SYMPOSIUM AA
Materials Science of Food–Processing-Structure-Property Relationships
December 1 – 2, 1999

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*Invited paper
8:30 AM **AA1.1**
THE MATHEMATICAL SCIENCE OF CHOCOLATE: CASTING AND SOLIDIFICATION. Peter J. Fryer, Heather Tewkesbury, Kerstin Pinchower and Andrew G.F. Stugl, School of Chemical Engineering, University of Birmingham, UNITED KINGDOM; Cadbury Ltd, Bourneville, Birmingham, UNITED KINGDOM.

Chocolate is a complex polymeric material whose consumer acceptance depends critically on it having the correct crystal form. There are at least five polymorphs that have been identified, and crystallisation is very dependent on the composition of the material. Chocolate is given a tempering pre-treatment prior to casting if this is not correctly carried out, as well as being unacceptable to the customer, the material may not mould. Understanding the effect of tempering on the final product quality is thus vital. The rate and extent of crystallisation, as well as the crystal form, is a strong function of the temperature, time and shear profile which the material has received. The crystallisation of chocolate has been followed using differential scanning calorimetry to study the thermal events in cooling for samples given defined process histories. Critical combinations of temperature and shear have been identified to ensure that the material adopts the correct form on solidification. The effective specific heat of chocolate varies greatly as a function of temperature and cooling rate, because of the amount of latent heat released. The temperature changes in casting of chocolate have been modelled using a one-dimensional system over a range of cooling rates of practical interest, it is possible to model the cooling using data for effective specific heat capacity, i.e. to approximate the kinetics of the crystallisation process. The shape change on cooling has been studied using non-invasive surface profiling to follow mould shrinkage: differences in shape due to different temper conditions can be clearly identified.

9:00 AM **AA1.2**
PHASE TRANSITIONS AND POLYMORPHISM IN LIPID FOODS: TEXTURE AND STABILITY. Richard Hartel, University of Wisconsin, Department of Food Science, Madison, WI.

Controlling crystallisation and polymorphism of lipids is important to the texture, stability and overall quality of many foods. However, due to the complexity of natural fats, our understanding of the principles of crystallisation in food products is generally quite limited. Compounding these difficulties is the lack of techniques for observation of lipid crystalline structure available to us. Recent efforts using confocal microscopy have allowed us to visualise the effects of processing conditions on crystalline structure of different model fat systems. Differences in crystalline structure (number, size, distribution, shape, polymorph, etc.) lead to different mechanical properties and, in some cases, to stability of the food product during storage. In two model systems (milk fat fractions and canola oil), processing parameters such as cooling rate, agitation rate, and crystallisation temperature had significant effect on crystalline structure and mechanical properties of the semi-solid material. However, subsequent changes in mechanical properties during storage were different for the two model systems. The model system made up of two milk fat fractions exhibited an increased hardness with storage time, whereas the model system made up of a hard milk fat fraction mixed with canola oil did not show this change. This difference was related to the structural changes (sintering, etc.) in the crystalline material over time.

10:00 AM **AA1.3**
MIXED BIOPOLYMER COMPOSITES. Ian Norton, Unilever Research, Colworth House, Sharnbrook, Bedfordshire, UNITED KINGDOM.

Biopolymers (Polysaccharides and Proteins) are used in the Food Industry to impart texture and appearance properties to manufactured foods. It is quite often the case that single biopolymer is incapable of delivering all the desired properties. Although in the chemical industry this problem can be overcome by chemical and biochemical modification of the polymeric species, this is not an option open to the Food Industry because of constraints on additives. It is with this background that we have studied mixed biopolymer systems and in particular biopolymer composites. Within this talk I will cover the mechanism of formation, kinetic trapping and flow modification of composite structure and then cover some of the mechanical consequences of the microstructures formed.

10:30 AM **AA1.4**
STUDIES OF PHASE SEPARATION UNDER DYNAMIC CONDITIONS. Niklas Lennart, Anne-Marie Herrmann, SIK, The Swedish Institute for Food and Biotechnology, Gothenburg, SWEDEN.

