Rapid assessment of potential malting quality of barley by near infrared diffuse reflectance spectroscopy

Yueshu Li, Gordon Laycock and Walter Fernets
Prairie Malt Limited, Box 1150, Biggar, Saskatchewan, Canada, S0K 0M0.

Introduction

Near infrared (NIR) diffuse reflectance spectroscopy has become a standard instrumental technique for performing rapid analyses of protein, oil and moisture contents in cereal and forage materials.[1–3] However, very limited attempts have been made to use this kind of technique in the malting industry to deal with various analyses of barley and malt samples.[4–10]

In this study, the objective is to examine the possibility of using NIR diffuse reflectance spectroscopy of unmalted barley to assess the malting quality, otherwise the assessment can only be carried out by a conventional micromalting test which may take 7–8 days to complete.

Materials and methods

The NIRSystems model 6500 was used in this study. The instrument is equipped with a whole grain sample cup and can be operated in both modes, reflectance and transmittance. The instrument generates monochromatic light ranging from 400 nm to 2500 nm (Figure 1).

Figure 1. A set-up of the NIR system. Shown here is one sample cell, the NIRSystems 6500 and a personal computer.

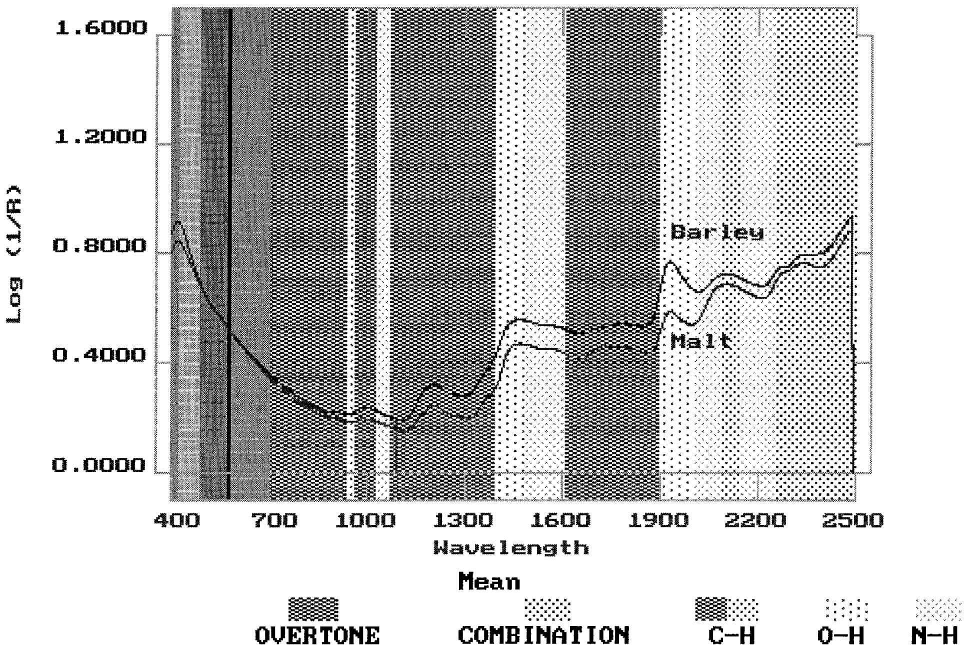

Figure 2. Typical NIR diffuse reflectance spectra of barley and malt samples generated by the NIRSystems 6500.

The barley samples used in this study were composed of 300 samples of two row or six row barleys (e.g. Harrington, Manley, Bonanza and other malting varieties). The barley samples were malted either by a Seeger Weihenstephan Micromalting unit or by using cages in production malthouses.

The chemical analyses of both barley and malt were carried out by the QC Laboratory of Prairie Malt Limited according to the published methods of ASBC and EBC.

Results and discussion

In reflectance mode, both barley and malt samples were scanned by a NIRSystems 6500 and the diffuse reflectance spectra of the samples were saved onto the hard disk of a personal computer. The typical spectra of barley and malt are illustrated in Figure 2. The barley spectrum is parallel to the spectrum of malt in the whole range from 400 nm to 2500 nm, which indicates a strong correlation between these two spectra. These spectra can be manipulated mathematically to enhance the resolution and the correlation between the energy absorption and the chemical components of the samples to be tested.

