Development of broadband multispectral imaging for analysis of dairy products

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Outline

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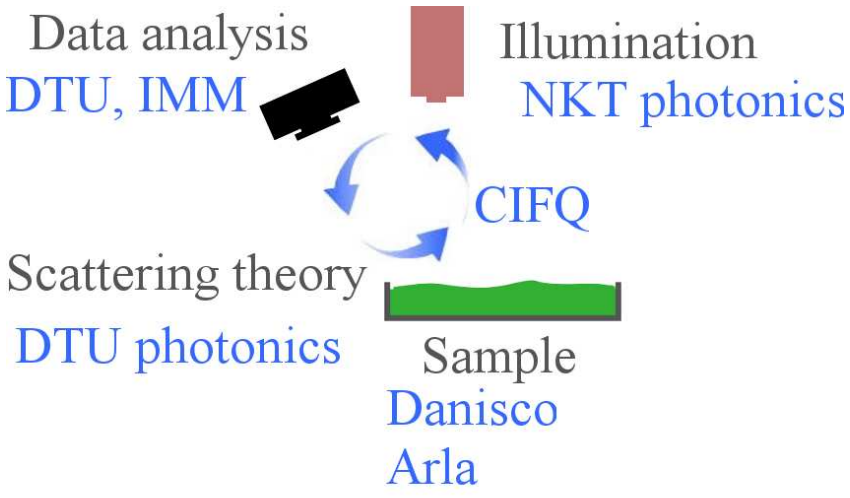
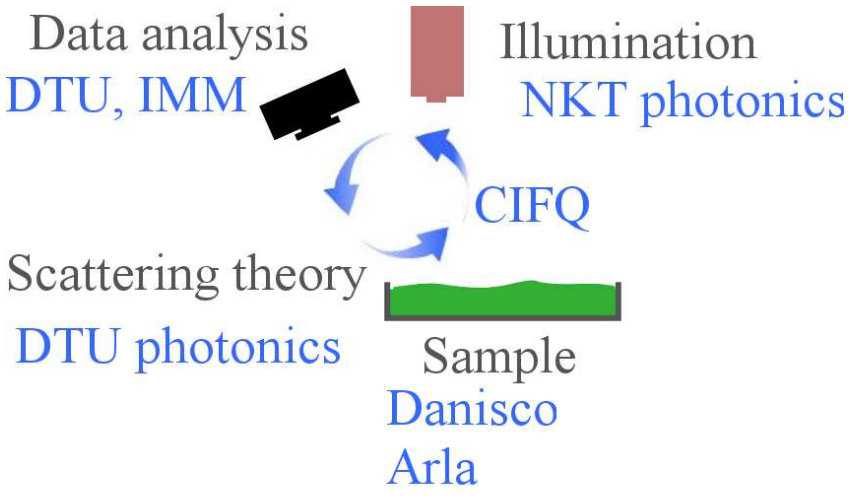
Spectral imaging for food diagnostics



Spectral imaging for food diagnostics



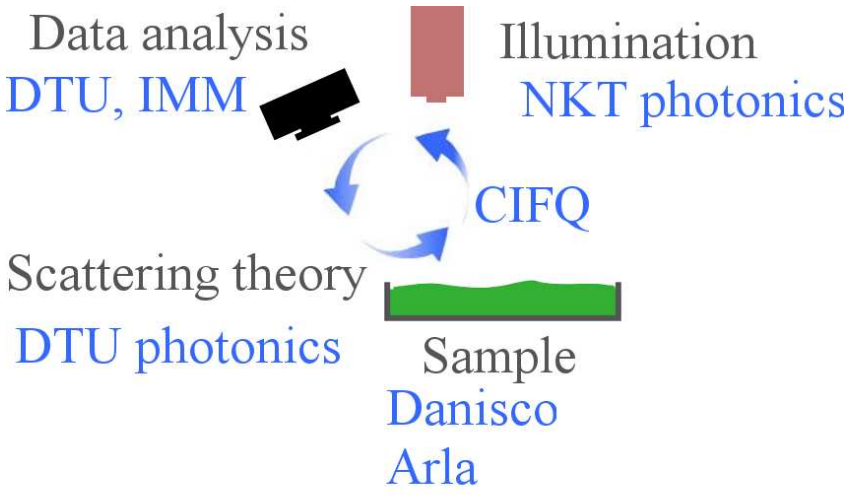
Vision systems

- Structural sample information
- Characterisation of biological samples

Spectroscopy

- Chemical analysis

Spectral imaging for food diagnostics



Vision systems

- Structural sample information
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Spectroscopy

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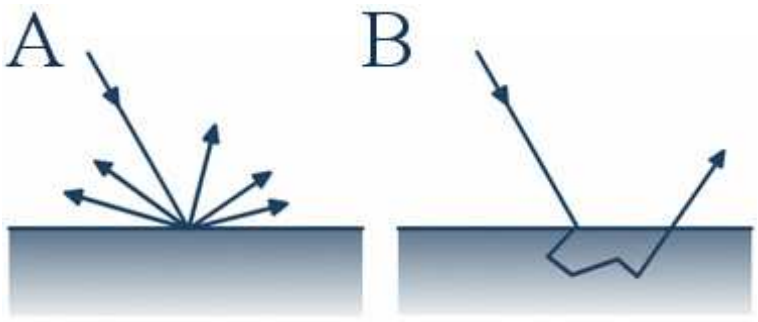
Advantages for food analysis:

- Fast
- Non-invasive

$\Rightarrow$ Suitable for in line process inspection

Inspection method for homogeneous products milk, cream, yoghurt etc.

Illumination sources, a collimated beam
Sub surface light scattering (SLS)



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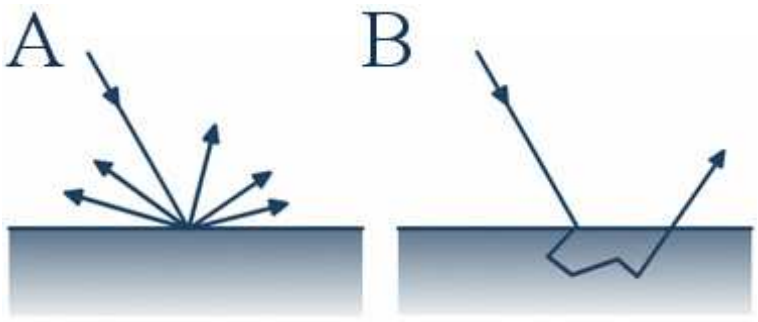

Scattering of biological particles is described my Lorentz-Mie theory.