There is an increasing interest to control phase-separation of biopolymer mixtures in order to impart the desired textural properties and stability to food products such as spreads, dressings, yoghurts and low-fat products. When phase separation occurs together with gel formation, the structure can be trapped by the formation of a three-dimensional network. Recently, work on mixed biopolymer systems have been studied by confocal laser scanning microscopy (CLSM) equipped with a Linkam table, transmission electron microscopy (TEM) and image analysis. The approach used is mainly stereological image analysis. By CLSM it is possible to follow the development of the microstructure with time and to obtain three-dimensional microstructures by combining confocal planes at different depths. Results have shown that the resulting microstructure depends considerably on the cooling rate, the composition and the temperature of phase separation. They also stress the importance of pH and the differences between different types of the same material. Three different zones of phase separation kinetics have been established due to the relative rates of phase separation and gel formation. On going research deals with the kinetics of phase separation and tries to establish further knowledge about the structural development with time for various morphologies such as droplets, bicontinuous and double phase separation morphologies. Mechanisms considered of importance for the kinetics of phase separation and gel formation are spinodal decomposition, nucleation and growth, diffusion and hydrodynamic coarsening. The main objectives with our research are to implement new image analysis methods to the field of mixed biopolymers and to understand more about the mechanisms of phase separation in connection to gel formation. The project is a part of an ongoing EU-funded biopolymer. Mechanism and application of phase separation [FAIR-CT96-1015].

10:45 AM **AA1.5**
QUANTITATIVE ASSESSMENT OF PHASE COMPOSITION IN AND MORPHOLOGY OF TWO PHASE GELATIN PECTIN GELS USING FLUORESCENCE-BASED ANALYSIS. Tor S. Nermark and Gregory B. Ziegler, The Pennsylvania State University, Department of Food Science, University Park, PA.

The interest in gums among manufacturers of prepared foods and confectionaries has markedly increased in recent years, since gums are available as texture and flavor modifiers, stabilizers, and fibers. The employment of binary gels appears to offer increased opportunities to improved performance. A technique for quantitative determination of the concentrations of pectinate and protein in the phases by fluorometry has been developed and compared with chemical analysis. In the first case, a general method for fluorescent labeling of carbohydrate polymers was developed. For the latter purpose, two micro-assays were developed based on the basis of recent polymer micro-assays. A blend of low-methoxyl pectin and gelatin B was used as model system. The commercial components were both subjected to multi-step purification procedures before they were employed in the experiments. Phase separation was initiated by the addition of to aqueous solutions of the two polymers. Samples were withdrawn for microscopy after different holding times at 600°C. Tilt-lines were determined while using both the fluorescent and chemical methods. The results from these methods were in fair agreement with each other and with literature data. A three-phase region was discovered in the pseudoternary phase diagram. The morphology of double-labeled gels was also studied in two and three dimensions in a confocal laser microscope. The results show promise for the quantitative assessment of phases that contain carbohydrate polymers and in the study of morphological changes that occur during thermo-mechanical processing. Keywords: Gum, low-methoxyl pectin, gelatin, fluorescence, morphology, phase diagram.

11:00 AM **AA1.6**
THE STATE DIAGRAM OF PHASE SEPARATED BIOPOLYMER BLENDS. Imdad A. Farhat; John R. Mitchell; Z. Moussin, Division of Food Sciences, University of Nottingham, UNITED KINGDOM.

The role of unequal distribution of water on the glass-rubber transitions of phase separated, low water content (less than 30 percent wet weight basis) gelatin-amylopectin extrudates was studied for different blend compositions. FTIR microspectroscopy revealed a high degree of phase separation where amylopectin-rich domains (10-80 microns diameter) could be clearly identified in the continuous gelatin matrix. The thermograms of these blends exhibited 2 transitions confirming the existence of two phases. The glass-transition temperatures for each of the 2 phases were successfully predicted based on the existing values for the binary systems if the
unequal partitioning of the plasticizer between the polysaccharide and the protein was accounted for. The selective hydration values were estimated using both mechanical and Confocal Scanning Microscopy (CSM) techniques. This study highlights the effect of the phase volume of the included phase on the fracture properties of the composite. The experimental results have been explained according to the fracture mechanisms observed in the fracture surfaces in terms of stress and fracture. CSM images of the fracture surfaces are presented showing the microstructure damages caused by the test at high temperatures. On the fracture surface. On the one hand, evidences of debonding of SA rich phase are close to the edge of the fracture. On the other hand, gelatin rich phase is the continuous phase, which suggests weak interface properties. On the other hand, gelatin rich particles present apparent plastic deformation with a dark line. The relationship between structures from dry foams, filled foams, and foams through concentrated emulsions are a particular challenge. The talk will assess the technical issues and current status of this area.

