Workshop on Micro-Rheology - Characterisation of the mechanical properties of food systems at the micrometer length scale

Wageningen Centre for Food Sciences, Wageningen, The Netherlands, June 21, 1999

SUMMARY

The heterogeneity of food microstructure on mesoscopic scale plays a crucial role in the perception of food texture. Micro-rheology (the study of mechanical properties on a micrometer length scale) opens new perspectives for the study of "structure – function relationships" of food systems, and overcomes current limitations of instrumental approaches that are generally accepted.

INTRODUCTION

On June 21 1999 a workshop on Micro-Rheology was organised at the Wageningen Centre for Food Sciences (WCFS). A total of 34 people invited in the workshop. Participants were evenly drawn from industry, research institutes and academia. Nearly 80% of participants work in food science. The workshop was a scientific meeting, with an informal open atmosphere, characterised by lively discussions and constructive contributions. There were lectures by 4 international experts during the morning and a Round Table Discussion (RTD) during the afternoon which was chaired by Dr. P. Kaplan (Unilever Research US) as moderator. The workshop's main objective was to discuss opinions, recent developments and experimental results to construct a clear view of the scope and challenges of micro-rheology. On the basis of these results opportunities for research were identified. The meeting was structured round the following questions:

1. What is the state-of-the-art in micro rheology?
2. What opportunities does micro-rheology offer for problem solving in Food Research?
3. What are the most prominent developments needed in the field?
4. Where are break through possibilities?
5. What will micro-rheology allow us to do over a period of 5 (to 10) years?

The participants were requested to submit their answers prior to the meeting.

BACKGROUND

The heterogeneity of food microstructure on mesoscopic scale plays a crucial role in the perception of food texture. Two main aspects of the texture are (1) structure: spatial distribution/organisation of ingredients/structural element "mass density" distribution in space and time and (2) rheology: the mechanical spectrum of a system (restricted motion in time). Imaging techniques are most suited for characterisation of the spatial organisation ("in real space"). Rheometrical techniques average out local differences and provide information on bulk properties. Direct information relating local interactions between structural elements and local heterogeneities to the resulting rheological system properties is missing. This is considered as the major limitation in correlating microstructure with functionalities. Due to the absence of techniques that allow the characterisation of both aspects at the micrometer length scale only a novel combination of selected techniques would provide this information. It was the aim of the workshop to discuss state-the-art, challenges and possible outcome of such developments.

PRESENTATIONS

Prof. Dr. J. P. Munch (Strasbourg University, France) presented a paper entitled: " Micro-rheology: Dynamic light scattering and the position echo technique". This presentation provided a quick introduction to light-scattering and the fundamental concept of thermally driven micro-rheology. The spatial thermal fluctuations of a probe particle reveal the local elastic properties of the material. In the position echo technique, changes in microstructure during a cycle of externally applied shear reveal the fraction of the system in which motion of sub-micron particles is possible. This technique is applicable for elastic modulus far larger than other light-scattering rheologies.

Dr. A. Bausch (Technical University Munich) presented a paper entitled: "A micro-rheological study of living cells by means of magnetic tweezers". Main points from the discussion are: Advantages over optical tweezers: larger forces (up to approximately 10 nN compared to pN range), and no heating effect. Disadvantage in respect to optical tweezers: forces can only be applied in one direction. The small number of beads limits the statistical evaluation of the data. Observation of the "strain field" is possible. The analysis of strain reveals the heterogeneity of the cytoplasm.

Dr. P. Fischer's (ETH Zurich, Switzerland) presentation was entitled: "Microstructure engineering of rheologically induced phases". Vari-

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ous techniques were presented. The importance was stressed to apply a combination of experimental techniques. In addition he advocated the integrated approach of experiments, modelling, and simulation.

Dr. M. Duits (Technical University of Twente, The Netherlands) presented a paper entitled: "Micro-rheology of aggregating dispersions: experiments and modelling". Main points from the presentation and discussion: The model allows application to various other systems and only needs few model parameters. The data obtained showed length scale dependence, which could be indicative for a multi-fractal organisation. Precipitation of aggregates during acquisition time of the CSLM could effect the data obtained. New approaches mentioned are: a configuration in which a flow shear cell and a CSLM are combined (challenges: fast detection and homogeneity of specimen), combined configuration of a CSLM and an Atomic Force Microscope (observation of deformation of isolated aggregates under applied force with the AFM cantilever).

ROUND TABLE DISCUSSION

First the WCFS project leaders briefly presented the main objectives of their projects (Dr. T. van Vliet: Stability of Emulsions and Foams, Dr. R. Visschers: Biopolymer dispersions and gels, Dr. H. van der Werff: Physical chemical characterisation of sensorial attributes). After the discussions of problems, we turned to a discussion of available techniques. For this part the following people participated in the "inner circle": Prof. Dr. A. M. Hermansson (SIK Sweden), Dr. E. ten Grotenhuis (NIZO food research, The Netherlands), Dr. A. Bausch, Dr. P. Fischer, Dr. M.A.J. Michels (Dutch Polymer Institute, The Netherlands), Dr. V. Morris (Institute for Food Research, UK), Dr. H. van der Werff, Dr. T. van Vliet, Dr. R. Visschers. In the third part of the RTD the problems were reviewed, and an attempt was made to identify their relevant parameters, and their match with techniques.

EVALUATION AND CONCLUSIONS FROM THE RTD

Due to the great volume of information that was generated only for a selection of parameters the matching with techniques was performed. Below in brief the most prominent insights from the workshop. Remarkable progress in understanding mechanical properties at short length scales has been made through recent advances in both instrumentation and understanding of small probes. The demands of food science to this field are clear – focus on heterogeneity and focus on multi-technique documentation of the evolution of food structures and their mechanical properties. The time is ripe, and the interest clearly exists for making important new insights into an extremely complex set of systems relevant to food science.

Marcel Paques
Wageningen Centre for Food Sciences / Unilever Research Vlaardingen
Kernhemseweg 2
6718 ZB Ede, The Netherlands
Telephone: x31.318.659690
Telefax: x.31.318.650400
paques@nizo.nl

Rob Hamer
Wageningen Centre for Food Sciences / TNO-voeding / Wageningen University
Diedenweg 20
6703 GW Wageningen, The Netherlands
Telephone: x31.317.485383
Telefax: x31.317.485384
rob.hamer@foodsciences.nl

The Wageningen Centre for Food Sciences

Wageningen Centre for Food Sciences is an alliance of food industry partners and research organisations carrying out long-term, strategic and fundamental research of industrial relevance. The alliance provides the critical mass of multidisciplinary scientific expertise to achieve breakthroughs in food functionality. Three key areas of research have been selected by the partners -Nutrition and Health, Structure and Functionality, and Processing and Functionality.

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