

A Review: Determination of Grain Moisture Content Using Ftir Spectroscopy



Technology

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ABSTRACT

Agriculture plays a vital role in stabilizing the economy of the country as it is the third largest sector of India's economy. Moisture content is the most important characteristics of cereal grains affecting their suitability for harvest, storage, transport, and processing. The rapid, non-destructive, reliable sensing of moisture content in cereal grains and other agricultural crops is essential in modern agriculture for prevention of losses and improvements in efficiency of production. A variety of techniques have been used for the measurement of moisture in grains and better results have been achieved with the use of new techniques. Spectroscopic moisture analysis methods are of considerable interest as they are non-destructive, efficient and accurate techniques. A variety of techniques have been developed over time and provided improved results. This paper reviews the various techniques of moisture content determination of grains and focuses on their merits and demerits.

Introduction

The term moisture refers to the presence of water, often in trace amounts in matter. Moisture content is usually measured from weight loss after drying the feed. Moisture content in grain is related to the relative humidity and the temperature of the surrounding air.

Measurement of moisture content is so critical throughout all handling process from harvest, through storage, to final sale of cereals and oilseeds. If moisture is too high, there is a risk of quality reduction, or even crop loss in store. On the other hand, excessive drying is wasteful and can lead to reduced returns. Balancing these opposing risks is not easy due to the variable nature of grains within a bulk and the inherent difficulties of measuring grain moisture accurately.

Moisture content measurement techniques of grain can be classified into-

i. Primary method

ii. Secondary method

Primary method of moisture measurement is based on weight measurements. Oven method and infrared moisture balance methods are the standard methods used to measure amount of water by removing it from the sample and then measuring it. Primary methods are often used as reference methods.

Secondary method measures moisture using an electronic instrument that uses electrical characteristics of the grains. Capacitive moisture content meter and Resistance moisture content meter are most popular and extensively used secondary methods.

Literature Survey

Moisture determination in grains was initiated in 1929 but momentum was gained after 1977 when kandala and nelson started working on these techniques, before them several researchers worked on these methods.

Nelson et al in [1], worked on the dielectric properties of agricultural products and found the variations in these with change in temperature moisture contents, frequency and density. The aim of research was to improve the product quality by improving seeds, keep nutritional value, and to control insects in grain. However, it also presented way to measure the moisture content of grains using these dielectric properties.

Nelson et al in [2], carried their work to find out moisture content of single kernel of corn, single in-shell pecan nuts and pecan kernel halves by measurement of change in capacitance and dissipation factor using parallel plate capacitor system at 1 MHz

and 5MHz frequencies. Hewlett-Packard impedance Analyzer 4192A LF was used to measure the capacitance and dissipation factor. The technique appeared useful for practical applications and provided a basis for development of practical instrument for single grain moisture measurement.

Lawrence et al in [3], presented the grain determination technique, independent of density variations of kernel. The technique was used on hard red winter wheat, using parallel plate capacitor arrangement and Hewlett-Packard Impedance Analyzer 4192A LF was used to measure the capacitance at 1MHz and 10MHz frequencies. The variations in permittivity were found and relation was found to measure moisture content independent to density variations.

Nelson et al in [4], developed moisture content determination technique for single field corn, popcorn and peanut kernels; soybean seeds, single in-shell pecan nuts and pecan kernel halves by measuring the impedance using parallel plate capacitor arrangement at 1MHz and 5MHz frequencies. This research could be used for developing practical instrument for measurement of moisture content of single grain.

Kandala et al in [5], presented a prototype instrument for practical demonstration of determination of moisture content non-destructively for single corn kernel. The instrument used parallel plate electrode assembly at 1 MHz and 4.5MHz frequency for single corn kernels. The technique showed promise for practical use with further developments.

Kandala et al in [6], extended the same technique for moisture content measurement of small sample of hard red winter wheat. Parallel plate capacitor arrangement was used to measure the impedance at 1MHz and 4.5MHz frequencies and measurements were made using Hewlett-Packard Impedance Analyzer 4192A LF. However, further testing of the method was advised and more research was required for the technique to be applied to hard red winter wheat.

