Determination of fat and protein content in milk using optical spectroscopy in the range 400–1100 nm

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The rapid growth of the food industry requires new solutions in the quality control of processes and products. The development of new methods enabling quick and accurate determination of the analyzed components is an important task especially for mass consumption products such as milk. Due to the presence of fat globules and protein micelles milk has pronounced light-scattering properties. Economically attractive visible and short-wave near infrared (Vis/SW-NIR) spectroscopy can be successfully used for the quantitative analysis of milk. In the present work a new scatter-based approach to the determination of fat and protein content in milk has been developed. The difference in scattering spectral patterns by fat and protein particles can be utilized for their accurate quantitative determination using multivariate modelling methods, i.e. partial least squares (PLS) regression analysis.

In the first step the dependence of diffuse transmittance spectra in the Vis/SW-NIR region has been systematically investigated using gradual homogenization of raw milk samples. The homogenization results in significant spectral changes, which were explained in terms of the representative layer theory and other scattering theories. The fundamental feasibility of scatter-based quantitative analysis of milk fat and protein content using their low-selectivity diffuse transmission spectra has been proved in a series of designed experiments. This new analytical technique is resistant to an essential variability of fat globule sizes that may occur in raw milk samples. The applicability of the approach to the homogenized milk analysis has been tested on a large set of different samples, which are available in trade networks in Russia and Germany. Finally, the global (i.e. resistant to seasonal, genetic, regional and other milk variations) models for determination of fat and total protein content in raw milk based on historical spectroscopic data collected during a year has been developed. In was also shown that full-range spectroscopy can be replaced by a set of light-emitting diodes (LEDs) as a light source and conventional digital camera as a detector. This simplified technology has shown an acceptable determination accuracy of fat and protein content in raw natural milk.

The presented results have significant practical value and the developed approach can be put into the basis of different devices such as portable inexpensive analyzers or analytical systems for in-line monitoring.