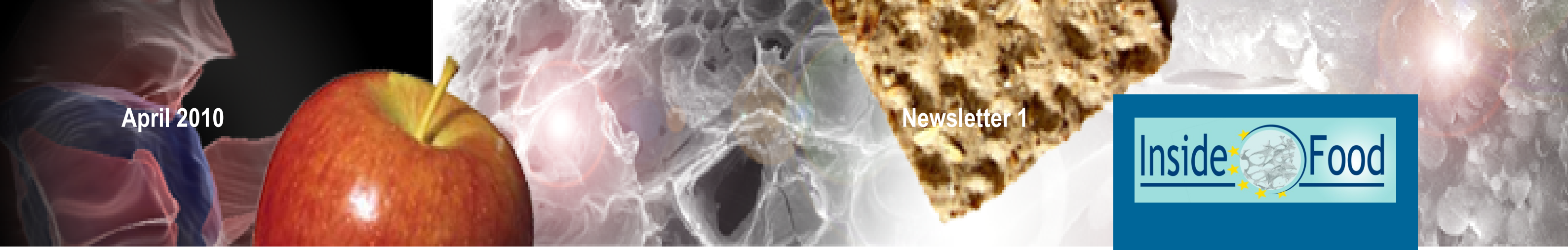


April 2010
Newsletter 1

InsideFood: new sensor technologies for quality food

EU FP7 project InsideFood brings together leading experts in food science, sensor and information technology to the benefit of the food industry.

To make significant advances in delivering foods with excellent quality, the role of microstructure and composition must be understood and used in the manufacturing process. This can only be achieved by accurate techniques that detect changes in the internal microstructure and composition.

InsideFood brings together 12 EU partners to force a breakthrough in food microstructure measurement and analysis

SEVENTH FRAMEWORK PROGRAMME

InsideFood, coordinated by K.U.Leuven, explicitly aims at measuring food microstructure, the spatial distribution of food components within foods, with state of the art tomographic, spectroscopic and texture measurement techniques including X-ray micro- and nano CT, MRI, OCT, NMR, TRS and SRS, and acoustic emission.

The consortium combines experts in food technology and engineering with sensor specialists, and IT specialists, involving a sensor SME (Skyscan), an IT SME (VSG) and a large sensor company (Bruker).

The results are directly to the benefit of end-users, includings 2 SMEs (VCBT, Chaber) and a large food company (Nestlé).

The techniques will be used ot improve the nutritional quality (sugar- and gluten-free cereal products), sensory quality (texture of all foods) and safety (foreign material detection in cereal products) of foods.

This first newsletter presents the new technologies that will be developed . Prototypes will be constructed by K.U.Leuven, the Institute of Food Research, Politecnico di Milano, RECENDT and Universidad Politecnica de Madrid.

Points of interest:

Food industry participates: Nestlé, Chaber and VCBT

InsideFood aims at dedicated applications for gels, mousses, fruit and cereals within the project scope. We encompass to develop spin-off activities for other segments of the food industry.

The Product Technology Center (PTC) Orbe is part of Nestec, the scientific and technical arm of **Nestlé SA**, the world-leading food, health and wellbeing company. The main focus of Nestlé PTC Orbe is linked to powdered beverages (coffee, cocoa, malt) and cereal-based products. To ensure a high innovation rate, the main responsibility of Nestlé PTC Orbe is to create proprietary innovations for the entire company by applying cutting-edge scientific and technological means. Substantial efforts are devoted to the understanding of the relationship between texture design and product quality as affected by food processing in order to deliver new benefits to the consumers.

Chaber Ltd is a producer of crisp bread and breakfast pillows in Poland since 1991 under the ownership of Konrad Banecki. Chaber cooperates with retailers in many countries in the world and produces private label products. The products of Chaber do not contain artificial ingredients. The company uses extrusion as modern technology for the production of dry breads. All recipes are prepared and examined by food technologists in the laboratory of the company.

The **Flanders Centre of Postharvest Technology** (VCBT) is a non-profit organisation, which was established in 1997 by the Katholieke Universiteit Leuven and the Association of Belgian Horti-cultural Auctions. The latter is the umbrella organisation for the Belgian horticultural sector and represents eight co-operative auctions and over 10,000 fruit and vegetable producers, mainly SMEs. The VCBT disseminates applicable research results to the horticultural industry. The VCBT has tight research links with many experimental research stations in Belgium and other EU countries.