Kenneth et al in [7], shows effects and management of grain moisture content. Moisture is determined using shrink factor. The shrink factor is the average shrink per point of moisture removed. Grain moisture content does not directly affect grain quality but can indirectly affect quality since grain will spoil at moisture contents above that recommended for storage. Managing grain moisture content is important to maximize economic return. The maximum economic return is received by marketing at the market standard moisture content.

Nelson et al in [8], has described the importance of grain mois-

ture content at the time of harvest and in preserving grain quality with the techniques for moisture measurement. Measurement or sensing of the relative complex permittivity, or dielectric properties, at microwave frequencies offers advantages that include density-independent sensing of moisture content and the reduction of variations that arise from ionic conductivity of high moisture grain samples at lower radio frequencies.

Rai et al in [9], has developed a portable, field usable digital grain moisture meter which is using capacitor type of sensors, from which the moisture percentage of diverse commodities have to be obtained. However the developed instrument is working satisfactorily for all practical purposes in the range of 5 - 25% of grain moisture with an accuracy of $\pm 1\%$.

Rai et al in [10], has developed microprocessor based grain moisture measurement system which has important features such as automatic temperature compensation, calibration facility at user level, facility to store the measured moisture content of the sample and facility to provide temperature of the commodity. A meter without density correction may affect the accuracy of measurement slightly. However, the developed instrument is working satisfactorily for all practical purposes in the range of 5% to 25% of grain moisture with an accuracy $\pm 0.5\%$. There is still scope to develop a system with density correction and better accuracy.

Kandala et al in [11], also compared two electrical techniques of moisture determination for single peanut; one was a destructive technique while other was non-destructive one. Comparison of DC conductance type instrument and complex impedance technique using parallel plate capacitor type arrangement were compared with standard air flow oven technique. Both the methods used showed good results as compared with standard air oven method. The accuracy of parallel plate instrument could be limited by the contributions of non-moisture related constituents of peanut to capacitance and phase angle values, which were used to determine moisture content.

Zhang Yaqiu et al in [12], has developed an intelligent grain moisture content measuring system based on SCM 8031 and by adopting the techniques of artificial neural network (ANN), virtual instrument (VI) and others. The system achieves digitization of the total moisture content measuring process with characteristics of high precision and stability, friendly work interface, powerful data processing and low application cost, which overcomes some disadvantages such as serious nonlinear and poor interference resist.

F.E. Dowell et al in [13], has predicted wheat quality characteristics and functionality using Near-Infrared Spectroscopy. NIRS can be used to predict many grain quality and functionality traits, but mainly because of the high correlations of these traits to protein content.

R. Nagarajan et al in [14], has determined moisture in powder milk using Near Infrared Spectroscopy. Forty samples with different moisture content were analyzed using NIR diffuse reflectance mode. NIR spectroscopic and KF titration result was compared. The results were very close which indicates the accuracy of an indigenously built low cost dispersive NIR spectrophotometer.

Bubner et al in [15], has developed a procedure that correlates spectral resolution trade-offs with target detection performance. It is expected the procedure can be further refined to allow ready application for a variety of current and envisaged signature measurement and surveillance roles. Surface reflection and sample emission were identified as a major problem when

attempting to identify spectral absorption features by single measurements. A two-temperature measurement procedure was developed and applied to circumvent this problem. Satisfactory agreement with the reference spectra was obtained using this method.

Armstrong et al in [16], has compared Dispersive and Fourier-transform (FT) near-infrared (NIR) instruments for their predictive performance of several wheat flour and grain constituents. Models at factor levels determined using the F-test criteria. Comparison of NIR and FT-NIR revealed that both instruments perform similarly for the F-test models developed, but the FT-NIR had an easier method for sample preparation and presentation.

Ritula Thakur et al in [17], developed a moisture prediction model using electrical properties of Indian wheat. Principal Component Analysis (PCA) was used to study the moisture dependence of various electrical properties. The various statistical studies were conducted using The Unscrambler Version X, a multivariate Statistical Analysis Software. It was observed that Conductance (G) and capacitance (C) show the maximum variation with moisture. Partial Least Square (PLS) Regression was then used to develop the moisture prediction model based on these two electrical properties.