1:30 PM **AA2.1**
SIMULATION TOOLS FOR STRUCTURES OF FOODS.
John McIvor, Polymers & Colloids Group, Cambridge University, UNIVERSITY OF CAMBRIDGE, CAMBRIDGE, UNITED KINGDOM.

2:00 PM **AA2.2**
COMPUTER SIMULATION OF AGGLOMERATE-GROWTH AND BREAKUP IN WET GRANULATION OF FINE POWDERS.
Gabriel L. Taraba, The City College of The City University of New York, Department of Chemical Engineering, New York, NY.

Granulation is a particle enlargement process in which fine powdery particles are agglomerated into larger granules. Agglomeration in wet granulation is achieved by spraying onto a shearing powder mass a "binder" fluid that binds the particles together. The granulation model presented here is essentially a co-sphere simulation of a shearing flow of solid particles, some of which are wet (powered by binder and therefore 'sticky') while the rest are dry.

The numerical simulations study two distinct regimes of agglomeration found in a typical granulator: that of granule growth and subsequent breakup. The models of granule growth and breakup use different granule size and shape distributions can be obtained by analyzing the size and shape of formed granules using a pattern-recognition routine. A second kind of simulation, also using rapid granular flow modeling, follows the motion and deformation of "agglomerates" made of "sticky" particles held together by a liquid, viscous binder. Results from these simulations yield critical values of the similarity number (dimensionless parameter of the model containing inertia and viscous dissipation). Below the critical value, the agglomerates are stable and only rotate in response to shear while above the critical value, they break into two or more pieces. At and around the critical value, they attain a steady elongation. These simulation results allow one to claim correlations of the stability versus different parameters of the problem. Comparison with experiments is also shown.

2:15 PM **AA2.3**
SOME RHEOLOGICAL BEHAVIORS OF FIBER-LIQUID SYSTEMS.
Harold Corey, NutraSweet-Kelco Co., Mt. Prospect, IL.

To better understand the flow behavior of fiber-containing food slurries, some aspects of rheology of such systems was studied using as a model asosiates fiber dispersed in an aqueous medium, 61% sucrose, and in a hydrophobic medium, mgs. Using a coaxial cylinder viscometer, flow curves were obtained at shear rates up to 500 sec^-1 for five fiber concentrations at temperatures from 10°C to 50°C. These dispersions are thixotropic and non-Newtonian, their rheology is no doubt a consequence both of fiber-fiber and fiber-liquid interactions. In this paper flow behavior is reported for the upper Newtonian region, beyond 1000 sec^-1 for these systems, where it is assumed the fibers are fully oriented with the flow lines, so that fiber-fiber interactions play only a minor role. Freed from shear rate dependence, the fiber concentration/viscosity/temperature
relations then presumably arise, in the main, from fiber-liquid interactions.

3:00 P.M. *AA2.4 THE EFFECT OF SURFACE INTERACTIONS ON THE UNFOLDING AND INTERMOLECULAR ASSOCIATION OF GLOBAL PROTEINS ADSORBED AT INTERFACES. Sarah Adams, Richard A.L. Jones, Sheffield University, Dept of Physics and Astronomy, Sheffield, UNITED KINGDOM; Rebecca Green, Ian Hopkinson, Cambridge University, Cavendish Laboratory, Cambridge, UNITED KINGDOM.

Proteins adsorbed at interfaces are widespread in food systems, where they often play a vital role in providing colloidal stability. The mechanism of colloidal stability and the efficiency in this role depends on the conformation of the adsorbed proteins, which in turn is strongly influenced by their interactions with the interface. We compared the conformational transitions that occur on heating solutions of globular proteins, unfolding and aggregation with the analogous transitions undergone by proteins adsorbed at interfaces.

Fourier Transform Infrared spectroscopy in solution and in the attenuated total reflection geometry revealed, for the globular proteins hen-egg lysozyme and bovine serum albumin, both qualitative and quantitative differences between the transitions as they occur in bulk and adsorbed at an interface. In the bulk, unfolding is a sharp transition, followed sequentially on further heating by the relatively sharp onset of the intermolecular association associated with heat set gelation. In contrast, for adsorbed proteins, we found that both processes occur simultaneously over a wide range of temperatures. Proteins were adsorbed in a relatively stable state at a relatively hydrophilic, solid surface, thus at a liquid, hydrophobic surface, in the latter case onset temperatures for both unfolding and intermolecular association were substantially lower than for bulk solutions.

