EDIBLE APPLICATIONS TECHNOLOGY

EAT 1: Structuring of Liquid Oil for Low SAFA and Non-trans Applications
Chairs: Jorge Toro-Vazquez, Universidad Autónoma de San Luis Potosí, Mexico; and Nils Hinrichsen, Archer Daniels Midland, Co., USA

Oleogels – from Scientific Feasibility to Applicability Eckhard Flöter*, *Technical University Berlin, Germany*

Given that saturated and trans fatty acids are known to increase the risk to suffer from cardiovascular diseases by raising the blood cholesterol level, it is recommended to reduce their daily intake to a minimum. Fat compositions like palm or milk fat, which consist i.a. of crystallized triacylglycerol (TAG) fractions, contain high amounts of saturated fatty acids, but provide unique texture and rheology. Sources of mono- and polyunsaturated fatty acids cannot match these properties in their native state. It is necessary to transform an oil into a gel with the help of structuring agents, hence oleogelation. A vast amount of different systems has been identified the last decades. The level of understanding of the mechanism of action and study depth differs widely between the various systems. Structuring agents that have been found range from proteins to ethylcellulose, from waxes to monoglycerides, and from combinations of tocopherols with lecithins to sterol/sterolester combinations. Scientific contributions show that oleogelation works and suggest product applications but no products are on the market. This contribution aims to formulate requirements to be met for a further implementation of oleogelation. In detail, different structuring systems will be benchmarked with respect to parameters such as availability, benefit, price and match with product contexts. In particular, the compatibility of the structured oil phases with manufacturing processes and product shelf life need to be considered. The set of conditions should help to evaluate the potential of structuring systems without hampering the scientifically rewarding quest for better approaches to oil gelation.

Addition of High-melting Monoglyceride and Candelilla Wax Significantly Improved Oleogelation of Pulse Protein Foams Athira Mohanan, Michael Nickerson, and Supratim Ghosh*, *University of Saskatchewan, Canada*

Oleogelation is considered a promising method to remove trans fat and reduce saturated fats in structured oils. We previously revealed that the porous structures obtained by freeze-drying pulse protein foams could be used to structure canola oil. The foams prepared using a mixture of 5% faba bean or pea protein concentrates with 0.25% xanthan gum at pH 7 and 9 were freeze-dried to hold canola oil 40 times their weights. However, the oil binding capacity of the oleogels was poor, about 30% oil leaked, which negatively affected their rheological properties. The present study explored the addition of small amount of high-melting monoglyceride and candelilla wax (CW) on the oil binding capacity, rheological properties and baking qualities of pulse protein-stabilized oleogels. Different concentrations (0.5-3%) of the additives were dissolved in canola oil at 80ºC. The hot oil was then added into the freeze-dried protein-polysaccharide foams and quickly transferred to a refrigerator. With an increase in additive concentration, oil loss reduced and became zero at 3%. Both firmness and cohesiveness of the oleogels increased with the addition of monoglyceride or CW. The storage moduli of the oleogels decreased with increase in CW while they rose

and then dropped with an increase in monoglyceride concentration. The textural properties of cakes, baked with oleogels, were also improved when monoglyceride or CW was present. The improvement in oleogel formation, stability and application could be attributed to lipid crystallization, which reinforced the biopolymer-network holding the liquid oil.

Water-induced Self-Assembly of Hybrid Gelator System (Ceramide and Lecithin) for Edible Oil Structuring Shenglan Guo, and Yaqi Lan*, *South China Agricultural University, China*

Ceramide is a highly effective organogelator with numerous health implications. Lecithin is often used as a crystal modifier to improve gel properties. It was found that in the presence of a small amount of water, ceramide and lecithin may self-assemble at specific ratios and form opaque oleogels in sunflower oil that is different from the structure by themselves. In order to figure out when gelation occurs, a phase diagram of ceramide/lecithin /water/sunflower oil was established. Several material states including gel, emulsion and phase separation were observed to cluster at specific regions in the pseudo-ternary phase diagram. In the gel region, inverted fluorescence microscopy (IFM) revealed that water was evenly distributed in the self-assembled microstructure. Fourier transform infrared spectroscopy (FT-IR) was utilized to reveal the non-covalent interactions involved between gelator and solvent. D_2O instead of H_2O was added to avoid the interference of H-bonding between water molecules. The peak associated to the stretching vibration of D-O shifted from ~2474 cm^{-1} to ~2507 cm^{-1}, indicating the presence of interaction between water and gelators, which confirmed the importance of water in self-assembly of this hybrid-gelator system. To clarify the vital role of water in formation of stable gel, a series of samples with varying ratios in ceramide and lecithin with and without water were explored. The gel appearance, fiber morphology, thermal properties, viscoelastic properties, as well as crystal packing were investigated. Water-induced conversion of oleogelation provides alternatives in producing hard stock fat replacers as well as possibilities to incorporate water-soluble nutrients in oil-based products.

Physicochemical Properties of Yellow Cake Produced with Menhaden Oil or Structured Lipid Organogels Sarah A. Willett*, and Casimir C. Akoh, *University of Georgia, USA*

Organogels were produced using either a phytosterol blend of β-sitosterol/γ-oryzanol or a blend of sucrose stearate/ascorbyl palmitate (SSAP) as organogelators. Four lipid phases were used in organogel formation for each organogelator blend: menhaden oil, structured lipid (SL) of menhaden oil containing 30 mol% caprylic acid (SL-C), SL of menhaden oil containing 14 mol% each of caprylic and stearic acid (SL-CS), and SL of menhaden oil containing 20 mol% stearic acid (SL-S). All SLs were produced enzymatically using the biocatalyst Lipozyme® 435, a recombinant lipase from *Candida antarctica*. The menhaden oil, SLs, and respective phytosterol or SSAP organogels were evaluated as alternatives to shortening (Crisco®) in the production of yellow cake. Cake texture, oxidative stability, microstructure, specific volume, and color were determined. Batter rheological properties, specific gravity, microstructure, and thermal analysis were also determined. The shortening, and all phytosterol and SSAP organogel batters, generally exhibited statistically similar specific gravities (0.85). The Power-Law Model was used to fit the shear thinning behavior of the batters. The shortening, and menhaden oil phytosterol and SSAP organogel batters, exhibited similar Power-Law values, while all SLs (and respective organogels) batters typically had higher viscosities, lower flow index values, and higher

consistency index values. All SLs (and respective organogels) cakes generally exhibited lower hardness and chewiness. Menhaden oil and SL-S phytosterol organogel cakes, and SL-CS SSAP organogel cake, showed textural properties similar to the shortening cake. Both the phytosterol and SSAP organogels showed acceptability as zero *trans*-fat substitutes to shortening in the production of yellow cake.

Advanced Structure-Functional Properties of Lipids in Product Reformulation Filip Van Bockstaele[1], and Koen Dewettinck*[2],[1]*Ghent University, Belgium;* [2]*University of Gent, Belgium*

Not surprisingly there is a growing scientific consensus about the essential role of lipids with respect to their nutritional and functional properties. One can discuss the pros and cons of all kinds of nutrients and how an equilibrated and healthy daily diet should look like but certainly oils and fats will continue to take up a very substantial and positive contribution in our everyday meal. Obviously, food composition attracts the attention of many consumers and such information is of primary interest to dieticians in formulating dietary recommendations. But both nutritional and technological sciences are evolving and translating that kind of fundamental knowledge into newly developed products to meet consumer expectations for innovative tasty and healthy food products is a great challenge. Clearly knowledge on how different food lipids are creating a certain food matrix by interacting at different structural levels is also very important in food reformulation and the creation of innovative foods. In this presentation new insights will be discussed with respect to structure-function relationships of lipids in different kind of food matrices and how this can result in real product innovations.

Chitosan-based Oleogels as Trans Fat Replacer Using Water-Continuous Emulsions as Templates Gabriela B. Brito*[1], Vanessa O. Di-Sarli[2], Matheus T. Martins[1], Denes K. Rosário[1], Karina F. Delgado[1], Carlos A. Conte-Júnior[1], Torres Alexandre[3], and Gabriela B. Baptista[1],[1]*Federal Fluminense University, Brazil;* [2]*Federal University of Rio de Janeiro, Brazil;* [3]*UFRJ, Brazil*

Oil structuring using biopolymers, as chitosan, is a promising strategy to reduce trans-fatty acids in processed food. The aims of this study were to investigate the physicochemical, oxidative and structural properties of chitosan-based oleogels and to evaluate its potential application as trans fat replacer in cookies. Oleogels were obtained using canola oil, chitosan (structuring agent), vanillin (cross-linker agent) and/or Tween 60® (emulsifier) adopting emulsion-templated approach. Five formulations were obtained and characterized by moisture and lipid content, oil binding capacity (OBC), peroxide value (PV), texture, rheology and Fourier Transform Infrared Spectroscopy (FTIR) techniques. Cookies were formulated with total or partial (50%, w/w) trans-fat replacement by each oleogel. Hardness and crispness of cookies were determined. All oleogels presented mean moisture, lipid content, PV and OBC of 1.61 ± 0.12 wt%; 97.5 ± 2.02 wt%; 4.0 ± 0.21 meqO2.kg-1 and 70.4% ± 6.67, respectively. There was no significant difference between the hardness of the oleogels (7.44 ± 0.77N) and commercial shortening (10.4 ± 2.17N). Oleogels showed time-dependence and structure-recovery behavior and also were stable in a wide range of temperatures (G'>G"). However, a structural effect of interaction between vanillin and emulsifier for these parameters was observed. FTIR results indicated that Schiff base between chitosan and vanillin is related to the tridimensional networks of the samples. Cookies with partial fat replacement showed higher hardness and crispness than control

cookies, whereas totally replaced cookies presented similar texture to the control ones. Therefore, chitosan-based oleogels showed promising results as a potential trans fat replacer.

Interactions Between Candelilla Wax and Saturated Triacylglycerols in Oleogels Formation Thais Silva*[1], Daniel B. Arellano[2], and Silvana Martini[3],[1]*Utah State University - Nutrition, Dietetics and Food Sciences Department, USA;* [2]*Unicamp, Brazil;* [3]*Utah State University, USA*

Based on the molecular similarity between fully hydrogenated oils (hardfats) and CLX, and differences on their structuring power the aim of this work was to evaluate the use of CLX and various hardfats to form oleogels. The hardfats used in this study were crambe (HCr), palm (HPl), palm kernel (HPk) and soybean (HSb). The total concentration of oleogelator was 5% in soybean oil. The proportions of CLX:hardfats were 0:1, 0.25:0.75, 0.5:0.5, 0.75:0.25 and 1:0. Oleogels formed by CLX alone showed crystal size of 6.99 µm, Tpeak of 46°C, G' of 1.5 x 10^5Pa and 10% of oil loss after 1 day. As the amount of hardfat increased in the sample, G' values decreased and oil loss increased. However, the 0.25 and 0.5 blends of HPl and HCr formed a stable and organized crystal network structure characterized by smaller crystals (<6.76µm) and lower Tp (<42°C). These samples had G' and oil loss values close to the ones obtained for the CLX oleogels. The 0.25HSb sample showed similar results to HPl and HCr, but with lower G'. HPk was completely soluble in soybean oil and did not interact with the CLX. These results showed that hardfats can potentially interact with CLX to form stable oleogels, especially HPl and HCr. Since these hard fats are readily available and inexpensive they could be used to decrease the amount of CLX which might be a better economical and sensory alternative for use in food application.

Oleogels Based on the Small Molecule Food Emulsifier: Macroscopic Property, Microstructure, and Application Zong Meng*[1], Ying Guo[2], and Yuanfa Liu[3],[1]*School of Food Science and Technology, Jiangnan University, China;* [2]*School of Food Science and Technology, Jiangnan University, China;* [3]*School of Food Science and Technology, State Key Laboratory of Food Science and Technology, Jiangnan University, China*

Sodium stearoyl lactylate (SSL) and Polyglyceryl fatty acid ester (PGE), two types of edible food emulsifiers, was used as a gelling agent to structure oleogels at concentration of 7%, 9%, 11%, and 13% (w/w) with sunflower oils in this study, respectively. The physical characteristics of oleogels such as solid fat content (SFC), oil bonding capability (OBC), and firmness were influenced by SSL or PGE crystals. Therefore, the microstructure and interaction of oleogels was further investigated by polarizing light microscopy (PLM), X-ray diffraction (XRD), rheology, differential scanning calorimetry (DSC), and fourier transform infrared spectroscopy (FTIR). The breads made using oleogels were characterized in terms of texture properties, water activity (Aw), and fatty acid compositions. It was found that the higher concentration of oleogelator resulted in a denser crystalline network which provided the stronger mechanical strength and enhanced the ability to retain the oil phase. However, the stacking method of crystal structures was not affected by the SSL concentration. Space-spanning networks were attributed to surface interactions among crystal of SSL such as van der Waals interactions and electrostatic repulsion. Crystal network in the SSL or PGE oleogels imitated the typical functionality of crystalline network structures formed by triacylglycerol, which also reduced the saturated fatty acid content and improved the nutritional profile of breads. This investigation

not only beneficial for filling the gap of SSL or PGE as the oleogelator to structure the edible oleogels, but also for providing a reference for their baking applications as a potential alternative for margarines.

Polymer Coated Fat Crystals as Oil Structuring Agents: Fabrication and Oleogelation Properties Mohd Dona Bin Sintang*[1], Tom Rimaux[2], Sabine Danthine[3], and Koen Dewettinck[4],[1]*Faculty of Food Science and Nutrition, Malaysia;* [2]*Vandemoortele R&D Centre, Belgium;* [3]*University of Liège, Belgium;* [4]*University of Gent, Belgium*

Oleogelation has attracted the interest of food scientists and food industry as an interesting alternative for oil structuring. Certain hydrophilic polymers, such as gelatin (GTA), is known to form gel structures in water but not in oil and need indirect approach for the application in fat. This research capitalized GTA as a stabilizer of oil-in-water emulsions, with fully hydrogenated rapeseed oil (FHRO) as the dispersed phase. During emulsification, GTA adsorbed at the interface, forming a polymer protective layer. Upon cooling, crystallization of FHRO fixed the polymer layer onto the droplets and existed as protective layer on the surface of crystallized fat droplets. The crystallized fat droplets were formed through creaming and drying processes. Subsequently, the resulting polymer-coated fat capsules (FC) were introduced as structurant in sunflower oil (SO). The confocal images revealed stained strands and droplets, which confirmed the presence of the polymers in the fat capsules surface. Differential scanning calorimetry analysis did not indicate an influence of the polymers on the crystallization of the FHRO in the capsules. Likewise, α polymorph was found in the FC alike neat FHRO. In SO, the FC at 10 %wt were dispersed using ultraturrax to obtain uniform solid-like suspension. The rheological characterization exhibited higher storage modulus (G') of the FC based suspension and signified the formation of oleogel. Interestingly, adding 1 %wt of water to the oleogel increased further G', more solid. Ultimately, we have shown the formation of FHRO coated with GTA which applicable as delivery vehicles besides as an oleogelator.

EAT 1.1/H&N 1.1: Structural Determinates of the Metabolic Response for Lipids

Chairs: Michael Rogers, University of Guelph, Canada; and Pamela Hutton, Bunge Loders Croklaan, USA

Replacement of Saturated Fat with Unsaturated Fats from Different Food Sources: Implications for Cardiovascular Risk Kristina S. Petersen*,*The Pennsylvania State University, USA*

Current dietary guidance for prevention and management of cardiovascular disease includes recommendations to replace saturated fats with polyunsaturated fatty acids (PUFA) or monounsaturated fatty acids (MUFA). This presentation will provide an overview of current research focusing on how replacement of saturated fat with MUFA and PUFA from different food sources modulates lipids and lipoproteins, blood pressure, and vascular health. Our lab has shown that replacement of saturated fat with walnuts, or vegetable oils rich in MUFA and PUFA improves lipids and lipoproteins, and blood pressure. Furthermore, data from a randomized, crossover controlled feeding study showed canola oil and high-oleic acid canola oil improved lipids and lipoproteins compared to an oil blend higher in saturated fat. Based on these data and other recent work the magnitude of lipid and lipoprotein lowering expected with different dietary replacement of saturated fat will be explored. In summary, the research presented will describe the effect of different fatty acids within the food matrix on cardiovascular risk and how we can assist consumers to choose foods and dietary patterns that are heart healthy.

Foodomics Insights in the Health Effects of Vegetable Oil YongJiang Xu*[1], Chen Cao[1], Zhaojun Zheng[1], and Yuanfa Liu[2],[1]*Jiangnan University, China; [2]School of Food Science and Technology, State Key Laboratory of Food Science and Technology, Jiangnan University, China*

Vegetable oil plays an important role in daily diet. The differences of fatty acid composition and micronutrient levels result in the varying health effects of different vegetable oils. However, the mechanisms underlying this phenomenon have largely remained elusive. Foodomics is a discipline that studies the food and nutrition domains through the application of advanced omics technologies to improve consumer's well-being, health, and confidence. The objective of this study was to investigate the health effects of different vegetable oils by foodomics analysis. The physicochemical properties and oxidative stability of seven commercial vegetable oils were evaluated, including soybean oil, rapeseed oil, corn oil, sunflower seed oil, rice bran oil, peanut oil and tea seed oil. And then SD rat were fed with high fat diet contained different vegetable oil for 12 weeks. Metabolites in serum and liver tissue were measured using liquid chromatography–and gas chromatography–mass spectrometry, and multivariate statistical analysis was performed by orthogonal projections to latent structures discriminant analysis. The finding showed vegetable oils, especially tea seed oil and rapeseed oil, decrease the liver lipid metabolism disorder in the high fat diet treated mice. This study provided the foundation for quality, nutrition and safety evaluation of vegetable oils and reasonable reference for consumers.

