Application of near infrared technology to sugar beet breeding programmes for energy uses

C. Magaña,[a,*] N. Núñez-Sánchez,[b] P. García,[a] A. Úbeda,[a] A. Moyano,[a] J.M. Pemán,[a] D. Pérez-Marín,[b] V.M. Fernández-Cabanás,[b] J. García-Olmo[a] and E. Alcalde[a]

[a]*Syngenta Seeds S.A., Barcelona, 08006, Spain.*
E-mail: cristina.magana@syngenta.com
[b]*NIR soluciones, S.L., Cordoba, 14006, Spain*

Introduction

Sugar beet breeding programs have traditionally been focused on developing varieties combining outstanding agronomic performance and improved quality characteristics for human consumption. With the recent interest in bio-fuels, new breeding criteria, mostly associated with several new quality parameters, need to be taken into consideration to develop varieties adapted to ethanol production. In consequence, it would be desirable to determine the bioethanol production potential of a particular variety directly from a beet sample. Most of the analytical methods used are costly and time consuming. Therefore, the aim of this project is twofold: to evaluate near infrared (NIR) technology as a fast and cost efficient tool to predict key beet quality parameters involved in ethanol production accurately, and to explore the ability of NIR to estimate the ethanol yield of a sugar beet sample directly.

Materials and methods

75 sugar beet samples from field trials sown in several locations across Spain in 2006/07 and 2007/08 were obtained. All the roots from each field trial were washed and passed through a machine with multiples saws to obtain a fine brei. About 240 g of representative homogenised brei were immediately frozen. The sucrose, total sugars and bioethanol contents were obtained for each sample. Sucrose content was obtained by polarisation with aluminium sulphate (ICUMSA GS 6–3, 1994. Total sugars and ethanol were measured by HPLC. Spectra were collected in reflectance mode using a FOSS-NIRSystems 6500 monocromator (400–2500 nm) equipped with a Direct Contact Food Analyser Module (DCFA) and provided with circular quartz cuvettes (Figure 1).

After being unfrozen, two cuvettes per sample were filled and the average spectrum was used in the data analyses (Figure 2).

Figure 1. NIR reflectance analysis of sugar beet.

The WinISI software package version 1.50 (Infrasoft International, Port Matilda, PA, USA) was used for the chemometric treatment of data. MPLS (modified partial least squares) and cross-validation were applied for regression purposes. Different spectral regions, and first and second derivative treatments were tested; SNV and detrending treatments were applied for scatter effect correction. The statistics used to select the best equations were: standard error of cross-validation (*SECV*), coefficient of determination for cross-validation (r^2), and *RPD* or ratio of the standard deviation (*SD*) of the original data to the *SECV*.

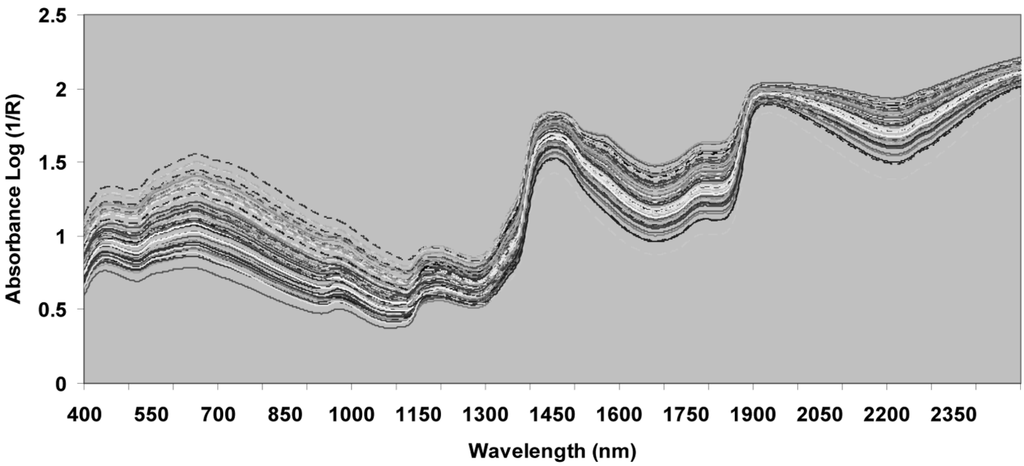

Figure 2. Reflectance spectra of the sugar beet set.

Table 1. Calibration statistics obtained to predict quality parameters and ethanol yield in sugar beet brei.

Parameter	Wavelength (nm)	N	Mean[a]	*SD*[b]	*SECV*[c]	r^{2}[d]	*RPD*[e]
Sucrose (%)	400–2500	75	16.45	1.08	0.22	0.96	4.9
Total sugars (g/)	1100–2500	75	64.49	5.48	1.58	0.92	3.5
Ethanol yield (gL^{-1})	1100–2500	75	26.53	2.01	0.54	0.93	3.7

[a]Mean of the calibration set; [b]standard deviation; [c]standard error of cross-validation; [d]coefficient of determination of cross-validation; [e]*RPD*: ratio *SD/SECV*.

Results and discussion

Highly accurate NIR equations for the prediction of quality parameters and bioethanol yield in sugar beet samples have been obtained (Table 1).

The results confirm the viability of NIR technology as a useful tool in the pre-selections of varieties in sugar beet breeding programs as it rapidly provides quality parameters, as well as the bioethanol yield of a sample, with enough precision and reliability. Further work is in progress with the objective of increasing the variance and the robustness of the equations developed for the NIR analysis of sugar beet.