Research Article

Performance of Transmittance Near-Infrared Spectrometry in Determining Wheat Quality

Shahid Yousaf[1]*, Salman Khurshid[1], Saqib Arif[1], Hafiza Mehwish Iqbal[1], Qurrat ul Ain Akbar[1], Najmus Sahar[1] and Ghulam Rasul[2]

[1]Food Quality and Safety Research Institute, SARC, PARC, Karachi University Campus, Karachi, Pakistan; [2]Pakistan Agricultural Research Council, Islamabad, Pakistan.

Abstract | Wheat quality characteristics play a vital role in processing and trade. Many techniques have been introduced to evaluate wheat quality. Near Infrared (NIR) is one of the suitable techniques that have an advantage of rapid response over other techniques. But investigations are needed to check its reliability on determining important quality parameters. The study therefore has been designed to evaluate the efficiency of NIR in comparison with standard techniques. Thirty samples of wheat (including 11 varieties and 19 composite samples) were analyzed. Samples were widely varied in test weight (72.4-79.9 kg/hL) and wet gluten contents (15.4-31.5%) but showed narrow ranged moisture contents (10.8-13.3%). The NIR values were significantly related to the referenced values for test weight, wet gluten content and moisture with the correlation coefficients of 0.96, 0.83 and 0.73, respectively. Three consecutive measurements of test weight, moisture and gluten contents by using NIR and referenced methods shown to have average repeatability of 0.2%, 0.3%, 2.4% and 0.1%, 0.7%, 1.5% respectively. The information is useful for maintaining the quality of wheat intended for milling and ultimate products.

Received | September 11, 2018; **Accepted** | November 20, 2018; **Published** | December 15, 2018
***Correspondence** | Shahid Yousaf, Food Quality and Safety Research Institute, SARC, PARC, Karachi University Campus, Karachi, Pakistan; **Email:** shahidyousaf160@yahoo.com
Citation | Yousaf, S., Khurshid, S., Arif, S., Iqbal, H.M., Akbar, Q.A., Sahar, N. and Rasul, G., 2018. Performance of transmittance near-infrared spectrometry in determining wheat quality. *Journal of Innovative Sciences,* 4(2): 114-119.
DOI | http://dx.doi.org/10.17582/journal.jis/2018/4.2.114.119
Keywords | NIR, Wheat, Test weight, Moisture, Gluten

1. Introduction

Wheat (*Triticum aestivum* L.) is a major crop in Pakistan; its production is less as compare to wheat growing leading countries like USA and China. It is grown on 37% of total crop cultivated area of Pakistan. Wheat is annually grown on approximately 0.90 million hectares and harvested with a yield of 2.38 million tons in Pakistan (Khan *et al*., 2012). Wheat is a staple food in Pakistan, miller and processor has major concern about defined properties i.e. test weight, moisture, gluten content and rheological characteristics. Millers and processors have to run series of analytical tests to check quality parameters, they meet economical and time interrelated cost (Miralbes, 2004).

Various methods and techniques have been developed to evaluate wheat quality. The conventional methods are physicochemical and sensory evaluation (Huang *et al*., 2008). For instance, the chemical analysis has certain limitations like influence of other substances, high cost, time consuming and required expertise for the analysis. To counter limitations of traditional methods new economical techniques have been introduced. Optical spectra and imaging have been

used for short time analysis without destruction and even touching of samples. Spectra base instruments offer low cost analysis and better option for conservative methods (Aulander *et al*., 2013).

Infrared spectroscopy is the influential and expedient analytical technique that can be utilized for evaluating the wheat quality attributes (Williams *et al*., 2001). First application of near-infrared (NIR) spectroscopy in crop sciences was the estimation of moisture content in grains. Analysis of other parameters (i.e. protein and fat) had also been explored in crops and agro base products (Singh *et al*., 2010). Flour milling industry is one using this technique for measuring protein, moisture content and test weight. It enables the miller and processor to access and maintain the quality by optical sensors useful in flour segregation on the basis of their qualities (Dowell *et al*., 2006). NIRs were also used to detect color, damage, mycotoxin and fumonisin (Dowell *et al*., 2002). For wheat grading and estimation of flour yield test weight is a major tool (Dowell *et al*., 2006).