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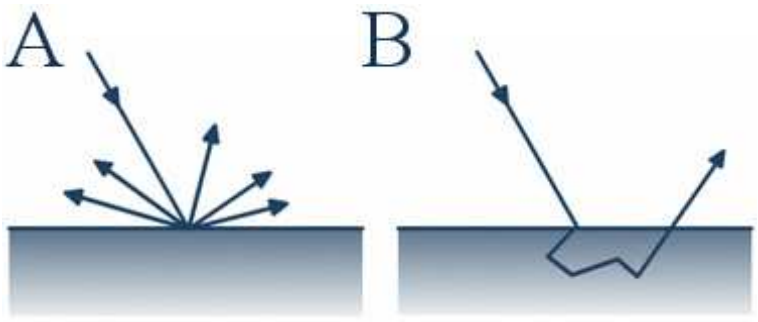

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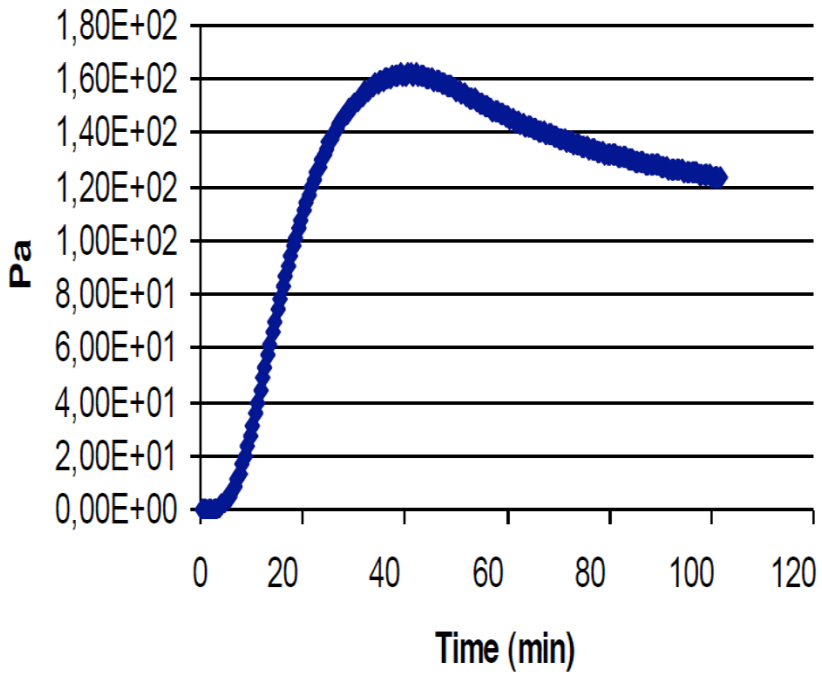
Can determine:

- Particle size
- Particle concentration
- Light absorption
- Light scattering

Previous measurements performed by Danisco[1].



[1] *On-line monitoring of food processes using subsurface laser scattering*

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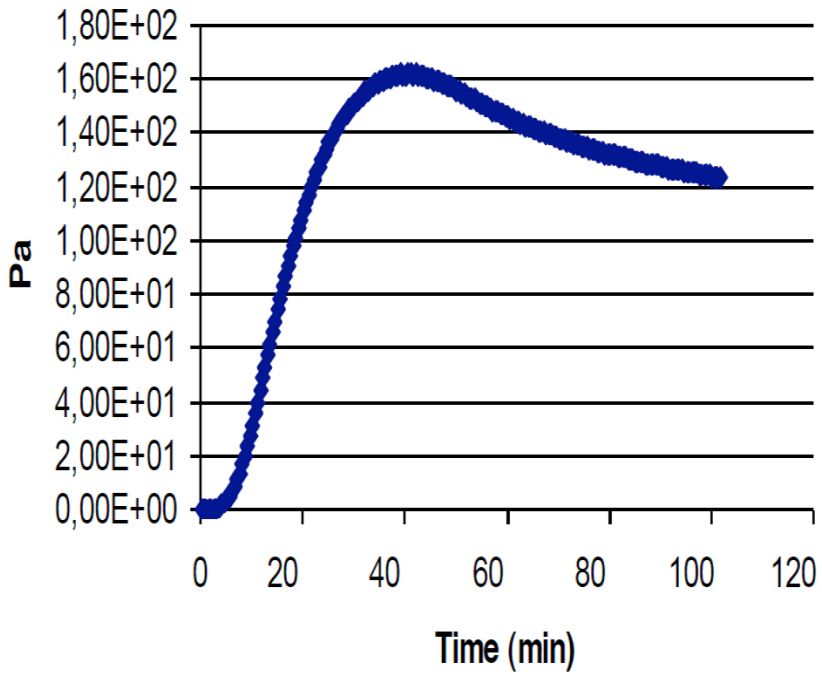

