EAT 1: Lipid Crystallization

Chairs: S.S. Narine, Trent University, Canada; and N. Widlak, USA

Combined Effects of Addition of Talc and Cooling Rates on Fat Crystallization. S. Yoshikawa*[1], H. Kida[1], and K. Sato[2], [1]Basic Research Institute, R&D, Fuji Oil Co., Ltd., Tsukubamirai, Ibaraki, Japan, [2]Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan.

Our group has newly found that novel types of additives promote the crystallization of triacylglycerols (TAGs) in bulk systems. In these findings, it has been indicated that the promotion effects are affected by many factors such as amounts of additives, cooling rates, and TAGs. In this study, focusing on talc as an additive, we examined the influence of cooling rates and talc-TAG combinations on the crystallization of different TAGs under the conditions of several cooling rates. The crystallization behavior was observed by the simultaneous use of X-ray diffraction (XRD) and differential scanning calorimetry (DSC), in addition to polarized optical microscope (POM). As a result, talc changed the polymorph-dependent nucleation rate (*J*) as a function of temperature (*T*) in a different way for each TAG. In the case of trilaurin (LLL), 1 °C/min cooling gave the initial crystallization at 26.4 °C (ß' form) without talc and 29.9 °C (ß form) with talc, whereas 5 °C/min cooling gave it at 24.8 °C (ß' form) and 25.4 °C (ß' form) respectively. All results of our present study indicate that the proper cooling rate adjusted to additive-fat combinations enables us to obtain the fat crystals of desired polymorphs at well-controlled crystallization temperatures.

Mixing Behavior of Symmetric and Asymmetric Mixed-acid Triacylglycerols Containing Palmitic and Oleic Acid Moieties. L. Bayés-García[1], T. Calvet[1], M.A. Cuevas-Diarte[1], S. Ueno[2], and K. Sato*[2], [1]University of Barcelona, Barcelona, Spain, [2]Hiroshima University, Higashi-Hiroshima, Japan.

Studies on binary mixture systems provide valuable information about molecular interactions among different lipid materials. In the present work, we examined the mixing behaviour of the TAGs containing palmitic acid (P) and oleic acid (O) moieties: symmetric POP and OPO, and asymmetric POO(rac) and PPO(rac) by using DSC and synchrotron radiation X-ray diffraction measurements. No miscible mixture was formed in any binary-mixture combinations between the above TAGs. Eutectic mixture was formed for POP:POO(rac) and PPO(rac):OPO (eutectic), and molecular compound (MC) formation was formed for POP:PPO(rac), POP:OPO, PPO(rac):POO(rac) and POO(rac):OPO. Specific interactions between the fatty acid chains (saturated/unsaturated) and glycerol conformations of the TAG molecules may be decisive to choose whether the binary mixtures are eutectic or MC forming systems, and whether the MC forming mixtures are thermodynamically stable or metastable.

Effects of Polyglycerine Fatty Acid Esters Having Different Fatty Acid Moieties on Crystallization of Palm Stearin. K. Shimamura*[1], S. Ueno[2], Y. Miyamoto[1], and K. Sato[2], [1]Sakamoto Yakuhin Kogyo Co., Ltd., Ako City, Hyogo, Japan, [2]Hiroshima University, Graduate School of Biosphere Sciences, Higashi-Hiroshima City, Hiroshima, Japan.

We studied the effects of adding emulsifiers, polyglycerine fatty acid esters (PGFEs), on the crystallization of palm stearin (PS), using synchrotron radiation X-ray diffraction and DSC methods. Our main aim was to examine the effects of the molecular shapes of PGFEs containing palmitic and oleic acid moieties at different ratios, the concentration of PGFE additives, and the cooling rate on the crystallization kinetics of PS in combined ways. We found that the effects of addition of PGFEs on fat crystallization occur in opposing manners, promotion or retardation, depending on molecular shapes of PGFEs, additive concentrations and cooling rates. The key is whether the PGFE additives act the roles of template for nucleation or disturb molecular clustering for nucleation.

Evaluation of Various Palm Shortenings on Pie Crust Attributes. W. Owens*, J. Tuinstra, R. Moyers, and R. Daniels, Stratas Foods, LLC, Bartlett, TN, USA.

This evaluation was performed to determine how the crystal structure of palm shortenings influenced the desired characteristics of a cooked pie crust product. Flakiness, height, coloration and overall uniformity are all preferred attributes that are directly related to the functionality of the shortening being used and ones that the bakery industry deems necessary in a quality pie crust. Shortening aids in the contribution of tenderness in the finished pie crust product due to its ability to incorporate and hold air. Research shows that palm

shortenings are more shelf stable with a higher melting. Palm shortening does not need to be hydrogenated making it free of trans-fats and a favorite among bakeries of all magnitudes. Two samples of palm shortenings, with different crystal structure characteristics, were compared in a pie crust formulation with a constant amount of shortening, dry ingredients, baking temperature and time. The samples made with a tighter crystal structure had the most height, were the flakiest, and had more even browning and overall consistency. Research suggests that the contributions to a finished pie crust product can be optimized by altering the crystal structure of the palm shortening during production.