Two sets of calibration were developed in our QC laboratory. One set is for analyses of moisture and protein content of the barley sample, another set can be used to predict the potential malting quality from the diffuse reflectance spectra of the unmalted barley. The basic information regarding these two sets of calibrations are listed in Table 1.

These calibrations were tested by another set of barley samples (validation set), which were not involved in calibration development. The test results are shown in Table 2.

Table 1. The quality parameters of barley and malt that can be predicted by NIR diffuse reflectance spectra of unmalted barley.

Parameters	Correlation with chemical analysis	*SECV*[a]	Reference method used
Barley analysis:			
Moisture (%)	0.87	0.26	Hot air oven
Protein (%)	0.91	0.26	Kjedahl
Malt analysis:			
Fine extract (%)	0.85	0.43	ASBC mash method
Coarse extract (%)	0.87	0.32	ASBC mash method
Friability (%)	0.79	3.18	Friability meter
Diastatic power (°wk)	0.77	30.0	Enzymatical method
Alpha amylase (DU)	0.62	0.28	Enzymatical method
Malt protein (%)	0.94	0.28	Kjedahl
Wort protein (%)	0.90	0.19	Kjedahl
Wort viscosity (cP)	0.79	0.02	ASBC

[a]*SECV*—standard error of calibration (based on cross-validation).

The results in Table 2 show that, in addition to barley moisture content and protein content, malt quality parameters such as extract, enzyme activities, friability, malt protein content etc., can be assessed reasonably well from the diffuse reflectance spectra of the unmalted barley, although these parameters mainly are controlled by the complex interactions of barley endosperm substrates and enzymes during malting. Barley selectors could thus have the ability to ensure that the barley being selected will most likely perform well in the malthouse.

Conclusions

The NIR technique offers a distinct advantage over conventional micromalting and related analytical procedures in barley quality assessment. This technique allows barley selectors to examine barley's potential malting quality in a rapid and cost efficient manner. Since this technique is non-destructive to the sample being analyzed, it may be used by barley breeders to analyze the very small amounts of barley samples in the early stage of a barley breeding program.

Acknowledgements

The authors wish to thank Prairie Malt Limited for permission to present this material. The help from Michelle Coote, Dr X.S. Yin and Judy Hoult in the preparation of this presentation is greatly appreciated.

Table 2. The comparison of NIR results with the results of QC laboratory. (The comparison was based on 15 randomly selected production barley samples).

Analysis	NIR result		QC lab result	
	Mean	Std	Mean	Std
Barley moisture	13.73	0.19	13.79	0.27
Barley protein	10.55	0.07	10.57	0.45
Fine extract	81.23	0.21	81.44	0.54
Coarse extract	79.91	0.27	80.09	0.45
Friability	82.28	2.97	81.84	4.20
Diastatic power	373.0	33.0	390.0	41.7
Alpha amylase	52.27	2.75	52.63	2.75
Malt protein	10.62	0.33	10.99	0.61
Wort protein	4.50	0.22	4.69	0.27
Viscosity	1.47	0.01	1.46	0.02

References

1. C.A. Watson, *Anal. Chem.* **49(9),** 835 (1977).
2. K.H. Norris, “NIR Instrumentation”, in *Near Infrared Reflectance Spectroscopy (NIRS): Analysis of Forage Quality: Agric. Handbook No. 643*, Ed by G.C. Marten, J.S. Shenk and F.E. Barton, II. USDA-ARS, US Government Printing Office, Washington, DC, pp. 12–17 (1989).
3. P.C. Williams and S.G. Stevenson, *Trends in Food Science & Technology*, August 1990, 44 (1990).
4. A.G. Morgan and P.G. Gothard, *J. Inst. Brew*. **85,** 339 (1979).
5. C.F. McGuire, *Cereal Chemistry* **59,** 510 (1982).
6. S.A. Halsey, *J. Inst. Brew.* **93,** 461 (1987).
7. M.J. Allison, *J. Inst. Brew*. **95,** 283 (1989).
8. M. Glennie Holmes, *J. Inst. Brew.* **97,** 283 (1991).
9. M.J. Allison and A.P. Maule, “Monitoring Biochemical Change in Malting by Use of Reconstructed Spectra” in *23rd EBC congress proceedings*. Lisbon 1991, pp. 133–138 (1991).
10. M.O. Proudlove, *Ferment* **5(4),** 287 (1992).