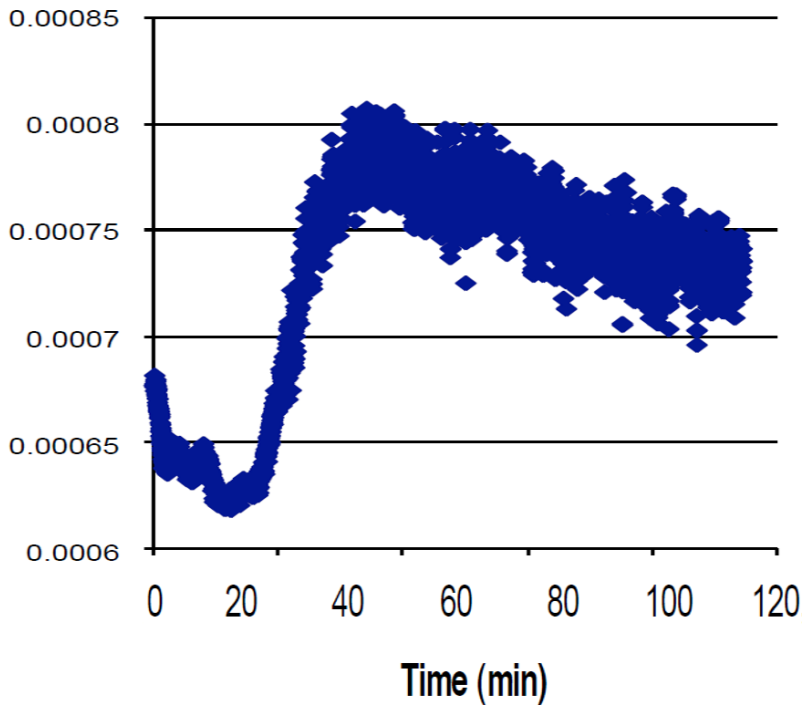

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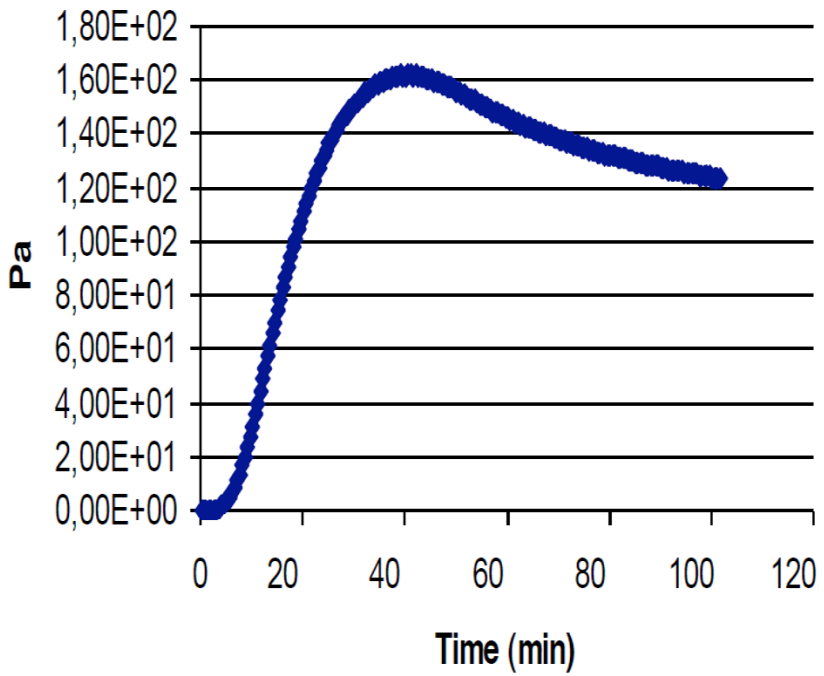
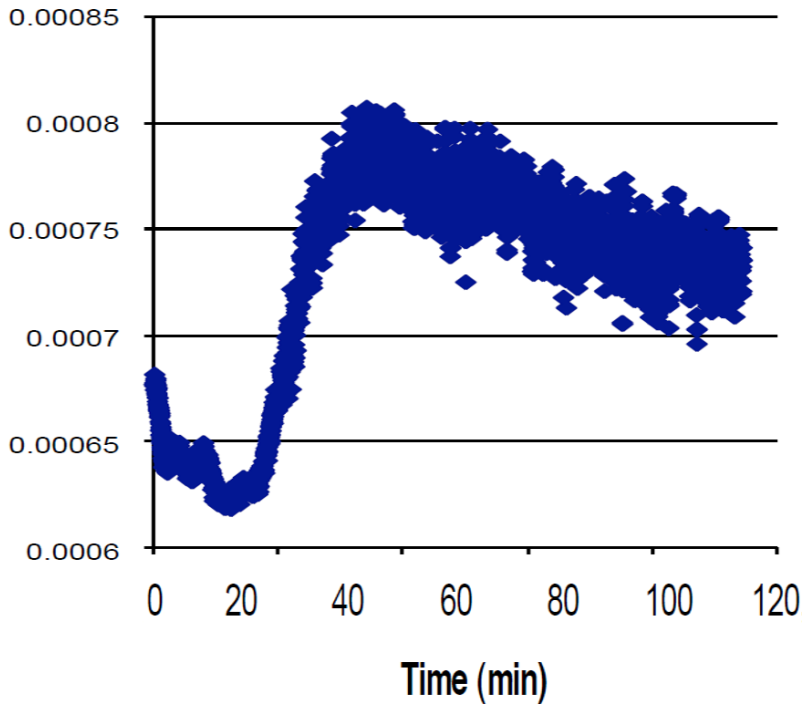
The structure of the sample relates it's optical properties. The characterisation method will be described later.





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Outline

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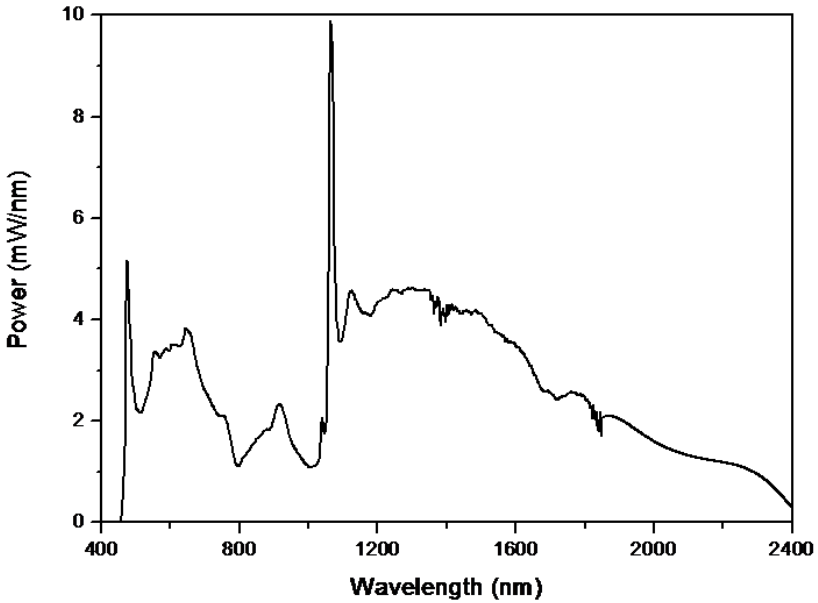
Illumination source

Light generation with a broad spectral profile

SuperK light source



Produces a bright output from 500 nm to 2500 nm, and the beam requires optical filtering to be used in spectral imaging.

Optical filtering ⇒ hyperspectral beam

Acousto-optical tunable filter (AOTF)

Can cover the spectrum from 500 nm to 2500 nm with two AOTF crystals

Returns two beams, one with visible light and a one for the NIR.