Structural Characterization of Commercial Palm-based-shortenings Using Ultra-small Angle X-ray Scattering and Its Relationship to Physical Properties. F. Peyronel*[1], P. Singh[1], D.A. Pink[2,1], and A.G. Marangoni[1], [1]University of Guelph, Guelph, ON, Canada, [2]St. Francis Xavier University, Antigonish, NS, Canada.

Ten commercial shortenings from Team Foods Colombia S.A were characterized. One of the shortenings was canola based while the other 9 where palm oil and palm kernel oil (PKO) based that differ in their functionality. Differential Scanning calorimeter results show a melting point peak between 38 °C and 44 °C for all of the samples and a second peak between 15°C and 18 °C except for the samples that contained either Palm stearin or PKO that showed a second peak at ~ 25°C.

X-ray diffraction suggested a ß' polymorphism for all the samples except the Hydrogenated Palm Oil that showed a ß polymorphic form. All of the shortenings formed a 3L lamellar conformation. Rheological measurements showed that the PKO shortening had the greatest G' ~10^7 Pa, while the Palm-PKO shortening had the lowest G' of 2 10^6 Pa. Solid fat content as a function of temperature profiles demonstrated the wide variability in plastic behavior. The technique of ultra-small angle X-ray scattering was used for the first time on these complex fat systems to characterize the size of structural units and the spatial distribution of mass for the fat crystals.

A Discrete Stochastic Model for Oil Migration in Chocolate-coated Confectionery. N. De Clercq*[1], P. Van der Weeën[2], C. Delbaere[1], B. De Baets[2], and K. Dewettinck[1], [1]Ghent University, Department of Food Safety and Food Quality, Ghent, Belgium, [2]Ghent University, Department of Mathematical Modelling, Statistics and Bioinformatics, Ghent, Belgium.

Oil migration is an important process in the formation of fat bloom on chocolate-coated confectionery, leading to consumer rejection. However, the exact mechanisms behind this phenomenon are still not completely elucidated, which hampers the development of a mathematical simulation model. In this paper, a model based on a cellular automaton (CA) is proposed and parameterized using experimental data obtained from confectionery model systems. This CA-based model is shown to be able to describe the oil migration in an adequate manner and can therefore be used to calculate an effective diffusion coefficient. Further, the potential of a CA-based approach for the further investigation of the fat bloom mechanisms is demonstrated by means of a case study where capillary rise is incorporated in the CA based model.

Kinetic Distortion to Thermodynamic Predictions in Crystallizing Triglycerides. P. Batchu* and G. Mazzanti, Dalhousie University, Halifax, NS, Canada.

Binary mixtures of saturated triglycerides were crystallized isothermally. Their x-ray diffraction patterns were acquired at regular intervals at the National Synchrotron Light Source, Upton, NY, US. The formation of pairs of phases, with compositions dependent on the composition of the liquid, was quantified using a semi-empirical model to correlate d-spacings with compositions. The mass balances of the liquid and solid phases allowed the determination of the crystallization paths, and the comparison of these paths with the prediction of a previously published kinetic-thermodynamic model. The results clearly indicate that such model is insufficient to predict the composition and ratios of phases of simple binary solid solutions for triglycerides. The methodology of this study allows further research into more lipid systems to provide data to validate new kinetic-thermodynamic models.

Effects of Processing and Formulations on Functional Properties of Cocoa Butter, Sugar and Lecithin. X. Shi*, M. Shavezipur, and F. Maleky, Ohio State University, Columbus, OH, USA.

Studies show that shear can affect the functional properties of cocoa butter (CB). However, knowledge of the impact of shear on crystallization of cocoa butter with addition of sugar, emulsifiers or

both is limited. To study the effect of shear on the functional properties of cocoa butter with addition of sugar and emulsifier, plain CB, a CB/Lecithin mixture, a CB/Lecithin/Sugar mixture were used and crystallized under three shear rates (0/s, 100/s, 250/s). DSC, powder X-ray diffraction, polarized light microscopy, NMR and MRI were conducted to measure the thermal, morphology, structural properties and oil migration rate in these mixtures. Our results suggested that the functional properties of fat crystal network are strongly related to the matric compositions and the process conditions.

Characterization of Cocoa Butter Crystallization Behavior Following Purification. C. Castrodale*[1], A. Lechter[1], D. Sikorski[2], and N. Widlak[3], [1]ADM Cocoa, Milwaukee. WI, USA, [2]ADM Research, Decatur, IL, USA, [3]Retired ADM Cocoa, Milwaukee, WI, USA.

Three unique cocoa butters (CB) with similar triglyceride (TAG) and fatty acid composition (FAC) but different crystallization behaviors were filtered, deodorized, and purified in order to characterize the differences in their crystallization as greater purification occurred. Crystallization behaviors of CBs were characterized following each processing step by solid fat content (SFC), rate of solidification (ROS), melt point, differential scanning calorimetry (DSC), and other methods. In addition, TAG, FAC and minor lipids were monitored. CBs showed crystallization differences during the processing stages, but purified TAG CB had very similar crystallization behavior, although different than the untreated cocoa butters. Therefore, minor lipids and FFAs that are lost during purification have an effect on crystallization.

EAT 2/H&N 2: Digestive Processing: Lipid Structure and Metabolism

Chairs: A. Wright, University of Guelph, Canada; and M.C. Michalski, INSA Lyon, France

Impact of the Food Matrix on Dietary Fat Digestion and Absorption. M.C. Michalski*, CarMeN laboratory, INRA USC1362, INSERM U1060, Villeurbanne, France.