Although it's utility in quality assurance of wheat has been highlighted commercially, but the scientific literature is still taking the studies conducted on performance evaluation of NIR- spectroscopy in wheat quality analysis. This study has therefore been designed to evaluate the performance of NIR spectroscopy in comparison to the standard techniques on wheat quality analysis.

2. Materials and Methods

2.1 Materials / sample description

Thirty samples of wheat (including 11 varieties and 19 composite samples) were selected for this study. All the samples were sound (non-infested) and had good keeping quality; these samples were analyzed for test weight, moisture percentage and wet gluten content.

2.2 Instrumentation

Near-infrared (NIR) spectrometry (OmagaAnalyzer G,Typ: Grain,Nr.: 22G1507B16) is a high performing, transmittance base instrument designed to analyze sample by absorbing near infrared of sample spectra.

Sample preparation for NIR-spectroscopy: Samples were cleaned from foreign materials including stones, straws, weed seeds and grains. About 1Kg wheat grains of each sample were poured in the sample receiving chamber for the analysis.

Principle of operation: Light from tungsten lamp fall on monochromator, where diffraction of light is took place by optical grating. Diverse wavelengths were recorded at exit end of slits. These NIR radiation fall on sample matrix in sample holding shaft and detected by a detector attached to one side of shaft. Photometric signals are generated after detection of radiations; result is computed on the basis of sample and reference value.

2.3 Referenced methods

AACC (2000) standard methods were followed to analyze test weight, moisture and gluten content. Test weight was determined in Seedburo Filling Hopper (model 151) in accordance with standard method. Briefly after filling the hopper with already prepared sample excessive grains were scraped away by a stick and result was recorded in Kg/hL. Moisture content was determined by using air oven according to standard method. Results were calculated by difference in weight of 10g of sample before and after drying in hot air oven at 130°C for 1hour.

Gluten content was determined by using Glutomatic 2200 following AACC Method No. 38-12.

2.4 Statistical analysis

All samples were analyzed in triplicate and results were expressed in mean value and standard deviation. Correlation coefficient was obtained between NIR values and referenced values by using SPSS software (IBM SPSS Statistics 21).

3. Results and Discussion

Wheat samples used in this study varied significantly in their quality parameters. Results shows that the test weight, moisture, and wet gluten ranging from 72.2-80.4 kg/hL; 10.4-13.3%; and 15.5 to 28.5% with the mean values of 76.4 ± 2.5 kg/hL; 11.6 ± 0.8 %; and 21.7± 3.2% respectively (Figure 1). All the wheat samples were sound. The performance of NIR in comparison with reference methods for determining the wheat quality has been evaluated and results are discussed below:

3.1 Test weight of wheat

Test weight gives the idea about soundness of wheat grains and higher flour yield is obtained from sound

grains. Results showed that the NIR values of test weight were strongly related (r = 0.96) to that of referenced values (Figure 2). This confirmed that the NIR can be utilized for determining test weight of wheat grains. It had also been observed that the NIR values of test weight of all the samples were marginally higher than the referenced values with the average differences ranging between 1.5 and 1.8% (Table 1). Such consistent difference can further be minimized with an exercise of calibration. As different devices were used for the analyses of test weights, the differences were recorded though correlations exist among the results obtained from those devices (Manley *et al.*, 2009).