OCT: Optical Coherence Tomography (Recendt)

The OCT system is well suited to image layered structures

Optical coherence tomography (OCT) is a relatively young and non invasive high resolution imaging technique which allows for two or three dimensional images to be acquired in situ and in vivo. So far the main interest for OCT has been directed towards biomedical diagnostics, like the detection of retinal diseases. OCT is based on the physical phenomenon of white light interferometry and therefore well suited to image layered structures. The image contrast is due to small inhomogeneities in the refractive index of the material and thus OCT gives complementary information to other imaging techniques like MRI and CT.

The use of special light sources allows path length differences in the range of one micrometer to be detected, what determines the axial resolution limit of an OCT system. The sample is commonly illuminated with light in the near infrared. With the right choice of the light source, penetration depths of several millimeters can be achieved. Generally the light is of very low intensity, making OCT a harmless technique for sensing and imaging.

In comparison to other high resolution microscopic techniques like confocal microscopy, OCT has the advantage that axial and lateral resolutions are independent of each other. Therefore the imaging optics can be located away from the sample without penalising the axial resolution. Furthermore the interferometric detection yields a higher sensitivity to weak signals, what also translates to a higher penetration depth. Additionally OCT allows for the study of sample characteristics like the absorption and polarisation properties or the velocity and the direction of fluids.


Extruded cereals

Good examples for applications of OCT in the food industry are fruit, sugar coatings or multilayered foils for food packaging.

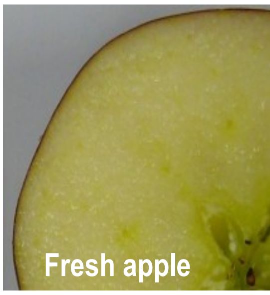

Micro-CT

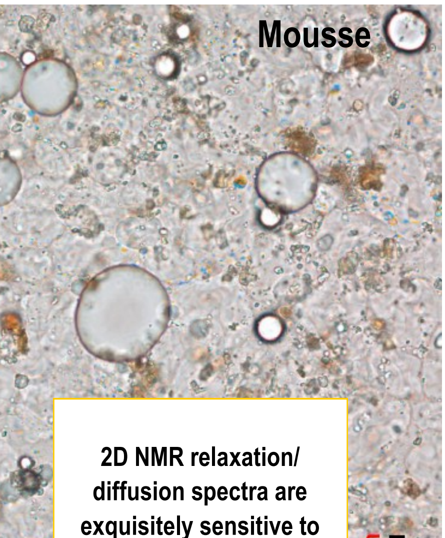
Micro– and nano–CT (K.U.Leuven, Nestec, Skyscan)

Micro– and nano-CT allow scanning real samples in 3D under normal environmental conditions without any preparation techniques

X-ray CT was developed in the late 1970's, enabling the non-destructive visualisation of the internal structure of objects. These first, mainly medical, CT scanners had a pixel resolution in the order of 1mm. Today, after technological advances towards micro-focus X-ray sources and high-tech detection systems, it is possible to peform micro-CT, with a pixel resolution 1000 times better than the medical CT scanners.

A new challenge in technology is the nano-CT system opening up a new era in X-ray imaging with a spatial resolution in the range of hundreds of nanometers. Proceeding to sub-micron pixel sizes requires increased performance of the X-ray source, rotation stage and X-ray detector. Micro-CT as non-invasive technique has been applied to the study of the internal 3D structures of several food products, e.g, marshmallow, aerated chocolate, chocolate muffin, cereals, banana, cucumber, pear and apple. Products may have to be scrutinized on 2 different resolutions, each providing insight in the changing composition and structure on the corresponding spatial level.


Fresh apple


Mousse

NMR & MRI (IFR, UPM, Bruker)

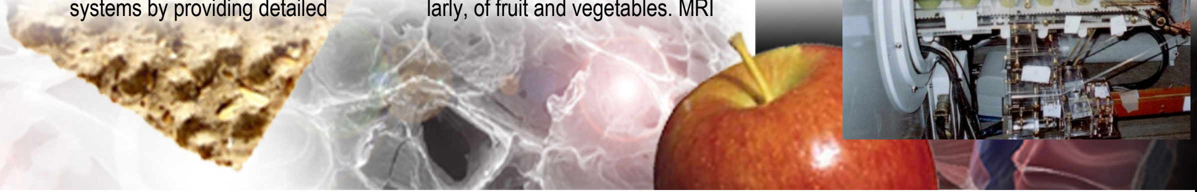
2D NMR relaxation/ diffusion spectra are exquisitely sensitive to microstructural changes and therefore to quality parameters

Nuclear magnetic resonance (NMR) studies magnetic nuclei such as protons by aligning them with an applied constant magnetic field and perturbing this alignment using an alternating magnetic field.