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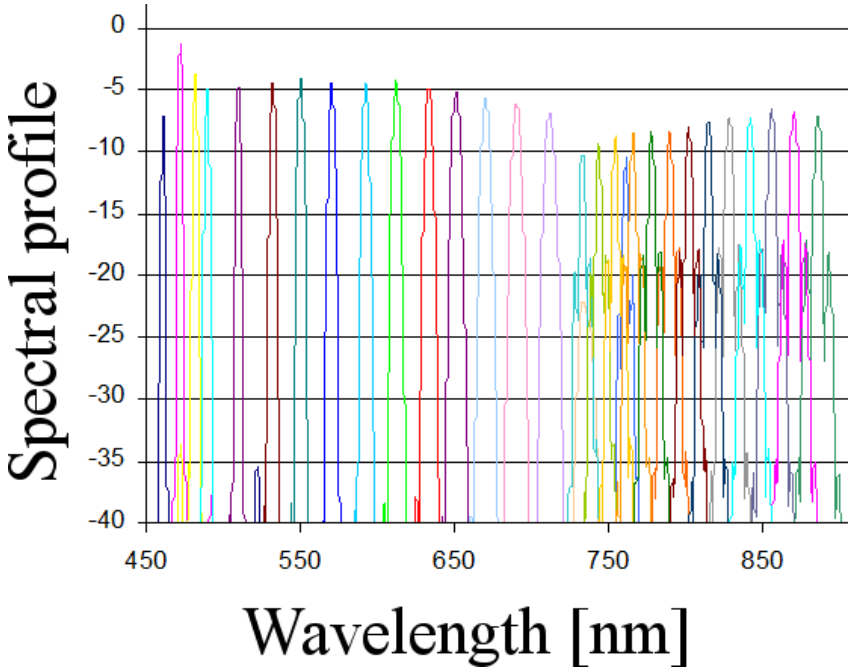

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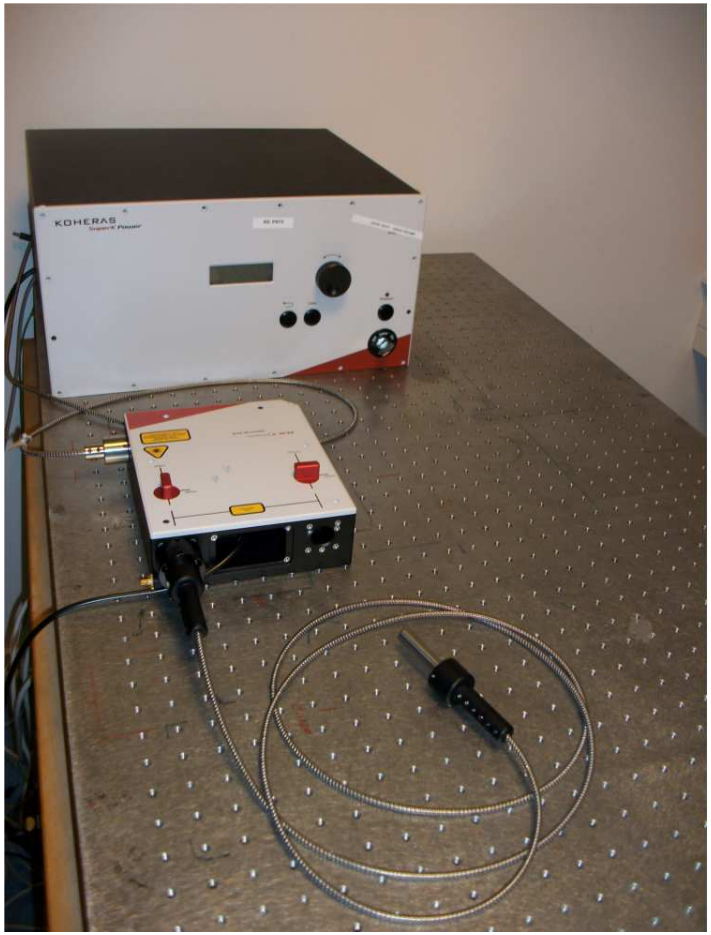
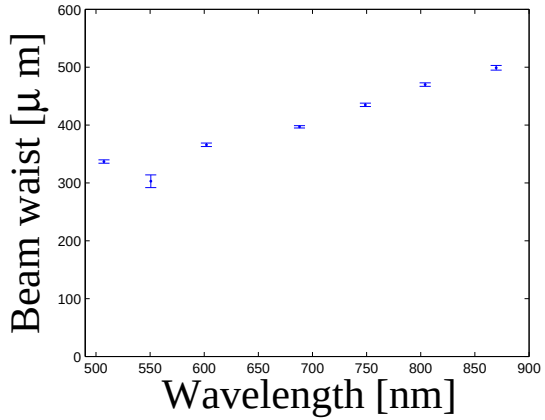
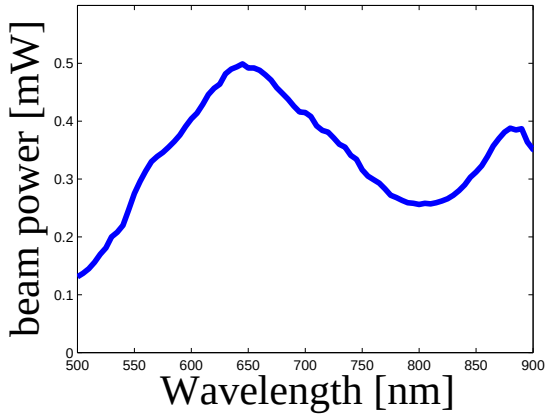
Final light delivery

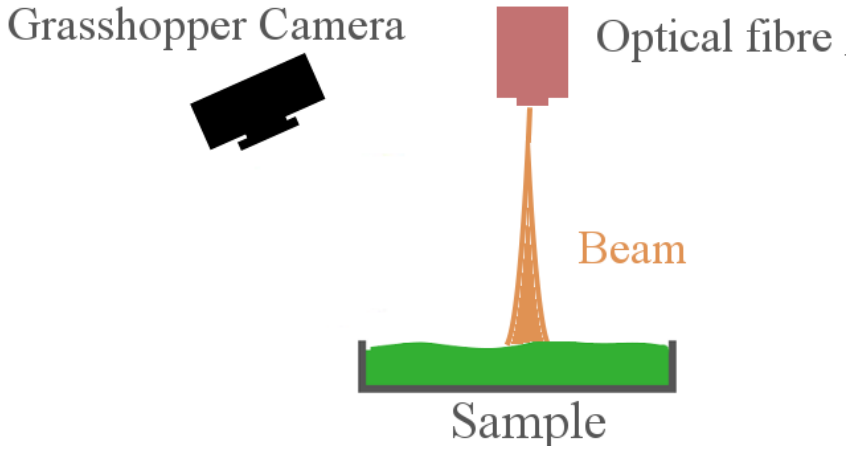
The light is delivered using an micro structured fiber (LMA5).