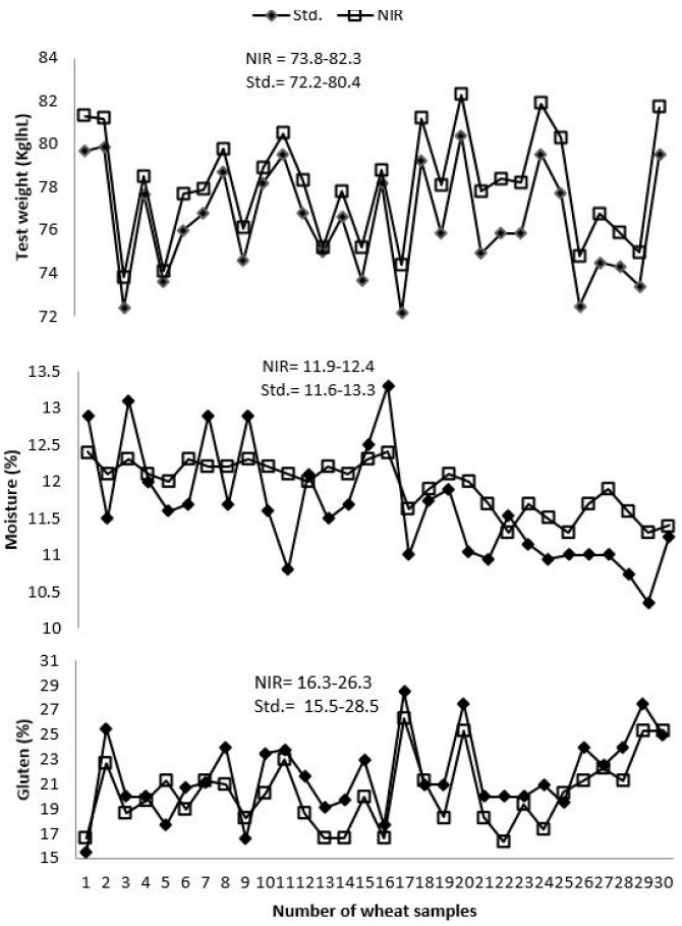

Figure 1: Test weight, moisture and gluten values obtained through near-infrared (NIR) spectrometry and referenced techniques.

In a study more than 100 wheat samples were selected to predict different quality parameters i.e. protein, wet gluten, moisture, test weight, color, particle size, vitreous of grains by using NIR. Correlation of different quality parameters was evaluated and this technique recommended for analysis (Dowell *et al.*, 2006). Two wheat varieties (Eta and Banti) were selected to investigate quality parameters including physical and technical characteristics. In physical properties test weight was one of parameter in addition to virtuousness, thousand grains mass, grain density, thickness, width and length which were correlated with technical attributes including protein, gluten and sedimentation values. Grains of selected varieties were different in most of physical and technical parameters (Warechowska *et al.*, 2013).

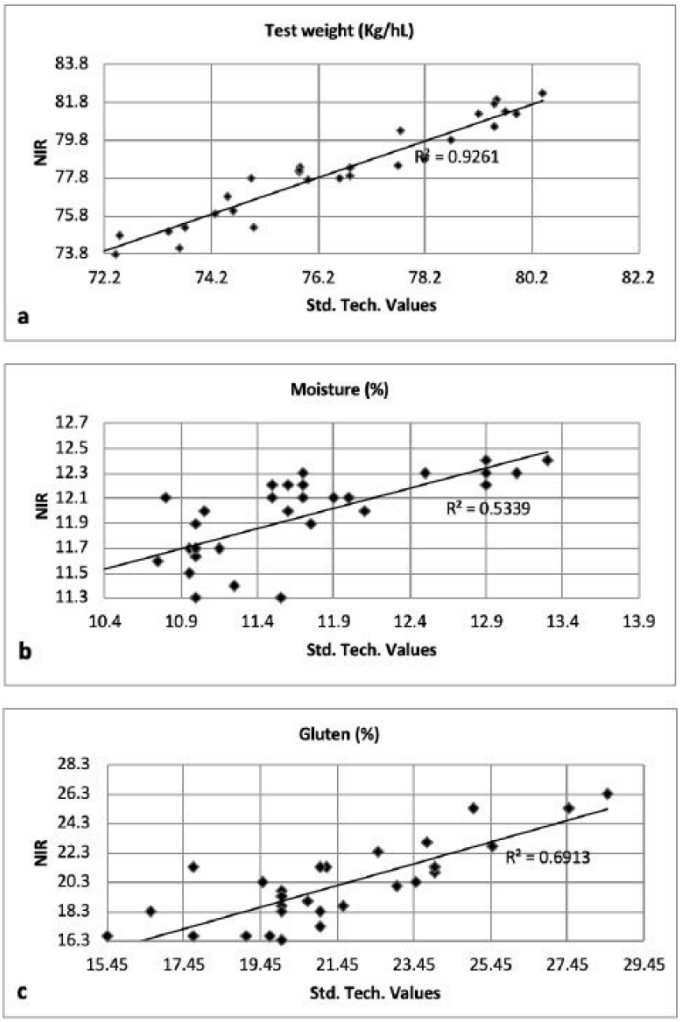

Figure 2: Relationships between near-infrared (NIR) spectrometry values and referenced technique values.

