



Aalborg Universitet

AALBORG UNIVERSITY  
DENMARK

## Visible light scatter as quantitative information source on milk constituents

Melentiyeva, Anastasiya; Kucheryavskiy, Sergey; Bogomolov, Andrey

*Publication date:*  
2012

*Document Version*  
Early version, also known as pre-print

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*

Melentiyeva, A., Kucheryavskiy, S., & Bogomolov, A. (2012). *Visible light scatter as quantitative information source on milk constituents*. Poster presented at Chemometrics in Analytical Chemistry, Budapest, Hungary.

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

### Take down policy

If you believe that this document breaches copyright please contact us at [vbn@aub.aau.dk](mailto:vbn@aub.aau.dk) providing details, and we will remove access to the work immediately and investigate your claim.

# Visible Light Scatter as a Quantitative Information Source on Milk Constituents

A. Melenteva<sup>1</sup>, S. Kucheryavski<sup>2</sup> and A. Bogomolov<sup>1,3</sup>

## Background

**Multiple light scattering** by colloidal **fat** (1–10  $\mu\text{m}$ ) and **protein** (80–200 nm) particles complicates spectroscopic analysis of milk. Visible light region (400–800 nm) with dominating scatter effect is typically avoided.

Our preceding research [1,2] has proved that diffused light by itself delivers quantitative information and can be used for accurate spectroscopic determination of milk fat and total protein in the region 400–1100 nm in the presence of essential variability of fat globule sizes (Fig. 1).