Dietary fats and oils present various fatty acid compositions that are widely studied regarding their nutritional impact. However, these fatty acids are organized into various lipid molecules, which can exist in different food products under several types of supramolecular structures such as emulsion droplets. This presentation will review current knowledge on the impact of lipid structures and the food matrix on lipid hydrolysis in the digestive tract and subsequent intestinal absorption and postprandial metabolism. A specific focus will concern emulsified structures and dairy products, which have been the subjects of great advances in the last years.

Membrane CD36 and Fatty Acid Signaling Coordinate Fat Absorption and Utilization. N.A. Abumrad*, Washington University School of Medicine, St. Louis, MO, USA.

The role of CD36 in cellular fatty acid (FA) uptake, which was identified in 1993, is now supported by strong evidence generated in CD36 deficient rodents and humans. Common polymorphisms in the CD36 gene have been linked to alterations in plasma lipids (fatty acids, triglycerides, cholesterol), to risk of metabolic syndrome and stroke. CD36 functions in high affinity cellular uptake of long chain FA and under excess fat supply CD36 can contribute to lipid accumulation and metabolic pathology. Recent evidence supports the view that CD36 FA uptake and signaling coordinate cellular fat utilization. This view is based on newly identified CD36 actions that involve gustatory fat perception, intestinal fat absorption, secretion of the peptides cholecystokinin and secretin, hepatic lipoprotein output and the production of the FA derived bioactive eicosanoids. Thus abnormalities of fat metabolism and the associated pathology might involve dysfunction of CD36-mediated signal transduction in addition to changes of FA uptake

In-mouth Mechanism Leading to the Perception of Fat and its Consequence on Post-prandial Lipid Metabolism in Humans: The Particular Role of Saliva. G. Feron*[5], C. Vors[1,4], E. Guichard[5], and M.C. Michalski[2,3], [1]Université de Lyon 1, Villeurbanne, France, [2]INRA, U1362 laboratoire CarMeN, Villeurbanne, France, [3]INSA-Lyon, IMBL, Villeurbanne, France, [4]CRNH-RA and CENS, Pierre-Bénite, France, [5]INRA, UMR1324 Centre des Sciences du Goût et de l'Alimentation, Dijon, France.

In humans, the in-mouth perception of dietary fat in food is a complex process involving many sensory modalities (texture, aroma, taste and trigeminal). During food oral processing, a bolus is formed in which saliva is significantly incorporated thus contributing significantly to the perception of fat. In particular, it has been shown that the levels of some salivary characteristics (lipolysis, lysozyme, flux, antioxidant status, level of carbonic anhydrase and proteins) are related to the sensitivity of the individual to triolein and oleic acid. Interestingly, the involvement of some of these salivary variables in the perceived intensity and preference towards model oil emulsions was also shown. In addition to fat perception and preference, recent results show an indirect relation between these salivary components, BMI and post-prandial lipid metabolism in human subjects. It is hypothesized that this relationship should be linked to a difference in fat sensitivity and liking according to the BMI. The role of saliva as a key factor in fat perception in one side and post-prandial lipid metabolism in another side is discussed.

Enhancement of Palm-Oil Derived γ -Tocotrienol Intestinal Uptake and Oral Bioavailability. S. Alqahtani*[1], B. Abuasal[2], A. Alayoubi[1], S. Nazzal[1], P.W. Sylvester[1], and A. Kaddoumi[1], [1]University of Louisiana at Monroe, Monroe, LA, USA, [2]U.S. Food and Drug Administration, Silver Spring, MD, USA.

γ-Tocotrienol (γ-T3) is one form of naturally occurring vitamin E present in palm oil that provide significant health benefits, including anticancer and anticholesterolemic activity, besides acting as a potent antioxidant. γ-T3 is a lipophilic compound with low oral bioavailability. The objectives of this work were to evaluate γ-T3 intestinal uptake mechanism and to improve its bioavailability. *In situ* rat intestinal perfusion studies showed that γ-T3 intestinal uptake is a saturable carrier-mediated process and its intestinal uptake is mediated by Niemann-Pick C1-like 1 (NPC1L1) transporter. Thus, to overcome the effect of this saturable process we have hypothesized that enhancing γ-T3 passive permeability would increase its oral bioavailability. Solid lipid nanoparticles and self-emulsifying drug delivery systems were tested as the delivery systems of choice to enhance γ-T3 permeability and bioavailability. *In vitro*, i*n situ* and *in vivo* studies demonstrated both delivery systems to significantly enhance the permeability and relative oral bioavailability of γ-T3 when compared to γ-T3 prepared as mixed micelles as control. In conclusion, our results showed for the first time that γ-T3 intestinal absorption is partly mediated by NPC1L1 and we successfully were able to improve its bioavailability using two different delivery systems.

