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Context

Sugar beet is the second biggest world contributor to sugar production and the only one grown in Europe. One of the main limitations for its competitiveness is the lack of effective tools for assessing sugar content in unprocessed sugar beet roots, specially in breeding programs. In this context, a dedicated NIR fiber-optic probe is proposed as a suitable approach. NIR technology is widely used for the estimation of sugar content in vegetable products, while optic fibers allow a wide choice of technical properties and configurations that can be specifically adapted as needed.

The objective of this work is to evaluate the effect of probe design (single fiber probe (SFP) and multiple fiber probe (MFP)) for the estimation of Soluble Solid Content (SSC) in intact sugar beets. Comparison is made based on the analysis of the measured spectra and the performance of the calibration models. In addition, the impact of different optical components of the probe were analyzed, such as fiber diameter, distance between illumination and collection fiber in order to optimize the optical setup of the probe.

Materials and methods

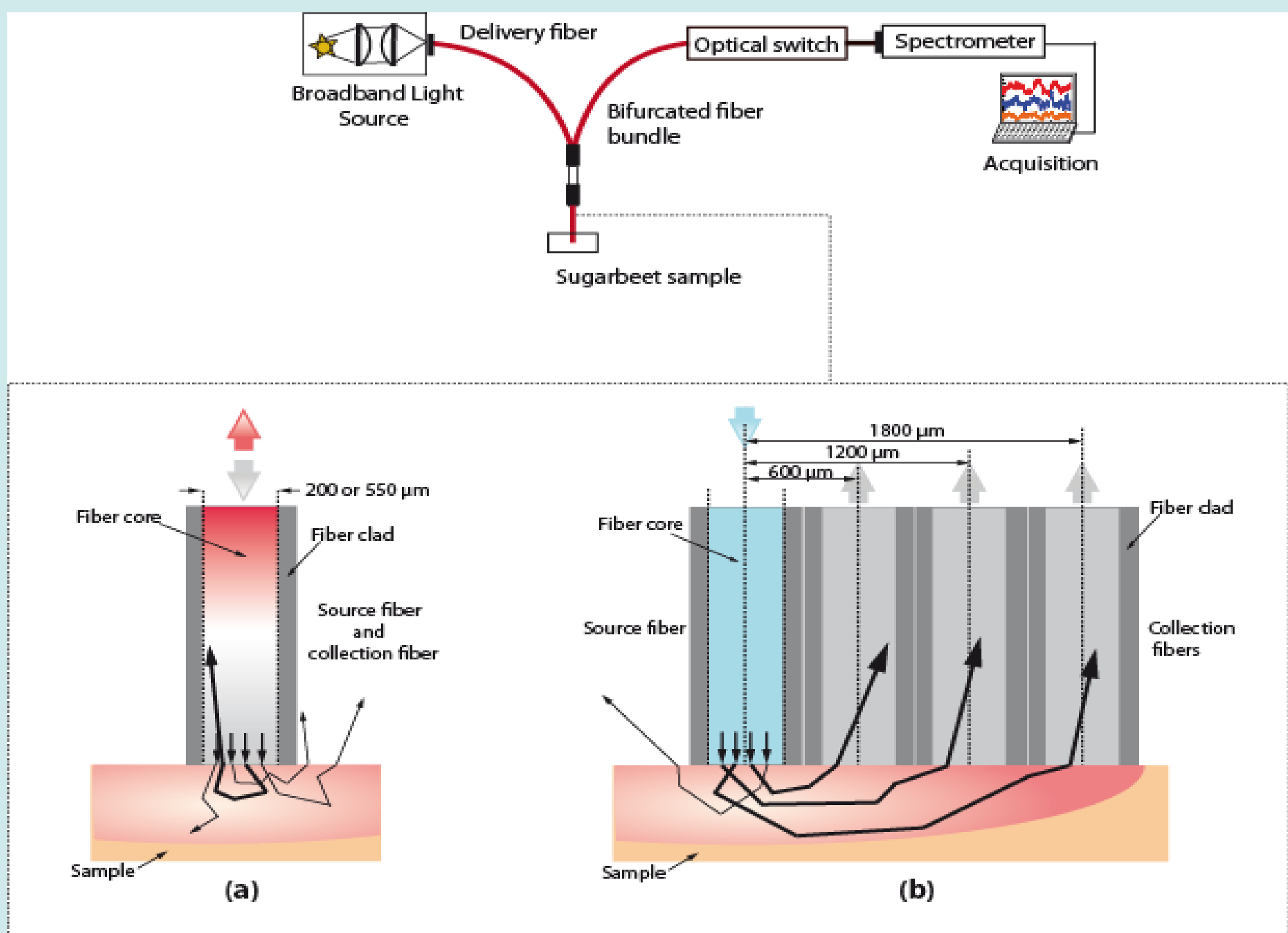

Figure: a) Schematic diagram of the single- fiber probe. b) schematic diagram of the multiple-fiber probes (F1 at 600 µm, F2 at 1200 µm and F3 at 1800 µm).