Musseling-up Program: Review of Greenshell Mussel Bioactive Lipids and Role in Inflammation Management and Joint Health Matthew R. Miller*[1], Marlena C. Kruger[2], Fran M. Wolber[2], Hong Tian Hong Tian[3], Parkpoon Siriarchavatana[2], and Saima Rizwan[4],[1]*Cawthron, New Zealand; [2]Massey University, New Zealand; [3]Sanford Ltd, New Zealand; [4]Riddet Institute, New Zealand*

Lipid extracts from New Zealand's iconic Greenshell mussel (GSM) are the world's most

expensive nutritional oil (~$2000 USD/kg). Traditional use of GSM by coastal Maori has been associated with improved joint health and a number of studies have examined the anti-inflammatory effects of GSM extracts. Objectives This review looks at outputs of Musseling up program a 3-year program under the New Zealand National Science Challenge "High Value Nutrition" by a) identifying, discriminating and verifying GSM active ingredients; b) producing novel GSM food/extract products; c) determining the mechanism and efficacy in pre-clinical and clinical trials. Methods We have determined GSM lipid content over seasons, developed rapid near infrared analytical methods and developed novel food applications. Efficacy of GSM was tested 1) in-vitro analysis in macrophage, cartilage osteoclast and pre-osteoblast cell lines, 2) in-vivo in female Sprague-Dawley rats with obesity-induced osteoarthritis and 3) in a clinical trial on bioavailability of the lipids fraction. Results We have determined the variation in GSM with female spring mussels having the highest lipid content. Novel stable GSM rich food ingredients have been made through emulsification and spray drying techniques. The inclusion of GSM in the rat diet significantly reduced blood levels of a cartilage degradation biomarker in rats In vitro, a non-polar lipid extract of GSM significantly reduced osteoclast differentiation in a dose-dependent manner. Clinical trials have determined the extent of the bioavailability of the lipid fractions in 4 different formats. Conclusions GSM food products, food ingredients and extracts provide exciting opportunities for improving joint health and inflammation management.

Serum β-carotene Concentrations is Inversely Associated with Reported Fatty Acid Intake in U.S. Adults Ambria Crusan*[1], Marla Reicks[1], and Susan K. Raatz[2],[1]*University of Minnesota, USA; [2]USDA, ARS, Grand Forks Human Nutrition Research Center, USA*

Objective: Dietary carotenoids are mainly sourced from fruits and vegetables. The bioavailability of carotenoids is dependent on dose, quantity and dispersion, and presence of other nutrients in the diet, specifically fat. However, there is a gap in research on whether specific fatty acid classes affect serum β-carotene concentrations. Our primary objective was to assess the association between serum β-carotene concentrations and reported intake of specific fatty acid classes, utilizing data the What We Eat in America (WWEIA)/National Health and Nutrition Examination Surveys (NHANES). Methods: Data from 9,182 male and female participants 20-85 years of age in the NHANES 2003-2006 nationally representative, cross-sectional survey were analyzed to estimate the relationships between serum β-carotene concentrations and reported saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acid intakes. Due to skewing, we log transformed serum β-carotene. Multiple linear regression estimated log(serum β-carotene) based on total reported fatty acid intakes adjusted for age, sex, and ethnicity. Results: Mean and standard error (SE) was 2.51±0.85µg/dL for log(β-carotene). Mean and SE for SFA were 26.72±16.9g, MUFA were 30.40±18.4g, and PUFA were 17.22±11.6g. β-carotene concentrations were weakly and inversely associated with fatty acid classes: SFA (r= -0.15, p

Oleogelation of Emulsified Oil Delays in vitro Intestinal Lipid Digestion Dérick Rousseau*, *Ryerson University, Canada*

The influence of oleogelation on the *in vitro* digestion of oil-in-water (O/W) emulsions was investigated. Rice bran wax (RBX) was used as an oleogelator at concentrations of 0, 0.25, 0.5 1 and 4 wt% of the emulsions, respectively. O/W emulsions containing 1 wt% whey protein

and 20 wt% oil were prepared via hot homogenization, and characterized by rheology, static light scattering, confocal/polarized light microscopy, X-ray diffraction and differential scanning calorimetry. The evolution in particle size distribution, structural changes during oral, gastric and intestinal digestion, and free fatty acid (FFA) release during intestinal digestion were all investigated. All emulsions were generally kinetically stable during the experimental timeframe (4 weeks), with the exception of the 4 wt% emulsion, given the eventual appearance of large RBX crystals (3-5 μm) in the droplets. The rheology and thermal behaviour of the emulsions, as well as the SBO-RBX blends used for each emulsion, demonstrated that addition of RBX led to the formation of rigid oil droplets. During both gastric and intestinal digestion, oil droplet coalescence occurred in all emulsions, and intestinal digestion led to oil droplet aggregation during the early stages of intestinal digestion. The FFA release profiles showed that oleogelation of emulsified oil delayed intestinal lipid digestion. This effect was enhanced with increasing RBX concentration up to 1 wt% due to the increased oil droplet rigidity. With a further increase to 4 wt%, the rate of lipid digestion increased, which was ascribed to the instability of the emulsions containing 4 wt% RBX during digestion caused by large RBX crystals.

Encapsulation, Protection and Controlled Relea se of Nutraceuticals using Biopolymer Microgel Zipei Zhang*, and D. Julian J. McClements,*University of Massachusetts Amherst, USA*

Microgels are one promising colloidal delivery systems widely used for the encapsulation and release of bioactive ingredients. In this study, a novel self-regulating hydrogel microgels were fabricated that contained acid sensitive compounds and a buffer agent (e.g., Mg(OH)2 or CaCO3). This buffer was selected because it is insoluble under alkaline conditions, but soluble under acidic conditions, and can therefore maintain a neutral pH inside the microgels when they are dispersed in a low pH solution (such as acidic gastric fluids). A quantitative ratiometric method based on laser scanning confocal microscopic imaging was also developed to map the microclimate pH inside microgels. The image method was used to detected the pH change of the microgels with or without the encapsulation of buffer agent during digestion process. It was indicated that the initial pH distribution was relatively uniform within the buffer-free microgels, being in the range from pH 6.8-7. For the buffer-loaded microgels, the center pH was slightly higher than the edge with the range from 7.2-7.6. After simulated stomach digestion, the microclimate inside the microgels changed to acid condition. Conversely, the pH value within microgels containing buffer agents was fairly similar to that of the initial value. The activity of loaded bioactives (i.e., enzymes, insulin or probiotics) were successfully reserved after encapsulation within the buffer-loaded microgels during the digestion process. Our results could provide valuable information for the design of microclimate pH mapping technique and development of nutraceutical delivery systems for acid sensitive bioactive ingredients.

The Role of Emulsifiers in Lipid Digestion of Oil-in-Water Emulsions Michael Rogers*, Natalie Ng, Saeed M. Ghazani, Peter Chen, Alejandro G. Marangoni, Amanda Wright, and Douglas Goff,*University of Guelph, Canada*

Fat digestion significantly influences health. Both food composition and food structure influence lipid digestion kinetics and the bioavailability of components they contain. Thus, we need to understand how ALL levels of food structure (i.e., nano-, micro-, macro- and

mesoscales) control the lipemic index of foods. Since surfactants are ubiquitously found in processed foods, there is potential benefit to design food emulsions with tailored lipid digestion profiles. Ultimately our aim is to limit the lipemic index of processed foods however, with the emergence of personalized nutrition there are applications where rapid digestion kinetics could be highly beneficial. 200 ± 20 nm, oil-in-water emulsions, structured using common chain-length (i.e., C18:0) surfactants (e.g. sn-1, and sn-2 monostearin, Span 60, and Tween 60) had their digestion kinetics studied using the TIM-1 simulated gastrointestinal tract. Lipid digestion rate constants, induction times and bioaccessibility were assessed over 5 hr simulated digestions. All parameters are significantly influenced by emulsifier structure, creating exciting new opportunities in structuring infant formulas, energy-dense meal replacements, etc.

Bioavailability of Pesticide Residue in Agricultural Products: Impact of Food Emulsions with Different Surface Properties Ruojie Zhang*, and D. Julian J. McClements,*University of Massachusetts Amherst, USA*

The residue of pesticides in agricultural products has been a big concern for human health since high exposure to pesticide could cause numbers of diseases, such as diabetes, neurological disorders, even cancer. The Bioavailability of pesticides residue in human body are highly impacted by the food components that consumed together. Food emulsions, such as dressings, dips, sauces, and creams, are commonly co-ingested with fruits and vegetables. The purpose of the current study was therefore to examine the potential impact of co-ingestion of emulsions with natural produce on the bioavailability of a hydrophobic pesticide. In current study, the influence of co-ingestion of food emulsions with tomatoes on the bioaccessibility of a model pesticide (chlorpyrifos) was studied. The results indicated that the bioaccessibility of chlorpyrifos (a highly lipophilic pesticide) was shown to depend on the emulsifier types of co-ingested excipient emulsion. Highest pesticide bioaccessibility can be observed for the excipient emulsion formed with phosphate lipid, followed by Tween 80 and WPI. Polysaccharide additions (chitosan, xanthan, β-glucan) can significant impact the bioaccessibility of pesticides that it also depended on the emulsifier type of excipient emulsions. Overall, these results suggest that the bioavailability of undesirable pesticides can be controlled by specificity design excipient emulsion.

Impact of Indigestible Oils on the Bioaccessibility of Vitamin D3 in Nanoemulsion-based Delivery Systems Yunbing Tan*[1], and D. Julian J. McClements[2],*[1]Dept. of Food Science, University of Massachusetts, Amherst, USA; [2]University of Massachusetts Amherst, USA*

These is interest in replacing digestible fats with indigestible ones to reduce the calorie content of foods. However, utilization of indigestible oils may have unforeseen nutritional consequences. In this study, the impact of an indigestible oil on the bioaccessibility of vitamin D3 (VD) encapsulated within nanoemulsion-based delivery systems was examined. Four different nanoemulsions were prepared using different combinations of a digestible oil (corn oil, CO) and indigestible oil (mineral oil, MO): CO only; MO only; 1:1 CO:MO system prepared by mixing oils before homogenization (oil mixture); 1:1 CO:MO system prepared by mixing MO and CO nanoemulsions after homogenization (emulsion mixture). A simulated gastrointestinal tract (GIT) was used to study the interaction between pancreatic lipase and the emulsions. The rate of

free fatty acid release and the VD bioaccessibility during 2 h intestine digestion decreased in the same order: CO > oil mixture ≈ emulsion mixture > MO. The digestion of the corn oil occurred primarily during the first 30 minutes, then gradually increased. Except for the MO nanoemulsion, the bioaccessibility of VD increased to a maximum value around 30 minutes of digestion but then decreased during the following 24 h. This effect might be attributed to solubilization of the VD in the mixed micelles, followed by their precipitation. These results show that lipid digestion, micelle solubilization, and micelle aggregation all impact vitamin bioaccessibility. The presence of indigestible oil in the nanoemulsion-based delivery systems reduced vitamin bioaccessibility, but may be useful for giving prolonged release in the colon.

EAT 2: Crystallization Behavior of Fats and Oils

Chairs: Alejandro Marangoni, University of Guelph, Canada; and Kiyotaka Sato, Hiroshima University, Japan

Pressure Induced Triolein Crystals André Roßbach[1], Leo A. Bahr[1], Sebastian Gäbel[1], Angela Mayer[1], Peter Ferstl[2], Andreas S. Braeuer[1], and Andreas Wierschem*[1],[1]*Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany;* [2]*Technische Universität München , Germany*

Treatment at pressures of several 100 MPa offers the possibility to optimize food processing and crystallization of fat-containing products. It may save time and energy, improve purity, homogeneity, crystal-size distribution and mechanical properties. To elucidate this option, phase diagrams and crystallization kinetics need to be established. As an example, we study the pressure-induced crystallization and melting curves of triolein. We examine the morphology with a microscope and the polymorphism with Raman spectroscopy. Melting curves are detected from solid layers with a polarization microscope or by observing melting of single spherulites. Triolein shows a significant nonlinear increase of the melting point with pressure. Apart from Raman spectra related to β-, β'- and α–crystals, we observed another type not yet described. Switching to less stable polymorphs at constant temperature can result in a considerable increase in the growth rate. For a given morphology, the growth rate declines with increasing pressure pointing to a transport-limited crystal growth. In the range studied so far, the growth rate seems to be governed mainly by pressure and depends only weakly on temperature. In a certain parameter range, cross-nucleation occurs.

Triglyceride Crystallisation Model based on Fatty Acid Interaction Coefficients Rasmus L. Miller*[1], and Eckhard Flöter[2],[1]*DuPont, Denmark;* [2]*Technical University Berlin, Germany*

Prediction of how much fat crystallise at defined temperatures are important in many food applications like margarine and confectionary. Thermodynamic modelling tools have successfully been developed (e.g. Hjorth et al. or Wesdorp). This work proposes a method based on the previous works (i.e. variations of the Margules model), but with considerably fewer parameters. The key in the model developed in this work is to exploit that crystallisation of triglycerides is governed by fatty acid interaction with fatty acid. The thermodynamic model proposed thus only need the interactions coefficients between each possible pair of fatty acid and a few generic conformational parameters (e.g. probability of chair / tuning fork formation). The model is a steady state model, which predict the solid fat content at equilibrium. The model parameters are fitted to triglyceride data available in Wesdorp's PhD thesis and compared to the data and to Wesdorp's model. There are three potential improvements in the new model: Capability to predict behavior of triglycerides even if they are not included in the data set used for parameter estimation, fewer parameters and information of conformation of the triglycerides.

A Phenomenological Theory of Polymorphic Phase Transitions in Triacylglycerol Crystals David A. Pink*, *St. Francis Xavier University, Canada*

There are few, if any, explanations of the origin of polymorphic phases and their transitions, in triacylglycerol (TAG) crystals. TAG molecular properties are characterized by their hydrocarbon chains and depend upon saturation or unsaturation, cis or trans double bonds, short or long chains, even- or odd-

numbered carbons and esterification. Polymorphism of symmetric TAGs is different from that of asymmetric TAGs. TAG crystals are characterized by three polymorphic phases which Larsson (Acta Chem. Scand., **20**, 2255, 1966) labelled, α, β' and β. These phases can be categorized by their hydrocarbon chain conformations, their subcell structure (Sato & Ueno, *Polymorphism in Fats and Oils*, 2005), and their thermal stability. The α polymorph has been referred to as "metastable". The β polymorph is, seemingly, the "most stable" and the β' polymorph stability is between α and β. Each polymorph has had associated with it a phase transition temperature, T_m^k, where $T_m^\alpha < T_m^{\beta'} < T_m^\beta$. The intent is to describe larger-scale phenomenological, Ising-like or other, models of phase transitions to identify what parameters might determine polymorphic phase transitions as the temperature changes. Objects representing TAG molecules will be characterized by their internal states (energies and degeneracies) and their interaction energies with other TAG molecules. Equilibrium statistical mechanics shall be used to calculate thermodynamic quantities such as order parameters and free energies, which will then be related to different phase transitions. Predictions can be made about the phase transitions. Equilibrium and metastable states as well as first and second order transitions will be identified.

Heterogeneous Nucleation of a Cocoa Butter Triglyceride on Surfaces Formed by Tristearin
Edmund Daniel T. Co*[1], Saeed M. Ghazani[1], David A. Pink[2], and Alejandro G. Marangoni[1], *[1]University of Guelph, Canada; [2]St. Francis Xavier University, Canada*

The following work investigates the heterogeneous nucleation of 2-oleodistearin (SOS) triglycerides on surfaces formed by crystals of tristearin triglyceride (SSS). The work shows, through computer simulations and nucleation kinetics, that SOS may heterogeneously nucleate on SSS surfaces. Atomic-scale molecular dynamics showed that SOS molecules exhibited an affinity ("wetting") to a simulated SSS surface. Nucleation kinetics using differential scanning calorimetry showed that the inclusion of minor amounts of SSS (from 1 % to 4 %) in a SOS melt resulted in an increase in the isothermal nucleation rate of crystallizing SOS. Using a model based on the Fisher-Turnbull approach, estimates of the surface free energy, activation free energy and the critical radius were calculated from the nucleation rates. The estimated parameters conclusively show the heterogeneous nucleation of SOS on SSS surfaces: reduced surface free energies, activation free energies and critical radii with the inclusion of SSS in an SOS melt.

Effects of Molecular Complementarity between Mono- and Triglycerides on the Interfacial Tension of an Oil-Water Interface
Nicole Green*, and Dérick Rousseau, *Ryerson University, Canada*

We have previously shown that in water-in-oil emulsions, glycerol tristearate (SSS) alone shows little to no interfacial activity. However, when paired with glycerol monostearate (GMS), a monoglyceride of matching fatty acid moiety, SSS further reduces the oil-water interfacial tension compared to a system with GMS alone. Using a temperature-controlled drop shape tensiometer to observe a pendant water drop in a purified canola oil continuous phase, we further explore this effect using palmitic and myristic acid-based mono- and triglycerides. Differences in length of even-chain fatty acids greater than two carbons have been previously shown to suppress cocrystallization, so by combining the mismatched mono and triglycerides we study the role that chain length has in inducing interfacial activity in triglycerides.