***e*-Polylysine Decreases Micellar Lipids Solubility and Enhances the Fecal Lipids Excretion in Rats.** R. Hosomi*[1], D. Yamamoto[1], T. Nishiyama[2], M. Yoshida[1], and K. Fukunaga[1], [1]Department of Life Science and Biotechnology, Faculty of Chemistry, Materials and Bioengineering, Kansai University, Suita, Osaka, Japan, [2]Department of Public Health, Kansai Medical University, Hirakata, Osaka, Japan.

e-Polylysine (EPL) has been used as food preservation substrate and has anti-microbial and anti-viral activities. In addition, EPL has also the hypotriglyceridemic effect through the inhibition of pancreatic lipase activity. In present study, we demonstrated that the effect of EPL on lipid absorption *in vivo* and miceller lipids solubility *in vitro*. Groups of male Wistar rats were fed AIN93G diet containing 1% EPL or 1% L-lysine. After 4 weeks of feeding EPL diet, markedly decreased serum cholesterol (CHOL) and triacylglycerol levels in partly due to enhanced fecal excretions of fatty acids (FAs), CHOL and bile acids (BAs) compared with AIN93G and L-lysine diets. To elucidate the mechanism of enhancing fecal lipid excretions by fed EPL, effect of lipid absorption was evaluated using *in vitro* gastrointestinal digestion model. Lipase activity, micellar solubility of lipids were significantly lower and BAs binding activity was higher in the presence of EPL digests compared with casein digests and L-lysine. These results suggest that the hypolipidemic effect of EPL is mediated by increased fecal FAs, CHOL, BAs excretions, which is due to the digestion products of EPL having reduced lipase activity and micellar solubility of lipids, and increased BAs binding capacity.

Digestion, Absorption, and Potential Toxicity of Edible Nanoemulsions. D.J. McClements*, Department of Food Science, University of Massachusetts, Amherst, MA, USA.

Edible nanoemulsions are increasingly being used within the food industry to encapsulate and deliver lipophilic functional agents, such as oil-soluble colors, flavors, preservatives, vitamins, and nutraceuticals. Nanoemulsions are thermodynamically unstable systems that contain oil droplets with radius < 100 nm. Nanoemulsions have

some advantages over conventional emulsions for certain food and beverage applications: higher optical transparency; greater physical stability; and, higher oral bioavailability of encapsulated lipophilic agents. However, there are also some potential risks associated with reducing the size of the lipid droplets in nanoemulsions that should be considered before they are widely utilized: alterations in the fate of bioactive agents within the gastrointestinal tract; potential toxicity of some of the ingredients used in their fabrication. This presentation provides an overview of the current status of our understanding of the biological fate and potential toxicity of edible nanoemulsions suitable for used in the food and beverage industry.

Influence of Emulsifier Structure on Lipid Bioaccessibility in Oil-Water Nanoemulsions. M. Rogers*, Y. Lan, and A. Sperannza, Rutgers University, USA.

The influence of several nonionic surfactants (Tween-20, Tween-40, Tween-60, Span-20, Span-60, or Span-80) and anionic surfactants (sodium lauryl sulfate, sodium stearoyl lactylate, and sodium stearyl fumarate) showed drastic differences in the rank order of lipase activity/lipid bioaccessibility. The biophysical composition of the oil and water interface has a clear impact on the bioaccessibility of fatty acids (FA) by altering the interactions of lipase at the oil-water interface. It was found that the bioaccessibility was positively correlated with the hydrophilic/lipophilic balance (HLB) of the surfactant and inversely correlated to the surfactant aliphatic chain length. Furthermore, the induction time in the jejunum increased as the HLB value increased and decreased with increasing aliphatic chain length. The rate of lipolysis slowed in the jejunum with increasing HL Band with increasing aliphatic chain length.

EAT 3: Innovative Technologies for *trans* Fat Reduction in Shortening and Oils

Chairs: D. Nakhasi, Bunge Oils Inc., USA; and G. List, Retired, Consultant, USA

PHO Free Bakery Shortenings-Form Follows Function. R.L. Daniels*, Stratas Foods, Memphis, TN, USA.

Bakery shortenings function to impart lubricity, and texture to baked goods. Desired attributes in a bakery shortening are elements which contribute to ease of product formulation, manufacture, and distribution while achieving a consumers' bakery products expectations. A consumers' bakery products expectations typically focused on taste, quality, and convenience, but with advances in nutrition science research and communication has expanded to nutrition attributes as well. Partial hydrogenation based shortenings with a resultant eladic acid content at a level approaching the saturated fat content of the bakery shortening employed traditionally achieved the stakeholders' goals with one obvious exception; fatty acid nutrition due to the presence of trans fats was not optimized. This paper will provide a perspective of options (off-shore oil blends, interesterification, trait enhanced oils, and wild card options like fat mimetics and novel fat blends) framed within the context that commercial viability and consumer product success is the sum of the functional form bakery shortenings achieve from the inputs and the shortening manufacture process employed.

Trait Modified Soybean Oils: Using Genetics to Produce *trans*-Free Oil Solutions that Work. S. Knowlton*, DuPont Company, Wilmington, DE, USA.

Since the initial decision by the FDA in 2006 to require labelling of *trans* fat, the food industry has removed approximately seven billion lbs of partially hydrogenated soybean oil (PHO) from the food system. However, there remains about two billion lbs of PHO still in the market. To further reduce the consumption of *trans* fat, the FDA announced in November 2013 its intent to remove PHO's from the generally recognized as safe (GRAS) list to incent removal of all PHO's from the US diet. Thus a second wave of conversion is expected as the last remaining food companies convert to oils which are naturally stable without the use of hydrogenation. In the mix of options this time however will be an exceptionally stable, soy-based solution in the form of high oleic soybean oil.