In this study two techniques were compared for same physical parameter (test weight) to check the performance of NIR- spectrometry. All above investigations have been reflected reliable results of test weight by NIR- spectrometry technique.

3.2 Moisture content of wheat

Moisture is one of the most critical factors, needed during processing, storage and trade. In this study, wheat samples were analyzed for moisture through air oven method and also through NIR technique. Results showed that NIR values were highly related (r = 0.73) with the air oven values (Figure 2).

Table 1: Frequency distribution of data to compare NIR values with the referenced values.

Parameters	Freq. on the basis of standard values	Actual values	No. of samples (n)		Avg. differences of NIR and standard techniques (%)
			NIR >Std.	NIR< Std.	
Test weight	70.0 -74.0	72.4-74.9	06	0	1.6
	74.1-78.0	75.0-77.5	14	0	1.8
	78.1-82.0	77.6-79.9	10	0	1.5
Moisture	10.0-11.0	10.8–11.5	09	0	0.8
	11.1-12.1	11.6–12.5	13	02	0.4
	12.2 -13.3	12.6–13.3	0	06	-0.6
Gluten	15.0-20.0	15.4–20.8	04	08	-0.6
	20.1-25.0	20.9–26.2	03	11	-1.8
	25.1-30.0	26.3–31.5	0	04	-2.3

In this study, we did not found any consistent differences in NIR and air oven values (Table 1). However, NIR gave better results within a range of 11.6 – 12.5% as the average difference of 0.4% was observed (Table 1). Maximum difference between NIR and air oven values was 1.3% (Figure 3).

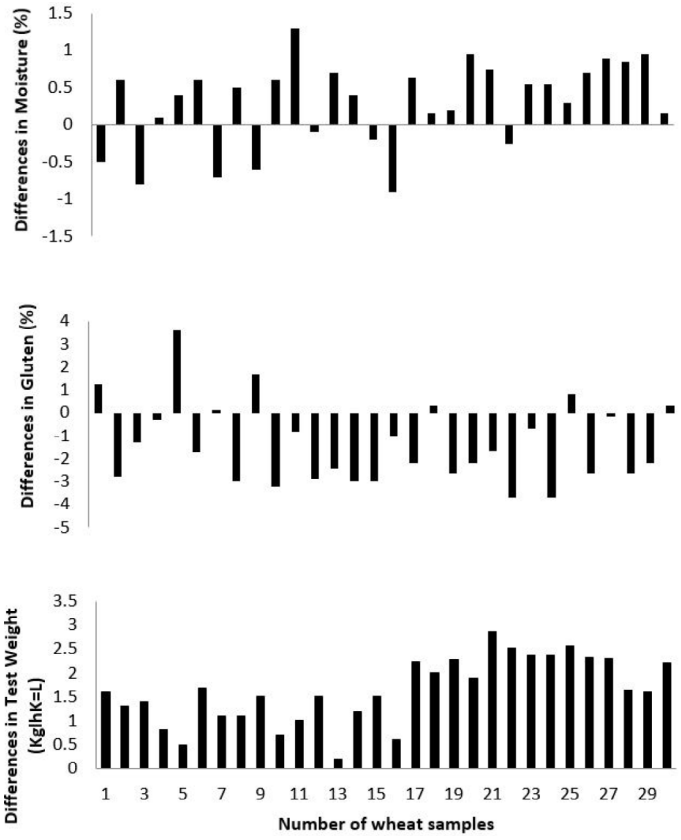

Figure 3: Differences between the values of near-infrared (NIR) spectrometry and referenced techniques.