Lipid Sonocrystallization: What have we learned? What is next? Silvana Martini*, *Utah State University, USA*

Over the past 10 years our research group has used high intensity ultrasound (HIU) to modify the crystallization of lipids. Ultrasound waves are acoustic waves that operate at

frequencies just above the human hearing range (> 18 kHz). HIU techniques use low frequencies in the range of 20 kHz and can be used to induce physicochemical changes in materials. This presentation will review current research related to the use of HIU to induce the crystallization of edible lipids (lipid sonocrystallization) and will provide insights into future research on this topic. Over the years studies have shown that HIU can be used to increase the crystallization rate of fats, generate crystalline networks with smaller crystals that are harder and more elastic and that melt over a narrow temperature range. Changes in these physical properties result in a fat crystalline network with improved oil binding capacity and lower oil loss. Sonication and crystallization conditions needed to induce changes in these physical properties will be discussed. The impact of these results is that HIU can be used in healthy fats that are free of trans-fatty acids and that have low levels of saturated fatty acids to increase their hardness and to improve their functional properties. Future research in this area include the incorporation of HIU into industrial settings and to optimize the use of this technology in other systems such as spreads and oleogels.

Crystallization and Polymorphic Behavior of Cocoa Butter in Fresh Cacao Beans Laura Bayés-García*[1], Teresa Calvet[1], Tetsuo Koyano[2], and Kiyotaka Sato[3], *[1]Universitat de Barcelona, Spain; [2]Meiji Co., Japan; [3]Hiroshima University, Japan*

The present study aims at observing the crystallization and polymorphic behavior of cocoa butter (CB) in fresh cacao beans with DSC and X-ray diffraction techniques with both synchrotron and lab-scale radiation source. Underlying idea of this study was to relate the necessary conditions of germination of cacao beans to the crystallization of CB, which are present in oil-in-water emulsion droplets, called lipid bodies having 1~2 micron-meter diameters. Different cooling and heating conditions, with rates of 15, 2, 0.5 and 0.1°C/min, were applied to fresh cacao beans and compared to bulk CB. The results showed lower crystallization temperatures of CB in fresh cacao beans at all the experimental conditions. In addition, significant differences were detected regarding the polymorphic behavior of CB crystals in fresh beans and bulk oil. In more detail, simpler polymorphic behavior, based on the occurrence of more stable forms, was observed in fresh cacao beans. This study indicates that the germination conditions of cacao beans are extended to low-temperature environmental areas by lowering the Tc values of CB than those of the bulk oil. The results were consistent with the germination behavior of fresh cacao beans at different temperatures.

New Insight into Molecular Origins of Cocoa Butter Polymorphism Saeed M. Ghazani*, and Alejandro G. Marangoni, *University of Guelph, Canada*

This research is a comprehensive study of the solid-state properties of the main triglyceride molecular species in cocoa butter, namely POP, POS and SOS. Two new triclinic crystal polymorphic forms (β3 and β2) of POS were discovered. Small and wide-angle powder x-ray diffraction patterns of these β3 and β1 crystal polymorphs of POS were identical to those of crystal forms V and VI in cocoa butter, while those of SOS and POP were not. Moreover, we also discovered that the crystal structure of CB in its meta-stable form IV and its transformation to form V was controlled by POS. The ternary phase behavior between POP, POS and SOS in their triclinic crystal polymorphic form was determined herein. POP:POS mixtures displayed a strong eutectic region. Also, POP addition always led to a decrease in the melting point of mixtures, while the opposite was true for SOS. In this work we showed that a novel algal butter was compatible with cocoa butter and could be used as an alternative for high SOS exotic butters in the design of CBEs. Additionally, we showed the potential for synthesizing a CBM, a coco butter mimetic, for full replacement of CB in chocolate. The CBM was synthesized from natural fat fractions using a simple single step

enzymatic conversion method. Since POS showed critical functionality in crystal polymorphism and melting behavior in ternary mixtures with POP and SOS, we recommend the inclusion of POS in the design of CBEs.

Physical Properties and Fat Bloom Stability of Dark Chocolate Made of Ternary Fat Blends of Cocoa Butter/OSO- Fat/Lauric-based CBS
Shimpei Watanabe*[1], Shinichi Yoshikawa[1], and Kiyotaka Sato[2],*[1]Fuji Oil, Japan; [2]Hiroshima University, Japan*

It has been well known that chocolate made of lauric-acid based CBS and cocoa butter (CB) exhibits serious fat bloom at ambient temperatures, which is caused by separation and polymorphic transformation eutectic mixture of CB/CBS. The present study showed improved fat bloom stability by adding OSO (1, 3-dioleoyl, 2-stearoyl-triacylglycerol) fat into CBS/CB blends. The OSO-fat forms molecular compound (MC) crystals of double-chain length structure (beta-2) with an equal ratio with CB. DSC, SFC and X-ray diffraction (XRD) structural studies revealed that the MC crystals were formed in wide concentration ranges of CB/OSO-fat/CBS=10/10/80~40/40/20. Because of the adding effect of the OSO-fat, fat bloom formation of dark chocolate made of CB/OSO-fat/CBS was retarded up to 6 months at 15~25 ºC, although dark chocolate made of CB/CBS alone exhibited fat bloom after 10 day at the same temperature range. The present study expanded the opportunity of CBS applications in confectionery fat formulation.

Fat Bloom Caused by De-oiling from Chocolate Surface
Sohei Sato*[1], Hironori Hondoh[2], and Satoru Ueno[2], *[1]Hiroshima University, Japan; [2]Graduate School of Biosphere Science, Hiroshima University, Japan*

Fat bloom in chocolate is a significant problem that greatly affects its sensory properties such as texture and appearance. It is due to a diffuse reflection of light on a roughened surface of chocolate caused by structural change of fat crystal under various temperature conditions. Although extensive research about fat bloom has been conducted for a long time, its actual mechanisms are not completely understood. In this study, we have discovered a thermal condition and the mechanism for a fat bloom formation which has not been well characterized yet. Fat bloom generated under this thermal condition shows an overall appearance with a bright brown surface, but the crystal polymorphism of cocoa butter does not show form βVI, unlike previously reported. The structural change of chocolate during the thermal treatment was observed by optical microscopy and polarized light microscopy to clarify the process of fat bloom formation. Under this thermal condition, it was found that bloom is formed by roughening the surface as liquid oil in partially melted chocolate moves toward the center of the chocolate during recrystallization. It was also shown that crystal polymorphic transition of cocoa butter to form βVI is not a direct cause of fat bloom formation.

Evidence of Molecular Clustering in Liquid Triacylgycerols
Gianfranco Mazzanti[1], Nicole Green[2], Alejandro G. Marangoni[3], David Pink[4], Giuseppe Milano[5], Carl Adams[6], Paul Butler[7], Liangle Lin[1], Rong Liu[1], Omar Qatami[1], Amro Alkhudair[1], Yujing Wang[1], Pavan K. Batchu[1], and Xiyan Deng[1], [1]Dalhousie University, Canada; [2]Ryerson University, Canada, [3]University of Guelph, Canada, [4]St. Francis Xavier University, Canada, [5]Yamagata University, Japan, [6]McGill University, Canada, [7]NIST, USA

The structure and distribution of triacylglycerol (TAGs) in fats and oils determines their physico-chemical properties. These properties go on to determine the characteristics of the fat crystal networks that are observed in their texture, appearance and mouth feel. Over the years, a few models have been proposed to describe the distribution of TAG molecules in the liquid state, since it determines the nucleation and subsequent crystal growth. However, these models were not consistent with the actual density of oils or our X-ray scattering (XRS) data. Liquid TAG samples were examined by XRS at temperatures

up to 210 °C. WAXS (wide angle XRS) data are consistent with the liquid phase of alkanes and other aliphatic molecules. SAXS (small angle XRS) data are analogous to those produced by alcohols and fatty acids, whose molecules strongly associate via hydrogen bonding. We proposed a new conceptual model to describe the clustering of liquid TAGs as "Loose Clusters", formed due to the polar nature of the glycerol cores. Using a space-filling scheme, we estimated that their average size is about 5 to 9 molecules. The average number of molecules decreases with temperature and increases with molecular weight. To further explore this hypothesis, we performed high-Q small angle neutron scattering (HSANS) experiments on deuterated tripalmitin, as well as other TAG. The results agree with the XRS observations. Numerical simulations, on the other hand, support this hypothesis as well. The non-ideality of liquid TAGs produces phase behaviors such as multiphase crystallization, crystal memory and glass avoidance. The proposed model provides clarity for the explanation and modeling of these peculiar treats of TAG melts.

Development of Peppermint Essential Oil-Loaded Hollow Solid Lipid Micro- and Nanospheres as Natural Food Antimicrobials

Junsi Yang*, Car Reen Kok, Robert Hutkins, and Ozan N. Ciftci,*University of Nebraska-Lincoln, USA*

There is a growing demand for natural antimicrobials; however, many of those natural antimicrobials such as essential oils are water-insoluble and very volatile; therefore, efficiently incorporating essential oils into foods is challenging. Our objective was to load peppermint essential oil (PEO) into novel hollow solid lipid micro- and nanospheres (HSLS) to develop food grade free-flowing powder antimicrobial lipids. PEO-loaded fully hydrogenated soybean oil (FHSO) was developed via our innovative approach based on atomization of CO_2-expanded lipids through 50 µm nozzle at 200 bar. The highest PEO loading efficiency (47.5%) was achieved at 50% initial PEO concentration. Shell of the HSLS provided slow release to the loaded PEO and exhausted after 6 days of storage at room temperature. Release behavior of the PEO was controlled by changing the lipid matrix. Antimicrobial effect of the particles was tested in skim milk using *Pseudomonas fluorescens*, *Bacillus cereus*, *Escherichia coli* ECOR, and *Lactococcus lactis*. PEO-loaded FHSO-HSLS achieved significant inhibition in the growth for all bacteria ($p<0.05$), caused a maximum of 3 and 7 log reduction in the growth of Gram-negative and Gram-positive bacteria, respectively. This improvement was related to the increased solubility of the PEO in aqueous phase, which improved the stabilization and bioavailability of the guest molecule.
This innovative approach generates simple and clean products, slow down PEO release, minimize its strong smell, and serve as natural food antimicrobials. Hollow structure provides high loading capacity, solid shell prevents degradation, and nanosize confers water solubility. Dry free-flowing product makes handling, storage, and transportation convenient.

EAT 2a/PCP 2b: Plant Protein Utilization in Food Products
Chairs: Graciela Padua, University of Illinois, USA; and Baraem Ismail, University of Minnesota, USA

Rheological Assessment of Ethanol Induced Plant Protein Gels Nahla Kreidly*[1], Graciela W. Padua[2], and Hakime Yavuz[1], *[1]University of Illinois at Urbana Champaign, USA; [2]University of Illinois, USA*

Plant protein based gels are currently of high interest due to consumers' preference over the use of animal proteins. Protein gelation is often achieved by heat treatment or by the addition of gelling agents. However, heat treatment may damage nutrients, while the addition of gel inducing agents may be objectionable in certain foods. In this study, we further investigate the effect of a novel ethanol induced gelation process that is carried out at room temperature. It is based on the instantaneous gelling properties of certain proteins when coming in contact with ethanol. Dynamic rheological measurements using oscillation tests were employed to investigate the viscoelastic properties of ethanol induced gels from almond, lentil, and pea proteins. Rheological assessment also aimed to reveal the effect of protein content (10-20% w/v) and ethanol (30-80% v/v) on the gelling ability of plant proteins in binary solvent systems of ethanol-water. All proteins formed instantons gels with G' > G'' immediately upon contact with ethanol. The stiffest gels were observed at a 40% ethanol and 20% protein content for all proteins. Structural differences between untreated protein powders and protein gels were investigated by scanning electron microscopy (SEM) and atomic force microscopy (AFM). Protein gels developed a porous structure after drying at room temperature, in contrast with the granular structure untreated protein powders. This work aims to enhance the utilization of plant proteins in the food industry as functional and inexpensive ingredients, by studying their ability to form instantaneous gels using novel ethanol induced gelation.

Plants to Meat: Utilizing Plant Proteins to Satisfy the Carnivores Ines Resano Goizueta*, *Impossible Foods, USA*

Animals to make meat is a prehistoric and unsustainable technology. Animal agriculture occupies almost half the land on earth, consumes a quarter of our freshwater and destroys our ecosystems. Due to the impact of animal farming on our world, there is commercial interest in developing foods made from plants that satisfy the carnivore to remove the farm-animal from the human diet. Plant-based meat companies are deconstructing the eating experience and re-designing meats from scratch by using only ingredients from plants. Consumers eat meat not only because it is delicious but because it is a good source of protein. Plant proteins replacing animal proteins have to provide the same protein quality and the same sensorial experience. This requires the proteins to be functional and flavorless. At the same time, the protein must be scalable and affordable. There is enough plant protein grown in the world to substitute animal protein but not all that protein is high quality. Protein functionality allows us to make a dynamic product where the proteins can gel, emulsify and stabilize the food during handling and cooking, but many current protein isolation processes limit the functionality. Proteins must be low in flavor and not distract from the meat-flavor, but bitterness and off flavors are present in many commercially available proteins. Developing a supply of plant proteins that are functional and have low flavor, at a scale that allows us to feed the world is one of the biggest challenges we face in the 21st century.

Soy Protein-based Nanoparticles and Derivatives as Bioavailability Enhancers for Bioactive Compounds Qin Wang*, *University of Maryland, USA*

Soy protein is one of the most widely utilized plant proteins with unique nutritional values. This study systematically investigated

the preparation, characterization, and application of soy protein-based nanoparticles as effective nutraceutical/drug carriers. The particle formation involved partial unfolding of protein molecules, limited aggregation in the presence of the antisolvent, hardening of particle structure via chemical bonds, and refolding of the protein molecules within the particles. Satisfactory dispersion stability, encapsulation efficiency (EE), and time-dependent release of curcumin, a chemopreventive compound, were observed. The nanoparticles were further subjected to conjugation with folic acid, a cancer cell-targeting ligand. The conjugation led to more extensive particle formation and higher loading efficiency (LE), probably due to an increase in surface hydrophobicity. More importantly, a pronounced increase in the accumulation in tumor cells such as Caco-2 was achieved upon folic acid, which demonstrated the potential of this technique for the targeted delivery of anti-cancer drugs. To overcome the rapid digestion of soy protein nanoparticles in the gastrointestinal tract, carboxymethyl chitosan (CMCS) was employed as a second coating layer by a simple ionic gelation method. CMCS rendered the gelation of soy protein molecules more effectively and required lower concentration of calcium crosslinkers. The CMCS/soy protein complex nanoparticles exhibited satisfactory EE for vitamin D3, reduced release in simulated gastric environment, and enhanced release under simulated intestinal conditions. This study demonstrated the potential of soy protein-based nanoparticles as an effective vehicle for carrying and delivering bioactives for various applications.

Overcoming the Challenges in the Production and Utilization of Plant Protein Isolates in Food Products Nagul Naguleswaran*, *Ingredion, USA*

The utilization of plant proteins in food products has rapidly increased during recent years. The food industry prefers the use of plant protein isolates primarily due to their high protein content and high nutritional value. However, there are numerous challenges in formulating food products with plant protein isolates, particularly in achieving the target functional properties in the ingredients. Although there is a number of plant protein isolates currently available in the market, many of them could not be used as alternatives to animal proteins. Several factors influence the production of plant protein isolates with desired functional properties that match the functionalities of animal proteins. At present, the protein isolates are produced from oilseeds, pulses, and cereals. The physicochemical and functional properties of the plant protein isolates vary primarily due to both the source and processing methods. This presentation reviews the challenges and opportunities associated with the production of selected plant protein isolates, with desired functional properties.

Improvement of Targeted Pea Protein Functionalities for Beverage Applications Serpil Metin*[1], Sonia Han[2], and Tasha Hermes[2],[1]*Cargill R&D, USA;* [2]*Cargill, USA*

There is a strong interest in the consumption of beverages containing plant proteins due to potential health benefits. Pea protein is an attractive protein for some consumers, especially for vegetarians, vegans and flexitarians. However, utilization of pea protein in beverages have challenges due to its low solubility, sedimentation, flavor, and thermal stability. Pea protein can be modified for target functionalities desired for beverage applications. In general, food protein functionality is commonly measured from the perspective of single protein molecules in solution. While this approach is very beneficial in understanding of functionalities of proteins, it is somewhat limited in predicting performance in final food applications. This presentation will include modification of pea protein to improve its solubility and flavor for beverage applications as well as measurement of target functionalities of both intact and modified proteins. It will also include an approach taken for prediction of performance

of both proteins in the presence of other ingredients (e.g. sweeteners, stabilizers, flavoring agents, etc.) and during processing steps in a beverage application.

Structural and Functional Properties of Plant Protein Isolates and Hydrolysates for Various Applications Baraem Ismail*, *University of Minnesota, USA*

The demonstration of equivalent or superior/new functionality of novel plant proteins compared to existing alternatives is essential to both the food industry and the consumer. However, there is limited consumer and producer knowledge of plant proteins other than soy. Food producers are seeking information on the nutritional, physiological and functional characteristics of plant proteins. Additionally, efficient extraction and functionalization procedures are needed. This presentation will cover the evaluation of various plant proteins from pea, camelina, and pennycress, highlighting their structural and functional properties as impacted by extraction and functionalization procedures, as well as potential applications. Structural characteristics and functional properties of the protein concentrates, isolates and hydrolysates will be discussed and compared to reference proteins, whey protein isolate (WPI) and soy protein isolate (SPI).