High oleic soybean oils (HOSO) are in the market today in limited volume as seed companies ramp production of these trait modified varieties. HOSO has stability enabling a 2x extension of fry life and shelf life, removal of synthetic antioxidants for clean labeling, and the ability to maintain functionality while reducing saturates in shortenings and food

products. HOSO competes favorably with other high oleic oils as a result of a natural base of antioxidants present in the oil. This talk will discuss the current state of HOSO from both a functional and market potential.

Health and Nutrition Update on *trans* Fatty Acids. J.E. Hunter*, Xavier University, Cincinnati, OH, USA.

This presentation will cover four topics related to current health and nutrition aspects of dietary *trans* fatty acids (TFA): (1) current dietary guidelines for TFA; (2) an updated exposure estimate to industrially-produced TFA; (3) a comparison of effects of TFA from industrial and ruminant sources; and (4) a discussion of effects of substituting stearic acid (STA) for TFA. Health professional organizations recommend that intake of TFA from industrial sources be as low as possible. Doell and coworkers have reported a substantial reduction in exposure to industrially-produced TFA in the U.S. from 4.6 g/person/day in 2003 to 1.3 g/person/day currently. Brouwer et al have concluded that all TFA, whether from animal or industrial sources, raise the ratio of plasma LDL- to HDL-cholesterol. Studies involving one-to-one substitution of STA for TFAs have shown a decrease or no effect on LDL-cholesterol concentration and an increase or no effect on HDL-cholesterol concentration. During the last 10 or more years, there has been a major reduction in TFA levels in the U.S. food supply, and efforts continue to reduce these levels further. On the other hand, during this same time period, predictions that elimination of industrial TFAs would likely prevent tens of thousands of coronary heart disease events worldwide each year have not yet materialized.

Reduced *trans* Hydrogenation. N. Higgins*, Bunge North America, Saint Louis, MO, USA.

This talk explores an effort made to develop a reduced *trans* technology as part of the industry's response to the regulatory process leading up to the inclusion of *trans* fatty acid content on product labels. A series of hydrogenation reactions were carried out with nickel catalysts that had been modified by treatment with an acidic organic phosphate ester. This treatment produced a catalyst with reduced selectivity for polyunsaturated fatty acids, with a reduction in the amount of *trans* fatty acids formed per IV drop. These two features resulted in building solids in soybean oil with a 15 to 20 IV drop. Shortening and margarine systems were formulated and commercialized from this type of base oil. These products had a 4% *trans* maximum with an elevation in saturated fatty acids compared to products formulated from traditional partially hydrogenated base stocks. Comparisons will be made between legacy formulations, the reduced *trans* approach, and zero *trans* formulations that were commercialized with respect to saturated and *trans* fatty acid levels.

Using Biotechnology to Produce Healthier Oils. J. Heise*, S. Vacek, and R. Wilkes, Monsanto, St. Louis, MO, USA.

Biotechnology has demonstrated its ability to provide agronomic advantages enabling better weed and pest management strategies in row crops that benefit the farmer and the environment. Recently, biotechnology has also been used to modify fatty acid compositions in soybeans producing healthier oils which directly benefit the consumer. One of these products, contains a high oleic, low sat, low lin fatty acid composition. The improved fatty acid composition results in a highly stabile oil with a reduced propensity towards polymerization without the need for hydrogenation to attain this enhanced level of performance. This high oleic soybean oil significantly reduces levels of saturated fat compared to commodity soybean oil and provides an excellent alternative to partially hydrogenated oils with essentially zero *trans* fat. Another soybean product, enriched with stearidonic acid can provide a sustainable plant-based source of omega-3 fatty acids that maintain the flavor and shelf life of traditional foods routinely formulated with soybean oil. Stearidonic acid helps maintain a healthy heart by significantly increasing levels of eicosapentaenoic acid in red blood cells. An overview of these products and their benefits will be discussed.

Application of Palm Oil as a Versatile Tool to Eliminate Partially Hydrogenated Oils From Food. G. McNeill*, IOI Loders Croklaan, Channahon, IL, USA.

With the proposed ban by the FDA of partially hydrogenated oils from the US food supply, a need for alternatives is urgently required. One approach to making zero *trans* shortenings, fats and oils is the use of naturally occurring semi-solid fats. Palm oil is a versatile, cost effective natural material obtained from the fruit of the oil palm. Without the need for chemical processing, an extensive range of fully functional semi-solid products can be made for a broad range of food categories. This presentation will describe how palm oil can effectively be used to

eliminate partially hydrogenated oils.

Algal Oil Approach to Reducing *trans* Fats in Food Products. W. Rakitsky*, Solazyme, Inc., South San Francisco, CA, USA.

As a result of the recent FDA proposal to remove partially hydrogenated fats/oil from the GRAS list, new technologies will be required to address the functional properties delivered by industrially created *trans* fat containing oils, in their absence. Solazyme's technology platform can address this challenge by using industrial fermentation powered by microalgae to create an entirely new source of triglyceride oils and structuring fats.

In its essence, the technology coverts simple sugars into customized algal triglycerides. Because the technology allows for precise control of fatty acid chain lengths, levels of saturation and position on the triglyceride, products can be designed and formulated that mimic the critical properties (stability, melting profile, crystallization kinetics and stable crystal structure) that *trans* fats have long provided the food industry, all while eliminating the use of industrially derived *trans* fats entirely. By combining and stacking the core transformation technologies, a wide range of properties can be generated using the same manufacturing infrastructure.

