultural and food industry in soybean breeding and genetic selection as well as soybean processing. Novel spectroscopic and microspectroscopic techniques were developed and evaluated for the analysis and characterization of important chemical components (protein, oil, moisture and isoflavones) of soybeans.

One state-of-the-art Diode-Array NIR (DA-NIR) instrument and five state-of-the-art Fourier-Transform NIR (FT-NIR) instruments were evaluated and tested for soybean analysis. Accurate, reliable, and robust NIR calibrations were developed for the DA-NIR instrument (DA-7000 model made by Perten Instrument Inc.) and the best FT-NR instrument (Spectrum One NTS model made by PerkinElmer). Such calibrations can be applied for rapid screening and selection of soybean developmental lines with optimized chemical composition and agronomical values for food applications. Furthermore, analysis can be performed with very flexible sample quantity requirements (from 40 grams of seeds to a single seed). NIR techniques developed in this research were then applied for the analyses of very large sets of soybean samples (>10,000) that were generated from breeding and genetic selection programs. The results proved that NIR analysis can provide very consistent and reliable results, in a cost-effectively and timely manner. In addition to applications in breeding and genetic selection programs, NIR techniques developed in this research can also be employed for rapid and reliable composition analysis of soybeans throughout the industrial soybean distribution chain, from harvesting to post-harvest processing.

Moreover, the high sensitivity of novel FT-IR and FT-NIR instrumentation techniques also allows analysis and characterization down to the microscopic level. Novel-design instrumentation for FT-IR/NIR microspectroscopy and chemical imaging can be applied to visualization of component distributions and developmental changes in soybean seeds and somatic embryos, with sensitivity close to the picogram range and spatial resolution to the microns level. Fluorescence Correlation Spectroscopy (FCS), with two-photon pulsed NIR laser excitation, furthermore, provides submicron spatial resolution, and sensitivity to single molecules level, thus offering the most exciting opportunities, for example, to monitoring ligand-receptor interactions, DNA binding and hybridization kinetics.*

*This dissertation is a compound document (contains both a paper copy and a CD as part of the dissertation). The CD requires the following system requirements: Microsoft Office.