EAT 3: Implication of Lipids Structuring in Food Application

Chairs: Jose Trujillo, Chemtech, Peru; and Kaustuv Bhattacharya, DuPont Nutrition & Biosciences ApS, Denmark

A Novel Strategy for Increasing Solid Fat Content of Oils without Addition of Saturated or trans Fats or Oil Gelling Compounds Alejandro G. Marangoni*, and Reed A. Nicholson, *University of Guelph, Canada*

In the modern world of clean label, minimum amount of e-numbers, health benefits, sustainable and green, animal friendly, religion, and possibly others, it has become increasingly difficult to manufacture a functional plastic fat. Fats and oils are essentially triglycerides (TAGs). There are physical, commercial and regulatory limits to what can be done with TAGs. Addition of oleogelators is a very interesting option, but their use in food products is mostly not allowed by current legislation. Structured emulsions can be an interesting option in the space, but here we will focus on a novel strategy to create a plastic fat or just increase solids in liquid vegetable oils by enzymatic glycerolysis. Mono and Diglycerides have higher melting points than their triglyceride counterparts and thus conversion of the endogenous TAGs into DAGs and MAGs will lead to an increase in solids and melting point. Here we present our new strategy and show applications in real food products.

Effect of Various Concentrations of Two Stabilizer Series on Peanut Butter's Physical and Functional Attributes Rachel E. Mertz, and Donald D. Gifford*, *Stratas Foods, USA*

Homogeneous peanut butters require the addition of stabilizers to keep the oil from separating from the other components. Peanut butter stabilizers are comprised of high melting point fats, which function as structuring agents via their contribution to the development of crystalline networks robust enough to hold the peanut butter ingredients with varying hydrophilic and hydrophobic properties in suspension. Conventional peanut butter contains stabilizers at a usage rate on average of 2.0% w/w, with a range of 1.0% - 4.0% w/w. The objective of this study was to investigate two different series of stabilizers at various concentrations and their effects on crystalline promoting tendencies and impact on peanut butter stability and texture as a function of storage time. Variable I a) fully hydrogenated soybean oil (Soy), b) blend of Soy and fully hydrogenated high erucic acid rapeseed oil (HEAR) (1:5 w/w), c) blend of Soy and HEAR (3:5 w/w), d) blend of Soy and HEAR (5:5 w/w), e) blend of Soy and HEAR (5:3w/w), Variable II a) fully hydrogenated cottonseed oil (Cotton), b) blend of Cotton and HEAR (1:5 w/w), c) blend of Cotton and HEAR (3:5 w/w), d) blend of Cotton and HEAR (5:5 w/w), e) blend of Cotton and HEAR (5:3 w/w). These variables were tested at the inclusion rate of 1.5% w/w in a standard creamy peanut butter formula. Digital scanning calorimetry (DSC) and textural analyzer were used to evaluate stabilizer crystalline behavior and textural attributes. Peanut butters were observed for oiling out over time and texture analysis was performed on finished product during storage.

Controlling the Texture of Oil-continuous Systems by Filler Particles Auke de Vries*, and Dérick Rousseau, *Ryerson University, Canada*

To control the final texture of a food product, pharmaceuticals, or a personal care product, different routes are available to modify its rheological properties. Many of these products are composite materials, where a three-dimensional network, or matrix, encloses filler particles. These particles can be solid, liquid, or gaseous and, in food products for example, includes sugar particles in chocolate,

oil droplets in a casein matrix or air bubbles entrapped in an aggregated fat globule matrix (whipped cream). Based on the surface chemistry of the filler particle and the nature of the matrix, filler particles can either have an attractive interaction with the matrix or there is an absence of such an interaction. When there is no interaction, the particles are called an 'inactive filler' and the addition of such particles will decrease the overall gel strength. When there is an attractive interaction between the filler particles and the surrounding matrix, the gel strength increases when the particle is more rigid than the network and are then called 'active fillers'. Although progress has been made to describe this phenomenon in water continuous systems, like emulsion gels, we are interested to describe these interactions in oil continuous systems. We show that by simple modifications similar particles can either behave either as inactive or active fillers, which is a simple, yet interesting route to modify the rheology and final appearance of the product.

Development of Solids in Palm Oil at Varying Cooling Temperatures Neil R. Widlak*, *Consultant, USA*

The intent of this paper is not to provide new information but to use this forum to help stimulate discussions between researchers to provide solutions to problems or lead to discoveries. While running continuous solid fat content on palm oil as it solidified at various temperatures over time, I observed that solids developed at a faster rate at 15C than at 10C during the early stages of cooling. While the correlation between temperature (0, 5, 10, 15, 20 and 25C) and solid content after 5 minutes and 60 minutes of cooling was quite strong (R2 greater than 0.95), solids developed at a greater rate at 15C than 10C between 20 and 30 minutes of cooling. This delay in crystallization was also found in other fat systems and not in others. I am presenting this data in the hope to find out why this occurred and if this information has any commercial relevance or value. Is the unexpected delay in solid development at 10C unique the test conditions, influenced by the ratio of heat generated from the heat of crystallization and amount of heat dissipated by the cooling capacity of the system, related to TAG composition, and/or related to competing sites for nucleation or changes in polymorphic behavior.

Structuring Lipids Through Enzymatic Glycerolysis Reed A. Nicholson*, and Alejandro G. Marangoni, *University of Guelph, Canada*

Hydrogenation, interesterification, and fractionation are processes commonly used to improve the functionality of edible oils by increasing the saturated fat content, thereby altering the crystallization behaviour of the lipids. Furthermore, monoacylglycerols (MAGs) and diacylglycerols (DAGs) have also been known to affect the crystallization properties. The purpose of this research is to use glycerolysis to produce partial glycerols to directly structure liquid oils without affecting the fatty acid composition. Glycerolysis reactions were performed at 65 °C for various lengths of time in the presence of glycerol using Candida antarctica lipase B as the catalyst. Differential scanning calorimetry demonstrated a 20 °C increase in the onset of crystallization of both cottonseed and peanut oils following glycerolysis. Pulsed nuclear magnetic resonance showed that the solid fat content of cottonseed and peanut oils increased from 6% to 21% and 3% to 20%, respectively, at 5 °C. The structured cottonseed oil represents a viable alternative to palm oil and hydrogenated vegetable oils for applications in margarine as well as shortenings. When incorporated into peanut butter, the peanut oil glycerolysis product decreased the oil loss to less than 6% of that of peanut butter containing unaltered peanut oil. Additionally, changing the conditions of the glycerolysis

reaction to obtain various partial glycerol compositions can subsequently be used to tailor the textural properties of the peanut butter to meet the demands of consumers. This research demonstrates that glycerolysis can be used to enhance the functionality of edible oils for their use in numerous food applications.

Effect of Storage Time on Physical Properties of Sonocrystallized All-purpose Shortening Juhee Lee*, Melissa Marsh, and Silvana Martini, *Utah State University, USA*

The purpose of this study was to determine the effect of high intensity ultrasound (HIU) on physical properties of an all-purpose shortening and evaluate how these properties changed during storage at 25°C and 5°C. Samples were crystallized at 30°C for 60min with and without HIU (20 kHz; 3.2 mm-diameter tip, 216µm amplitude, 10s). After crystallization physical properties such as hardness, elasticity, melting behavior, and solid fat content were measured after 60min of crystallization and after storage for 48 h, 4 weeks, and 12 weeks at 5°C and 25°C for 12 weeks. The effect of HIU was most significant in changing the hardness of samples stored at 25°C. Sonicated samples were always harder (p0.05) and hardness increased in all samples as a function of storage time. No significant difference was observed in either enthalpy values after crystallization or the melting behavior of sonicated and non-sonicated samples stored at 25°C as a function of time. Elasticity of the sonicated samples were slightly higher compared to the non-sonicated ones and elasticity values increased as a function of time in samples stored at both 5 °C and 25 °C. These results indicate that sonication increases the hardness and elasticity of samples in freshly made samples. If samples were stored at 25°C sonicated samples remain harder, but this is not the case in samples stored at 5°C where hardness values level off between sonicated and non-sonicated samples.

Application of Spray-dried Oil Powder in Oil-in-Fat Dispersions Iris Tavernier[1], Bart Heyman[2], Tony Ruyssen[1], Paul Van Der Meeren[1], Filip Van Bockstaele*[1], and Koen Dewettinck[3], *[1]Ghent University, Belgium; [2]Vandemoortele Lipids R&D, Belgium; [3]University of Gent, Belgium*

To make fat-based products such as margarines and shortenings more healthy, partial replacement of saturated fatty acids (SaFAs) by unsaturated ones is considered. However, this largely impacts the structuring of the lipid phase and hence the texture and functionality of the fat-based product. To counteract this, extensive research is conducted on alternative structuring techniques. In our research, oil powder containing an internal oil phase is introduced in a crystalline fat matrix. It is hypothesized that the outer fat phase will be more concentrated and requires less solid fat to be structured. Soy protein stabilized oil powder was self-produced by spray drying and further applied as an ingredient in the molten continuous fat phase (palm oil and palm stearin) in concentrations of 30, 40, 50 and 60% of powder. The static crystallization of the continuous fat phase resulted in the formation of oil-in-fat dispersions, as was visualized with light microscopy and cryo-SEM. The isolation of the liquid oil in the internal oil droplets ensured that the continuous fat phase dominated the structuring of these newly developed oil-in-fat dispersions, which was rheologically demonstrated with amplitude sweeps. However, thixotropic tests revealed that the oil-in-fat dispersions are shear sensitive which can limit their applicability. These findings provide a potential approach to reduce the saturated fat content of fat-based food products using only food-grade ingredients and traditional food processing techniques. Nevertheless, further optimization of the emulsion formulation and preparation and of the spray drying process is essential to improve the shear stability of these oil-in-fat dispersions.

Sensory Evaluation and Physical Properties of Wax-stabilized Peanut Butter Jill Moser*, Julie Anderson, Hong-Sik Hwang, Jeffrey A. Byars, and Mukti Singh, *USDA, ARS, NCAUR, USA*

Four natural waxes were evaluated as stabilizers to prevent oil separation in peanut butter. Beeswax (BW), candelilla wax (CLW), rice bran wax (RBW), sunflower wax (SFW), and a commercial peanut butter stabilizer, hydrogenated cottonseed oil (HCO), were added to three natural peanut butter brands at levels ranging from 0.5 – 2.0 % (w/w). Samples were tested for oil binding capacity, long-term stability, firmness, and rheology. SFW and HCO had the highest oil binding capacity, followed by RBW, CLW and BW.All waxes reduced the amount of oil separation after six months at room temperature compared to no added stabilizer. Firmness and yield stress increased in association with higher levels of wax or HCO, with SFW increasing firmness the most, followed by HCO, RBW, and CLW, while BW had the lowest effect on firmness and yield stress values. A sensory panel conducted descriptive analysis of appearance, texture, mouthfeel, and flavor of wax stabilized peanut butters using HCO-stabilized peanut butter as a reference. The results indicate that the waxes may be feasible replacements for HCO as stabilizers in peanut butter and other nut or seed butters.

Practical Experiences on Fat Crystallization in Food and Non-food Industry Jose Trujillo*, *Chemtech, Peru*

Fats play an important role in the food, feed and non-food industries. Fats if not processed, stored, transported and applied correctly, variations can occur in fat structure that may affect the performance of the product. Typical cases in the food are pastry fats/ margarines, filling fats, CBA, liquid shortenings, calcium soaps, crystallization of pure fatty acids etc. The replacement of trans fats by non-trans was real challenge in many food industries, mainly because the speed of crystallization of non-trans fats are different. Understanding the physics of fats in each case the solutions are easy and can represent important savings in the industry.

ANA 3.1 / EAT 3.1 / IOP 3.1: Analysis of Food Applications of Low Saturated Fats/Oils; and PUFA, and Fat-Soluble Vitamins with Emphasis on Nutrition Labeling

Chairs: Jillonne Kevala, Food and Drug Administration, USA; and Serpil Metin, Cargill R&D, USA

Modernizing the Nutrition Facts and Supplement Facts Labels Jillonne H. Kevala*, *Food and Drug Administration, USA*

Objective: To modernize the Nutrition Facts and Supplement Facts labels (NFL and SFL) to reflect current scientific information on nutrition and enhance its presentation to consumers. Methods: Review and analysis of information from sources including the U.S. Department of Health and Human Services' and the U.S. Department of Agriculture's, "Dietary Guidelines for Americans 2015–2020"; the Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans (February 2015); The Institute of Medicine, which reviewed several reports on individual nutrients, from 1997 to 2011; consensus statements from the National Institutes of Health; and a Surgeon General report on Bone Health and Osteoporosis (October, 2004). FDA also relied on data from the National Health and Nutrition Examination Survey (2003-2008). Results: FDA's review and analysis of the large body of information described above showed that a significant number of different elements in the NFL and SFL, established in January 1993, were out of date with respect to current nutrition science. Other elements of the label needed updating to present nutrition information in a manner more clear and useful to consumers. Conclusions: FDA made numerous amendments to the requirements for mandatory and voluntary declarations of specific nutrients and amendments addressing different aspects of label formatting and issues related to serving sizes. The final rules published in May of 2016. FDA is drafting numerous guidance documents, in different stages of development, to aid manufacturers in implementing changes in the NFL and SFL. The presentation will provide an overview of the key changes.

Low Saturate High Oleic Canola Oil in Health and Nutrition Xiaolan Luo*[1], Nisa Tharayil[1], and Diliara Iassonova[2],[1]*Cargill, USA;* [2]*Cargill Inc., USA*

Nutrition research has been focused on specific food ingredients beneficial to nutrition and health as diet has been linked to various diseases such as diabetes, obesity and cardiovascular disease. Fats and oils are one of the most important components of diet as one-fourth of total daily dietary energy is supplied by these fatty acids. Recently, Cargill scientists have developed a low saturate high oleic canola oil with a high level of mono-unsaturated and moderate level of polyunsaturated fatty acids. The new canola oil has the lowest saturated fat content on the market and can offer a 40% reduction in saturated fat from conventional canola oil. Oxidative stability and performance in food applications of the new canola oil was evaluated by analytical tests such as rancimat and schaal oven tests as well as sensory test in comparison with other specialty and commodity oils. The new canola oil demonstrated superior flavor and high oxidative stability. Its OSI slightly decreased from 18.6 to 18 even after storage for over 3 years at 55F. Food fried in low saturate canola oil showed favorable flavor, texture and high overall liking score while containing significantly reduced saturated fat content. The impact of natural antioxidants on oxidative stability of low saturate canola oil was also investigated. With high oxidative and application performance, low saturate high oleic canola oil offers a healthier choice through reduced saturated fat per serving in labelling of a wide range of foods.

Validation of a HPLC Method for Analysis of Provitamin A Carotenoids (β-carotene, α-carotene and β-cryptoxanthin) Sneh Bhandari*, and Ming Gao, *Merieux NutriSciences, USA*

The 2016 Nutrition labeling regulation by US FDA (FR 33741) replaced the International unit (IU) for label declaration of vitamin A to mcg Retinol Activity Equivalents (RAE). β-carotene, and α-carotene, and β-cryptoxanthin have different RAE values. There is a need for an accurate and precise method for analysis of α-carotene, β-carotene and β-cryptoxanthin in foods for labeling of correct amount of total vitamin A, the current study is an attempt to validate such a method. The carotenoids were extracted using a hot sponification followed by the solvent extraction. The extract was analyzed by a reverse-phase HPLC on a C30 column. The method did provide a good chromatograppy and response of the carotenoids. The NIST SRM 2383 a baby food and BCR 485 vegetable powder reference material were analyzed by the method and the results of β-carotene, α-carotene and β-cryptoxanthin as well as trans-β-carotene were with in the range specified by the respective reference materials for the corresponding carotenoids. The method precision in different food matrices in terms of % RSD values for β-carotene, α-carotene and β-cryptoxanthine were in the range 1.9-5.4%, 3.1-15.1% and 1.6-7.9% respectively. Spike recovery in different matrices of carotenoids was found to be in the range of of 86- 106%. LOD and LOQ of the method in terms of mcg/100g was in the range 1.1-2.2 and 2.1-3.6, respectively.The method was found to be accurate and precise for the analysis of carotenoids in different food matrices. The method can be used for carotenoid analysis for nutrition labeling of vitamin A.

Rheology and Baking Stability of Water in Oil Emulsion Designed as Low saturated Bakery Shortening Fernanda Davoli*[1], Serpil Metin[2], and Paul Smith[3],[1]*Cargill, USA;* [2]*Cargill R&D, USA;* [3]*Cargill Global Foods Research, Belgium*

There is a strong drive for low SAFA shortenings, but development is challenging because of the difficulty in reproducing the "plasticity" of traditional systems with reductions in SAFA. In this study, a two-step approach was taken. First water in oil emulsions were produced and their rheology was manipulated by emulsifier composition (including combinations), in order to find the behavior most resembling a traditional shortening. Then, the water phase was structured as a stable hydrocolloid gel to allow better water management during baking. Emulsion systems (water in oil emulsion) containing 35% saturated fat were prepared using a variety of different emulsifiers and crystallized with careful processing control in a pilot scale SSHE and characterized by rheology and water droplet size. Fat systems with good rheological behavior were selected, then used to further prepare emulsions with alginate to structure the water phase. Application tests were then performed with cookies. Control and manipulation of rheological properties were achieved, showing that the mechanical properties of the emulsion could be manipulated through the choice of emulsifier. Emulsions where the water phase was an alginate gel presented the best application performance in terms of cookie dimensions, suggesting better water control during baking. This research aims to build the foundational knowledge to lead to the development of a low saturated fat system that deliver the expected plasticity of a bakery shortening (responsible for proper dough formation) as well as an emulsion which maintains the final cookie dimensions by managing water loss during the baking process.

