Poster presentations

Revealing Structure from Micro to Macro	
pRS-1	**(SE)SANS as a tool to bridge the length scale of anisotropic protein structures** Bei TIAN, Wim BOUWMAN, Atzejan VAN DER GOOT *Delft University, the Netherlands*
pRS-2	**Effect of stabilizers on the mesostructure of cellulose microfibrils studies by small-angle X-ray scattering** Evgenii VELICHKO, Ruud DEN ADEL, Gert-Jan GOUDAPPEL, John VAN DUYNHOEVEN, Wim BOUWMAN *Delft University, the Netherlands*
pRS-3	**Milk protein hydrolysis during *in-vivo* and *in-vitro* digestion: Peptide generation and degradation** L.EGGER, H. STOFFERS, P. SCHLEGEL, D. GUGGISBERG, P. STOLL, G. VERGERES, R. PORTMANN *Agroscope Institute for Food Sciences, Switzerland*
pRS-4	**Microfluidics to study emulsifier adsorption and emulsion stability** Kelly MUIJLWIJK, Claire BERTON-CARABIN, Karin SCHROEN *Wageningen University, The Netherlands*
pRS-5	**Diffusing Wave Spectroscopy for the characterization of fat crystals** Maxime BAZIN, Giavanni BRAMBILLA, Mathias FLEURY, Pascal BRU, Gerard MEUNIER *Formulaction, France*
pRS-6	**The supramolecular assembly behaviour of oleic acid and sodium oleate in hydrophobic environments** Steven CORNET, Marta MARTINEZ-SANZ, Anna SOKOLOVA, Andrew WHITTEN, Elke SCHOLTEN, Elliot Paul GILBERT *Wageningen University, the Netherlands*
pRS-7	**Dynamic structural characterisation of fat crystal networks under shear** Tatiana NIKOLAEVA, Daan DE KORT, Adrian VODA, Ruus DEN ADEL, Henk VAN AS, John VAN DUIJNHOVEN *Wageningen University, the Netherlands*

pRS-1

(SE)SANS as a tool to bridge the length scale of anisotropic protein structures

Bei TIAN[1], Wim BOUWMAN[1], Atze-Jan van der GOOT[2]

[1] Delft University of Technology, Delft, the Netherlands

[2] Wageningen University, Wageningen, the Netherlands

Producing meat analogues instead of real meat is one effective way to reduce carbon emission and improve animal welfare. One promising building block for meat analogues is calcium caseinate. It was shown that calcium caseinate combined with transglutaminase can form fibrous structure under heat and shear while sodium caseinate cannot[1]. The anisotropic alignment of the calcium caseinate are observed from hundreds of nanometer to several micrometer, from which a structural hierarchy is suspected.

To have a complete picture of the structural hierarchy and to bridge the length scale in between, we use two non-invasive methods to extract information from the sample, namely small angle neutron scattering (SANS) and spin-echo SANS (SESANS). SESANS is a real-space method that determine the structure of materials without collimation of the neutron beam[2]. It has a measuring range of 20 nm to 20 μm, which can be suitable to examine bulk behaviour of the material. SANS covers smaller length scale from a few to a hundred nm, which is suitable to see the building block of the materials. Because those two methods are complimentary we are able to have a complete view of the sample.

We examined different parameters that will result in different end structures using (SE)SANS. Those parameters include: 1) a series of caseinate dispersion with concentration varies from 3%-30 w/w%; 2) a 30% caseinate gel with or without the presence of transglutaminase; 3) a 30% caseinate gel (with transglutaminase) subject to shear for 3-15 minutes. The results give characteristic lengths of different samples through processing.

Reference

1. Manski J M, van der Goot A J, Boom R M. Formation of fibrous materials from dense calcium caseinate dispersions[J]. Biomacromolecules, 2007, 8(4): 1271-1279.
2. Bouwman W G, Krouglov T V, Plomp J, et al. SESANS studies of colloid phase transitions, dairy products and polymer fibres[J]. Physica B: Condensed Matter, 2004, 350(1): 140-146.

pRS-2

Effect of stabilizers on the mesostructure of cellulose microfibrils studied by small-angle X-ray scattering

Evgenii VELICHKO[1], Ruud den ADEL[3], Gert-Jan GOUDAPPEL[3], John van DUYNHOVEN [2,3], Wim BOUWMAN[1]

[1] Delft University of Technology, Delft, the Netherlands

[2] Wageningen University, Wageningen, the Netherlands

[3] Unilever R&D, Vlaardingen, the Netherlands

Cellulose microfibril (CMF) dispersions find many applications in food industry [1]. They are typically prepared by defibrillation of plant cell wall material under high shear [2]. Aqueous CMF dispersions have to be protected from agglomeration by a stabilizer, typically soluble polymer, such as pectin, which coexists with cellulose in plant cell walls. In industrial processing, CMFs undergo series of processing steps, most of which apply shear-stress on CMFs. Under certain shear-rates plant CMFs start to agglomerate, despite the presence of stabilizers [3]. This behaviour could be mimicked in dispersions of bacterial cellulose (BC) (already produced in microfibrillar form) with water-soluble CMC [4]. The mesostructure of CMF dispersions and it's changes with addition of stabilizer is poorly understood so far.

