A rapid way of evaluating barley grain for malting quality and as functional food

Primetta Faccioli,[a] Andrea Cavallero,[a] A. Michele Stanca,[a] Flavio Fornasier[b] and Miriam Odoardi[a]

[a]*Istituto Sperimentale Cerealicoltura, I-29017 Fiorenzuola d'Arda (PC), Italy.*

[b]*Istituto Sperimentale Colture Foraggere, I-26900 Lodi, Italy.*

Introduction

Barley is characterised by a wide range of uses, as whole plant and grain meal, for animal feed, for the malting industry and as human food. As a consequence, hundreds of cultivars are available, each devoted to specific uses. For this reason it is of great importance to define an analytical method which is useful for testing all the basic quality parameters in an easy, fast and economic way and also suitable for analysing a very high number of samples. Today, near infrared (NIR) spectroscopy can represent the best answer to these needs, being one of the most useful techniques for grain quality testing.[1]

In the present study, two important constituents of the barley kernels, crude protein and β-glucans, have been identified as the most qualified to show the widest grain uses. In fact, high levels of β-glucans and proteins adversely affect malt and beer production by causing filtration problems, reducing the amount of extract and lowering the quality of the final product. However, seed storage proteins have a significant influence on the nutritional quality of barley for feeding, while β-glucans are important contributors to the dietary fibre supply for human nutrition and for these utilisations their content has to be enhanced. Development of functional foods, based on barley tocols and β-glucans, is strongly increasing the actual potential uses of barley. Particularly attention is focused on the biological activity and the nutritional effects of β-glucans.[2]

β-glucans

(1-3),(1-4)-β-D-glucans are the major cell wall constituents of the starchy endosperm. These molecules are linear chains of β-glucosyl residues polymerised through β-(1-3) and β-(1-4) linkages in the proportion of 30 and 70% respectively. They are a family of polysaccharides that is heterogeneous with respect to size, solubility and molecular shape.

Most of the problems associated with barley β-glucans in the malting industry are due to their ability to form aqueous solutions of high viscosity. However, viscosity is one of the most important physical characteristics of β-glucans, both for their beneficial health effects and for their use in the cosmetics, food and beverage industries.[3]

With the objective to provide the barley breeder with a simple and rapid method of screening a high number of seed samples for quality testing, specific calibration equations have been developed using an NIRSystems 5000 spectrophotometer.

Near Infrared Spectroscopy: Proceedings of the 9th International Conference

Materials and methods

Two-rowed barley genotypes with contrasting morpho-physiological traits—spring vs winter habit, naked v. hulled grains—were evaluated in six different locations within the Italian network of multilocation replicated yield trials.

Agronomic traits were scored and a grain sample from each replication, ground with a cyclone mill (0.5 mm sieve), was used for quality traits evaluation. Two parameters have been determined on the dry matter basis: crude protein and β-glucan content. Chemical analysis for protein content was carried out according to Reference 4 by means of a Carlo Erba NA 1500 nitrogen analyser (N × 6.25), while β-glucans were determined by an enzymatic procedure (AOAC Method 995.16).[5] On the same samples an NIRSystems model 5000 monochromator (NIRSystems Inc., Silver Springs, MD, USA) was used to generate spectral data. Reflectance spectra (log 1/*R*) from 1100 to 2500 nm were recorded at 2 nm intervals, giving 700 datapoints per sample. CALIBRATE option of NIRS 2 Software (ISI International, Port Matilda, PA, USA) was used, with first derivative as math option and eight groups of validation to obtain calibrations, by applying the MPLS (modified partial least squares) procedure. Calibrations were validated using the standard error of cross-validation *(SECV)* and the coefficient of determination (R^2). The optimal calibration was defined as the calibration with the lowest error (*SECV*) and the highest fraction of explainable variance (R^2).

Results and discussion

Table 1 shows the range of the chemical components analysed: crude protein content (% DM) reveals a wide and statistically significant range of variation (8.7–17.5), indicating that the samples used here can be considered as representative of the range of variation found in the Italian environmental conditions. Also, for β-glucans, the data displayed wide variations, ranging from 3.2 to 6.2 % DM, as they cover the most representative production locations in Italy.

Table 2 shows the results of the calibrations developed for predicting the two quality parameters, together with the statistics of cross-validation.

Particularly appreciable was the result for crude protein content, with a high coefficient of determination (0.96) and a low standard error calibration (*SEC* = 0.40). For β-glucan content, the coefficient

Table 1. Range of the chemical composition (%DM) of the set of samples analysed.

Variable	*n* samples	Mean	Range	*SD*
Crude Protein	123	12.94	8.7–17.5	1.9
β-glucan	114	4.35	3.19–6.2	0.63

Table 2. Statistics of calibration and cross-validation, including standard error of calibration (*SEC*), coefficient of determination (R^2), coefficient of determination of cross validation (R^2CV) and standard error of cross-validation (*SECV*).

Variable	*n*	*SEC*	R^2	*SECV*	R^2CV
Crude Protein	120	0.40	0.96	0.42	0.95
β-Glucan	104	0.25	0.78	0.28	0.73

was lower (0.78) but statistically significant: however it must be pointed out that the reference measurement of this contituent is associated with quite a large laboratory error.

These results indicate that, for the two traits considered, NIR analysis could be proposed as an efficient method in routine evaluation of barley grains. In breeding programs for malting quality, in particular, NIR analysis can be considered a powerful tool to be introduced in the selection process to screen, within segregant populations, new high malting quality genotypes. Due to the low cost of the analysis in comparison with the conventional wet chemistry methods, NIR techniques can also be suggested in the early stages of selection for high β-glucan content. Preliminary results indicate in fact that barley flour mixed with bread wheat flour and durum wheat semolina can easily be evaluated for enhancing β-glucan content in functional foods (bread and pasta).

References

1. R.O. Pierce, D.B. Funk and C.A. Brenner, in *Near Infrared Spectroscopy: The Future Waves*, Ed by A.M.C. Davies and P. Williams. NIR Publications, Chichester, UK, p. 251 (1996).
2. S.J. Jadhav, S.E. Lutz, V.M. Ghorpade and D.K. Salunkhe, *Crit. Rev. Food Sci*. **38(2),** 123 (1998).
3. D. Oakenfull, in *Proc. 5th IOC and 7th IBGS*, Ed by G. Scoles, B. Rossnagel and C. Fairbairn. University of Saskatchewan, Saskatoon, Canada, p. 50 (1996).
4. W.J. Kirsten, *Microchem. J.* **28,** 529 (1983).
5. B.V. McClearly and E.J. Nurthen, *J. Inst. Brewing* **92,** 168 (1986).