In NMR relaxation the different time constants for the nuclei to return to their thermodynamic rest state after an electromagnetic pulse is applied are measured. The time constants are related to, amongst others, concentrations of the magnetic nuclei but also their mobility. NMR relaxometry has been revolutionising the approach to complex microstructured systems by providing detailed "relaxation spectra" giving separate peaks for water, solutes and polymers in different compartments of microstructured systems. 2D NMR relaxometry is a useful and sensitive probe of microstructure in different food systems, such as gels and foams, but also fruit and cereals. A novel relaxation technique to probe differences in these complex structures is being developed.

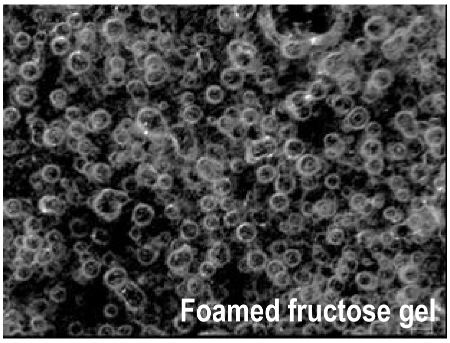
Magnetic Resonance Imaging (MRI) greatly broadens the range of applications devoted to the inspection of food products and, particularly, of fruit and vegetables. MRI provides a picture that contains combined spectroscopy and relaxometry information, both spatially resolved. MRI is used to explore the internal characteristic of agrobiological products as well as to evaluate metabonomic changes during storage and processing of apples in the agroindustry (crispness, developing of disorders).

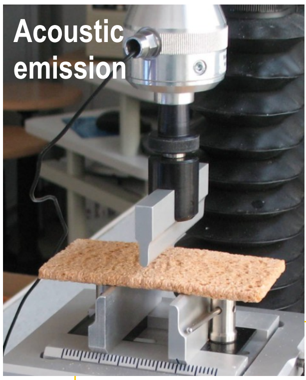

Online MRI



Acoustic emission (SGGW)

Acoustic emission can be understood as a phenomenon of generation and propagation of elastic waves in solids, liquids and gases caused by external force or by sudden release of energy accumulated in the material. The acoustic signal is generated as a result of the heterogeneous distribution of internal energy in the material, which arises from structural defects, impurities, internal stresses and other factors. Disintegration of food material during eating generates elastic waves, which are conducted by air, bones and soft tissue and reach the ear. Traditionally, acoustic measurements of food involved the application of microphones as sensors of the acoustic emission signal (non-contact method). The acoustic emission contact method is based on using a piezoelectric accelerometer in mechanical contact with the product sample. The acoustic signal is registered by the sensor during crushing, bending or compressing of a food sample. Piezoelectric sensors are able to register the acoustic signal in a wide range of frequencies. The sensors do not record vibrations conducted by air. The acoustic emission method is used to measure texture of food products. Combining the results of acoustic emission with mechanical tests can be applied to predict the textural attributes of foods. The acoustic emission method is very sensitive: the manufacturing technology, different recipes as well as changes of water content of materials significantly affect the descriptors (parameters) of acoustic emission of food products. The acoustic emission contact method has now found wide application in testing of mechanical properties of agricultural raw materials and crispy food products (extruded or baked cereal products, dried fruits, chips), and may also be applied to identify physical and chemical processes in foods.