In order to understand effect of stabilizer on CMF, two systems were chosen for investigation: citric fibrils with pectin (CF-P) as a natural heterogeneous system and bacterial cellulose with CMC as a better defined model system. Series of both systems with different component ratios were prepared. All prepared samples were studied by small angle X-ray scattering, allowing to see characteristic features in lengths range from about few nm up to few µm. Dependencies of mesostructure on concentration of stabilizer have been discovered for both systems. Peculiar similarities and mesostructural differences between both types of CMF dispersions are revealed.

Reference

1. Zh. Shi, Y. Zhang, G.O. Phillips, et al. Food Hydrocolloids, 2014, **35**, 539-545.
2. Kuijk, A., Koppert, R., Versluis, P., et al. Langmuir, 2013, **29**, 14356-14360.
3. Saarikoski, E., Saarinen, T., Salmela, J., et al. Cellulose, 2012, **19**(3), 647–659.
4. Veen, S., Kuijk, A., Versluis, P., et al. Langmuir, 2014, **30**, 13362-13368.

pRS-3

Milk protein hydrolysis during *in-vivo* and *in-vitro* digestion: Peptide generation and degradation

L. EGGER[1], H. STOFFERS[1], P. SCHLEGEL[2], D. GUGGISBERG[1], P. STOLL[2], G. VERGERES[1], R. PORTMANN[1]

[1] Agroscope Institute for Food Sciences, Schwarzenburgstr. 161, 3003 Bern, Switzerland

[2] Agroscope Institute for Livestock Sciences, Tioleyre 4, 1725 Posieux, Switzerland

The digestion processes are the interface between food and bioavailability of nutrients and understanding the molecular mechanisms is a prerequisite to develop food with improved properties. During the digestion process, protein hydrolysis and subsequent generation of peptides and free amino acids depend on the structure and sequence of each protein. During the gastric phase, proteins are denatured in the acidic conditions of the stomach and protein hydrolysis starts through the action of pepsin. At the intestinal stage of digestion, proteases, such as trypsin, chymotrypsin, elastase and others, further degrade the proteins and peptides until they are absorbed through the intestinal epithelium. Generation and destruction of specific peptides during digestion of skim milk powder were investigated *in vitro* using the international consensus COST Infogest digestion protocol and verified *in vivo* in a pig model. The hydrolysis of the five most abundant milk proteins – their peptides and free amino acids – was investigated by mass spectrometry and HPLC after the gastric and the intestinal compartment and compared between both models. Moreover, with time-resolved in vitro digestion experiments, generation and degradation of specific peptides and release of free amino acids were followed and compared with the *in vivo* pig data. The protein specific hydrolysis was visualized by generation of abundance-dependent peptide patterns. Highly abundant peptides observed after complete digestion indicate digestion-resistant protein sequences and represent interesting sources of bioactive peptides or allergenic epitopes.

pRS-4

Microfluidics to study emulsifier adsorption and emulsion stability

Kelly MUIJLWIJK[1], Claire BERTON-CARABIN[1], Karin SCHROËN[1],
[1] Food Process Engineering group, Wageningen University, Wageningen, The Netherlands

Where food production lines are judged on their throughput, which is often in the order of m^3 per hour, interestingly enough the scale at which a lot of phenomena relevant to food structure take place is much smaller: the micro- and nanometre scale. Microfluidics are used to bridge this gap, and the present work shows that droplet formation and stability in food emulsions can be investigated in close detail with high speed recording and image analysis.

Microfluidic methods used to increase the level of understanding of droplet formation and stability include: I) Dynamic interfacial tension measurements in the millisecond range with a microfluidic Y-junction[1] (Figure 1), and II) Measurements of emulsion stability to coalescence under regular flow conditions[2] or under enhanced gravity[3]. For the coalescence studies, a microfluidic coalescence channel and a microcentrifuge (Figure 2) were used.

We discuss the underlying principles of these microfluidic methods and their potential for the food industry, which we believe to be very versatile, since the flow conditions during production and storage can both be covered adequately. Through this, we give evidence that microfluidic investigations can add greatly to the knowledge needed for the rational design of large scale emulsion production.