Optical configurations	Number of beet samples	Mean sucrose value (brix)	Standard deviation (brix)	Sucrose content range (brix
Single-fiber probe D= 200µm	170	24,31	6,49	[17,8 – 45,2]
Single-fiber probe D= 550µm	170	24,67	6,96	[17,1 – 43,2]
Mutiple-fiber probes (all positions)	170	24,42	6,65	[17,1 – 45,5]

Table : Soluble solid content values for the different batch per optical configuration

Results

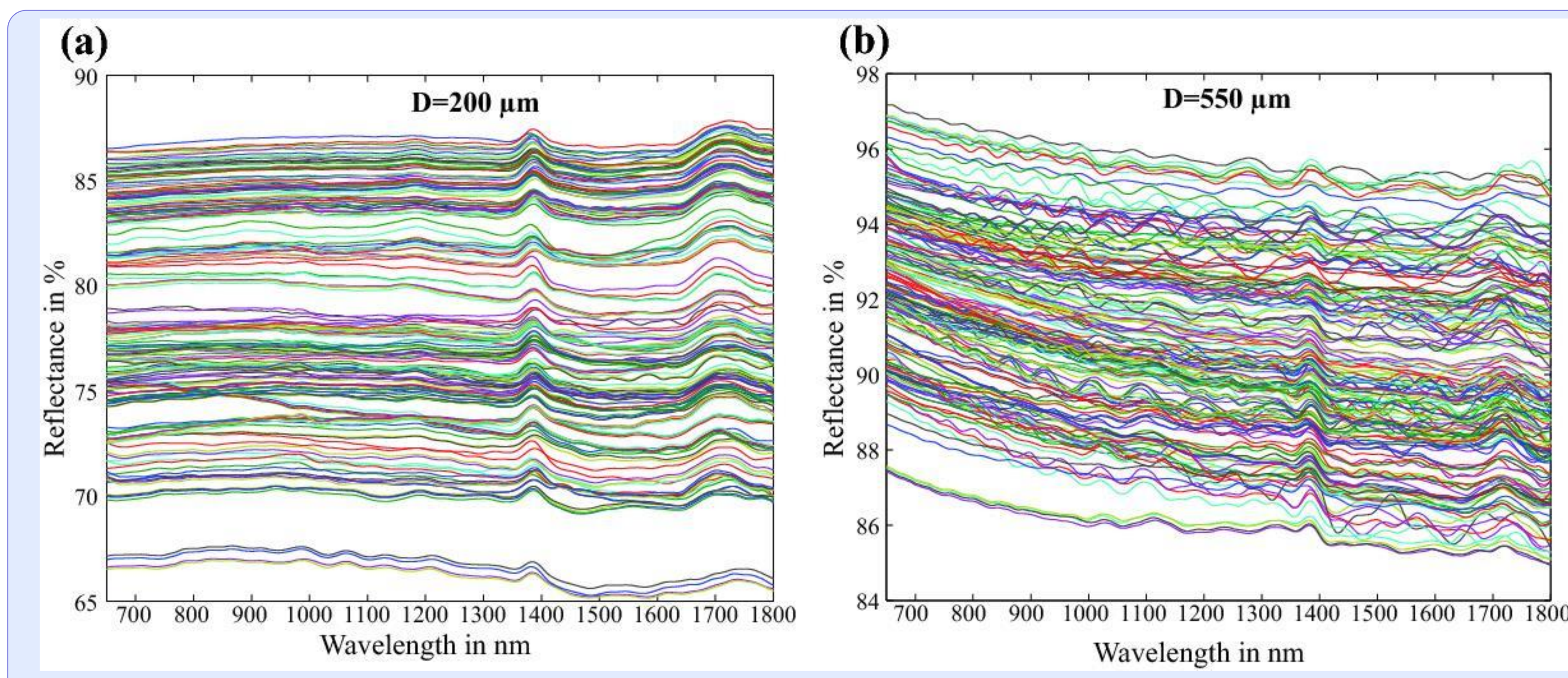

Figure : Raw reflectance spectra of the single-fiber probe with two diameter (a) 200 µm. (b) 550 µm .