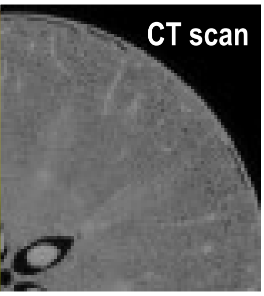


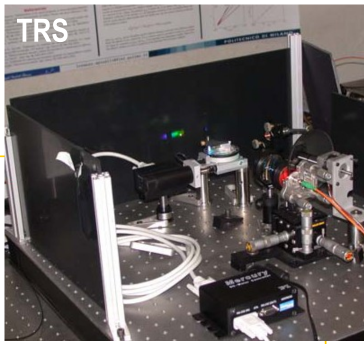


Combining acoustic emission with mechanical tests can be applied to predict the textural attributes of foods

Time and space-resolved spectroscopy (PoliMi, K.U.Leuven)

A common feature of most foods is their opacity to visible light. In these media, due to the microscopic spatial changes in the refractive index, light undergoes multiple scattering events and its overall distribution (i.e., attenuation) is determined by the interplay between light scattering and light absorption. Scattering is very much dependent on the microstructure of the product. In classical continuous wave Vis/NIR spectroscopy only the attenuation of the incident light beam due to interaction with the matter is measured. This single measurement is insufficient to accurately separate the information on the chemical composition (absorption) from that on the microstructure (scattering). As a result, continuous wave spectroscopy requires recalibration for each new batch of samples. On the contrary, time-resolved diffuse reflectance spectroscopy (TRS) and space-resolved diffuse reflectance spectroscopy (SRS) provide a complete optical characterisation with the simultaneous non-invasive measurement of the optical properties (absorption and scattering) of diffusive media. This can be of special interest for most fruits and vegetables as well as for other foods (e.g. meat, fish, and cheese), because information derived by TRS and SRS refers to the internal properties of the medium, and is not so much affected by surface features as is the case for continuous wave spectroscopy.





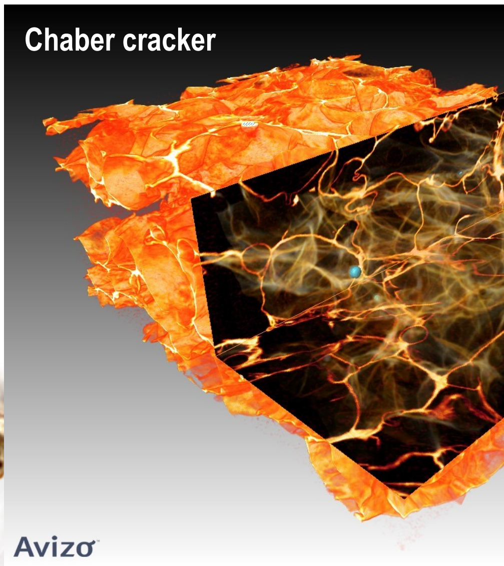
TRS and SRS have the capacity to probe internal microstructural properties with minimal influence from the optical properties of the surface, therefore allowing for non-destructive applications

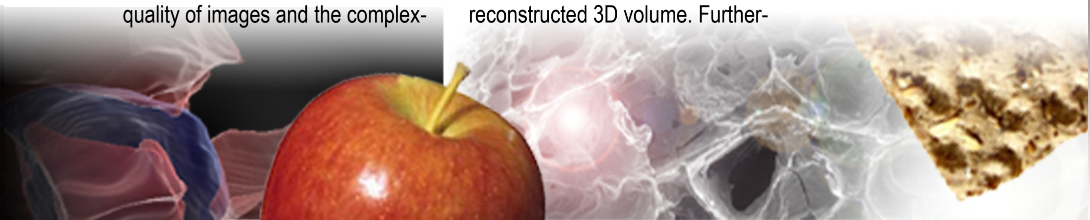
Information technology (K.U.Leuven, VSG–Avizo® Fire)

Scanning food samples at different steps of a specific process and being able to visualize, analyze and understand the evolution of the materials microstructure is an innovative and powerful approach to help the food industry delivering products with always better quality and safety.

The procedure of image analysis is tedious due to the large size of image data, the sometimes poor quality of images and the complexity of the mathematical manipulations. With dedicated software, we aim to make progress in reliable image processing and analysis for a wide range of foods. Physical and multivariate statistical models will be required to understand better the effect of microstructure on physical properties and quality of food.

Avizo® Fire enables to directly visualize and interact with the reconstructed 3D volume. Furthermore, thanks to analysis tools, Avizo Fire provides quantitative data on the material structure and gives precise numerical information on the material properties. Using additional mathematical software tools, numerical simulations can even be performed on the 3D model.





InsideFood

Sensor technologies for quality food

InsideFood: an EU-wide initiative

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