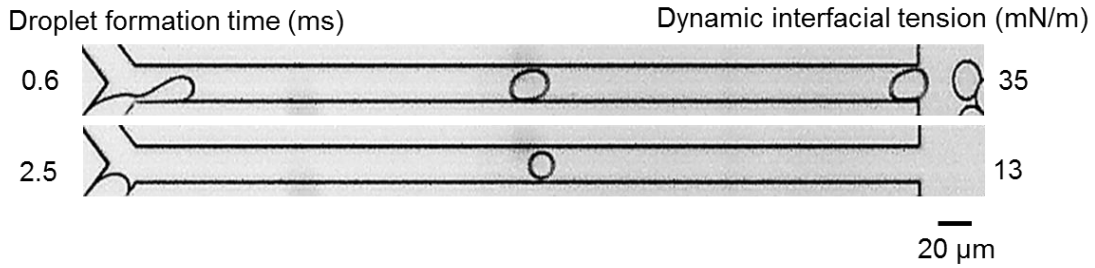

Figure 1. Hexadecane droplets formed in 0.5 wt. % SDS at different droplet formation times.

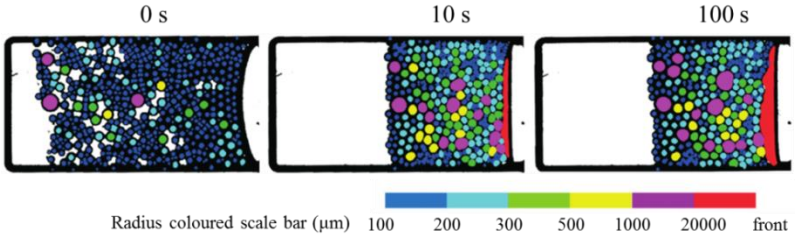

Figure 2. Microscope images of the microfluidic sample chamber during centrifugation.[4]

References

1 M. Steegmans, A. Warmerdam, K. Schroën and R. Boom, *Langmuir*, 2009, 25, 9751–9758.
2 T. Krebs, K. Schroën and R. Boom, *Soft Matter*, 2012, 8, 10650.
3 T. Krebs, D. Ershov, K. Schroen and R. Boom, *Soft Matter*, 2013, 9, 4026.
4 H. Feng, D. Ershov, T. Krebs, K. Schroen, M. a Cohen Stuart, J. van der Gucht and J. Sprakel, *Lab on a Chip*, 2014, 15, 188–94.

pRS-5

Diffusing Wave Spectroscopy for the characterization of fat crystals

Maxime BAZIN[1], Giovanni BRAMBILLA[1], Mathias FLEURY[1], Pascal BRU[1], Gérard MEUNIER[1]
[1] Formulaction, 31240 L'Union, France

The crystalline form of fats in chocolate, butter and vegetable oils was studied thanks to microrheology. Passive microrheology studies the mobility and displacement of micron sized particles [1]: we used Multi Speckle Diffusing Wave Spectroscopy (MS-DWS) coupled with a temperature ramp in order to probe the particle displacement to analyze the viscoelastic properties of an opaque product.

Under heating or cooling conditions, particle movements can be related to the crystalline form of the fat: the rearrangements occurring during melting or during crystallization provide crucial data about the fat's polymorphic transitions.

Crystalline form and melting temperature of fats are important data for the elaboration of new products or for quality control of finished products. In the case of chocolate, the microrheology analysis during melting can identify the crystalline form of finished chocolate products, and so help to predict its stability against blooming.

Moreover, microrheology can be used to study the impact of formulation and process on melting temperatures of low-fat butters. In addition to the analyses of crystalline forms of fat, the MS-DWS provides data on viscoelastic property changes. This technique can be applied also to other fat containing products.

pRS-6

The supramolecular assembly behavior of oleic acid and sodium oleate in hydrophobic environments

Steven CORNET[1], Marta MARTINEZ-SANZ[2], Anna SOKOLOVA[2], Andrew WHITTEN[2], Liliana DE CAMPO, Elke SCHOLTEN[1] and Elliot Paul GILBERT[2]

[1] Physics and Physical Chemistry of Foods, Wageningen University, P.O. Box 17, 6700AA, Wageningen, The Netherlands