NIR technique have been compared with standard technique for analysis of moisture content in wheat samples, higher value of moisture (11.07 ± 0.03%) was recorded through NIR than standard technique values (9.50 ± 0.10%) (Chukwu *et al.*, 2014). Seven different air oven drying methods have been used to determine moisture contents in pearl millet. Drying temperature was adjusted at130°C for 1, 2, 16, 20 h and 105°C for 5, 48, 72 h; analysis showed suitability of each methods for removal of moisture content (at 35% wet basis) in given sample (Obi *et al.*, 2016). Acoustic technique has been applied for estimation of moisture content in grains and seeds, impact of grain sound when fall on surface and surface sound in relation to moisture content was detected by microphone in form of sound waves and generated electronic signal. Linear equation was applied to find relationship between acoustic characteristics and moisture percentage. Same samples were analyzed by standard technique, both techniques were significantly (R2≥ 0.95) correlated with each other (Lotfi and Darvishi, 2015).

3.3 Gluten content in wheat

Gluten content is considered to be the most influential factor in wheat processing. A strong correlation (r = 0.83) was found between the NIR and glutomatic values (Figure 2). A comparable result of NIR has suggested that it can be utilized for analyses of gluten content in wheat. An irregular trend was observed. Glutomatic values of 23 samples (77% of total samples) were higher as compared to the NIR values (Table 1). In this study, it has been observed that the NIR gave better results for the wheat samples showing the gluten contents ranging between 15.4-20.8% (Table 1). Differences in NIR and Glutomatic values are shown in Figure 3. Minimum and maximum differences were -3.7 and 3.6 respectively between the values of NIR and Glutomatic.

In previous study, 40 wheat samples were analyzed

for various quality parameters (including wet gluten contents) aiming to compare standard and NIR techniques. They recorded higher values of gluten contents from standard technique (i.e. Glutomatic) in all the wheat samples (Hruskova *et al.*, 2000). Wet gluten content has been analyzed by two methods; manual washing and Gluten Index Method. Romanian wheat cultivars were analyzed for wet gluten quantity and quality. Results indicated no significant differences between these two methods of analysis (Vasilean *et al.*, 2010). Gluten content, protein percentage and rheological properties of gluten have been studied by using wheat gluten quality analyzer (WGQA), extensigraph and farinograph. Fifty-nine wheat samples were collected for analysis through these instruments; all instruments were used efficiently to evaluate behavior of wheat flours. Significant variation has been recorded in results of medium hard wheat. Wheat gluten quality analyzer was preferred on the basis of small amount of sample, time saving and easy to run as compare to other instruments (Ferrari *et al.*, 2014).

Table 2: Advantages and disadvantages of near-infrared (NIR) spectrometry and referenced techniques.

	Advantages	Disadvantages
Near-infrared (NIR) spectrometry	Non- destructive, rapid, low cost and time saving, no sample preparation need, rapid and easy to use.	Matrix specific, calibration need.
Referenced techniques	No matrix specific, less need of calibration as compare to NIR.	Sample preparation, calibration need, expertise are require to run test, cost of test is high, time consuming and waste produce by destroying sample.

Conclusion

Performance of NIR and standard techniques for the wheat analyses is shown in Table 2. High correlations of NIR values with the standard values have suggested that the NIR can be utilize for the analyses of wheat quality. Most of the results varied marginally from the standard values. Keeping in view the rapidity and easy handling of NIR, it may further be explored for different quality parameters including w value, falling number and water absorption of wheat. This will support the monitoring of wheat quality and also useful in decision making during the trade of wheat.

Author's Contribution

All author of the manuscript contributed equally in overall planning, sample analysis, data interpretation and writing of research article.

References

AACC. 2000. Official methods of analysis. *American Association of Cereal Chemists. U.S.A. Gaithersburg.*

Aulander, J.T., Bochko, V., Martinkauppi, B., Saranwong, S and Mantere, T. 2013. Review of optical nondestructive visual and near-infrared methods for food quality and safety. *International Journal of Spectroscopy*, 1-36. https://doi.org/10.1155/2013/341402

Chukwu, O. and Durojaiye, I.A. 2014. Comparative analysis of non-destructive and destructive measurements of some proximate compositions of wheat for confectionery and pasta production. *African Journal of Engineering.* 2(2): 44-50.