Sunflower Oil and Its Applications. M.K. Gupta*, MG Edible Oil Consulting Intl. Inc., Lynnwood, WA, USA.

Sunflower is one of the oldest oilseeds in the Americas. It constitutes a significant segment of oilseeds production in the former Soviet Union Block.

The oil has very good taste and appearance. Today, there is the traditional sunflower oil, which is high in linoleic acid content that makes it excellent for applications as salad oil or cooking oil. The high linoleic acid content makes the oil unstable in industrial or institutional frying. Mid-oleic sunflower, which contains higher oleic acid and lower level of linoleic acid than the garden variety sunflower oil is more suitable for industrial and institutional frying along with the applications such as salad oil and cooking oil. High oleic sunflower oil, which contains 80% or higher oleic acid and very low linoleic acid, is one of the most stable oils for all applications, including industrial and institutional frying.

Sunflower oil has faced the great challenge from soybean and other crops in USA, which has steadily reduced the acreage for sunflower in USA in addition to the reduced demand for the oil in the Middle East. Shorter growing time required for soybean has allowed the Pacific North West and Canada to grow more soybeans. This also has greatly reduced the available acreage for sunflower oil in North America.

Supply of sunflower oil from the Ukraine and the Balkan region will continue to remain strong.

Benefits of High Stability Oils in Food Service. D.M. Booher*[1] and F.T. Orthoefer[2], [1]Dow AgroSciences, Indianapolis, IN, USA, [2]FTO Consulting, USA.

Studies have been conducted to examine the potential for high stability oils to offer longer fry life, longer flavor acceptability, improved nutritionals, operational efficiencies and an overall savings for food service operators.

The first study evaluated a grouping of oils for fry life studying: total polar materials, tocopherols, and Anisidine value and sensory based on frying of French fries, chicken strips, and battered fish. This study was conducted in a controlled setting with TPM being the deciding factor for oil discard.

A second study was conducted in cooperation with a QSR in order to evaluate the useful life of oil when using product sensory/quality as the deciding factor for oil discard. The two oils were also compared for nutritional components and economic impact related to oil usage.

A third study was conducted to look a polymerization of oils to understand the potential for oils to aid in overall operational efficiencies through lower level of polymer formation on kitchen equipment. The Rancimat method was used to determine the oxidative stability and polymer formation.

Enzymatic Interesterificatiion and the Development of Low *trans* Alternatives. T. Tiffany*, ADM Oils, Decatur, IL, USA.

The North American edible oil industry went through a significant change beginning in 2003 when the FDA indicated that in Jan. 1, 2006 mandatory *trans* fats labelling would need to present on NLEA panels. Enzymatic interesterification has been an effective modification technique over the past 14 years in the development of low *trans* alternatives for the North American edible oil industry to address the negative attention paid toward the consumption of *trans* fatty acids. Various feed stocks can be used in the production of enzymatically interesterified

oils, shortenings and hard stocks. Applications utilizing enzymatically interesterified oils and fats are varied and have met with great success. This paper will review various physical and chemical attributes of enzymatically interesterified oils, shortenings and hard stocks in use today and in development.

EAT 4: Delivery Systems

Chairs: N. Garti, Hebrew University of Jerusalem, Israel; and E.J. Acosta, University of Toronto, Canada

Novel Lipid-Based Fluid Molecular Architectures for Delivery of Bioactives and Macromolecules. N. Garti*, Hebrew University of Jerusalem, Jerusalem, Israel.

After years of studying physical properties and polymorphism of fats and oils and attempts to develop novel molecular architectures of surface active agents and lipids we learned to prepare two families of vehicles for delivery of bioactives, nutraceuticals, antioxidants and drugs. The first delivery vehicle was termed NSSL (Nano Size Self-assembled Liquid) and the second LDS (Modified Lyotropic Delivery Systems).
The two types on nano vehicles were studied extensively and utilized in variety of potential applications.

In this presentation we will focus on the LSD mesophases which are modified liquid crystals of cubic and hexagonal symmetries.

Fluid cubic mesophases were made by incorporation of hydrotropes within the head groups of the major lipophilic surfactant (glycerol monooleate and phosphatidyl choline) and triglycerides as spacers within the tails of the surfactants. As a result novel very fluid mesophases were constructed and termed QL. Similarly we managed to form stable fluid modified reverse hexagonal mesophases ($H^{m}II$) in room temperature.

Strategies for Increasing Thermal and Isothermal Stability of Vitamin E-enriched Nanoemulsions Produced Using Spontaneous Emulsification. A.H. Saberi* and D.J. McClements, University of Massachusetts Amherst, Amherst, MA, USA.