[2] Bragg Institute, ANSTO, Locked Bag 2001, Kirrawee DC, NSW 2232, Australia

The current dietary guidelines are focussed on limiting the consumption of saturated and *trans* fats in food products. This has created the need for novel food ingredients to replace solid fats in food products without compromising the food's sensory properties. One approach is the solidification of unsaturated fats (liquid oils) through the addition of oleogelators, which yields a soft-solid material named an oleogel. Nikiforidis et al. (2015) showed that unsaturated fatty acids can act as oleogelators and that the gelling behaviour is tuneable by varying the ratio between oleic acid and sodium oleate.[1] We hypothesise that the oleic acid incorporated in the triglycerides of the oil can associate with the mentioned oleogelators, thereby strengthening the gel. To examine this, rheological measurements have been performed on oleogels prepared with three different edible oils with various oleic acid contents. In addition, two purely hydrophobic solvents have been used. We present data using small-angle neutron and x-ray scattering and link the rheological data to the nano-structure of the prepared oleogels. The concentration and ratio of oleic acid and sodium oleate have been varied to gain a deeper understanding of the behaviour of oleic acid and sodium oleate in hydrophobic environments.

References:

Nikiforidis, C. V., Gilbert, E. P. & Scholten, E. Organogel formation via supramolecular assembly of oleic acid and sodium oleate. RSC Adv. 5, 47466–47475 (2015).

pRS-7

Dynamic structural characterisation of fat crystal networks under shear

Tatiana NIKOLAEVA[1], Daan de KORT[1], Adrian VODA[2], Ruud den ADEL[2], Henk Van AS[1], John van DUYNHOVEN[1,2]

[1] Laboratory of Biophysics, Wageningen University, Wageningen, The Netherlands

[2] Unilever Discover Vlaardingen, Vlaardingen, The Netherlands

Many food products contain fat crystal networks that provide texture and prolonged shelf life. In these networks, fat crystals are dispersed in oil and their hierarchical multi-scale organisation (Fig. 1) critically determines macroscopic product properties [1-2]. Whereas extensive knowledge on crystal polymorphism exists[1-5], the behavior of fat crystal network under dynamic processing conditions (shear) is poorly understood. This constitutes a bottleneck for rational design and engineering of fat-based food materials with enhanced shelf-life stability and sensorial quality. There is a strong industrial need to establish relationships between dynamic processing conditions, in particular shear forces, and the growth and disruption of multi-length scale fat crystal networks.

We studied the time-dependent (thixotropic) yield stress behavior of fat crystal dispersions using viscosity bifurcation and oscillation sweep experiments. Also, rheo-MRI velocimetry was used to characterize shear-controlled flow behavior of these dispersions. This approach provided insight in the shear-induced 'rejuvenation' effects and competing ageing effects on the fat crystal network at both meso- and micron scales. Thus, destruction and recovery processes of fat crystal networks were observed in the characteristics of the flow behavior under shear.

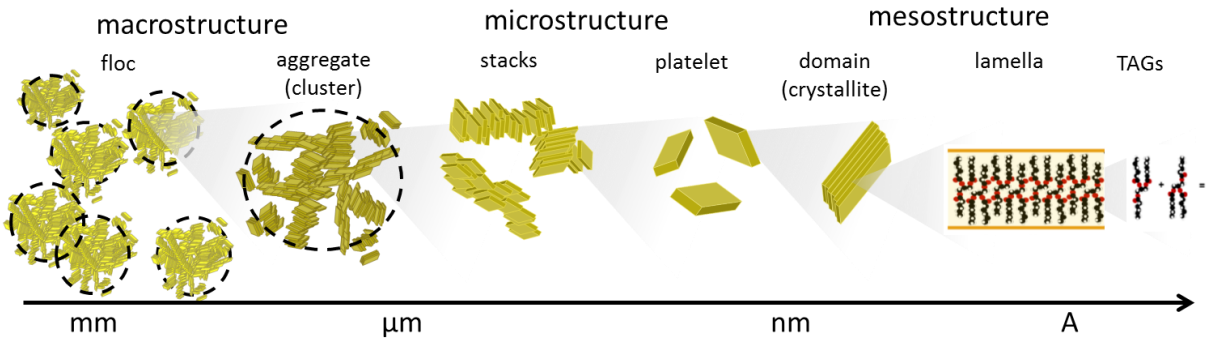

Figure 1. A hierarchical multi-scale network model for crystalline fat dispersed in oil.

References:

1. F. Peyronel, D.A. Pink, A.G. Marangoni; Curr. Op. Coll. Int. Sci. 2014, 19, 459-470
2. A.G. Marangoni, N. Acevedo, F. Maleky, et al.; Soft Matter 2012, 8, 1275-1300
3. R. W. Hartel, Annu. Rev. Food Sci. Technol. 2013, 4, 277-292
4. K. Sato, L. Bayes-Garcia, T. Calvet et al.; Eur. J. Sci. Technol. 2013, 115, 1224-1238
5. S.D. MacMillan, K.J. Roberts; Crystal Growth and Design, Vol. 2, 3, 221-226