Dowell, F.E., Maghirang, E.B., Xie, F., Lookhart, G.L., Pierce, R.O., Seabourn, B.W., Bean, S.R., Wilson, J.D. and Chung, O.K. 2006. Predicting wheat quality characteristics and functionality using near-infrared spectroscopy. *Journal of Cereal Chemistry*, 83: 529-536. https://doi.org/10.1094/CC-83-0529

Dowell, F.E., Pearson, T.C., Maghirang, E.B., Xie, F. and Wicklow, D.T. 2002. Reflectance and transmittance spectroscopy applied to detecting fumonisin in single kernels infected with Fusarium verticillioides. *Journal of Cereal Chemistry*, 80: 222–226. https://doi.org/10.1094/CCHEM.2002.79.2.222

Ferrari, M.C., Pedrosa, M.T., Clerici, S and Chang, Y.K. 2014. A comparative study among methods used for wheat flour analysis and for measurements of gluten properties using the Wheat Gluten Quality Analyser (WGQA). *Food Science and Technology*, 34(2): 235-242. https://doi.org/10.1590/fst.2014.0038

Hruskova, M., Hanzlikova, K. and Varacek, R. 2000. Wheat and flour quality relation in a commercial mill. *Czech Journal of Food Science,* 19: 189-195. https://doi.org/10.17221/6606-CJFS

Huang, H., Yu, H and Ying, Y. 2008. Near infrared spectroscopy for on/in-line monitoring of quality in foods and beverages: a review. *Food Engineering*, 87(3): 303-313. https://doi.org/10.1016/j.jfoodeng.2007.12.022

Khan, M.H., Din, N., Khakwani, A.A., Baloch, M.S., Zubair, M. and Khan, A.W. 2012. Gomal-8, a high yielding, disease tolerant wheat variety for irrigated areas. *The Journal of Animal and Plant Sciences*. 22(2): 403-407.

Lotfi, M., and Darvishi, H. 2015. In-line measurement of moisture content of wheat by Acoustic method. *International Journal of Agriculture and Crop Sciences*, 8 (2): 163-167.

Manley, M., Engelbrecht, M.L., Williams, P.C and Kidd, M. 2009. Assessment of variance in the measurement of hectoliter mass of wheat, using equipment from different grain producing and exporting countries. *Biosystems Engineeering*, 103: 176 -186. https://doi.org/10.1016/j.biosystemseng.2009.02.018

Miralbes, C. 2004. Quality control in the milling industry using near infrared transmittance spectroscopy. *Journal of Cereal Chemistry*. 88: 621-628. https://doi.org/10.1016/j.foodchem.2004.05.004

Williams, P.C. and Norris, K.H. 2001. Near-infrared technology in the agricultural and food industries, 2nd ed. *American Association of Cereal Chemists, St. Paul, MN*. pp. 296.

Obi, O.F., Ezeoha, S.L. and Egwu, C.O. 2016. Evaluation of air oven moisture content determination procedures for pearl millet. *International Journal of Food Properties*, 19: 454–466. https://doi.org/10.1080/10942912.2015.1038566

Singh, C.B., Chaudhary, R., Jayas, D.S. and Paliwal, J. 2010. Wavelet analysis of signals in agriculture and food quality inspection. *Journal of Food and Biotechnology*, 3: 2-12. https://doi.org/10.1007/s11947-008-0093-7

Vasilean, I., Aprodu, I. and Banu, I. 2010. Comparative evaluation of wet gluten quantity and quality through different methods. *The Annals of the University Dunarea de Jos of Galati, Fascicle VI – Food Technology*, 34 (2): 1-5.

Warechowska, M., Warechowski, J. and Markowska, A. 2013. Interrelations between selected physical and technological properties of wheat grain. *Journal of Technical Sciences*. 16(4): 281–290.