We investigated the influences of post-homogenization cosurfactant addition, organic phase, and aqueous phase composition on the thermal and isothermal stability of vitamin E-enriched nanoemulsions containing ethanol as cosolvent (prepared using spontaneous emulsification). Initially, these systems were highly unstable to droplet growth, which was attributed to droplet coalescence and/or Ostwald ripening (OR). Addition of anionic and cationic cosurfactants significantly increased the droplet charge. Also, they appreciably increased the cloud point, but did not improve storage stability. However, organic phase composition (varied by diluting with corn oil) and aqueous phase composition (varied by diluting with water) had an appreciable impact on the cloud point and stability of the nanoemulsions. Addition of corn oil to the organic phase increased the cloud point and long-term stability of the nanoemulsions, which was attributed to decreased droplet coalescence and OR. Decreasing the ethanol concentration in the aqueous phase by dilution with water also improved nanoemulsion stability, which was attributed to decreased droplet coalescence. Nanoemulsions with the highest long-term stability could be prepared by adding corn oil to the organic phase, and water to the aqueous phase.

Measuring Oil Diffusion Through a Fat Crystal Matrix Using Fluorescence Recovery After Photobleaching (FRAP). N.L. Green* and D. Rousseau, Ryerson University, Toronto, ON, Canada.

The question of how liquid oil migrates through a fat crystal matrix is one that impacts the processing and long-term storage conditions of many foods. We use a microscopy-based approach, fluorescence recovery after photobleaching (FRAP), to photobleach a small region within fat crystals and monitor the fluorescence recovery with time. By quantifying the fluorescence recovery, we are measuring the diffusion of liquid oil (canola oil) through a matrix of solid fat (fully hydrogenated canola oil). We vary the ratio of solid fat to liquid oil thus changing the solid fat content and resulting microstructure to explore the role of crystal morphology on oil diffusivity. Our calculated diffusion constants span two orders of magnitude from 0 – 100% liquid oil. Having control over the selected region to photobleach, we can focus solely on certain morphological features, i.e., single

spherulites versus liquid oil boundaries between bordering spherulites. We show that this characterization method, thus far underutilized in food-based systems, is useful for directly probing the effects of local heterogeneties on bulk properties.

Sterol-based Organogels as Extended Delivery Systems. O. Chung, M. Nouraei, and E. Acosta*, University of Toronto, Toronto, ON, Canada.

In this work, transparent and rigid organogels suitable, for drug delivery applications, were produced with pharmaceutical/food grade polar and amphiphilic solvents with HLB values ranging from 0-19. The mechanical properties of the resulting organogels were studied via rheological evaluations as a function of time and temperature, gel texture analysis, differential scanning calorimetry and small angle x-ray scattering. The studies suggests that, independently of the solvent use, the structure of the sterol fibril are similar, producing similar gel structures. The biggest difference is in the stability of the gels after they are placed in aqueous environment, and the release profile from the gels. The more stable organogels are produced with solvents that have low water uptake. The largest release profile (up to six month of zero order release) are obtained with drugs that are more soluble in the solvent than in water. The potential use of these materials as drug delivery systems will be discussed.

Enhanced Body Fat Utilization as Energy by Green Tea Catechins. K. Yasunaga*, Kao Corporation, Tokyo, Japan.

Green tea, one of the most popular beverages consumed in Asian countries, contains a series of polyphenols known as catechins. Tea and tea catechins have been reported to possess various biological and pharmacological effects such as; anti-oxidation, anti-carcinogenic activity, and improving blood lipids and glucose. With pre-clinical studies, we found favorable effects on body fat metabolism after repeated ingestions of 500-600 mg green tea catechins per day. We further conducted a series of studies in animals and human to clarify the enhanced body fat metabolism induced by green tea catechins. In this presentation, we will summarize the results from these studies into following four sections: 1) enhanced body fat metabolism in human studies 2) body weight reduction in human studies 3) animal studies supporting the anti-obesity effects 4) studies examining other health benefits in various populations. These studies suggested that ingestion of 500-600mg green tea catechins per day may reduce body fat, especially abdominal fat, through enhanced body fat utilization as energy, which may contribute to the prevention of metabolic syndrome.

Liposomal Nanoencapsulation of Bioactive Compounds and Their Bioefficacy on Cancer Cells. M. Kulak*, I. Gulseren, A. Guri, and M. Corredig, University of Guelph, Guelph, ON, Canada.

Due to their potential health promoting effects, a wide variety of bioactive compounds from natural resources are being intensely investigated. The prospective applications of these extracts include functional foods, cosmetic and pharmaceutical products. The aim of this research was to encapsulate hydrophobic and hydrophilic bioactive compounds in soy and milk phospholipid nanoliposomes in order to enhance their stability and extend their biological activities. Epigallocatechin gallate (EGCG, beta-carotene and curcumin bearing nanoliposomes were prepared using high pressure homogenization. Cryogenic Transmission Electron Microscopy (Cryo-TEM) micrographs demonstrated that the soy and milk phospholipid nanoliposomes were mostly spherical and unilamellar. Dynamic Light Scattering (DLS) was used to determine the physical stability of the liposomes including particle size distributions. High-performance liquid chromatography (HPLC) was used to determine encapsulation efficiency of all the bioactive compounds.

The bioefficacy of curcumin bearing nanoliposomes was tested in a cancer cell culture environment based on cells originally isolated from human colon carcinomas (i.e., Caco-2). This research found that the nanoencapsulation curcumin is a viable and stable method of destroying cancerous cells.

Impact of a Structured Monoacylglycerol Gel Shortening on Postprandial Lipids and Glucose Following Consumption of Cakes and Cookies. A.J. Wright*, H.M.R. Tulk, A. Goldstein, A.G. Marangoni, and K. Seetharaman, University of Guelph, Guelph, ON, Canada.

