Near Infrared Diffuse Reflectance Spectroscopy with Partial Robust M- Regression(PRM) as Sensory Tool for on-line Control of Biscuit Dough Production

Geоrgi Gergov1\*, Aylin Alin2, Jordy Cruz3, Elisaveta Kirilova1, Liudmil Antonov4

1Bulgarian Academy of Sciences, Institute of Chemical Engineering, Acad. GeorgiBontchev Str., Bl. 103, Sofia 1113, Bulgaria, ggergov187@gmail.com , e.kirilova@iche.bas.bg

2 DokuzEylul University, Department of Statistics, Alsancak, No: 144 35210, CumhuriyetBlv, 35220 Konak, Izmir, Turkey, aylin.alin@deu.edu.tr

3Escola UniversitàriaSalesiana de Sarrià (EUSS), Passeig de Sant Joan Bosco, 74, 08017 Barcelona, Spain, jcruz@euss.cat

4Bulgarian Academy of Sciences, Institute of Electronics, 72,Tsarigradskochausseeblvd.,

Sofia 1784, Bulgaria, lantonov@gmail.com

\*ggergov187@gmail.com

Biscuit dough mixing is a critical stage in the breadmaking process that affects biscuit quality. The mixing step must ensure a uniform distribution of ingredients (water, sucrose, fat, and flour). Developing a monitoring sensor for the biscuit dough mixing process is crucial for effective quality control. Most online systems are based on the indirect survey of biscuit dough rheological properties changes using torque and consistency probes. Non-invasive near-infrared spectroscopy (NIRS) offers a possibility for fast measurement times that simultaneously deliver critical sample properties like water, sucrose, fat, and flour. Developing the NIR sensor with a fiber optic probe positioned inside the mixer is important for further automation of the industrial mixing process.

In the present study, we investigate the ability of the diffuse reflectance NIR spectroscopy to monitor the real biscuit doughs data in the wavelength range (1100–2500 nm). The presence of a vertical outlier and some leverage points in that data set may cause an unreliable calibration model with misquantified components. As a solution, we propose using Partial Robust M-regression (PRM) (Serneels et al., 2005) to determine fat, flour, sucrose, and moisture content. PRM has been combined with different pre-processing techniques such as first derivative Savitzky Golay algorithm (D1), standard normal variate (SNV), multiplicative signal correction (MSC), and the combinations of MSC and SNV with first derivative (D1+SNV, D1+MSC). The obtained results are comparable with pre-processing in the literature using the first differences according to Marx and Eilers. The optimal pre-processing for every component (water, sucrose, fat, and flour) was found. PRM regression improves the performance compared with the results of classical PLS1 regression.

Together with the facility of NIR technology to be implemented in the process engineering, these improvements make it ideal for the quality control of the bread dough mixing process and other food manufacturing processes.

**Keywords:** NIR, outliers, leverage points, PRM

**Acknowledgements:** First Author gratefully acknowledges receiving funding from programme COST ACTION, Horizon Europe, European Commission, CA19145 “European Network for assuring food integrity using non-destructive spectral sensors”.

REFERENCES

Serneels, S., Croux, C., Filzmoser, P., Van Espen, P. J. 2005. Partial robust M-regression. Chemometrics and Intelligent Laboratory Systems, 79(1-2), 55-64.