Schematically setup



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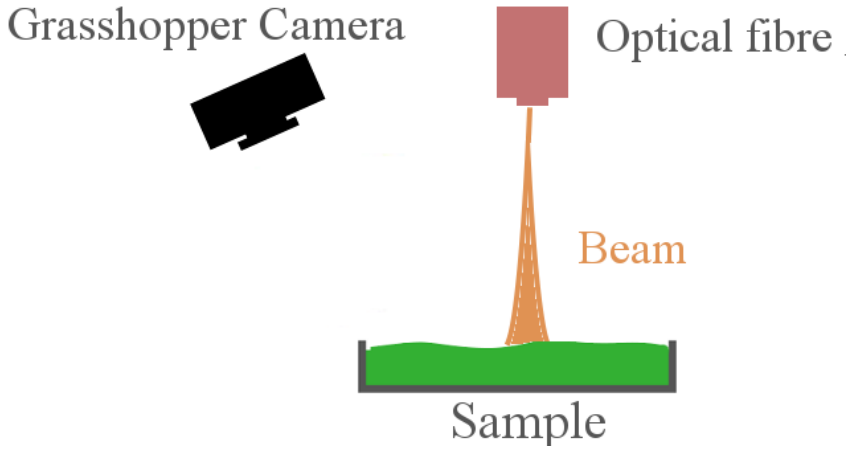
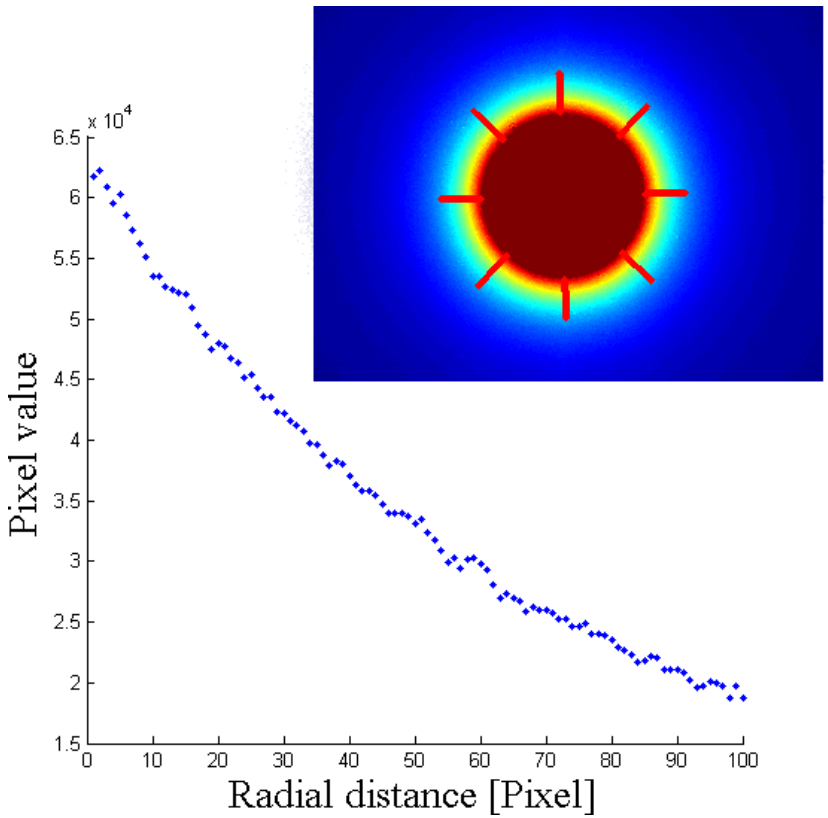


Novel features of the illuminations system

- An small fibre output $\rightarrow$ easy to handle
- Collimated Gaussian beam $\rightarrow$ simple scattering pattern
- Broad spectral range (500 nm to 900 nm) $\rightarrow$ chemical specificity
- Fast switching of wavelengths $\rightarrow$ usable for industrial inspection

Outline

Image example with whole milk, $\lambda = 670$ nm



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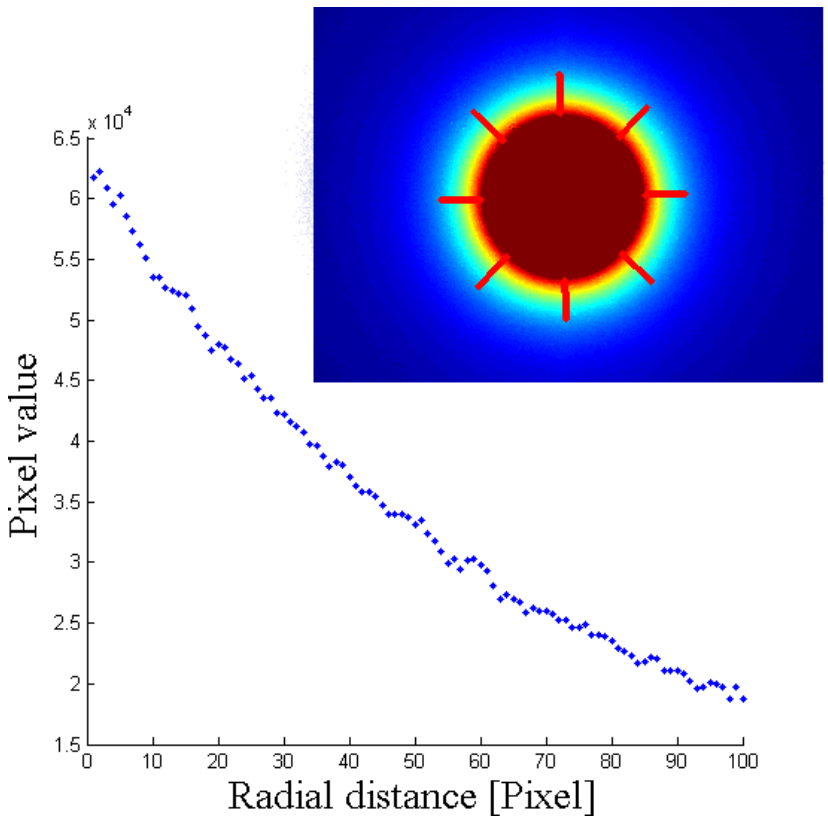