3:30 P.M. AA2.5 ALPHA-LACTALBUMIN SOLUBILIZED IN AOT MICROEMULSIONS UNDERGOES STRUCTURAL CHANGES AND AFFECTS AOT MICROEMULSION PHASE BEHAVIOR. Justin W. Shimek, Catherine M. Pinsky, Stephanie R. Dunagan, Univ of California-Davis, Dept of Food Science & Technology and Dept of Chemical Engineering and Materials Science, Davis, CA.

Surfactant stabilized water-in-oil microemulsions spontaneously form and are thermodynamically stable. Protein containing microemulsions show potential for use in separations, bioanalysis, and food or pharmaceutical systems. Characterization of protein-stabilized microemulsion structures upon solubilization in microemulsions is key in optimizing extraction methodology and predicting recovered protein functionality. Our objective was to characterize the structural changes of alpha-lactalbumin incorporated into a microemulsion. Conformational changes in alpha-lactalbumin may be related to its unusual effect on the microemulsion phase behavior. Alpha-lactalbumin was allowed to partition into a sodium bis(2-ethylhexyl) sulfosuccinate (AOT) containing microemulsion from an excess aqueous phase and reach transfer equilibrium. The protein conformation and the partitioning of protein, water, isoctane, and surfactant were both monitored using the microemulsion transition was observed as a function of the total protein and surfactant present. Circular dichroism spectroscopy was used to identify changes in protein secondary structure. Protein concentration and water transfer were confirmed by ultraviolet spectroscopy and X-ray diff.

SESSION AA3: IN-ROOM POSTERS
Chair: Jay-Lin Jane
Wednesday Afternoon, December 1, 1999
4:00 P.M.

AA3.1 FUSED 1H NMR STUDY OF THE HYDRATION BEHAVIOUR OF VARIOUS STARCH-SUGAR BASED EXTRUDATES. Carla W. P. Cavallaro, Imed A. Farhat, John R. Mitchell, Nottingham University, Food Sciences Division, Loughborough, UNITED KINGDOM.

Maize grits - sucrose (M/G-S) and wheat flour - sucrose (WF-S) mixtures were produced by twin screw extrusion. The amount of sucrose and the extrusion water content varied between 0 and 20% and 14 and 26% (wt basis), respectively. At constant water and sucrose concentrations, both the degree of starch conversion, specific mechanical energy and sectional expansion achieved varied between systems formulated with maize grits and wheat flour. In order to understand the role of water and sugars in plasticizing the various bio-polymers of these two systems, low field (23 MHz) 1H NMR was used to study the interactions of the various components with water over the water content range between 5% and 35% (dry basis). These water contents were obtained by storing the extrudates in different RH conditions.

AA3.2 DEFORMATION AND FRACTURE BEHAVIOR OF AGAROSE GELS IN BOTH TENSION AND COMPRESSION. Kevin Pucknett, Unilever Research, Colworth Laboratory, Sharnbrook, Bedfordshire, UNITED KINGDOM.

Biopolymer gels such as agar and agarose are promising structuring additives for a number of food applications. Consequently, their large deformation behavior is of considerable interest. In the current work, the deformation and failure behavior of agarose biopolymer gels has been assessed in both tension and compression. A spherical apparant elastic modulus increased in an essentially linearly manner with increasing biopolymer concentration. Conversely, the failure strain was independent of biopolymer concentration, with compressive failure strains being approximately twice those observed in tension. In addition, the initial elastic moduli were approximately three times greater than the shear moduli, which is consistent with a Poisson ratio of 0.5. Observed stress/strain curves generally showed evidence of strain hardening for all biopolymer concentrations and test conditions, except at the lowest displacement rates (i.e. 5 mm/min), where stress-relaxation occurs within the time scale of the test. These general observations where consistent to other 'brittle' gels. The distribution of measured tensile strengths was found to be suitably described by the Weibull distribution function, which is typically applied to conventional 'brittle' materials such as glasses and ceramics, and the values obtained for agarose gels were comparable to those materials. The influence of agarose gel structure upon failure properties will be discussed.

AA3.3 CORRELATION OF STRUCTURE AND TEXTURAL INSTABILITY IN INTERMEDIATE-MOISTURE, FLOUR-BASED EXTRUDATES. Ann Barrett, Nora Beck Tan, Paul Maguire, Sustainability Directorate, U.S. Army Soldier Systems Center, Natick, MA; *Wageningen and Matheus Research Directorate, Aberdeen Research Laboratory, Aberdeen Proving Grounds, MD.