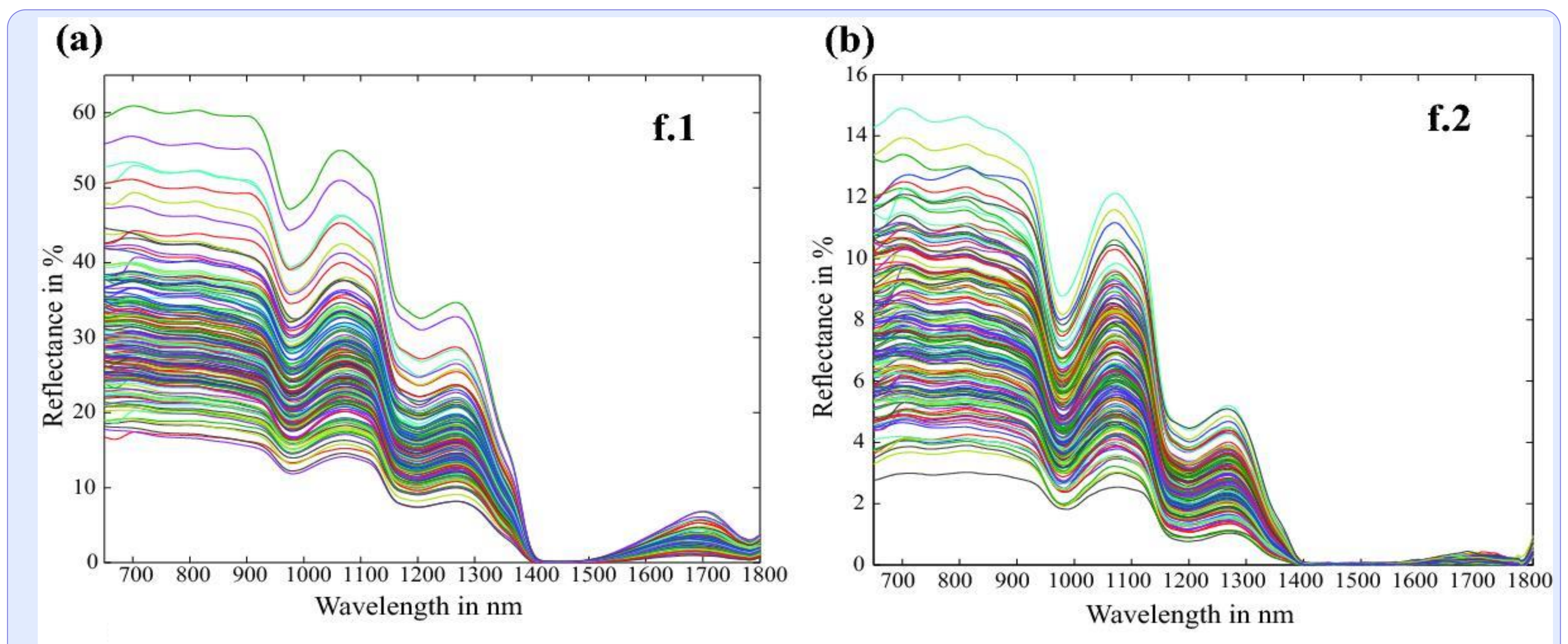

Figure: Raw reflectance of the multiple-fiber probes (a) position F1 of the collecting fiber (b) position F2 of the collecting fiber.

Optical configuration	Preprocessing	R^2_c	SEC (brix)	R^2_p	SEP_c(brix)	RPD
Single fiber probe D=200µm	SG1	0,69	3,66	0,757	3,21	2,02
Single fiber probe D=550µm	SG1	0,645	3,93	0,689	3,95	1,76
Multiple fiber probe F1	SNV	0,95	1,49	0,904	1,95	3,36
Multiple fiber probe F2	SNV	0,927	1,81	0,908	1,94	3,38
Multiple fiber probe F3	SNV	0,828	2,75	0,807	2,8	2,347

Table : Figure of merit of the calibration and prediction for the different optical configurations

Conclusions

These first results are very promising for the position F1 and F2 of the multiple fiber probe. However, further improvement is needed in order to achieve a satisfactory accuracy:

- optimization of the distance between emitting and collecting fiber,
- reducing the multiple scattering using several signal preprocessing methods,
- increasing the number of samples in order to increase the robustness of the model.

This "plug and play" optical method offers the potential to be easy to implement to a commercial spectrophotometer and provides the ability to assess sugar content on intact sugar beets. That is a first necessary step for quick in-field assessment, which is, in turn, the main current bottle neck on the varietal selection in breeding programs.