Quantification of Furan Fatty Acids by LC-MS/MS and their Identification in New Zealand

Marine Oils Matthew R. Miller*[1], Donato Romanazzi[2], Hajime Uchida[3], Johnathon Puddick[2], Yutaka Itabashi[3], Masashi Hosokawa[4], Toshiyuki Suzuki [3], and Michael Boundy[2], *[1]Cawthron, New Zealand; [2]Cawthron Institute, New Zealand; [3]National Research Institute of Fisheries Science, Japan; [4]Hokkaido University, Japan*

Furan fatty acids (F-acids) are heterocyclic fatty acids with a furan moiety in the acyl chain. They are generally found as minor components in the lipid fraction of marine organisms, plants and mammals. F-acids are potent antioxidants and radical scavengers and are thought to contribute to the health benefits of fish-rich diets. The role and benefits of dietary F acids are yet to be fully understood, however they show promising potential as therapeutic marine drugs for the treatment of inflammatory-disorders. Objectives To develop a rapid quantitative liquid chromatography tandem mass spectrometry (LC-MS/MS) method for un-equivocal identification and quantitation of F-acids in marine oils Methods For the past two years, the Cawthron Institute (NZ) has been engaged in an international research collaboration with the Hokkaido University (Japan) and the National Research Institute of Fisheries Science (NRIFS) of Japan to develop novel methods to identify and quantify F-acids. We have developed LC-MS/MS methods that in positive ESI mode, F-acids gave a prominent [M + H] ion, by which individual F-acids could be detected and identified to a level of 5 ng/mL. Results Our LC-MS/MS method provides selective detection of F-acids in marine oils without the need of lengthy sample processing. Through our research we have also identified a new source of F-acids, a unique New Zealand marine oil with surprisingly high levels of these minor fatty acids, offering new research opportunities in this field.

Physicochemical Properties, Chemical Composition and Risk Assessment of Polycyclic Aromatic Hydrocarbons of Commercial Fragrant Rapeseed Oils Youfeng Zhang*, *School of Food Science and Technology, Jiangnan University, People's Republic of China*

Fragrant rapeseed oil is a type of hot-pressed oil in China. In this work, physicochemical properties, chemical composition, presence and risk assessment of (PAHs) polycyclic aromatic hydrocarbons in 38 representative Chinese fragrant rapeseed oil samples were evaluated for the first time. The acid value (0.64-2.68 mg KOH/g), peroxide value (1.58-4.86 mmol/kg) and color value (R=2.6-5.8 Y=35) were all within codex limits. Thirty-two samples whose erucic acid concentrations exceeded 2%. A well negative linear correlation between oleic acid and erucic acid was shown (R2=0.876), which suggested to be a potential marker for prediction of adulteration. Benzo[a]pyrene and PAH4 (chrysene, benz[a]anthracene, benzo[b]fluroranthene, and benzo[a]pyrene) were nd-6.93 and nd-30.79 µg/kg, respectively. Monte Carlo simulation was applied to deal with the uncertainties in the dietary exposure and risk estimation. The median dietary exposure of BaPeq contents from total PAH4 were found to be 0.0826, 0.0530, 0.3082 and 0.0724 ng·kg-1·d-1 for children, adolescents, adults and seniors of male, respectively, whereas that for the above groups of female were 0.0777, 0.0504, 0.3014 and 0.0659 ng·kg-1·d-1. Results from health risk estimation indicated high potential carcinogenic risk. Fragrant rapeseed oil is still a product subject to contamination by PAHs. Limits for PAH4 of fragrant rapeseed oil should be included in Chinese regulation to improve the safety.

The Role of Fat in Determining the Structural and Textural Properties of Semi-sweet Biscuit

Hasmadi Mamat*, *Universiti Malaysia Sabah, Malaysia*

Fat plays a unique role in many food products due to its hygroscopic nature. In the area of baked goods, biscuits belong to a group of products that contains considerable fat and the overall quality is largely determined by the type of fat used. In this study, the effect of fat type on dough rheology properties and quality of semi-sweet biscuit (rich tea type) was investigated using varies techniques. Four types of fat, namely palm oil, palm olein, palm mid-fraction and butter, which varied in composition and solid fat content, were used to produce semi-sweet biscuits. The role of fat and type of fat were analysed in terms of the texture, appearance and the starch behaviour of the final baked biscuit. Rheological properties of the dough were also compared. Texture profile analysis results showed that the type of oil significantly influenced dough rheological properties. Hardness measurement showed that biscuit produced with higher solid fat oil had higher breaking force, but this was not perceived when tested with a human panel. Gelatinization and pasting results showed that fat type also influenced thermal profiles of starch granules in biscuits with most of the granules retaining their crystallinity. Microscopy observations showed that biscuit produced with palm mid-fraction had an open internal microstructure and heterogeneous air cells as compared to the other samples. As conclusion, fat is an important ingredient in baking products and it plays many roles in providing desirable textural properties of baking products, particularly biscuit.

Effect of Tempering Parameters on the Plasticity and Hardness of Puff Pastry Margarine Miroslav Buchmet*, *DuPont Nutrition Bioscience, Denmark*

Puff pastry margarine is one of the most challenging products for the margarine industry. There are many demands to good puff pastry margarine; it must be stable, plastic and non- greasy. Plasticity of margarine is determined by fat base and processing. Usually, fat base consists of palm oil and/or its fractions and some liquid oil. Such blends give good plasticity and workability. But to achieve that, it is necessary to temper margarine at proper temperature right after production and before distribution. Results of this study have proven that tempering conditions have a great influence on the margarine quality. Freshly produced samples of full-fat puff pastry margarine were tempered for one week at temperatures of 10, 20, 30°C, and followed by evaluation after one week's and two months' storage at 20°C. Samples were evaluated by hand for plasticity and workability. Hardness of margarine was measured by means of texture analyzer. The samples demonstrated different plasticity and hardness. Hardest and most plastic were samples tempered at 10°C, followed by samples at 20°C. Samples tempered at 30°C were brittle. Observed behavior can be explained by the polymorphic nature of fat. Data can be used as a guideline during margarine production and troubleshooting.

EAT 4: Phase Transition and Interfacial Phenomena in Complex Food System
Chairs: Dérick Rousseau, Ryerson University, Canada; and Ravin Gnanasambandam, USA

Hydrophilic Fat Crystals: Partitioning Across an O/W Interface Richard W. Hartel*, *University of Wisconsin-Madison, USA*

Under the right conditions, an emulsifier added to a partially-crystallized lipid emulsion can change the dynamics of the fat crystals contained within the globule, causing them to partition out of the liquid oil and into the aqueous phase, effectively creating hydrophilic fat crystals. This was already well documented in 1905 when Lanza patented the detergent fractionation method, but has been studied in numerous examples over the years. The science behind this phenomenon has developed through application of the adhesion tension diagram. By manipulating the contact angle and interfacial tension in the oil-crystal-water system through addition of emulsifiers, conditions can be created where fat crystals within the oil droplet will dewet into the aqueous phase. Interestingly, if fat crystals form inside an oil droplet under the right dewetting conditions, they can also partition through the interface, creating structures that depend on the relative rates of crystallization and dewetting. The importance and mechanisms of fat crystal dewetting will be reviewed and new insights provided.

Aqueous Droplets as Active and Inactive Fillers in Crystal-stabilized Water-in-Oil Emulsions Dérick Rousseau*, *Ryerson University, Canada*

Water-in-oil (W/O) emulsions are increasingly being sought by the food industry as a novel approach to develop foods with reduced saturated fat content, lower caloric load, novel mouthfeel or lessened production costs. Contrary to bulk fats, whose texture and structure largely depend on fat composition and processing conditions, the introduction of a dispersed aqueous phase as an active or inactive filler material into a host bulk fat offers an additional tool to tailor product texture, solidification and microstructure. By interacting with the surrounding crystal matrix, aqueous droplets are active fillers that enhance the rigidity and resistance to deformation of the resulting emulsion whereas inactive fillers show little or no interactions and have either little effect, or reduce, the rigidity of the composite. Recent examples demonstrating this effect are highlighted, namely in rice bran wax and solid fat-stabilized W/O emulsions generated with either glycerol monostearate or polyglycerol polyricinoleate. The former surfactant creates solid shells around dispersed droplets and enhances interactions between the surface of the droplets and surrounding crystalline matrix, which results in many-fold increases in emulsion modulus. Conversely, the latter surfactant greatly limits interactions between the droplets and matrix, resulting in either no effect, or a reduction, in elastic modulus. In both cases, these effects are highly-dependent on the dispersed phase volume fraction. Overall, in addition to the crystalline network itself, the presence and activity of a dispersed aqueous phase exerts an influence on the rheological profile of W/O emulsions and must be considered as a potentially significant contributor to overall rheology.

The role of oscillatory structural forces in the gelation behaviour of Citrem-stabilized nanoemulsions Kunal Kadiya*[1], and Supratim Ghosh[2], *[1]Department of Food and Bioproduct Sciences, University of Saskatchewan, Canada; [2]University of Saskatchewan, Canada*

Nanoemulsions are metastable systems with extremely small droplet size and unique rheological behavior. For example, sodium dodecyl sulphate (SDS)-stabilized 40wt% oil-in-water nanoemulsions transformed into viscoelastic nanogels below a critical droplet

radius due to an increase in the effective droplet volume fraction (Φ_{eff}) beyond random jamming. However, at a very high SDS concentration excess emulsifier micelles triggered oscillatory structural forces (OSF) leading to loss of gelation. In this research, we aimed to form similar nanogels with a food-grade emulsifier, Citrem (citric acid ester of monoglycerides). With an increase in Citrem concentration (0.5-5wt%) the droplet size reduced from 842 to 150 nm, although no gelation was observed. The lack of gelation was attributed to an increase in excess Citrem and corresponding counterion concentration in the continuous phase leading to a decrease in Debye screening length (DSL), and repulsive charge cloud. Hence, Φ_{eff} remained significantly lower than random jamming. Using a mathematical model, we show that the excess Citrem micelles in the continuous phase led to OSF between the droplets, which prevented the transformation of liquid nanoemulsions into viscoelastic nanogels. Interestingly, when the excess Citrem from the continuous phase was removed by multiple centrifugations followed by reconstitution of the nanoemulsions, their gel strength significantly increased due to higher DSL, which significantly improved electrostatic repulsive forces between the two approaching droplets and hence, Φ_{eff} beyond random jamming. Overall, the formation of nanogels at a lower oil volume fraction using Citrem would facilitate low-fat food applications of this novel soft materials.

Crystal Stabilization of Edible Oil Foams Filip Van Bockstaele*[1], Lien Tytgat[1], Robbe Heymans[1], Tom Rimaux[2], and Koen Dewettinck[3], *[1]Ghent University, Belgium; [2]Vandemoortele R&D Centre, Belgium; [3]University of Gent, Belgium*

Edible non-aqueous foams are emerging aerated structures which are prepared by whipping of a cooled mixture (oleogel) of oil and a structuring agent into an air-in-oil system. The structuring agent is usually a high melting component which forms a crystal network upon cooling. During whipping, these fat crystals are present at the air-oil interface and in the continuous oil phase providing interfacial and network stabilization. In our current research, we investigated the impact of processing and type of high melting component on foamability and stability. First, the impact of tempering on a 10% MAG – sunflower oil foam was investigated. Secondly, different types of MAG, DAG and TAG high melting components were applied in foam production following a standard protocol. Rheological properties of the oleogels were determined whereas foam properties included overrun, rheology, bubble size distribution, firmness and oil drainage during storage. The use of tempering revealed that monoglyceride-oil mixtures that were fully crystallized and stored for more than 5 hours at 20°C were seen to form stronger gel networks which included less air, contained smaller air bubbles and were stable during storage. Further, it was found that MAG, DAG and TAG were able to form oil foams but differences were found in overrun and foam stability during storage. Results show options for the production of edible oil foams with different characteristics.

Formation of Low Density and Free-flowing Hollow Microparticles from Butter and Fractionated Palm Oil Mixture Junsi Yang*, Joshua Gudeman, and Ozan N. Ciftci, *University of Nebraska-Lincoln, USA*

The use of solid fats is challenging due to difficulty in incorporating into foods, handling during industrial food production, and relatively high calorie contributions. The objective of this study was to form free-flowing and low density hollow microparticles from nonhydrogenated fats, namely, low-moisture butter and fractionated palm oil, using a novel method

based on atomization of a carbon dioxide (CO_2)-expanded lipid mixture. Melting point of the fractionated palm oil decreased from 66.2 to 47.3 °C above 120 bar in pressurized CO_2. The density of the particles decreased 5 folds compared to that of the original fats. The average particle size D [4,3] decreased from 67.0 µm to 27.1 µm when the concentration of fractionated palm oil was increased from 50 to 100%. Particle size decreased with increasing fractionated palm oil content. The hollow structure was more pronounced for the particles from higher melting oil/oil blends, as well as with more spherical uniformity. Ten percent ($d_{10\%}$) and fifty percent ($d_{50\%}$) of the palm oil particles were smaller than 4.49 µm and 23.0 µm, respectively, whereas they were 14.5 µm and 58.3 µm when mixed with 50% butter, respectively. Polymorphic form of α was more pronounced in the lipid particles. This new method forms low density and free-flowing lipid powders that make the handling and storage of solid lipids feasible and convenient. The higher surface area to mass ratio due to its hollow nature and small size could provide reduced fat usage and calorie intake, and more rapid fat melting in mouth.

High Shear and Ultrasound-assisted Emulsification as Methods for Preparing Sacha Inchi (Plukenetia volubilis L.) Oil Emulsions
Lina-Marcela Gonzalez Cardozo*[1], Claudia Elizabeth Mora Huertas[2], and Luis-Felipe Gutiérrez[3], *[1]Facultad de Ciencias Agrarias - Universidad Nacional de Colombia Sede Bogotá, Colombia; [2]Departamento de Farmacia, Universidad Nacional de Colombia Sede Bogotá, Colombia; [3]Instituto de Ciencia y Tecnología de Alimentos - Universidad Nacional de Colombia Sede Bogotá, Colombia*

Sacha Inchi oil (SIO) is of great attention because of its high content of polyunsaturated fatty acids and tocopherols, and its potential benefits for the human health. Consequently, the possibilities for its use as a high value ingredient for nutraceutical and cosmetic products are of quite interest. In this work we have investigated the high shear (UT) and the ultrasound-assisted (USAE) emulsification processes, using maltodextrin and modified starch (Hi-Cap 100) for preparing SIO emulsions. The effects of the preparation methods on the organoleptic, physicochemical, mechanical, and stability properties of the obtained emulsions were studied. O/W emulsions were prepared with loadings of SIO (20-30%) and solids (30%). The processing conditions were 15000 rpm during 10 min, and then 20000 rpm during 5 min when using UT, and 15000 rpm during 5 min followed by sonication at 50% amplitude during 5 min, when applying the USAE. The results indicated that the droplet size of the emulsions was dependent on the preparation method (UT: 0.1–1.45 µm; USAE: 0.1–2.75 µm). Regardless the preparation method, the emulsions were stable for 3 months, because of the steric effect of the biopolymers adsorbed at the oil-water interface, and the electrokinetic effect. The zeta potential had values around -25 mV. The emulsions exhibited a pseudoplastic behavior, and increased oxidation stability was observed as the oil loading increased. These results indicate that both methods can be employed for preparing stable SIO emulsions, and that the USAE method allows to reduce the processing time.

Performance of a Dairy Based Phospholipid Ingredient in a Low-fat Spread Product
Pravin Gadkari, Ravin Gnanasambandam, and Supratim Ghosh*, *University of Saskatchewan, Canada*

A dairy phospholipid-protein ingredient (DP), produced from buttermilk, was utilized in the development of a 40% fat spread produced with butterfat and canola oil, and their physicochemical properties were compared with products made with traditional oil-soluble

emulsifiers (monoglyceride, PGPR, lecithin). Anhydrous milk fat (20%) was dissolved in canola oil, heated above 40ºC to prepare a molten fat phase and different concentration of the oil-soluble emulsifiers were added. DP was dissolved in the aqueous phase instead of the fat phase. 40% oil-in-water emulsions were prepared with an aqueous phase containing 0.1% xanthan gum using a rotor-stator blender followed by immediately pouring the warm emulsions (>40ºC) into a stainless steel vessel held in an ice bath. The emulsions were mixed vigorously for 10 min while continuously scrapping the crystallized material from the cold surface of the vessel. This process led to phase inversion and the formation of a thick viscoelastic fat continuous spread. The microstructure, spreadability and rheology of the spread samples were evaluated. All samples showed a strong linear viscoelastic region during strain sweep analysis where the storage moduli were higher than the loss moduli. Except for PGPR, all other emulsifier showed comparable values of storage moduli and crossover strain indicating similar rheological behaviour. The spread made with DP was soft, and its spreadability was comparable to the PGPR and monoglyceride-lecithin-based spreads. However, monoglyceride and monoglyceride-PGPR-based spreads were least spreadable than the rest. In conclusion, DP could be successfully used as an emulsifier in the development of fat continuous spread products.