Flavored flour-based, intermediate-moisture extrudates are under development as jerky-type operational rations, which both simulate a popular military item and provide a source of performance-enhancing carbohydrates. However, these products firm substantially during storage, undermining sensory quality and acceptance. Test extrudates consisting of pure potaio flour and potato flour containing 5% of a plasticizer (glycerol, glucose, sucrose or fructose) were produced on a Brabender extruder using a 3mm round die. Samples were placed into accelerated storage at 35°C and withdrawn after 1, 2, and 3 weeks. The effects of the plasticizer type and aging on the extrudates was subsequently evaluated through mechanical testing and x-ray diffraction. Results showed that modulus increased asymptotically for all samples, and after 3 weeks storage was 600-700 percent higher than that for 6-time control. Each plasticizer at least slightly reduced the degree of firming, with glycerol having the most pronounced effect on texture (17% reduction in average stored modulus). Diffraction spectra for stored samples showed splitting of the broad maximum at 23 degrees, characteristic of all non-stored products, into sharp peaks at approximately 15, 17, 20, and 23 degrees. Results were consistent with published spectra for increasingly hydrated potatos starch, indicating movement of moisture from proteolysis to starch regions in the flour. These results suggest that increased protein association is causative of firming; they furthermore demonstrate that the kinetics of firming may be adjusted through formulation.

AA3.4 PHASE TRANSITIONS IN TRIGLYCERIDES. Lina Steinhofen, Anthony Robinson, Athene M. Donald, Cavendish Laboratory, University of Cambridge, UNITED KINGDOM.

Triglycerides are commonly used in many foods, and it is well known
that they are polymorphic. In order to achieve the correct textures, it is important to stabilise the triglyceride in the correct form.

Synchrontron radiation has been used to study phase transitions in several different triglyceride systems during controlled thermal histories. For the case of cocoabutter, which contains several related triglycerides with slightly different chemistries, it appears that phase segregation of the components may occur. This may have significant implications for the behaviour of cocoabutter in confectionery according to its processing history. Other triglycerides are also subject to instabilities during storage, again with significant implications for their use.

AA3.5 THE CONFIRMATIONAL RESPONSE OF GUAR

GALACTOMANNAN TO DIFFERENT SALT ENVIRONMENTS.

Mr. Gittinger, M. Ing., C. Marques, Rhodin/CNRS Joint Laboratory, Rhodin Inc., Cranbury, NJ. L. J. Lul, IPNS, Argonne National Laboratory, Argonne, IL. L. Cipollitti, V. Trappo, D. Weit, Dept. of Physics, Univ. of Pennsylvania, Philadelphia, PA.

Guar is a naturally occurring polysaccharide known mostly for its ability to notably increase solution viscosity at relatively low concentrations. Randomly distributed galactose units along a mannose backbone ensure good polymer solubility in water through steric effects. However, it is believed that the random nature of the substitution leads to inter- and intramolecular associations through the guar chain segments which render it viscous. These stereochemistry regions have important consequences for the structure of the chains and for the physical behavior of the solution. Despite its widespread use, very little is known about the conformation of guar in solution and the response of the chains to varying solvent conditions. It is wellknown that certain ions are more effective than others at reducing the solubility of some water-insoluble molecules (the Hofmeister effect). The conformation of guar in the presence of four different ionic strengths is presented. The data were collected using light and neutron scattering and cover a wide q-range.

SESSION AA4:
Chair: Michael J. Gidley
Thursday Morning, December 2, 1999
Norwich, UNITED KINGDOM

8:30 AM *AA4.1 CREATING NEW STARCHES
Alen M. Smith, John Innes Centre, Norwich, UNITED KINGDOM.

I shall discuss the extent to which the properties of starch can be altered by manipulation of the enzymes responsible for its synthesis in the plant. The enzymes involved in the synthesis of starch polymers from ADP glucose - starch synthase and starch branching enzyme - are present in plants in multiple isoforms, each of which plays a distinct role in determining the structure of the starch polymers and hence the properties of the starch. The contribution of a particular isoform is dependent not only on its intrinsic properties but also upon the complement of other isoforms present in the plant. The great complexity of the process of starch synthesis makes it difficult to design starches with specific, desirable physical properties by manipulating the complement of isoforms in the plant, but also allows a wide range of different starch properties to be generated by this means.