J. Sundaram et al in [18], has attempted to determine the moisture content of in-shell peanuts by NIR Reflectance spectroscopy. However, if the MC values can be determined while the nuts are in their shells, it would save lot of labor and money spent in shelling and cleaning the nuts. The use of NIR spectroscopy described in this paper would result in large savings in time and labor during drying, processing and storage of peanuts. By virtue of a low SEP and a high R value, the model obtained with reflectance data subjected to normalization was selected as the preferred calibration model, for MC prediction, for both Valencia and Virginia type in-shell peanuts.

N. Vlachos et al in [19], has used FT-IR spectroscopy as an effective analytical tool in order to determine extra virgin olive oil adulteration with lower priced vegetable oils sunflower oil, soybean oil, sesame oil, corn oil and to monitor the oxidation process of corn oil samples undergone during heating or/and exposure to ultraviolet radiation. In addition, an analytical technique for the measurement of carbonylic compounds in oils, produced after heating, is applied. The possible antioxidant effect of oregano is also discussed.

Willem F. Wolkers et al in [20], used Fourier-transform infrared spectroscopy (FTIR) to study the hydrogen-bonding interactions that take place in vitrified carbohydrates of different chain lengths. The band position of the OH stretching band and the shift in band position as a function of temperature were determined from the FTIR spectra as indicators for the length and strength of intermolecular hydrogen bonds, respectively. Differential scanning calorimetry (DSC) was used to corroborate the FTIR studies and to measure the change in heat capacity (ΔC_p) that is associated with the glass transition.

Abdul Rohman et al in [21], concluded that FTIR Spectroscopy combined with multivariate calibration of PLS at frequency regions of 4000-650 cm^{-1} can be used to quantitatively analyze BSO contents in binary mixture with SFO and with WO providing the highest R^2 and the lowest values of error during calibration and validation modeling.

Conclusion and Future Scope

It has been found from previous work that capacitance type of instruments suffers from demerits of variation of output with variations in temperature. Digital meters gives reading instantly

but they are not accurate. Techniques used for moisture content measurement till date are time consuming and destructive.

The scope of the present work is to introduce non destructive technique for moisture measurement which provides precise measurement. Technique with increased speed and accurate result can be developed.