Relationship between stability and structure of sodium caseinate-stabilized emulsions Juan M. Montes de Oca[1], Cristián J. Huck Iriart[1], Federico L. Jara[2], Maria V. Borroni[2], Roberto J. Candal[3], and Maria L. Herrera*[4], *[1]National University of San Martin, Argentina; [2]University of Buenos Aires-ITPN, Argentina; [3]3IA- UNSAM, Argentina; [4]University of Buenos Aires, Argentina*

O/W Nanoemulsions stabilized by sodium caseinate and containing sunflower oil as dispersed phase were prepared using a combination of a high-energy homogenization and evaporative ripening methods. The effects of protein concentration (1 to 4 wt.%) and sucrose addition (2 to 8 wt.%) on physical properties were analyzed by dynamic light scattering (DLS), Turbiscan analysis, confocal laser scanning microscopy, and small angle X-ray scattering (SAXS). To evaluate nanostructure from the SAXS patterns, the Guinier-Porod model was selected. Droplets sizes were smaller (~ 100 nm in diameter) than the ones obtained by other methods (200 to 2000 nm in diameter). The stability behavior was also different. If migration occurred (1 wt.%), sedimentation was noticed. However, in most cases, as droplets were so small, gravitational forces were negligible. On the contrary, when they showed destabilization the main mechanism was flocculation. Stability of nanoemulsions increased with increasing protein concentrations. Nanoemulsions with 3 or 4 wt% NaCas were slightly turbid systems that remained stable for at least two months. According to Turbiscan results, aggregates remained in the nano range showing small tendency to aggregation. Droplet sizes calculated from the SAXS model were in agreement with values measured by DLS. Guinier-Porod parameters showed that the ratio “protein concentration at the interface/free protein” increased with the increased in total concentration, resulting in greater stability than conventional emulsions. Although in less magnitude, sucrose also increased droplet coverage. Due to the small diameter of flocs, protein-protein interactions were weak and therefore systems were stable for long time.

Vegetable and Mineral Oil Organogels Based on Monoglyceride and Lecithin Mixtures Jorge F. Toro-Vazquez*[1], Mayra Aguilar-Zarate[1], Flor Alvarez-Mitre[2], and Miriam A. Charo-Alonso[1], *[1]Universidad Autónoma de San Luis Potosí, Mexico; [2]Universidad Autónoma de San Luis Potosi, Mexico*

We studied the synergistic effect between monoglycerides (MG) and lecithin (LC) to develop organogels in vegetable (VO) and mineral (MO) oils, using concentrations below their minimal gelling concentration. The organogels were developed using mixtures of 2% MG with LC at 2.5%, 1.0%, 0.5%, and 0.25% (wt/wt). The elasticity (G') of the VO organogels showed a logarithmic increase as the LC concentration decreased, attaining a plateau after achieving 7.6 $Moles_{MG}/Mole_{LC}$. In contrast, G' of the MO organogels showed a logarithmic increase as the LC concentration increased. The gelators were less soluble in MO than in VO. However, G' of the MO organogels decreased exponentially as the organogels solid content (%SC) diminished. In contrast, the VO organogels' elasticity showed an direct linear relationship with the %SC. These showed that the synergistic interaction between the MG and LC to develop an organogel occurred in each oil at different $Moles_{MG}/Mole_{LC}$. Infrared studies showed that the MG-LC interaction was mediated through hydrogen bonds, and could be modified through the addition of low amounts of water (≤ 3.2×10^{-3} $Mols_{H2O}/Mol_{gelator}$). The water addition resulted in a change in the crystal habit due to the development of cylindrical micelles (VO) or a higher number of smaller cylindrical micelles (MO). These organogels showed higher rheological properties that the organogels formed without water addition. Compared with MG and LC organogels, the MG-LC organogels had longer stability (≈12 months) against phase separation.

Characterization of Whey Protein-Lipid Interactions within Oleocolloid Matrices through Infrared and Raman Spectroscopy Clifford Park*, Terrence Dent, Rafael Jimenez-Flores, and Farnaz Maleky, *Ohio State University, USA*

Recent consumer demand for high protein content and plant-based fat has necessitated novel approaches to healthy food products. Recently, development of oleogels (semi-solid fat systems structured with liquid oils and organogelators) opened a new area for food formulations. One potential application of oleogels is a novel means of food protein delivery. Therefore, the objective of this work was an in-depth study of Oleocolloid matrices with whey protein in oleogels to generate innovative functionalities in food. Our hypothesis is that whey protein denaturation through thermal and mechanical processing in a hydrophobic environment will expose hydrophobic cores of protein, which would then enable protein-lipid interactions. To evaluate our hypothesis, several Oleocolloid (whey protein, rice bran wax, and high-oleic soybean oil) and Hydro Oleocolloids (Oleocolloid + water) were designed at varying whey protein concentration (2.5 ~ 7.5%). Then, infrared (IR) and Raman spectroscopy were used to characterize the nature and extent of protein-lipid interactions within the developed colloidal systems. Spectra from IR and Raman spectroscopy indicated that thermal and mechanical processing had significant effects on the final whey protein structure. Moreover, there were signs of different protein-lipid interactions when comparing whey protein dispersed and solubilized in either oil or water in the Oleocolloid and Hydro Oleocolloids, respectively. This novel research presents another functionality to other reported oleogels and may facilitate applications of various forms of Oleocolloids in food systems for textural and nutritional applications.

On the Importance of Minor Components and Oil Properties for Oleogel Strength Maria Scharfe*[1], and Eckhard Flöter[2], *[1]TU Berlin, Deutschland; [2]Technical University Berlin, Germany*

In previous studies it was shown that the physical properties of oleogels can be manipulated, amongst others, by the type of oil used. Although the influence of solvent composition has been recognized the detailed mechanisms contributing to the changes in e.g. hardness of the gels have not yet been unraveled in detail. It is believed that a variation of the fatty acid composition as well as the presence of polar molecules (PM) of either natural origin or lipid oxidation alternate the appearance of the elements of scaffolding of β-sitosterol/γ-oryzanol oleogels by concentrating at the surface of primary building blocks and changing the nature of their interaction. To fully address this question properties of the continuous phase as well as their corresponding gels were put into context. These include viscosity, POV and water content (solvent) as well as amplitude sweeps, sol-gel and gel-sol transition, behavior under compression and AFM images (oleogel). The latter showed that tubule bundling was remarkably altered in the presence or absence of TPC. Only little changes in gel-sol transition temperature were observed which indicates that the variations of network properties are not related to changes in the solubility of either β-sitosterol or γ-oryzanol. Gel-sol transition revealed two distinct mechanism of gel disintegration: first tube bundles vanish within a broad temperature range, followed by the disappearance of the tubes themselves. On the other hand, there was a strong dependence of sol-gel transition temperature on TPC content which is associated to stronger gelator-solute interactions in the presence of polar molecules.

EAT-P: Edible Applications Technology Poster Session
Chair: Farnaz Maleky Ohio State University USA

1. **Influence of Physical Fat State Properties on Lipid Digestibility.** Megan Borduas*, *University of Guelph, Canada*

The objective of this study is to determine the influence of physical state of edible emulsified oil properties on lipid digestibility in 0.8 weight (wt.) % Tween 80 stabilized oil-in-water (o/w) emulsions. The oil phase consists of 10 wt. % lipids of one of five ratios of palm olein (PO) and palm stearin (PS) with 25% increments. Development of particle size, zeta potential, distributions and high-quality images from inverted microscope were evaluated for emulsion stability. The emulsion was undercooled to 23 °C (for 30 minutes) then transferred to 4°C, the emulsion was then fed to the TIM-1 after the sample had been warmed to 37°C. This protocol preserved the undercooled state of the lipid and did not contain any crystalline material. A second set of samples was supercooled from ~80°C to 2°C for 20 minutes to induce crystallization. Results between the two trials were compared to ensure changes in lipid digestion, measured on the TIM-1, an in vitro model simulating upper gastrointestinal (GIT) digestion, were associated with changes in the lipid physical state. The rate of lipid digestion is hypothesized to decrease with increasing solid fat content (SFC) and will be altered by physical state of dispersed oil phase within an o/w elusion. The object of this research is to assess how physical lipid state properties of edible emulsion influence lipid digestibility?

2. **Regression Analysis as a Tool to Explore Processing Effects in Palm-based Dispersions.** Ryan West* and Dérick Rousseau, *Ryerson University, Canada*

Though bulk oils such as palm oil have been well-studied, fat-continuous dispersions that include secondary ingredients are much more complex due to ingredient interactions and the resulting changes in properties such as fat crystal morphology and crystallization pathway. These implications restrict the ability to extrapolate responses from bulk oils towards multi-ingredient systems. The effects of processing on the physical properties of both bulk oil and oil-sugar blends over four weeks of storage are explored in this presentation. Predictive regression models were generated to overcome extrapolative limitations and correct for these behavioural differences. This work is of industrial significance as it limits the dependence on anecdote and empiricism to explain results, identifies optimal process values for desirable physical attributes, and opens the door for further investigation into dispersion effects.

3. **In-vitro Release Profiles of Compounds from Water-in-Oil Emulsions Stabilized with Crystalline or Liquid Interfaces.** Vivekkumar H. Patel* and Dérick Rousseau, *Ryerson University, Canada*

The purpose of this study was to explore the retention and release of a water-soluble dye from water-in-oil emulsions stabilized with either glycerol monostearate, glycerol monooleate (4 wt.%, GMS/GMO) or polyglycerol polyricinoleate (2 wt.%, PGPR) as surfactant, along with fully hydrogenated soybean oil (10 wt.%, FHSO) as a continuous phase stabilizing fat. Emulsions were subjected to three stages of in-vitro digestion, namely the oral, stomach and upper intestinal stages, using the INFOGEST method, along with some modifications. Emulsions (20 wt.% dispersed phase) contained methylene blue (1.5 mM) encapsulated within the aqueous phase. Emulsion digestion of these emulsions explored the release of methylene blue from inner

(encapsulated) aqueous phase to the outer (gastrointestinal fluids) under physiological conditions (37°C, and associated pH changes, etc.). The concentration of methylene blue release was characterized and quantified using its absorbance peak at 665 nm. Results dictate that GMS- stabilized emulsions provided better protection against typical in-vitro digestion environments compared to PGPR-stabilized emulsions. Importantly, PGPR emulsions stabilized in combination with FHSO offered greater retention than PGPR alone, but still less than GMS-stabilized emulsions. These results suggested that W/O emulsion stabilization with a solid crystalline shell offers enhanced protection of water-soluble compounds than liquid interfaces, with or within a continuous phase stabilizing, during in-vitro digestion.

4. **Performance of Sunflower Waxes Recovered from Oil Tank Settlings as Oil Structurant Agents.** Cintia Redondas[1], Anabella S. Giacomozzi*[2], Erica Baumler[1], and Amalia Carelli[3], *[1]Planta Piloto de Ingenieria Quimica (CONICET), Argentina; [2]Universidad Nacional del Sur, Argentina; [3]Planta Piloto de Ingeniería Química (PLAPIQUI, UNS-CONICET), Argentina*

The performance of sunflower waxes (SW) recovered from oil tank settling as structuring agents in oleogels was evaluated. SW were recovered from oil tank settlings using hot hexane, and to purify the waxes, they were washed with cold hexane, room-temperature ethanol and filtered through diatomaceous earth. The SW were characterized through color, TLC, GC, polarized microscopy and DSC. A full factorial 32 design was applied to formulate the oleogels, the factors considered were the percentages of waxes (C=1.5, 2.5, 3.5% wt/wt) added to sunflower oil, and the gelling temperature (TG=5, 15, 25 °C). The response factors measured were texture and oil binding capacity (OBC). In addition, the microstructure of the oleogels was studied through optical and polarized light microscopy. The optimum and weakest conditions were characterized by their rheological behavior, color, DSC and SEM. SW was composed of esters between C40-C60 atoms; their color was slightly yellow (b*=1.76±0.21) with red components (a*=9.00±0.03) due to the presence of traces of phospholipids and carotenes, and presented high luminosity (L*=87.74±0.06). The melting and crystallization temperature were 77.64±0.93 °C and 72.69±0.36 °C, respectively. It was concluded that C was the most influential parameter, having a positive effect in the textural parameters and OBC. The optimum condition corresponded to C=3.5%, TG=5 °C and the weakest one to C=1.5%, TG=5 °C. In conclusion, it was verified that SW recovered from oil tank settlings can be used as structuring agents, and that the physicochemical characteristics of the oleogels depends mostly on the content of SW.

5. **Characterization of Emulsions Based on Oleogels Structured with Commercial and Recovered Sunflower Waxes.** Julie Merchan Sandoval[1], Anabella S. Giacomozzi*[2], Camila Palla[3], Amalia Carelli[4], and Erica Baumler[1], *[1]Planta Piloto de Ingenieria Quimica (CONICET), Argentina; [2]Universidad Nacional del Sur, Argentina; [3]Departamento de Ingeniería Química (DIQ) - Universidad Nacional del Sur (UNS), Argentina; [4]Planta Piloto de Ingeniería Química (PLAPIQUI, UNS-CONICET), Argentina*

The aim of this work was to compare textural and rheological properties of emulsions prepared using oleogels of high-oleic sunflower oil (HOSO) with commercial (CW) or recovered sunflower waxes (RW) obtained from sunflower oil winterization waste. Three concentrations of structurant (2, 3.5 and 5 %wt/wt oleogel) were evaluated keeping the amount of remaining components constant, with the final objective of developing a product similar to a commercial margarine. Samples were prepared at

controlled temperature and stirring. First, a molten oleogel was prepared by hot mixing HOSO, wax (CW or RW) and lecithin. Second, an aqueous solution containing salt, skim milk, EDTA, and potassium sorbate was also prepared. Afterwards, these two phases were homogenized to create the emulsion and subsequently stored at 5°C for 24 h allowing the obtention of a semi-solid material. Texture profile analysis and oscillatory frequency sweep tests were performed. The textural results at 3.5 %wt of wax/wt oleogel showed that the hardness of CW emulsions (1.17±0.06 N) was greater than that of RW (0.76±0.01 N). This tendency was also obtained for the adhesiveness (2.25±0.28 vs 0.84±0.05N) and the other structurant concentrations. In addition, an increase in these properties was noticeable with the increase of wax content. Considering rheological results, the tendency was preserved, being G' values greater for CW emulsions. It is important to note that emulsions of CW and RW showed rheological and textural properties comparable to those obtained in a commercial margarine, especially at high concentrations of wax.

6. **The Effect of Lipophilic Emulsifiers in Water-in-Oil Emulsions Gelled in the Continuous Phase.** Jaime D. Pérez-Martínez[1], Diego Orlando García-González*[2], Bernardo Yánez-Soto[2], and Elena Dibildox Alvarado[2], *[1]Lab. Biopolímeros Alimentarios, Facultad de Ciencias Químicas, Universidad Autónoma de San Luis Potosí, Av. Manuel Nava No. 6, 78210, México., Mexico; [2]Universidad Autónoma de San Luis Potosí, Mexico*

The effects of food-grade emulsifiers including polyglycerol polyricinoleate (PGPR), sorbitan monostearate (Span 60) and mono- and diglycerols from high oleic sunflower (GMO), rapeseed oil (GMR), or vegetable fat (GMV) were analyzed at the interface of water and high oleic safflower oil (HOSFO), and on the rheology of water in oil emulsions gelled in the lipid phase with candelilla wax (CW) and fully hydrogenated soybean oil (FH). The interfacial tension was reduced to a higher extent by non-crystallizing emulsifiers. That is, a decrease from 25.6 mN/m^2 for interface without emulsifier to < 1 mN/m^2 for 5% GMO, and 2.3 mN/m^2 for >1.0% PGPR vegetable oil solutions. Solutions with >0.5% Span 60, GMR, and GMV crystallized at room temperature. Emulsions with 5 or 25% of aqueous phase (AP) were prepared with a high-pressure homogenizer at 65 °C and then cooled to 5 °C using a surface excess of emulsifier to reach an average droplet size of 3-micron diameter. Nonetheless, emulsions with 10% FH-0% CW showed phase separation with and without emulsifiers. Most emulsions with 0% FH-3% CW were stable, but those produced with GMV. The elastic modulus of emulsions produce with PGPR always were lower than that produced without emulsifier, and decrease with the increment in AP. A similar trend was shown in emulsions produced without an emulsifier. In contrast, GMO and GME showed and slight increment with the amount of AP. Adding 10% FH to emulsions gelled with 3% CW did not increase the system elasticity.

7. **Phase Behavior, Structure, and Rheology of Oleogels Produced with Candelilla Wax, Saturated Fat and Microcrystalline Cellulose.** Jaime D. Pérez-Martínez[1], Luz Vriridiana Pérez-Meza*[2], and Miguel Ángel Ruíz-Cabrera[2], *[1]Lab. Biopolímeros Alimentarios, Facultad de Ciencias Químicas, Universidad Autónoma de San Luis Potosí, Av. Manuel Nava No. 6, 78210, México., Mexico; [2]Universidad Autónoma de San Luis Potosí, Mexico*

The consistency of plastic fats is determined by the structure of a three-dimensional network of lipid and/or non-lipid solid particles. This study reports on the crystallization process, final rheology, and microstructure of vegetable oil oleogels

produced with candelilla wax (CW; 0 or 3%), fully hydrogenated soybean oil (FH; 5, 10 or 15%) and microcrystalline cellulose (MC; 0, 6 or 9%). Thermal analyses showed that MC had no effect on the crystallization of CW or FH within the temperature range studied. On the other hand, it was found that CW, independently of the concentration of FH and MC, acted as a nucleation site for FH. Therefore, the FH microcrystals were smaller with the addition of CW. The MC increased the elastic modulus (G') of the oleogeles, although, this effect was larger in systems without CW. On the other hand, CW increased G' by more than two orders of magnitude, compared to systems structured just with FH. The scaling behavior of the elastic properties fitted to the Wu and Morbidelli model on the transition regime. The flow point and mechanical reversibility of the studied oleogels were compared to commercial stick margarine. 3% CW oleogels had very low flow point and reversibility, in comparison to stick margarine. Adding MC and FH increased both parameters for 3% oleogels.