9:00 AM AA4.4 HIGH AMYLASE POTATO STARCH: PRODUCTION AND GELATINISATION PROPERTIES.
Mike Gidley, Martin Debet, Gerhard Schwall and Steve Jobling, Unilever Research, Colworth, House, Shrubbrook, Bedford, UNITED KINGDOM.

Gene technology has the potential to expand the range of ingredients and components available to the food industry, by providing molecular compositions not currently available at commercial scale. One such possibility is that of a high amylase potato starch. Although high amylase varieties of many starch producing crop plants are available (e.g. corn, barley, pea), none had previously been described for potato. Through the down-regulation of two isoforms of starch branching enzyme, it has been possible to generate potato plants with starch having more than twice the usual level of amylose. This has a profound impact on swelling and gelatinisation properties, opening up a wider range of properties than had previously been obtainable from potato starch.
phases. In this talk, we’ll present material selected from among our recent studies on starch structure-function relationships, as related to cooking of rice, wheat, and vegetables, which is important for processing of rice starches, flours and grains, functionality of potato and waxy maize starch ingredients in chip-like baked snacks, wheat starch gelatinization during cookie baking and retrogradation during shelf-life, and oilcontent.

11:00 AM AA4.7
EFFECTS OF ULTRA PRESSURE TREATMENTS ON THE
CRYSTALLINE STRUCTURES OF STARCH GRANULES
Kaneto Nakagawa, Kit-Sum Wong, Andrew E. McPherson, Jay-Jin Jung,
Department of Food Science and Human Nutrition, Iowa State
University, Ames, IA.

Native starches display various x-ray diffraction patterns, which are
categorized to A-, B-, and C-types. X-ray patterns of starches relate
to the branch chain-length and the branch linkage locations of
amylopectin. The branch-chain length distributions and branch
linkage locations also determine the gelatinization temperature,
temperature digestion, and surface pin-holes of starch granules. It
is known that starches displaying the A-type x-ray pattern have shorter
branch chain-length, with branch linkages scattered in the crystalline
and amorphous regions, and are more easily digestible by enzymes. In contrast, starches of the B-type pattern possess longer average chain-lengths, with branch linkages mostly clustered in the amorphous region, and are more resistant to
enzymes. A recent study on isolated B-type starch, by using an ultra-pressure treatment at 650Mpa, ambient
temperature, and without water, we have observed that the
A-type starches changed to B-type, as expected the A-type starches remained unchanged. The difference may be attributed to the branch structures of the amylopectins. The B-type starches, with long branch-chains and the branch linkages clustered in the amorphous region, are more difficult for branch-chain rearrangement. The pressure-treated starches displayed pasting properties resembling that of cross-linked starches.

11:15 AM *AA4.8
MOBILITY CHARACTERIZATION OF HYDRATED STARCH
USING NMR AS RELATED TO GLASSY-RUBBERY
TRANSITION. Yang Kou, Pawnee Chemical, Dept of Food Science,
Univ of Massachusetts, Amherst, MA.

Plasticization of starch systems was studied by the mechanical
relaxation and Nuclear Magnetic Resonance (NMR) spectroscopy.
Relationships between the mechanical and molecular relaxation
dynamics (e.g., water) will be discussed. The summarized results on
solid state NMR investigation over a moisture and temperature range revealed a discrepancy between the long-range glass transition and short-range glass transition water mobility. Hydrated starch was studied by carbon-13 CP/MAS and wide-line 1H NMR changing in intensity with moisture content and temperature indicating carbon chain mobility change. However, T1/2(1H) values [based on single exponential modifications] failed to show any indication of mobility change, very significantly over a 2.11% moisture for waxy corn starch and over 5.60°C for wheat starch. Broad and narrow component T2* (from linewidth) and narrow T2 (CPMG) indicated a decrease in mobility with increasing solid concentration with a break point at 23.29% water content. T1 minimum was observed also at the same concentration. Water molecules remained very high in mobility regardless of the relative rigid starch molecules in the glassy state.

11:45 AM AA4.9
PULSED MAGNETIC FIELD CONTROLLED ENTHYMATIC
PROCESSES IN FOOD INDUSTRY. Mark N. Levin,
Voronoi State University, Novosibirsk, Dept, RUSIA; Valery V.
Avdeenov and Irina A. Glotova, Voronezh State Technological Academy, Dept of
Product use and Product Research, RUSIA.