REFERENCE

- [1] Stuart O. Nelson, "Dielectric Properties of Agricultural Products: Measurements and Applications," IEEE Transactions on Electrical Insulation, Vol. 26, No. 5, pp. 845-869, 1991. [2] Stuart O. Nelson, Chari V. K. Kandala, and Kurt C. Lawrence, "Moisture Determination in Single Grain Kernels and Nuts by RF Impedance Measurements", IEEE transactions on Instrumentation and Measurements, Vol. 41, No. 6, pp.1027-1031, December 1992. [3] K. C. Lawrence, S. O. Nelson, "Radio-Frequency Density-Independent Moisture Determination in Wheat," Transactions of ASAE, Vol. 36, No. 2, pp. 477-483, 1993. [4] S. O. Nelson, Kurt C. Lawrence, and Chari V. K. Kandala, "Parallel-Plate Impedance Sensing of Moisture Content in Single Seeds and Grains Kernels," IEEE Instrumentation and Measurement technology conference, pp. 56-68, 1993. [5] C. V. K. Kandala, S. O. Nelson, K. C. Lawrence, R. C. Davis, "Instrument for Single-Kernel Non Destructive Moisture Measurement," Transactions of ASAE, Vol. 36, No. 3, pp. 849-854, 1993. [6] C. V. K. Kandala, S. O. Nelson, K. C. Lawrence, "Determining Moisture Content in Small Wheat Samples by Dual-Frequency RF Impedance Sensing," Transactions of ASAE, Vol. 39, pp. 1185-1188, 1996. [7] Dr. Kenneth J. Hellevang, "Grain Moisture Content Effects and Management," NDSU Extension Service, March 1995. [8] Stuart O. Nelson, Samir Trabelsi, and Andrzej W. Kraszewski, "Principles of Microwave Moisture Measurement in Grain," IEEE Instrumentation and Measurement Technology Conference, pp. 99-102, May 2002. [9] A.K. Rai, Sivadasan Kottayi, S.N. Murty, "A Low Cost field Usable Portable digital Grain Moisture Meter with Direct display of Moisture(%)," African Journal of Science and Technology(AJST), Science and Engineering series, Vol. 6, No. 1, pp. 97-104. [10] A. K. Rai, P. K. Khare and Prashant Mor, "Microprocessor based Measurement System for Grain Moisture," International Conference on Information and technology in Electrical Sciences, Dr M.G.R. University, Chennai, Tamil Nadu, India, Dec-20-22,2007, pp850-856. [11] C. V. K. Kandala, C. L. Butts, "Performance Comparison of RF Impedance and DC Conductance Measurements for Single Peanut Kernel Moisture Determination," Transactions of ASABE, Vol. 50, No. 1, pp. 117-122, 2007. [12] Zhang Yaqiu, Wu Wenfu, Li Junxing, Wu Guanghua, "Research of Intelligent Grain Moisture Content Measuring System Based on Virtual Instruments Technology," Third International Conference on Measuring Technology and Mechatronics Automation, pp. 1077-1080, 2011. [13] F. E. Dowell, E. B. Maghirang, F. Xie, G. L. Lookhart, R. O. Pierce, B. W. Seabourn, S. R. Bean, J. D. Wilson and O. K. Chung, "Predicting Wheat Quality Characteristics and Functionality Using Near-Infrared Spectroscopy," AACR International, pp. 529-536, Vol. 83, No. 5, 2006. [14] R. Nagarajan, Parul Singh, and Ranjana Mehrotra, "Direct Determination of Moisture in Powder Milk Using Near Infrared Spectroscopy," Journal of Automated Methods and Management in Chemistry, Vol. 2006, pp. 1-4. [15] T. Bubner, S. Frost, V. Develis, "A Procedure to Predict the Spectral Resolution Requirements of a Fourier Transform Infrared Spectrometer," Defence Science and Technology Organisation, pp 1973-1975, 2001. [16] P. R. Armstrong, E. B. Maghirang, F. Xie, F. E. Dowell, "Comparison of Dispersive and Fourier-Transform NIR Instruments for Measuring Grain and Flour Attributes," Applied Engineering in Agriculture, Vol. 22, pp. 453-457, 2006. [17] Ritula Thakur, S. Chatterji, Amod kumar and S. Bansod, "Studies on Electrical Properties of Wheat as a Function of Moisture Content," Quality Assurance and Safety of Crops and Foods, Vol.3, No.4, pp 198-204, May 2011 [18] Jaya Sundaram, Chari V. Kandala, konda Naganathan Govindarajan, jeyam Subbiah, "Sensing of Moisture Content of In-Shell Peanuts by NIR Reflectance Spectroscopy," Journal of Sensor Technology, Vol. 2, No. 1, pp. 1-7, March 2012. [19] N. Vlachos, Y. Skopelitis, M. Psaroudaki, V. Konstantinidou, A. Chatzilarzou, E. Tegou, "Applications of Fourier Transform Infrared Spectroscopy to Edible Oils," Analytica Chimica Acta, Vol. 573-574, pp 459-465, May 2006 [20] Willem F. Wolkers, Ann E. Oliver, Fern Tablin and John H. Crowe, "A Fourier Transform Infrared Spectroscopy Study of Sugar Glasses," Carbohydrate Research, Vol. 339, No. 6, pp 1077-85, April 2004. [21] Abdul Rohman, Desti Wibowo, Sudjadi, Endang Lukitaningsih, Arief SALLEH Rosman, "Use of Fourier Transform Infrared Spectroscopy in Combination with Partial Least Square for Authentication of Black Seed Oil", International Journal of food Properties, Vol. 18, No. 5, Jan 2015.