8. **Assessing the Bioaccessibility of Curcumin Solubilized in Oleogels.** Robert M. Hallinan*, Chureeporn Chitchumroonchokchai, and Farnaz Maleky[2], *Ohio State University, USA*

Curcumin is a lipophilic bioactive compound with many health promoting properties; however, its therapeutic application in food and medicine is limited by its poor oral bioavailability. This study aims to introduce a novel food-grade oleogel delivery system for curcumin. The solubility of curcumin (0.1% w/w) was tested in different oils by manipulating processing time and temperature. Corn oil was shown to solubilize curcumin most effectively at high temperature. Various concentrations of rice bran wax (RBW) (2%, 6%, and 10% w/w) were used to prepare corn oil oleogels loaded with solubilized curcumin. An oil and curcumin sample prepared without RBW was also prepared to serve as an ungelled control. As expected, sample hardness increased with increasing wax concentration; however, they all showed comparable microstructural properties. The effectiveness of corn oil oleogels as a delivery system for curcumin was assessed and quantified via high performance liquid chromatography after an in vitro simulated digestion study. The gelled systems were shown to promote significant increases in percent bioaccessibility of curcumin compared to the ungelled control. The findings of this study provide insight into the future utilization of oleogels in food, pharmaceutical, cosmetic, and dietary supplement applications.

9. **Optimizing Fat Matrices for the Minimization of Moisture Transport.** Dennis R. Heldman, Farnaz Maleky, and Brandon Howard*, *Ohio State University, USA*

Moisture transfer from a water source to lipid systems was quantified in various fat matrices crystallized under different processing conditions. The most pronounced parameter for decreasing moisture effective diffusivity in samples was found to be the solid fat content (SFC). At > 90% SFC in 100% trilaurin samples, differences in diffusivity became insignificant regardless of the processing parameters. When samples had < 90% SFC, processing conditions, such as shear rate, had a more conspicuous affect by creating a stable, compact crystal network, which caused a decrease in the moisture diffusivity. However, when the shear rate was held constant for lower SFC (<= 40%) samples, processing at slower cooling rates significantly increased the diffusivity, due to increase in crystal size. Surprisingly, it was found that when void space is present in the sample matrix, diffusivities through the void may mask the effects that structural differences have on the diffusion of moisture. Diffusivity was also found to be affected by the presence of additives. When lecithin was added to palm

oil, micelles were formed and seeded a more rapid crystallization in static samples, which caused an increase in the diffusivity. lecithin in sheared palm oil samples interfered with the development of an ordered structure and caused a decrease in diffusivity. Adding cocoa powder to palm oil decreased moisture uptake and different migration mechanisms were induced due to different crystallization conditions. This study concludes that moisture transport in fat matrices is directly influenced by SFC, processing parameters, void space and type of additives.

10. **Use of High Intensity Ultrasound to Change the Physical Properties of Oleogels and Emulsion Gels.** Thais Silva[1], Daniel B. Arellano[2], and Silvana Martini*[3], *[1]Utah State University - Nutrition, Dietetics and Food Sciences Department, USA; [2]Unicamp, Brazil; [3]Utah State University, USA*

The objective of this work was to evaluate the effect of high intensity ultrasound (HIU) on the physical properties of a soft oleogel (2% of candelilla wax, 2% of monoglyceride, and 2% of hardfat) and of water-in-oil (W/O) emulsion gels with various amounts of water (0, 5, and 25%). Physical properties of these systems such as thermo-resistance, microstructure, melting profile, hardness, rheology, and oil loss were measured. When HIU was applied to the oleogel for 3 min using a 3.2 mm-diameter tip at an amplitude of vibration of 216 µm a reduction in crystal size and crystal area ($p < 0.05$) was observed with an increase in hardness and no change in G' nor in oil loss compared to the non-sonicated oleogel ($p > 0.05$). Other sonication conditions (lower power levels, shorter durations, and bigger tips) tested in this study reduced the hardness and elasticity of the sample and decreased oil loss. When HIU (3.2 mm-diameter tip, 216 µm, 3 min) was used in emulsions, harder and more elastic ($p < 0.05$) samples were obtained only in the samples with 25% water. This study shows that the texture of oleogels and emulsion gels with 25% of water can be improved by using HIU. The impact of these results is that the fat content of an emulsion gel can be reduced by 25% by adding water and HIU can be used to recover the structure lost due to water addition.

11. **Revealing the Modulation of Temperature on Triacylglycerol Crystal Networks in Semicrystalline Oil-in-Water Emulsions.** Liu Chunhuan*[1], Zheng Zhaojun[1], Chen Cao[2], and Yuanfa Liu[3], *[1]jiangnan university, China; [2]Jiangnan University, China; [3]School of Food Science and Technology, State Key Laboratory of Food Science and Technology, Jiangnan University, China*

Objective: Partial crystalline oil-in-water emulsions, such as ice cream and whipped cream, should be cooled and stored at low temperature (generally 4°C) for a period of time to establish fat crystal networks and refrigeration is essential during storage, transportation and sales, leading to hefty cool-chain consumption. In order to improve the storage temperature of the cream, exploring the influence mechanism of temperature on this system is imperative. Methods Used: The effect of isothermal crystallization temperature (4 and 20°C) on triacylglycerols (TAGs) crystal networks in oil-in-water emulsions were investigated using recombined cream model by pulsed nuclear magnetic resonance (p-NMR), X-ray diffraction (XRD), differential scanning calorimetry (DSC), polarizing microscope (PLM) and rheometer. Results: Isothermal crystallization temperature did not affect the crystal polymorphs, lamellar packing structure, and slightly affected nanoscale crystal thickness (ξ) in the level of TAG molecules and nanostructure, but significantly changed the crystallization kinetics leading to different spatial distribution of crystals crystallite in the microstructure. Needlelike (N-type) crystals and

higher solid fat content (SFC) were established during stored at 4°C, which induced fat crystal penetration causing partial aggregation of fat globules in emulsions. Accordingly, sufficient stiff fat crystals presented to facilitate the efficient sticking together of the globules via liquid fat bridges into a rigid crystal-based network to allow air bubbles trapping at 4°C. Conclusions: Our findings gave an in-depth the effect of storage temperature on the mechanism of partial aggregation, which is helpful to provide direction for designing cream stored room temperature.

12. **Crystallization Behaviour of Cocoa Butter and Cocoa Butter-sugar Composites Affected by Lecithin and PGPR.** Selvyn Simoes* and Dérick Rousseau, *Ryerson University, Canada*

Cocoa butter exhibits 6 different polymorphs, forms I – VI in ascending thermodynamic stability. Formation of form V crystals is promoted in chocolate as it imparts a glossy finish, a satisfying snap, and desirable melting profile, yet remains solid at ambient temperature. The ability of emulsifiers commonly used in chocolate such as lecithin or polyglycerol polyricinoleate (PGPR) to affect the crystallization behaviour and polymorphic transitions of cocoa butter currently remains unknown. This work explores the relationship between added emulsifiers, lecithin or PGPR, and the crystallization behaviour of cocoa butter, with the aim to enhance the formation of form V crystals during chocolate production and to retard the onset of form VI crystals. We demonstrate that emulsifier structure has a significant impact on crystallization kinetics of cocoa butter, though this depends on the addition of dispersed particulates

13. **The Influence of Lecithin and PGPR on the Properties of Oil-Sugar Dispersions.** Jessica K. Phulchand* and Dérick Rousseau, *Ryerson University, Canada*

The influence of emulsifiers on the interactions of milled sugar particles dispersed in canola or cocoa butter was investigated, using measurements of rheology, interfacial tension, sedimentation, light microscopy, and turbidity. The addition of soy lecithin or polyglycerol polyricinoleate (PGPR) at 0.2, 0.6, and 1.0 wt% of the oil phase was used to evaluate the nature of the interactions between the hydrophilic sugar particles at 30 wt% in the triglyceride oils. Interfacial tension measurements were conducted to determine the adsorption of emulsifier to sugar particles to establish a concentration range for ensuing rheology experiments. Gravity settling observations were made for dispersions of the sugar crystals in the oils containing lecithin or PGPR via turbidity measurements. Lecithin reduced the volume of the sugar sediment to a lesser extent compared with PGPR, suggesting a difference in sugar particle packing density. The higher sediment particle packing density implied that the nature of the emulsifier was important in altering the strength of the attractive forces between the sedimenting sugar particles and this was supported with rheological and microscopy data.

14. **Effect of Degree of De-acetylation of Chitosan on the Gelation Behavior of CITREM-chitosan Stabilized Bilayer Nanoemulsions.** Kunal Kadiya*[1], and Supratim Ghosh[2], *[1]Dept. of Food and Bioproduct Sciences, University of Saskatchewan, Canada; [2]University of Saskatchewan, Canada*

Emulsion gels are used in many foods where the flow behavior is restricted due to either random jamming or the formation of the network of aggregated droplets. For nanoemulsions, random jamming could also be induced by decreasing the droplet size to nanoscale and increasing the interfacial shell-layer thickness. In this work positively charged chitosan with the different degree of de-

acetylation (DDA 40 to 93%) was used to form layer-by-layer electrostatic deposition on negatively charged Citrem (citric acid esters of mono- and di-glycerides)-stabilized oil droplets with the aim to determine the influence of interfacial shell-layer thickness on repulsive gelation. The primary Citrem-stabilized liquid nanoemulsions (d_{32} < 200 nm) were prepared by high-pressure homogenization. After removal of excess Citrem by multiple centrifugations, the secondary nanoemulsions were prepared by adding different concentrations of chitosan at pH 4. With an increase in chitosan DDA, the zeta potential of the oil droplets increased. The secondary nanoemulsions showed a significant increase in viscoelasticity, however, at an optimum chitosan concentration (0.15wt%, 93% DDA), gel strength reached a maximum and the nanoemulsion converted into elastic nanogel. Further increase in chitosan concentration led to liquid nanoemulsions. The repulsive gelation in bi-layer nanoemulsions was attributed to an increase in the overall interfacial thickness due to the formation of a steric interfacial layer and an increase in the DLVO repulsive interaction leading to an increase in effective oil volume fraction beyond random jamming. Such gelation in bi-layer nanoemulsions using a combined electrostatic and steric repulsion can serve as an attractive option to produce low-fat products.

15. **Phase Behavior of Monoglyceride Mixtures in Vegetable and Mineral Oil.** Maria E. Charó-Alvarado*, Flor Alvarez-Mitre, Miriam A. Charo-Alonso, and Jorge F. Toro-Vazquez, *Universidad Autónoma de San Luis Potosi, Mexico*

Several studies describe the phase behavior of monoglycerides (MG) in water. However, there is limited information when it comes to understanding how MG behaves in hydrophobic solvents (i.e., vegetal or mineral oils). Understanding the MG behavior in hydrophobic solvents, would help describing MG-organogels, which recently, represent novel materials with thermo-mechanical properties that could be used as substitutes for lipid spreads, or cosmetic products. MG-organogels are formulated with mixtures of MG where usually the main component is monostearate glyceryl (C18). We investigated the phase behavior of pure MG (C14, C16 and C22) and their blends with C18 in safflower oil and mineral oil. The phase behavior and mechanical properties of the organogels were studied through DSC, X-rays and rheological measurements. The pure and mixed MG-solutions in vegetable and mineral oils, showed the characteristic crystalline transitions (lamella-α, and sub-α). We showed the existence of conditions that affect the development of the crystalline phase (i.e., sub-α2) responsible of the instability of the MG organogels. Apparently, the affinity extent of the MG's aliphatic chains for the solvent (i.e., hydrophobic oils) might favor or prevent the development of the sub-α2 phase. Despite previous reports, we showed that the aliphatic chains are directly involved in the initial self-assembly of MG and that the chain length difference in mixtures of MG modifies the crystallization and melting temperatures of the MG phases.

16. **Melting Behavior and Volumetric Expansion of Solid Lipids in Pressurized Carbon Dioxide.** Junsi Yang* and Ozan N. Ciftci, *University of Nebraska-Lincoln, USA*

Supercritical carbon dioxide (SC-CO_2) has recently attracted great interest to develop clean processes in chemical, pharmaceutical, food, and cosmetic industries. Among them, particle formation has successfully produced composites and microcapsules to develop drug and bioactive carriers. Particularly, SC-CO_2 offers novel green approaches for solid lipid

particle formation. However, the fundamentals needed to design such particle formation processes remain untapped. Therefore, the objective of this study was to investigate the melting behavior and volumetric expansion of lipid classes in SC-CO_2, and to determine the effect of structural differences on the melting and volumetric expansion. Melting point of the CO_2-saturated lipids decreased linearly with increasing pressures up to a certain level and then remained constant. Monoacylglycerol (MAG) exhibited higher melting point depression (18.8%) than triacylglycerol (TAG) (11.2%) and TAG blends with MAG (6.5-15.3%). There was no obvious difference between glyceryl 1,2-distearate (15.0%) and glyceryl 1,3-distearate (15.3%). A positive correlation between the melting point depression and volumetric expansion was observed. Higher volumetric expansion occurred for the MAG (14.4%) compared to the TAG (9.3%) in the linear region of melting point depression curve. Volumetric expansion of the solid lipids at 150 bar/60 ºC was dictated by the competing effects of pressure and temperature on CO_2 solubility. This study generates new knowledge on physical properties of solid lipids in pressurized CO_2 and contributes to the optimization of the novel solid lipid particle formation processes using SC-CO_2. Optimized particle formation will reduce energy consumption due to the melting point depression, and protect heat sensitive oils.

17. ***In vitro* Digestibility of the Novel Fish Oil-loaded Hollow Solid Lipid Micro- and Nanoparticles.** Junsi Yang* and Ozan N. Ciftci, *University of Nebraska-Lincoln, USA*

Effectively incorporating fish oil into foods and beverages is challenging due to water insolubility and sensitivity to oxidation. In addition, omega-3 fatty acids in fish oil, such as EPA and DHA, are structurally resistant to lipolysis, consequently leading to low digestibility and bioavailability. Therefore, the objective of this study was to develop a novel free-flowing powder fish oil formulation that can be added into foods and can protect fish oil from oxidation, and to assess its *in vitro* digestibility. Fish oil was loaded into fully hydrogenated soybean oil (FHSO) via our innovative approach based on atomization of CO_2-expanded lipids through 50 µm diameter nozzle at 200 bar. Nanoparticles were successfully separated from microparticles by filtration, and formed clear liquid when added into water. Moreover, fish oil-loaded particles obtained at 30% initial fish oil concentration ($d_{50\%}$= 8.6 µm) significantly increased the oxidative stability of the loaded fish oil compared to crude fish oil (p*in vitro* sequential simulated digestion, the free fatty acids released from the 30% fish oil-loaded particles (69.7%) was significantly higher than physical mixtures of crude fish oil and bulk FHSO (44%) or empty particles (57%), and the average particle size D [4,3] increased to 24.0 and 166 µm, respectively. This novel method is simple and green, produces easy-to-use dry free-flowing powder fish oil formulation with superior digestibility and potentially high bioavailability. Solid shell prevents fish oil from oxidation and masks fishy smell, hollow structure provides high loading capacity, and nanosize allows fish oil incorporated beverage preparation.

18. **Effect of Polysaccharide Charge on the Formation and Properties of Pea Protein Isolate-pectin Complexes.** Yang Lan* and Jiajia Rao, *North Dakota State University, USA*

Protein–polysaccharide interactions play an important role in a wide range of food and biomaterial applications. Few studies have been carried out on pea protein isolate (PPI)/pectin system and none has provided a complete phase behavior between PPI and pectin. The main objective of this study was to determine

the conditions for the formation of complexes and types of complexes using pectins with different physicochemical characteristics. Pectin allows for the control of both the overall charge by degree of methyl-esterification (DE) including high methyl pectin (HMP) and low methyl pectin (LMP). The effect of pH (8-2), mixing ratio (PPI: pectin, 1:1- 20:1) on phase behaviors of PPI-pectin were studied using phase diagram and zeta potential. Co-soluble biopolymer solutions, soluble and insoluble complexes were obtained in PPI-HMP and PPI-LMP mixtures at specific pHs. Functional properties of complexes (soluble complexes, complex coacervates) were evaluated using isothermal titration calorimetry (ITC), Fourier transform infrared spectroscopy (FTIR) and confocal laser scanning microscope (CLSM). The interaction between PPI and pectin was spontaneous exothermic process ($\Delta G<0$, $\Delta H<0$) during the formation of insoluble complexes, and the stoichiometric ratio of PPI-LMP (3.74±0.39) was much higher than that of PPI-HMP (0.99±0.3). The shift and intensity changes in all amide peaks obtained by FTIR indicated that the electrostatic and hydrophobic interactions were responsible for the formation of insoluble and soluble complexes, and the degree of interactions were highly affected by DE of pectin. Our results might have important implications to apply pea proteins in pea protein fortified food.

19. **Effect of the Addition Order of α-tocopherol and Candelilla Wax on the Oleogel Texture.** Vanessa O. Di Sarli[1], Gabriela B. Brito[2], Karina F. Delgado[2], Denes K. Rosário[2], Carlos A. Conte-Júnior[2], Torres Alexandre[3], and Vanessa N. Castelo-Branco*[2], *[1]Federal University of Rio de Janeiro, Brazil; [2]Federal Fluminense University, Brazil; [3]UFRJ, Brazil*

The macrostructure of oleogels is widely affected by composition of the system (vegetable oil + structuring agents). However, there is a lack of studies about the influence of the order of addition of structuring agents on the oleogels texture. The aim of the present work was to investigate the influence of order addition of α-tocopherol on physical property of hardness of the oleogels. The oleogels were prepared by the mixture (90 °C/30 min) of canola oil, candelilla wax as structuring agent (0.5 or 4%, w/w) and α-tocopherol as co-structuring agent (0 or 5%, w/w). The order addition of the components on oleogels was as follow: 1) canola oil, candelilla wax and α-tocopherol or 2) canola oil, α-tocopherol and candelilla wax. Hardness of oleogels was determined in triplicate in a TA-XT plus texturometer (Stable Micro System, Surrey, UK). Hardness property was affected by the concentration of wax with 0.5% wax-based oleogel showing the lowest hardness, independently of the presence of α-tocopherol, 0.36 N (without α-tocopherol), 0.37 N (addition α-tocopherol after of the wax) and 0.39 N (addition α-tocopherol before of the wax). Otherwise, the addition order of α-tocopherol clearly influenced for hardness of 4% wax-based oleogel. Consequently, wax-based oleogel with α-tocopherol added firstly showed higher hardness (19.7 N) than oleogel with tocopherol added after (16.7 N) and without α-tocopherol (16.5 N). Thus, we observed that hardness of structured network increased proportionally with wax concentration which was also influenced by the addition order of co-structuring agent.