Biological processes and treatments become widely used in
technology of food industry nowadays. In this report we present an
effective method of controlling the enzymatic processes and
treatments by pulsed magnetic fields (PMF). The method is based on the recently reported possibility of relatively small weak (<1 T) PMF to
to change activity of enzymes and kinetics of the enzymatic reactions. Effect of long-time [tens of hours] when of activity of extracted enzymes after the short-time (several seconds) PMF treatment is presented for the first time. The effect is caused by conformation changes of the enzymes due to breaking of hydrogen bonds in their secondary structure by the PMF. The other effect, namely PMF influences on kinetics of enzymatic reactions, takes place at the stage of formation of intermediate enzyme-substrate complexes, which
represent themselves spin-correlated radical pairs. Physical

mechanisms of the both effects are given. High sensitivity of the effects to the PMF parameters allows one both to activate and to suppress enzymatic processes. Of great importance is the possibility of selective activation (or suppression) of individual enzymes in complexes. The stimulating effect of the PMF treatment was successfully demonstrated in preparing high-quality meat products, improving collagen substances with controlled properties, accelerating cultivation of mycelium, increasing extra-activity of meat, activating of seeds before sowing etc. The suppressing effect of the PMF treatment was effective for stabilization of food products quality in storage. The relevant biocatalytic mechanisms of the
PMF-controlled processes are considered.

SESSION AA5
Chair: Richard A. Jones
Thursday, December 2, 1999
Provincetown/Ottawa (M)

1:30 PM AA5.1
THE PROCESSING OF SOFT CHEESE: RELATIONSHIP
BETWEEN PROCESS HISTORY AND PRODUCT STRUCTURE.
Coralee A. Dugoni, Lynn F. Gladen* and Peter J. Fryer*, Univer
Research, Colworth House, Sharnbrook, Bedford, UNITED
KINGDOM, *Dept of Chemical Engineering, University of
Cambridge, UNITED KINGDOM, * School of Chemical Engineering,
University of Birmingham.

Cheese has a complex structure which controls its material properties and thus consumer qualities: the same material can make hard (parmesan) and soft (gverege) cheese, depending on moisture content and history. The aim of this work was to relate the process history to the specific properties of the final product's rheological properties. Systematic experiments were undertaken to develop a processing route which was quantified by an imaging sense. In which the Rheo was known. Experiments then studied the behaviour of the material as a function of the process history, it proved possible to correlate the strength of the final product with the degree of denaturation of the proteins in the cheese matrix. Micrographs of the structure of cheese were studied using image analysis and relationships between the fractal dimension of the structure and the process history characterized. The work demonstrates how material science techniques can be applied to such materials. However the chemistry of the system makes the prediction of quality difficult.

1:45 PM AA5.2
MECHANISMS OF PHASE SEPARATION IN GELLING
BIOPOLYMER MIXTURES. R. A. L. Jones, Department of Physics
and Astronomy, University of Sheffield, Hicks Building, Sheffield,
UNITED KINGDOM.

Mixtures of biopolymers often contain at least one component that can physically gel, so the morphology that results from these mixtures phase separate arise from the competition between phase separation and gelation. The interaction between these two processes results in a very rich range of possible morphologies. We have studied such morphologies in mixtures of gelatin and dextran. Our experiments are done both in real space, using confocal microscopy, and in reciprocal space, using time-dependent light scattering experiments. Confocal microscopy is particularly powerful in elucidating the connectivity of the phases, which largely controls the rheological properties of the mixture, while light scattering permits a quantitative analysis of the phase separation mechanism in terms of classical theories such as the Carnal linear theory of spinodal decomposition.

2:00 PM *AA5.3
BREAKDOWN AND RHEOLOGY OF FOOD IN THE MOUTH.
Peter Lilford, Univer Research, Colworth House, Sharnbrook,
Bedfordshire, ENGLAND.

The origin of perceived textural attributes of food in the mouth is not well understood. Early work successfully identified the initially perceived properties with the modulus, elasticity and fracture properties of the whole food piece. However, it soon became apparent that discriminating attributes were associated with the whole process of breakdown during chewing and could not be described by or associated with the initial food structure. Attempts to understand in-mouth breakdown by experimentation alone, construction of mouth analogue devices and mathematical simulation will be described for both rod and liquid foods. Attention will be drawn to the significance of early training which relaxes breakdown pathways and perception to final product preference.

