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Testing Feedstuffs Using Near-infrared Reflectance Spectroscopy (NIRS)

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Introduction

Over 16 years ago, an analytical instrument was developed that could rapidly determine the concentration of organic compounds from the spectra produced by the bonding between certain molecules. The instrument is based on the principle that those molecules absorb electromagnetic radiation in the infrared region. Compounds may be quantitated by using a computer to compare absorption bands in the near-infrared spectrum to those from a large calibration set of known composition. Peaks from compounds such as water, protein, fat, and carbohydrate may be translated into nutrient components such as moisture, crude protein, crude fat, acid detergent fiber, etc. All this can be accomplished in minutes rather than the hours or days required for the routine chemical analyses presently available.

The Instrument

The instrument consists of a near-infrared scanning sensor with either a scanning monochrometer (research instrument) or a set of rotating filters (routine unit). A computer, specialized software for data analyses and a grinder and sample cups for sample preparation are also needed. A chemical laboratory is necessary to analyze reference standards used as a learning set for the instrument.

The advantages of such an instrument are several. The analyses are rapid--one person can analyze 200 samples daily. It would take several technicians 3 or 4 months to make these determinations by traditional chemical means. Dr. Frank Barton III of the USDA lab in Athens, Georgia, predicts that near-infrared reflectance spectroscopy (NIRS) will be the method of choice for forage analyses in the 21st century. It is a nondestructive method that can analyze for any organic compound at concentrations of about 1% or more of the feed dry matter. It is especially valuable for analyzing the small samples generated by plant breeders. Mixed feeds can be analyzed, if appropriate learning sets are available.

There are several disadvantages to such a system. The initial cost of a research instrument is between $75,000 and $100,000; an instrument for routine analyses would cost much less. A minimum "learning set" of 30 reference standards analyzed for nutrient composition by traditional chemical means is necessary. Each type of feed needs its own calibration set, and equations must be updated as environmental, varietal, or regional factors change.

Forage Testing Programs Using NIRS

Several states use NIRS units for routine testing of forage samples. Many testing programs are designed to span a 3- to 5-year period as an education tool to

encourage feed analysis and proper ration formulation. Most of those programs have been highly successful, especially where forage diversity is low, i.e., limited to alfalfa, clovers, and corn silages.

Kansas State University has NIRS units for research purposes. The Grain Science Department does extensive testing of wheat and its products. The Department of Animal Sciences and Industry has recently obtained a NIRS unit. The equations delivered with the instrument work well for alfalfa hay, mixed hay, and corn silage. Work with other forages suggests shortcomings in equations and software, but not in instrumentation.

Kansas has a diverse group of forages, ranging from brome and fescue to wheat straw and a large number of forage sorghums. The software to accurately determine the constituents in this diverse group has not been sufficiently refined for routine use. Once reliable calibration data are available, the near-infrared scanning spectrometer may become the method of choice for feedstuff analyses.

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To do a nutrient analysis by scanning infrared spectroscopy, the sample is first ground in a special mill, then tightly packed into a special sample holder. Specific wavelengths of infrared light are projected onto the sample, and a detector reads the amount of each wavelength reflected. Specific nutrients absorb specific wavelengths, so the more of a particular nutrient, the less infrared light is reflected. All this information is passed into a computer, which compares the spectrum of the sample with spectra from forages of known composition. Through a complex mathematical process, nutrient composition is derived and printed. The whole process takes about 45 seconds after the sample is placed in the scanner. A photograph of the system appears on the cover.

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