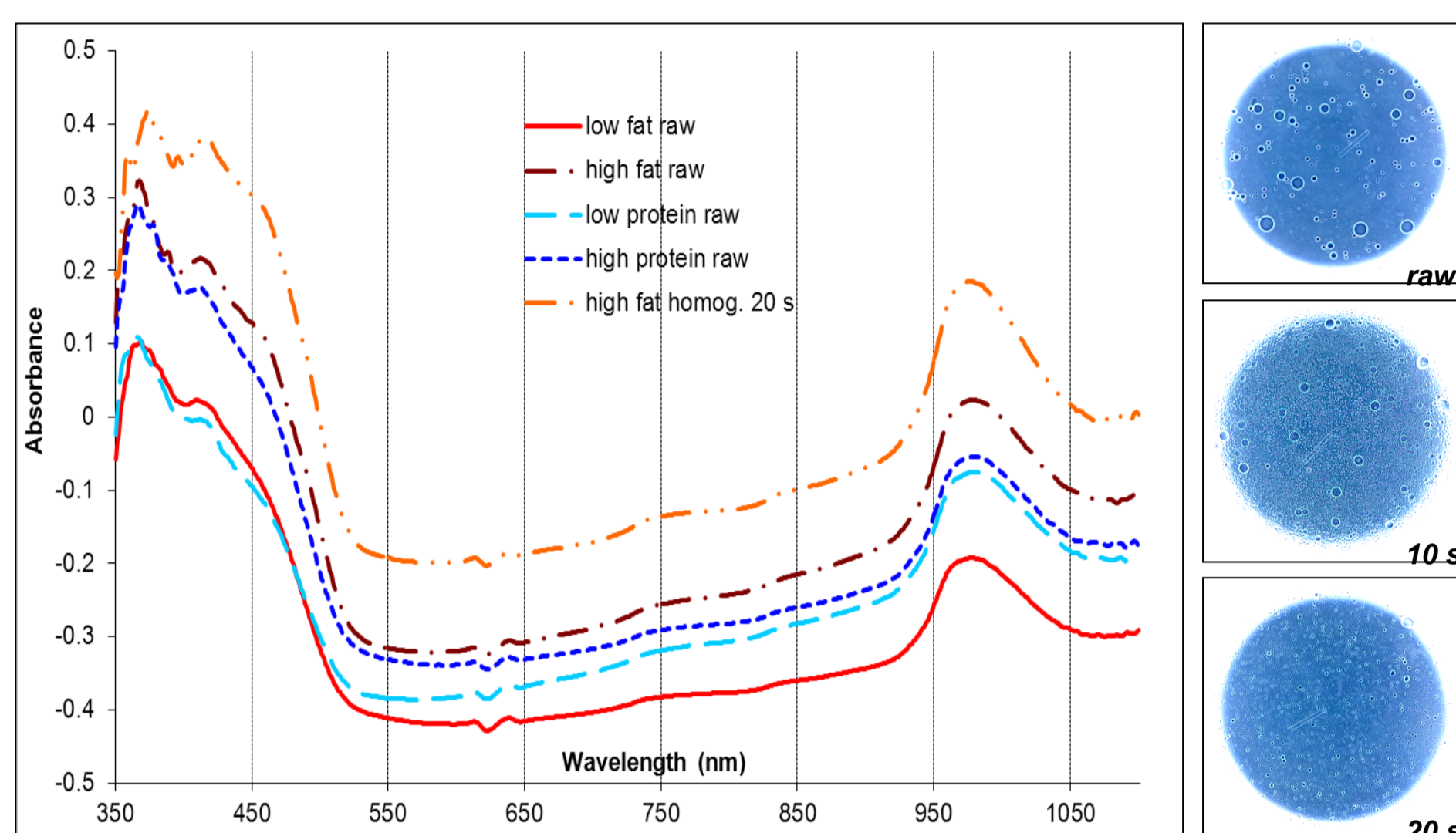


Figure 1 – Spectra of milk samples with different fat and protein content at different homogenization grades

- [1] A. Bogomolov, S. Dietrich, R.W. Kessler, Food Chem. 134 (2012) 412–418  
 [2] A. Bogomolov, A. Melenteva, Chemometr. Intell. Lab. Syst. (2012) submitted

## Challenge

Replace spectroscopy with a **low-end detection** technique, such as **digital imaging** combined with multivariate image analysis.

## Experimental

**Two series** of 16 samples with **varying fat and total protein** content were prepared from milk standards of exactly known composition (Table 1) by a **pair-wise mixing** design (Fig. 2). Vis/SW-NIR transmittance spectra were acquired using a 4-mm cavity. To simulate the variation of fat globule sizes each sample was analyzed 3 times: raw and after **two partial homogenizations** for 10 and 20 s with an **ultrasound** processor.

		%Fat	%Protein
F-series	11	2.37	3.47
	22	3.28	3.49
	33	4.24	3.57
	44	5.46	3.61
P-series	11	3.64	3.00
	22	4.00	3.37
	33	4.32	3.66
	44	4.13	4.09

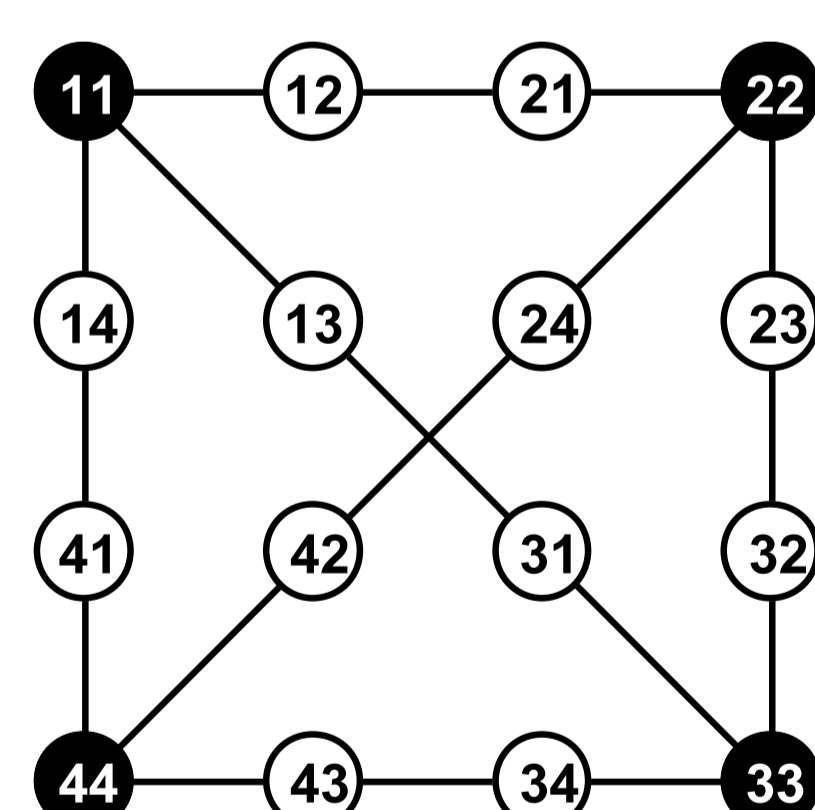


Table 1 – Composition of milk standards used for the preparation of fat (F) and protein (P) sample series

Figure 2 – Pair-wise mixing design for a sample series

Each sample was placed in a Petri-dish and sequentially illuminated from below by red, green and blue LEDs through a fiber cable. The photos of diffusely transmitted light spot on the milk surface were acquired by Cannon 400D using bracketing with five exposition steps, thus, giving 15 images per sample.