20. **Tailoring Physical Properties of Monoglyceride Oleogels by using High Intensity Ultrasound and Cooling Rate.** Anabella S. Giacomozzi*[1] ***(AOCS Honored Student Award Winner)***, Camila Palla[2], María E. Carrín[2], and Silvana Martini[3], *[1]Universidad Nacional del Sur, Argentina; [2]Departamento de Ingeniería Química (DIQ) - Universidad Nacional del Sur (UNS), Argentina; [3]Utah State University, USA*

The aim of this work was to evaluate the effect of high intensity ultrasound (HIU- 20kHz, 96W, 10s on/5s off) and cooling rate (0.01 and 10°C/min) on the physical properties of monoglyceride (3, 4.5, and 6%) oleogels. Physical properties such as microstructure, melting profile, elasticity (G'), and solid fat content (SFC) were measured after samples reached 25°C (t=0) and after 24h of storage at 25°C. Samples' hardness (HA) and oil binding capacity (OBC) were evaluated after 24h at 25°C. In general, samples stored for 24h were less elastic than samples analyzed at t=0. Slow cooling rate resulted in lower G' after 24h compared to the ones obtained using 10°C/min and HIU did not affect elasticity. However, sonicated samples showed higher G' at t=0 compared to the non-sonicated samples suggesting that HIU increased the crystallization rate. The 3% samples did not form a gel when they were crystallized at 0.1°C/min without HIU, whereas the sonicated samples did form a gel. The 6% samples processed at 0.1°C/min were softer than the 10 °C/min ones. Sonication increased hardness in both cases (0.41±0.01N and 0.49±0.05N for 0.1°C/min and 10°C/min, respectively). Sonicated 6% samples had higher OBC (64.3%±3.0 vs. 85.4%±1.5 for 0.1°C/min, and 70.5±2.4% vs. 91.5±1.8% for 10°C/min, for non-sonicated and sonicated samples, respectively). Smaller crystals were obtained in sonicated samples but no effect of HIU was observed on the melting profile nor on SFC. These results showed that HIU can be used as a potential tool to tailor the physical properties of monoglyceride oleogels.

21. **[Canceled] Oleaginous Potential of Ozoroa insignis and Zanthoxylum zanthozyloides, Two Tropical Plants.**

22. **Effects of Chemical Interesterification on the Palm Oil based Triacylglycerols Solid Fat Content and its Application in Plastic Fats.**

Zhen Zhang*, *South China University of Technology, China*

The chemical interesterification (CIE) reaction between palm oil and different types of oil catalyzed by sodium methylate (CH3ONa) was studied and found that it was still inclined to β'form, and the crystallization rate was increased obviously when interesterified with beef tallow (BT). Adding soybean oil into CIE can significantly increase S/U/U in the system. For pure vegetable oil base, the crystallization rate changed slowly and kept dominant β form. Palm kernel oil (PKO) can reduce S/U/U content after CIE, and when it acts with soybean oil, PKO had a stronger ability to stabilize S/U/U and enrich the triacylglycerols compositions, especially increase the C44 triacylglycerols content, so that the crystallization rate was expedited, and the sample tended to be β'crystal form. The addition of palm mid fraction (PMF) above 30% can improve the high-temperature solid fat content to expand plasticity range during CIE. However, the addition below 30% was ineffective.

23. **Development of Oleogels by Ethylcellulose and Monoglycerides in Vvegetable Oil.** Jorge F. Toro-Vazquez*, Martha Garcia-Ortega, Miriam A. Charo-Alonso, Anaid De la Peña-Gil, and Flor Alvarez-Mitre, *Universidad Autónoma de San Luis Potosí, Mexico*

The ethylcellulose (EC) is a linear polysaccharide derived from cellulose with unique ability of developing oleogels. In the presence of a surfactant (e.g., monoglycerides), the thermo-mechanical properties of EC oleogels are modified because a plausible plasticizing effect by the surfactant. Nevertheless, no experimental results support this. The aim of this research is to evaluate the effect of different concentrations of glycerol monostearate (GMS) in the thermomechanical properties of EC gels in a vegetable oil. The EC

used had a 48%-49.5% (wt/wt) ethoxyl content and according to the manufacturer, a 5% (wt/vol) EC solution in 80% toluene and 20% ethanol provided a viscosity of 4 mPa·s (25 °C). The results obtained by DSC and oscillatory rheology showed that at EC concentration lower than the one required to form a gel (< 8%), a combination of 7% EC and 0.25% of GMS have a synergistic effect developing an organogel. The presence of higher GMS concentration increased the organogel's elasticity. The DSC, infrared spectroscopy and microscopy analysis showed that during cooling a small fraction of the GMS (i.e., 0.25 % to 0.5 %) interacts with the functional groups of EC, decreasing the "free" concentration of GMS in the system. Upon further cooling, the "free" GMS crystallized throughout the EC fiber network acting as filler and increased the oleogels' elasticity. The "free" GMS might act as emulsifier in the formation of O/W emulsions stabilized by the EC network (i.e., organogelled emulsions.

24. **Impact of Curcumin-loading Methods on Lipid Nanoparticles Bioaccessibility: Comparison of Heat-driven and pH-driven Method.** D. Julian J. McClements[1], Xiaoyun Zhang[1], Shengpeng Pen[1], and Bingjing Zheng*[3] ***(Edible Applications Technology Division Student Award Winner)***, *[1]University of Massachusetts Amherst, USA; [2]University of Massachusetts Amherst, Food Biopolymers and Colloids Lab, USA*

In this study, nanoemulsion-based delivery systems fabricated using three different methods. Powered curcumin was dispersed into the oil-in-water nanoemulsions using three methods: the conventional oil-loading method; the heat-driven method; and, the pH-driven method. The conventional method involved dissolving powdered curcumin in the oil phase (60 °C, 2 h) and then forming a nanoemulsion. The heat-driven method involved forming a nanoemulsion and then adding powdered curcumin and incubating at an elevated temperature (100 °C, 15 min). The pH-driven method involved dissolving curcumin in an alkaline solution (pH 12.5) and then adding this solution to an acidified nanoemulsion (pH 6.0). The encapsulation efficiency of the curcumin in the three nanoemulsions was determined and decreased in the following order: pH-driven (93%) > heat-driven (76%) > conventional method (56%). The different curcumin formulations were then subjected to a simulated gastrointestinal tract (GIT) model consisting of the mouth, stomach, and small intestine phases. All three nanoemulsions prepared in this study led to fairly similar curcumin bioaccessibility values (74-79%) although the absolute amount of curcumin present in the mixed micelles was highest for the pH-driven method.

25. **Polymorphic Behavior of Cupuassu Fat and its Fractions as Affected by Thermal Treatments.** Ana C. Rodriguez Negrette[1], Maria J. Rodriguez Batiller[1], and Maria L. Herrera*[2], *[1]University of Buenos Aires-ITPN, Argentina; [2]University of Buenos Aires, Argentina*

Cupuassu fat is a semi-solid vegetable fat obtained from a tree called Theobroma grandiflorum, native to the Amazon. The aim of the present work was to study the polymorphic behavior of cupuassu fat and its fractions (obtained by dry fractionation at 24, 26, and 29°C) crystallized at different temperatures and under a temperature cycle. Samples were analyzed for fatty acid and triacylglycerol compositions, solid fat content (SFC), thermal behavior, crystalline morphology, and polymorphic behavior by small angle X-ray scattering (SAXS) using synchrotron light. Stearin fractions showed a higher content of saturated fatty acids, a higher content of the triacylglicerols POP, POS, SOS, and SOA, and a higher SFC with temperature than original

sample and olein fractions. Cupuassu fat crystallized in the α form up to 17°C. Then, the α form suffered a polymorphic transformation to β'_2. At 18°C the α form did not crystallized. The first polymorphic form that appeared was the β'_1. To crystallize the β_2 form it was necessary to applied a temperature cycle. Oleins and stearin obtained at 24°C showed the same behavior as original sample. Stearins obtained at 26 and 29°C did not showed β' crystals when crystallized under a temperature cycle: α form transformed in β_2 form or in β_1 form, respectively. From these results, stearin crystallized at 26°C that had a β_2 tendency, would be the best for chocolate and confections.

26. **Enzymatic Hydrolysis of Cricket (*Acheta domesticus*) Protein to Generate Functional Peptides for Their Use in a Corn Tortilla Formulation.** Andrea M. Liceaga, Gabriela Calzada Luna*, Fernanda San Martin, and Lisa J. Mauer, *Purdue University, USA*

Insects are an emerging protein source with potential to alleviate the demand for food in the growing world population. Cricket flours are becoming more popular, however binding between protein and chitin limits their functional application in foods. Enzymatically hydrolyzing cricket protein can improve the functional parameters important in food formulations, such as corn tortillas. Alcalase (AL) and Flavourzyme (FL) were used to create cricket protein hydrolysates (CPH) with degrees of hydrolysis (DH) of 5-15%. Functionality was measured by solubility over varying pHs (3-9), and water hydrating capacity (WHC). Physicochemical parameters of CPH-tortillas included mixograph tests, rollability, toughness and extensibility. Overall, CPH were more soluble (50 – 100 %) than the cricket flour (42 – 54 %) at all pH values, while FL- peptides showed superior solubility (52 – 100 %). AL-peptides showed higher WHC (5.7 – 6.7 mL/g) compared to the control (3.8 mL/g) and FL peptides (2.7 – 3.6 mL/g); this correlates to the increased hydration seen for AL-CPH tortilla doughs during mixograph tests.
Rollability tests showed that tortillas formulated with AL-CPH had a weak tortilla matrix, while tortillas formulated with FL-CPH gave excellent rollability properties, suggesting bonding of these CPH with the corn macromolecules. Tortillas formulated with higher hydrolyzed (12 – 14.5 DH %) FL-CPH showed a stronger, more flexible structure, while the AL-CPH tortillas with the same DH had the weaker and least extensible toughness (572.7 - 697.6, 155.1 – 283.8 g, respectively). In conclusion, enzymatic hydrolysis of cricket protein enhances solubility and WHC parameters, while choice of enzyme governs the physical changes that CPH impose on the tortilla matrix. Considering these parameters, CPH can be applied for future food formulations.

27. **Formation of Oleogel as a Replacement of Shortening in Cookies: Impact of Oil Type.** Leqi Cui* and Bingcan Chen, *North Dakota State University, USA*

The overall goal of this research is to develop semi-solid soybean oil that can be used to replace partially hydrogenated soybean oil in the bakery industry. Soybean oil oleogels were fabricated using a single gelator (BS and MAG),or the combinations of two gelators (BS/MAG or BS/GO). The physical,chemical,and rheological properties of the oleogels prepared by two different types of soybean oil have been characterized. The cookies have been successfully prepared using soybean oleogels. The texture of them is identical to the one made by commercial shortenings. The findings from the current study could be applied to produce high oil baking products with improved fatty acid profile.

28. **Effect of Dissolved CO_2 and Low Power Ultrasound on Crystallization Behaviour of Anhydrous Milk Fat.** Bhaskar M. Adhikari*[1] ***(Australasian Section Student Travel Grant Winner)***, Tuyen Truong[2], Nidhi Bansal[2], and Bhesh Bhandari[2], *[1]The University of Queensland, Australia; [2]School of Agriculture and Food Sciences, The University of Queensland, Australia*

A study was designed to observe the effect of dissolved CO_2 (0-2000 ppm) in presence of low power ultrasound on crystallisation and melting behavior, fat polymorphs, microstructure and hardness of pure anhydrous milk fat (AMF) under non-isothermal crystallisation conditions. A calculated amount of dry ice was added to generate 2000 ppm CO_2 at low partial pressure. An ultrasound (205 kHz, 10 s; US) treatment was delivered at 25°C through non-contact metal transducer on the AMF melt. Dissolution of CO_2 followed by US treatment was found to induce the higher onset of crystallisation temperature during cooling from 35 to 5°C at the rate of 0.5°C min^{-1}. The results indicated that dissolved CO_2 influenced the crystallisation behavior resulting in smaller and more number of crystals. This shift in the crystalline structure of AMF with CO_2 treatment also increased the hardness of the AMF at room temperature and refrigerated conditions. The work suggested the potential use of dissolved CO_2 gas with an emission of low power ultrasound to control the crystallisation behavior and thereby the physical properties of milk fat-containing dairy products.

29. **On the Invention of Milk Chocolate by Daniel Peter in 1875.** Kiyotaka Sato*, *Hiroshima University, Japan*

Milk chocolate was created by Daniel Peter at a small village of Vevey of Switzerland in 1875 as one of the top-revolutionary inventions together with cocoa butter extraction (1828), eating chocolate (1847) and conching (1878). In many literature, it has been written that Daniel Peter's success of making milk chocolate was a result of collaboration with Henri Nestlé, the founder of Nestlé Ltd. and the inventor of infant cereals as breastmilk substitutes of newborn babies in the year of 1867. There may be a few reasons for such a story to be highly possible: two persons were neighborly in Vevey, and worked to utilize Swiss milk for foods in the years of 1860s-1870s. However, recently unveiled experimental notes of Daniel Peter, describing precise recipes of milk powder and milk chocolate, clearly show that the milk chocolate invention was performed by the original work of Peter alone without any evidence of the collaboration between Peter and Nestlé. Apart from the different business records, it should be noted that the structures of milk powders of Peter and Nestlé were completely different: the whole milk powder with small amount of water in Peter's powder, whereas the powder with milk, sugar, starch and minerals in Nestlé's powder. We re-constructed Peter's milk powder and milk chocolate, following to Peter's notes, with great success and surprise, since the structures and tastes of Peter's milk chocolate are quite similar to what we can purchase nowadays.

30. **Molecular Features of 1,3:2,4 Dibenzylidene-D-sorbitol (DBS) that Drive Self-Assembly.** Pedram Nasr*, France-Isabelle Auzanneau, Jarvis Hill, and Michael Rogers, *University of Guelph, Canada*

Organogels have the potential to replace trans and saturated fats in foods to serve as transdermal delivery systems and cosmetics. We need solutions to reduce saturated fat, eliminate trans fats, increase polyunsaturated fat and omega-3 fatty acid consumption, while improving on the sustainability of food production. Gelled oil, i.e., organogels, can fulfill all the above requirements. 1,3:2,4

Dibenzylidene-D-sorbitol (DBS) is the most well-known molecule among the Low Molecular weight Organogelators (LMOGs) because of its potential to produce a gel with a broad range of organic solvents. This study will address the role of H-bonds at different positions of DBS in the formation of the self-assembled fibrillary networks (SAFiNs) via synthesizing and isolating DBS-derivatives. These newly synthesized molecules possess different potentials of forming H-bonds while keeping all the other properties of DBS. It is anticipated that these DBS-derivatives will form a gel in fewer organic solvents in comparison to what DBS does; additionally, they may be different in the HSPs. Furthermore, some of the macrostructure properties of the gels corresponding to hydrogen bonds will be studied. This, will provide valuable data on what drives self-assembly in different solvents, filling an extremely important knowledge gap. Once our data set becomes robust enough, a prediction of what gelator HSPs is required to form a gel in a solvent will be feasible. For vegetable oil, once the region in Hansen space has been identified corresponding to gels, HSPiP software, containing more than 1,000,000 HSPs will be searched for edible gelators.

31. **Modelling food protein gels as particle-filled soft solids: Considerations for readdressing established theoretical approaches** Andrew J. Gravelle*, Reed A. Nicholson, Shai Barbut, and Alejandro G. Marangoni, *University of Guelph, Canada*

Fat-containing foods including various dairy products and emulsified meats consist of a dispersed fat phase embedded in a protein matrix. These foods can be described as particle-filled soft materials, and well established particle reinforcement theories are often used to describe their rheological and mechanical behavior. However, existing models provide an incomplete description of food systems, as they do not consider aspects such as filler size, clustering, or imperfect interfacial adhesion. In this work we use a model system to demonstrate established theories do not follow the general trends observed in experimental data; heat-set whey protein isolate (WPI) gels prepared with varying NaCl content, and filled with glass microspheres of distinct size ranges. We present a new, empirically-derived model which more accurately describes the impact of incorporating model fillers on the elastic modulus of the filled protein gels. In the absence of added salt, the proposed model provided excellent fits of experimental data ($R^2 \geq 0.97$). Increasing filler size and associated polydispersity resulted in a reduction in the observed reinforcement. This effect was attributed to an improved filler packing efficiency, which was explicitly expressed in the model through a maximum packing fraction term. Increasing the ionic strength of the WPI gels via addition of NaCl caused a decrease in the extent of filler-matrix interactions. We further demonstrate the empirical model could be adapted to incorporate imperfect interfacial adhesion by combining contributions of bound and unbound fillers using a weighted average approach.