2:30 PM AA5.4
A RANDOM SQUEEZE TECHNIQUE FOR THE
DETERMINATION OF THE VISCOELASTIC PROPERTIES OF FOODSTUFFS. Anthony C. Fashen-Coppo, John S. Field, Bruno Pfister, CSIRO Division of Food Research and Industrial Physics, Sydney, AUSTRALIA; Geoffrey W. Francis, Sanya Hung, Food Science Australia, Sydney, AUSTRALIA.

A method of rapidly determining the complex modulus of foodstuffs over two decades of frequency is described. The method utilizes random squeezing with Fourier analysis to provide the complex modulus as a function of frequency and time. The method uses very small samples (requiring a maximum volume of 5 ml) and is applicable to a wide range of sample types. Application of the method to the food industry allows subjective mouth feel tests to be quantified and also to provide information for the purpose of optimizing food processing procedures.

2:45 PM AA5.5
STUDIES OF BIOPOLYMER GELATION UNDER SHEAR. Howard L. Ellis, School of Chemical Engineering, University of Birmingham, UNITED KINGDOM.

Biopolymer sheared gels from polysaccharides such as xanthan, carrageenans and alginites provide the food industry with new opportunities for structuring foods and making foods with novel properties. The application of sheared gels will be facilitated if it is possible to predict the development of sheared gel microstructure as a function of process conditions, such as shear rate, biopolymer concentration and cooling rate. The ultimate aim is to control the microstructure of the material as a function of the applied process conditions and to provide a basis for improved structure control. Sheared gel techniques can produce a suspension of microgel particles rather than a solid mass. The gel is liquid like and consists of a matrix of polymer rich particles surrounded by a polymer depleted liquid. Structural properties of the final gels have been characterised by techniques such as rheology and microscopy using simple rheological expressions which give information about flow properties of the material but this does not enable the prediction of structure formation. Fluid gels are thought to form when shear disrupts the quiescent gelation mechanism at the gelation point to produce particles. Since the quiescent gel mechanism is not completely understood it is unclear if the sheared gel particles form as a result of shear breaking the critically branched quiescent gel structure, nucleation of growth of particles under shear or if shear changes the processing environment so that particles form as a result of phase separation/spheroidal decomposition mechanism. This work examines these underlying mechanisms relating to the formation of a sheared gel, the composition of the sheared gel phases and their relationship to microstructure.

3:30 PM AA5.6
MECHANICAL BEHAVIOUR OF EDIBLE FILMS. Mats Steding, Martin Anker, Anne Marie Herrmannsson, Chalmers University of Technology and SK-The Swedish Institute for Food and Biotechnology, Gothenburg, SWEDEN.

Films of biopolymers such as polysaccharides, proteins and lipids have many potential uses in food applications. Free-standing biopolymer films for packaging use were already developed during the fifties but were driven out of competition by plastics. Biopolymer based films are again considered as alternatives to plastics due to environmental concerns. Packaging solutions based on materials from renewable resources gives no net increase of atmospheric carbon dioxide and biopolymers are more degradable facilitating closed waste management systems. Edible biopolymers can be applied directly on foods to give new solutions for prolonged shelf-life as alternative to conventional packaging. An edible coating is either consumed with the product or digests during processing. Internal migration of moisture or fat in, especially prefabricated foods, decreases quality and shelf-life. An edible barrier between the different components of the food product can prevent this. The mechanical and barrier properties of biopolymer films are strongly dependent on the microstructure. We have studied solution-gelcast films based on potato starch and whey protein to elucidate this dependence. Films of native starch pure amylose and pure amylopectin have been shown to behave differently in respect to barrier and mechanical properties. Amylose forms strong films with constant relative crystallinity whereas amylopectin forms films of varying crystallinity depending on the humidity during formation. The sensitivity to humidity during formation of amylopectin films also influence the properties, which was related to the microstructure rather than the crystallinity. The effect of the biopolymer network was studied in whey protein films. The protein concentration was varied around the critical concentration needed to form the network in the gel state. The film strength did not increase uniformly with increasing protein concentration, instead a maximum was found. The existence of a maximum was attributed to a change in the protein network structure.
testing and confocal laser scanning microscopy. Samples were prepared by dispersing spherical biopolymer microgel particles (20-200 microns) in gelatin solutions, which were subsequently allowed to gel. This resulted in the formation of mixed gel composite systems having an included phase of known volume fraction and well-defined particle size. Compression and tension tests were performed upon a range of samples having varying particle radii, and the trends in material properties noted. Confocal laser scanning microscopy of composite samples under varying degrees of applied strain was used to observe debonding of the matrix from the surface of the particles, and to monitor this process as a function of particle size.