Increase of fat or protein content results in a higher light extinction in a sample: compare spot intensities and sizes in Fig. 3. Sample homogenization produces a similar effect.

Figure 3 – Photos of samples with smallest and largest fat content (a), with smallest and largest total protein content (b) and sample with smallest fat content before and after homogenisation.

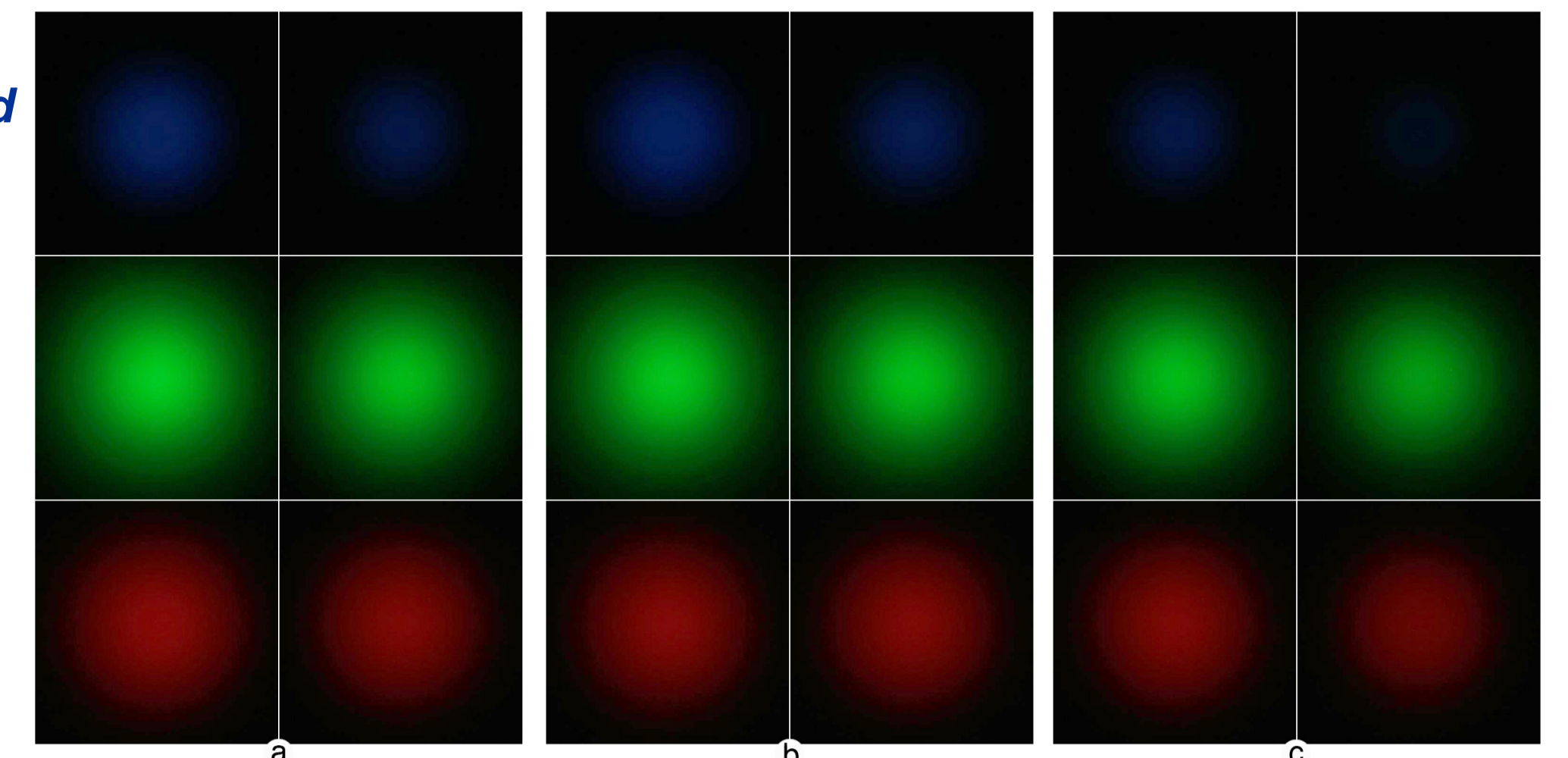
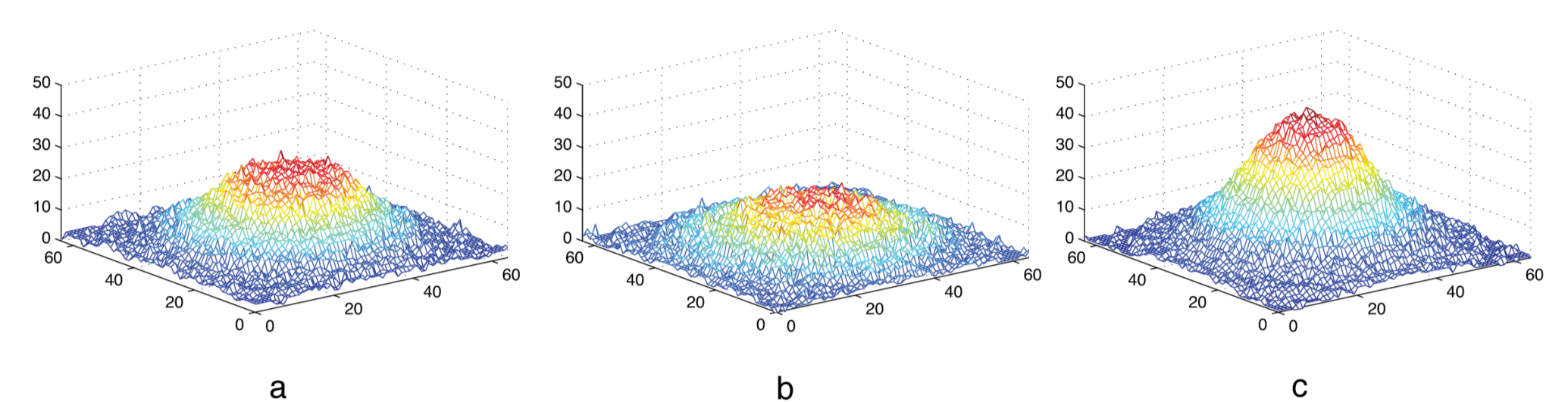