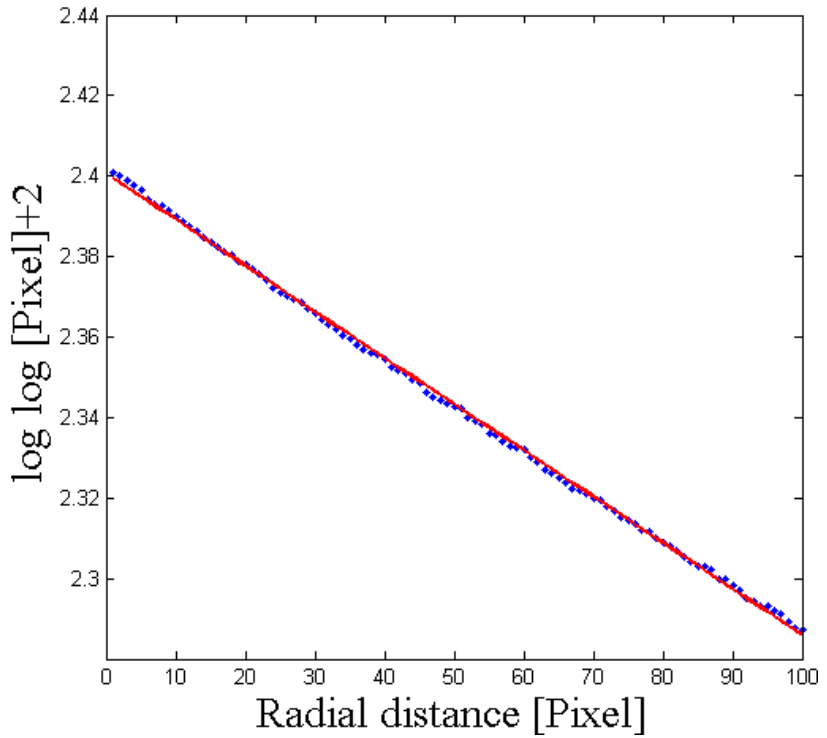

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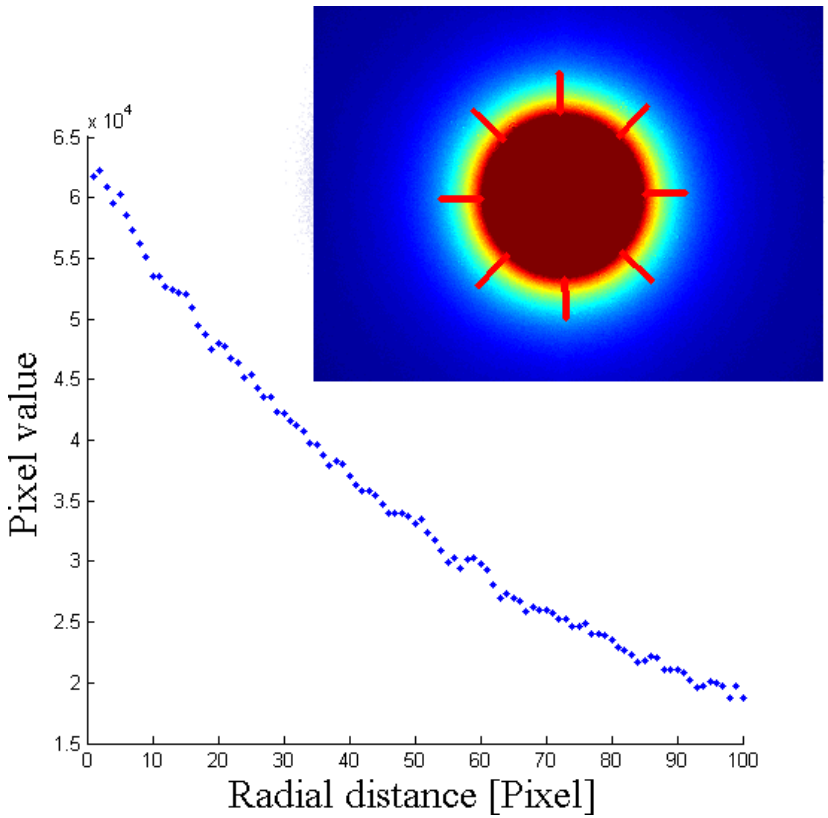
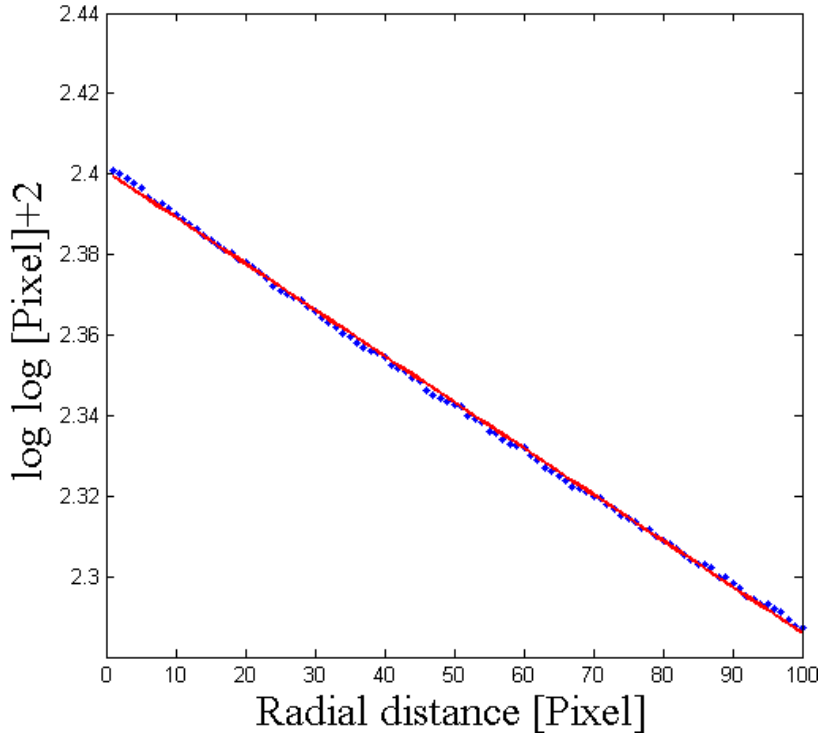
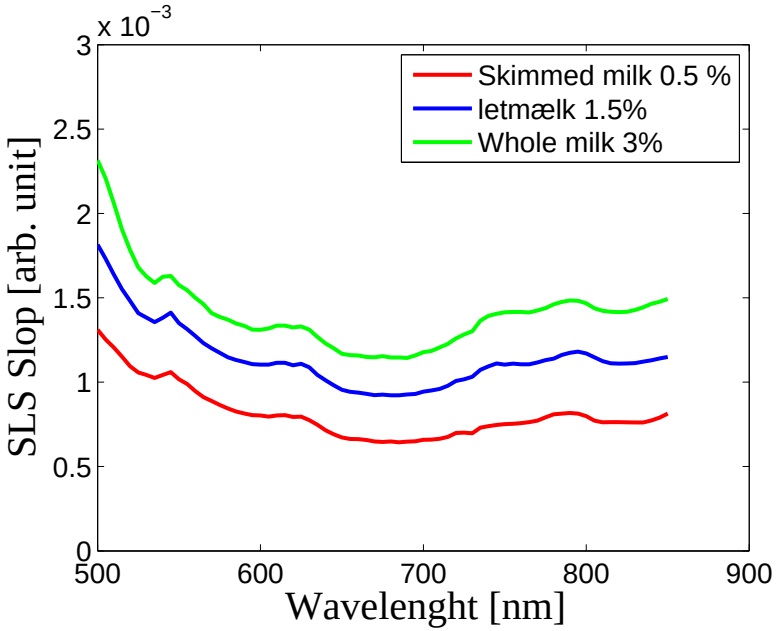




