DETECTION OF BIDDER INSECTS IN GRAIN BY AUTOMATED NIR REFLECTANCE SPECTROPROTOMETRY

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Chemical protectants and fumigants have been cornerstones of most insect pest management programs in stored grain and grain products. However, both groups of insecticides are under pressure as environmental constraints and consumer demand for residue-free food products increase. With pesticide use reduction policies in place, management of insects in stored products will rely more heavily on knowledge-based IPM. A key component of most insect management programs in stored grain will be sophisticated sampling techniques for determining the presence and extent of insect infestations in a given product or commodity. Detailed information on location and size of pest populations will allow a more effective, economical, and environmentally friendly targeting of control procedures.

Sampling for insects such as weevils and borers in whole grain is complicated by the presence of hidden immature stages (eggs, larvae, and pupae) inside kernels. Samples of grain may appear to be insect free if no adults are present, when in fact they could be heavily infested. While adults outside the grain can be easily located, many physical and chemical methods have been developed in efforts to detect hidden insects. These methods include staining kernels to detect weevil egg plugs, density separations, crushing kernels between ninhydrin-impregnated paper, detection of carbon dioxide produced by insects, detection of uric acid using high-performance liquid chromatography, nuclear magnetic resonance spectroscopy, x-raying infested kernels, acoustical sensors, and enzyme-linked immunosorbent assay. All of these procedures can detect insects hidden in kernels with varying degrees of success. However, all these techniques either are slow, labor intensive, difficult to automate, require expensive specialized equipment, or are currently applicable only to specific species. Therefore, some improved method is needed to detect insects in wheat kernels. The method should be simple and fit into the current grading process.

In the study below, we investigated the potential of a nearinfrared spectrometer (NIRS) integrated with the single kernel wheat characterization system (SKWCS)(Perten Instruments, Reno, NV) to automatically and rapidly detect hidden insects in single. kernels of wheat. NIRS is a procedure that detects and measures the chemical composition of biological materials. Molecules comprising organic matter vibrate at frequencies corresponding to wavelengths in the infrared region. When the wavelength of infrared energy corresponds to the frequency of vibration of a specific molecule, this energy is absorbed by the molecule. Optical sensors measure this absorption and the amount of absorption is related to the concentration of the particular constituent of interest. Thus, MRS can measure wheat quality parameters such as moisture, protein, starch, color class, etc. Ridgway and Chambers used MRS (1100-2500 nm) to detect larvae in bulk grain samples as well as manually-placed single wheat kernels. Their study showed differences in NIR absorption possibly due to the presence of chitin in kernels containing a larva. In our study, we used an automated system to determine the minimum detectable larval size of three species of whole grain pests, *Sitophilus oryzae (L.)* (rice weevil), *Rhyzopertha dominica (F.)* (lesser grain borer), and *Sitotroga cerealella* (Olivier) (Angoumois grain moth), in single wheat kernels. We also determined the effect of wheat class, moisture content, and protein content of hard red winter wheat on insect detectability.

The integrated NIRS-SKWCS was used to automatically collect spectra from single wheat kernels. The spectrometer measures absorbance from 400-1700 nm using an array of silicon and indiumgalium-arsenside sensors. The diode-array collects spectra at a rate of 30/s. The system automatically delivers and randomly positions a single kernel in the spectrometer viewing area. Eight spectra are collected from the kernel before another kernel is delivered to the viewing area. The eight spectra are averaged to reduce noise. Kernels are delivered at a rate of one kernel per four seconds (potential of 2 kernels/ sec). The spectra are stored on a computer for subsequent analysis using GRAMS/32 software (Galactic Industries Corporation, Salem, NH). Spectra were analyzed using partial least squares (PLS) regression. Half of the kernels in each treatment were used to develop a calibration and the remaining half were used for validation.

In this automated system, kernels infested with larvae and pupae of all three species were easily detected. The final calibration excluded moisture, protein, and wheat class effects and included spectral characteristics in the wavelength ranges of 1000-1350 and 1500-1680 nm. Larval size was a factor in sensitivity of the system, with 3rd and 4th instar rice weevil larvae being detected with 95% confidence. In contrast to many procedures used to detect hidden insects, this single system can be readily incorporated into the current inspection process. In addition, the system can simultaneously provide the wheat industry not only with automated information on hardness, protein content, moisture content, and wheat color class, but also with critical information necessary to monitor and manage insect infestations in wheat.