Figure 4 – Difference in light intensities for the green images

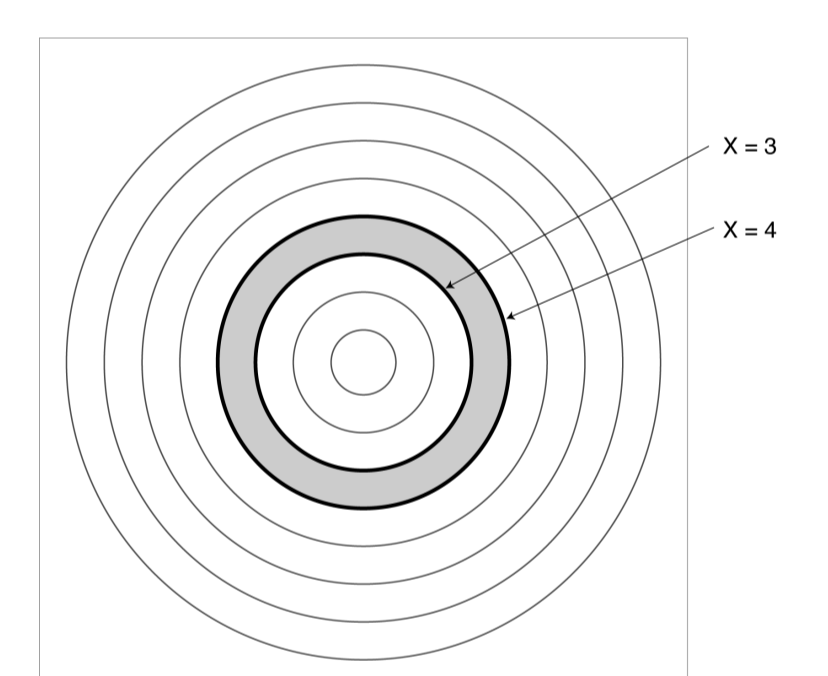


However, visual inspection of the images at different light colors reveals differences of fat, protein and homogenization effects; these are in correspondence with spectral differences in Fig. 1. Beside the overall extinction, some differences in radial intensity distribution are observed using the difference images in Fig. 4. Therefore, spatial distribution of diffusely transmitted light should be taken into account by the feature extraction algorithm converting the raw data into a model input.