The scattering can be characterised by the slope of the loglog curve and the spot size of the saturated.

SLS slope characteristics of diary products



Can discriminate between products of different fat contents.

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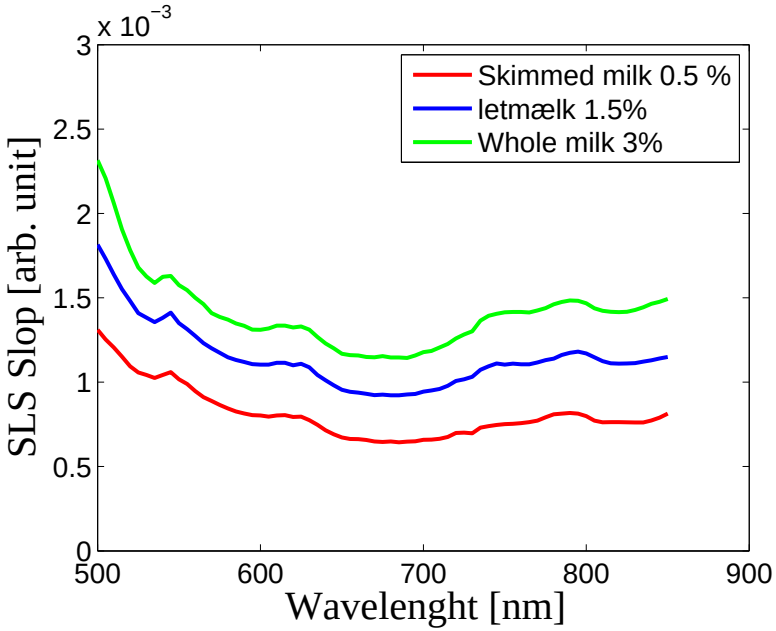

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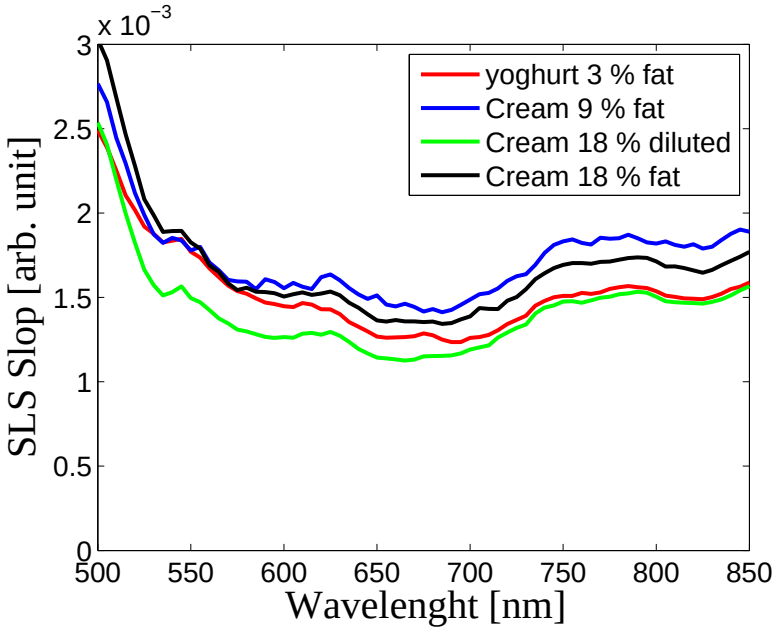
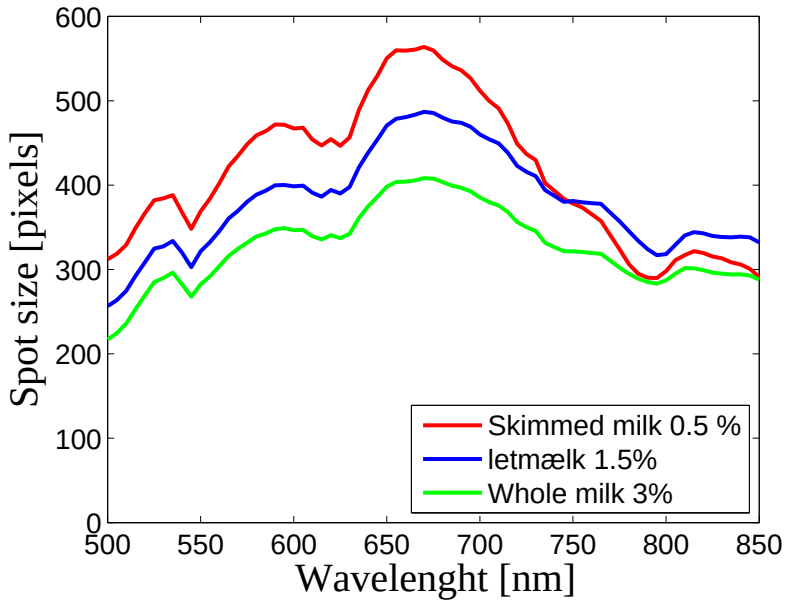


