Acoustic Chemometrics for Determination of Skim Milk in Water - Preliminary Results

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Introduction

Acoustic chemometrics (1) is a new in-line measurement method, which can be used to monitor processes generating sound/vibrations. The principle of AC is as follows: obtaining acoustic signals induced by the process, followed by signal transformation and chemometric data analysis.

Experimental

A skim milk in water system with concentration varied from 0 to 50 -% (0-4,29% dry matter) in 2,5% steps was evaluated in 6 trials (subexperiments) by in-line acoustic chemometrics. A non-cavitating exerimental rig (Figure 1) (1) was used.

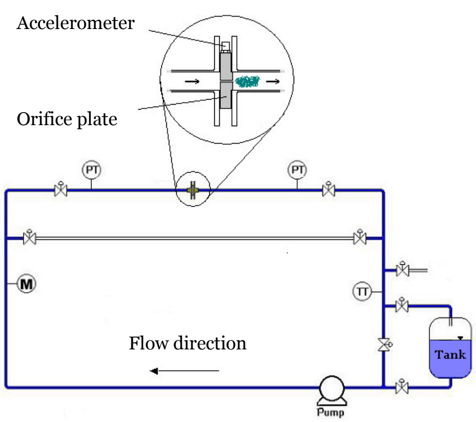

Figure 1. *Experimental rig.*
M – manometer, PT – pressure transmitter, TT – temperature transmitter, ⋈ – valve.

Figure 1 illustrates the turbulence phenomenon that develops downstream of an orifice plate. Flow approaching the constriction will accelerate and a jet of fluid will emerge at the other side of the plate. A pressure drop and an energy loss will develop across the constriction. This energy loss will appear in form of vibration and as heat loss (1) .

Acoustic "noise" (vibration) from the turbulent flow was sampled and transformed by Fast Fourier Transform giving 630 frequency spectra (50-25600 Hz) of 126 samples. PLS-regression was performed on these spectra and the models were validated using segmented ("leave-one-trial-out") cross validation. O-PLS (Orthogonal projections to latent structures) (3) was used as a preprocessing method prior to the PLS analysis. The prediction sets were corrected using the parameters calculated in calibration models.

Results

Figure 2 illustrates clear changes in the sound spectra after increasing the milk concentration.

The whole spectra were used in the PLS-regression. Good predictions were obtained using original PLS regression and O-PLS (Table 1 and Figure 3). O-PLS pretreatment gave models with slightly lower prediction errors comparing to the original PLS-models (Table 1).

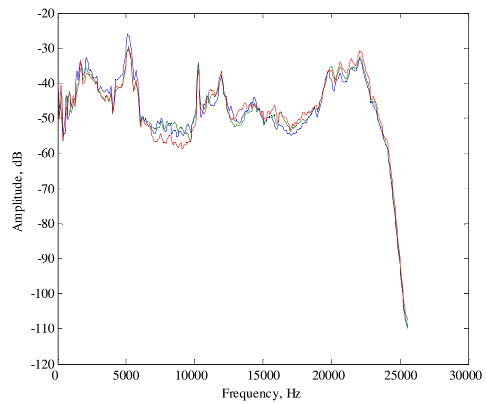

Figure 2. *Power spectra of 0 (blue), 25 (green) and 50% (red) milk-in-water samples (Trial 1).*

Table 1. *PLS model summary. Segmented ("leave-one-trial-out") cross validation results. Number of orthogonal components was 6.*

Test-set	Regression	# PLS comp.	Correlation	RMSEP
Trial 1	PLS	7	0,98	5,04
	O-PLS	1	0,98	4,94
Trial 2	PLS	4	0,98	3,56
	O-PLS	1	0,99	1,89
Trial 3	PLS	3	0,97	5,51
	O-PLS	1	0,96	4,52
Trial 4	PLS	5	0,94	7,40
	O-PLS	1	0,91	6,89
Trial 5	PLS	4	0,94	5,70
	O-PLS	1	0,94	5,20
Trial 6	PLS	5	0,97	4,12
	O-PLS	1	0,95	4,95

Conclusions

Preliminary results indicate that AC has a potential as an in-line measurement method for the aqueous foods processing.

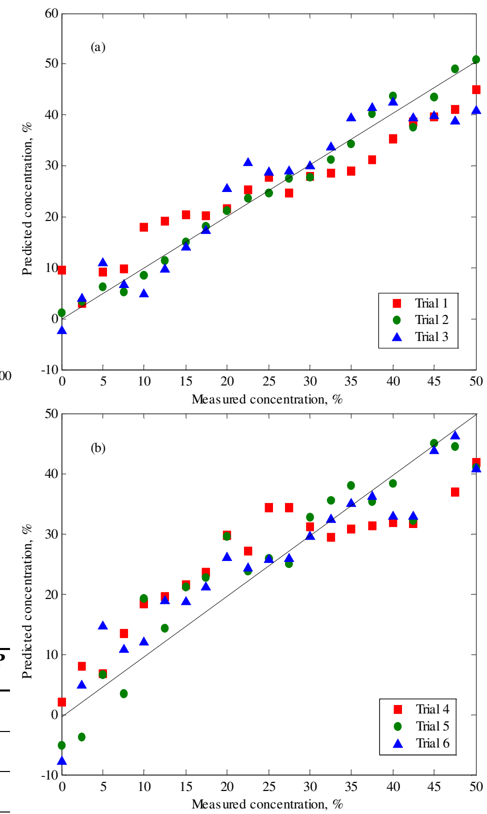

Figure 3. *Predicted vs. measured plot for the O-PLS pretreated PLS-models (a) Trials 1-3, (b) Trials 4-6. The diagonal is the target line. One outlier (45%) in trial 4 was removed.*

References

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2. Esbensen, K.H, Hope, B., Lied, T. T., Halstensen, M., Gravermoen, T. and Sundberg, K. 1999. Acoustic chemometrics for fluid flow quantifications II: A small constriction will go a long way, Journal of Chemometrics, 13: 209-236.

3. Trygg, J. and Wold, S. 2002. Orthogonal projections to latent structures (O-PLS), Journal of Chemometrics, 16: 119-128.