## Results

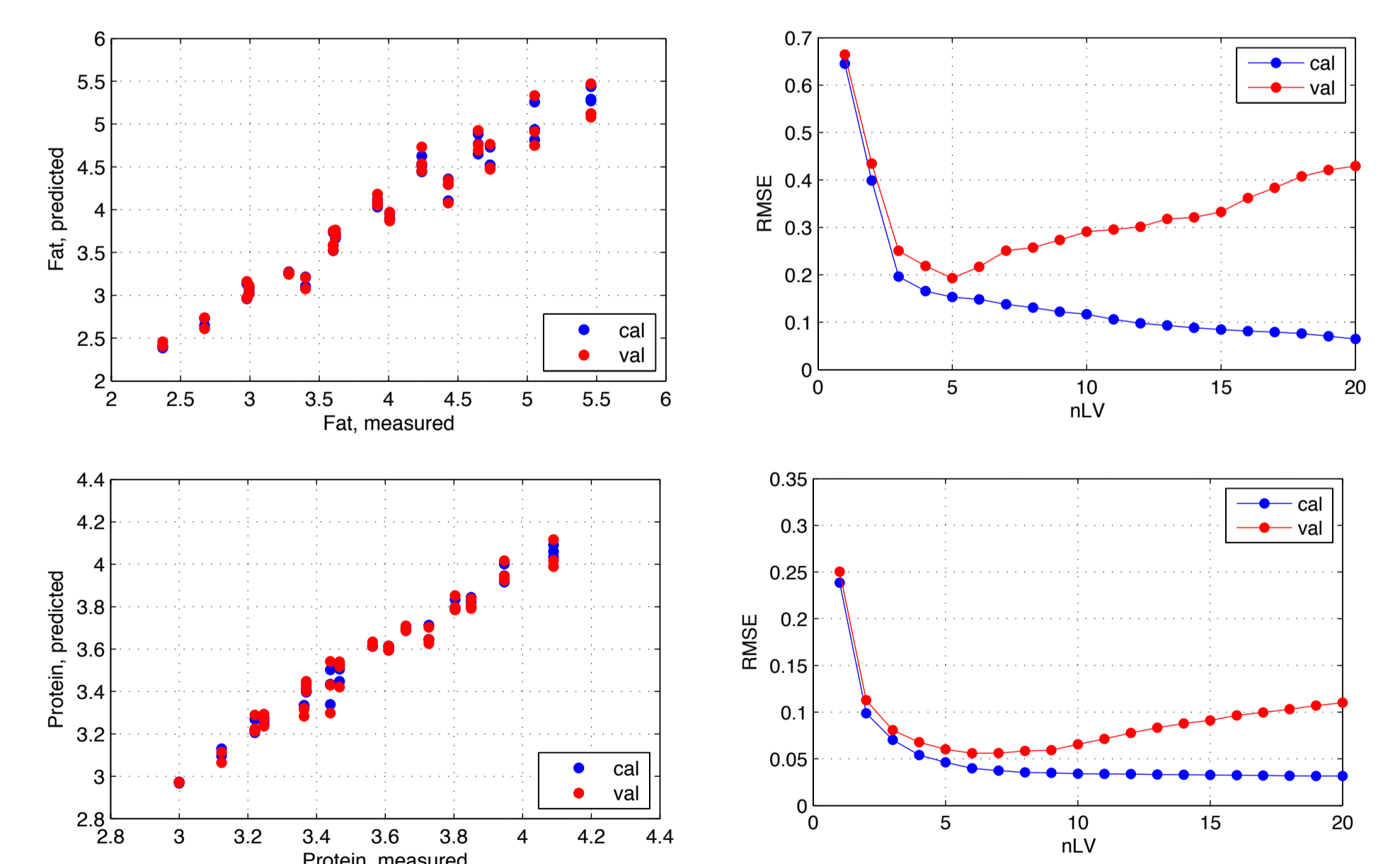
A new feature extraction algorithm, developed for this purpose, calculates average intensity values for N concentric rings built with an equal radius step around the center of a light spot (Fig. 5). N=8 was found to be an optimal resolution for subsequent modeling.

Figure 5 – Scheme of concentric rings based features calculation for N = 8.



The calculated features were used as predictors in PLS regression models for of fat and total protein content. The best models, obtained after iPLS variables selection are presented in Fig. 6.

Figure 6 – PLS models for prediction of fat (top, RMSECV = 0.190) and protein (bottom, RMSECV = 0.048) content.



## Conclusions

Multivariate modeling of conventional digital images enables fat and total protein content prediction in raw milk with a reasonable accuracy. The method is resistant to essential variations of fat globule size distribution.

<sup>1</sup> Samara State Technical University, 244 Molodogvardeyskaya Street, 443100 Samara, Russia, [www.samgtu.ru](http://www.samgtu.ru)

<sup>2</sup> Aalborg University, campus Esbjerg, Niels Bohrs vej 8, 6700 Esbjerg, Denmark, [www.esbjerg.aau.dk](http://www.esbjerg.aau.dk)

<sup>3</sup> J&M Analytik AG, Willy-Messerschmitt-Strasse 8, 73457 Essingen, Germany, [www.j-m.de](http://www.j-m.de)