Different slope for same fat contents

Spot size analysis of diary products



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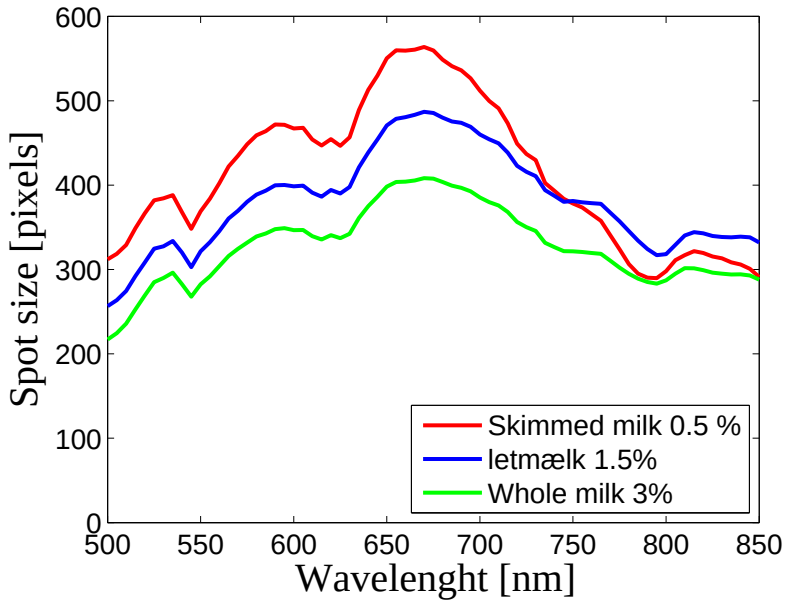

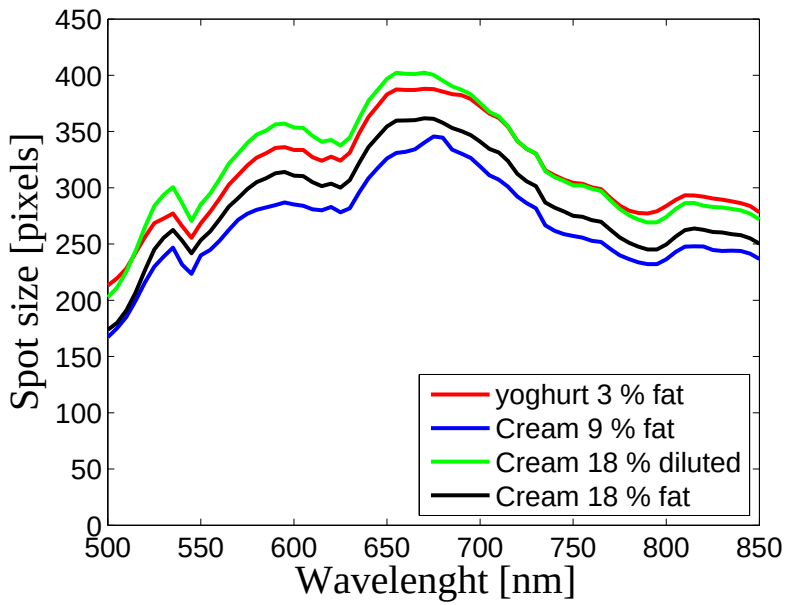

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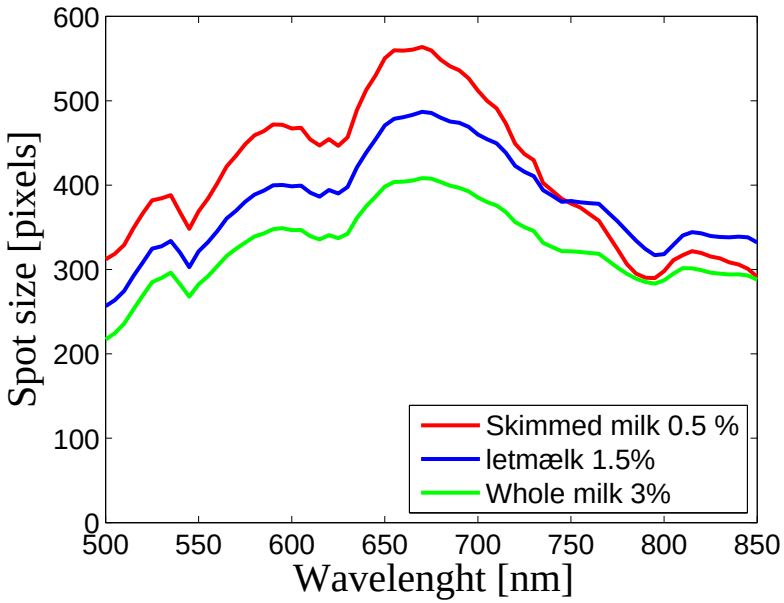

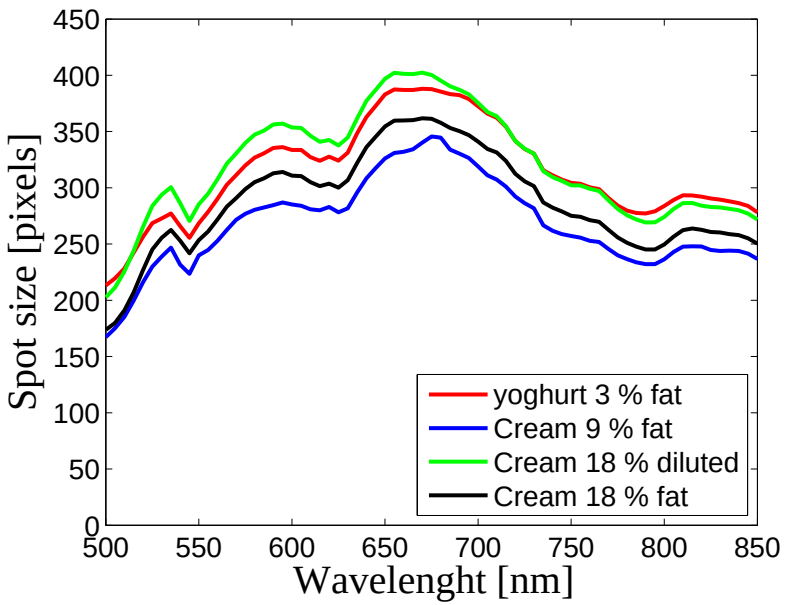

Line crossings at long wave lengths, showing interesting features.

Outline

Future implementations

- Analyse products with simple changes (fat contents and particle size). Make correlation between the SLS spectrum and the food property based on statistical models.
- Combining the illumination system with a robot to move the fibre. This will make it possible to examine non symmetric scattering distribution and surface reflection.
- Perform instrument independent characterisation of the samples intrinsic scattering parameters.

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Acknowledgements

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- Videometer - imaging equipment and data analysis
- NKT photonics - construction and tuning of the illumination system
- Danisco - introduction to food analysis