Structured emulsions may be used as bioactive delivery vehicles as well as alternatives to shortenings rich in saturated and *trans* fatty acids. A better understanding of their physical and nutritional functionality is required. This randomized crossover human study was undertaken to compare

postprandial lipemia and glycemia following consumption of sugar free cakes and cookies manufactured with a canola oil-containing monoacylglycerol (MAG) gel or the compositionally equivalent ingredients. Comparison with an industry standard shortening was also included. 18 healthy men (19-40 y & BMI = 27 kg/m^2) participated in 6 study visits separated by at least one week. Postprandial triacylglycerol (TAG), glucose, insulin and free fatty acid responses were the same following consumption of the controls versus MAG gel products. Therefore, MAG gel structure had no impact on postprandial metabolism, as measured, although differences in *in vitro* starch digestibility were observed and related to ingredient interactions. The cookies (i.e. lower moisture product) had higher TAG responses than cakes, even when matched for fat content. This agreed with the higher lipolysis observed for the cookies in an *in vitro* digestion assay. Commercial recipe sugar cookies with the MAG gel versus industry standard shortening were lower in fat but similar in postprandial metabolism.

Dynamic of Moisture Diffusivity in Solid Triacylglycerols. Q. Duong*, A. Purgianto, and F. Maleky, The Ohio State University, Columbus, OH, USA.

Moisture migration through multi-compartment foods negatively affects product quality and safety. The effect of processing condition, crystallization temperature, emulsifier, solid particle, and storage conditions on vapor migration through lipid moisture barrier were studied. Palm oil and palm oil blends were structured under laminar shear applications and static conditions. Gravimetric experiment was conducted by sealing uniform-sized lipid disks over plastic cups containing known relative humidity (RH), then put into desiccators containing a different known RH. For pure palm oil, lipid barriers formed under laminar shear gave lower water vapor permeability compared to barriers formed under static condition. The addition of emulsifier into the fat system agreed with this result, showing similar trend with sheared samples having lower moisture permeability. Interestingly, when solid particle (cocoa powder) was introduced into palm oil, the opposite trend was observed. These results suggest that media formulation in combination with processing conditions affect moisture barrier properties differently. It would be of interest to look further into the role of formulation in functionality in future studies.

Improvement of the Water Solubility, Oxidative Stability, and Antioxidant Capacity of Conjugated Linoleic Acid for Enrichment of the Beverages. S. KoohiKamali*, Department of Food Science and Technology, Faculty of Agriculture, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran.

Conjugated linoleic acid (CLA) reported to be a functional fatty acid. The water insolubility and oxidative instability of commercial CLA have limited the applications of CLA. Aim of this research was to produce an oxidative stable hydrophilic CLA by attachment of Lysine (Lys), a polar amino acid, into CLA structure. Formation of Lys-CLA was confirmed by FT-IR at 1650 and 1550 cm-1. The highest water solubility was at pH 2, Lys-CLA of = 1.75% with no added salt (two weeks at 25 ± 1 °C). Peroxide value (PV) was increased by approximately 16-fold (12 h at 60 ºC) for CLA; however, the PV of Lys-CLA was increased by only 1.4-fold, showing that oxidative stability of Lys-CLA has been improved compared with CLA alone. Antioxidant activities of Lys-CLA, CLA and Lys were evaluated using ABTS and DPPH assays. All samples displayed radical scavenging activities in both assays. Lys-CLA with the smallest half maximal inhibitory concentration (IC50) showed the maximum antioxidant activity among the rest ($p < 0.05$). The antioxidant activity of Lys-CLA found to be synergistic in DPPH. This study showed that incorporation of Lys into the CLA molecule can improve the oxidative stability, antioxidant capacity and water miscibility of CLA.

Improved Bioavailability of Rosemary Supercritical Extract Through Encapsulation in Different Delivery Systems After *in vitro* Digestion. E. Arranz*[1,2], M. Corredig[1], A. Guri[1], T. Fornari[2], G. Reglero[2], and S. Santoyo[2], [1]University of Guelph, Guelph, ON, Canada, [2]Institute of Food Science Research (CIAL, CSIC-UAM), Madrid, Spain.

For more than a decade, supercritical fluid extraction has been employed to obtain bioactive ingredients. *Rosmarinus officinalis* is an aromatic plant well studied for its health promoting properties. Carnosic acid and carnosol, the main compounds of the supercritical rosemary extract (SRE) have shown to display low bioavailability due to their high hydrophobicity. The aim of this work was to enhance the bioavailability of carnosic acid and carnosol by encapsulation of SRE using different delivery platforms, protein nanoparticles (casein

micelles) and oil droplets (soybean oil in water emulsion). Emulsions and casein dispersions were digested *in vitro* with simulated gastric and intestinal fluids and their bioavailability on Caco-2 cell monolayers was determined. Carnosic acid and carnosol present in the apical, basolateral fractions and accumulated in the cell were analyzed by HPLC-MS/MS. Results indicated that encapsulation using casein micelles and emulsions increased the bioavailability of carnosic acid and carnosol, by protecting degradation during digestion. Almost 10% of carnosic acid was detected in the bioavailable fraction, only after 4 h incubation time. These results demonstrated that SRE can be successfully incorporated into food grade formulations with enhanced health promoting properties

Co-crystallization of Free-phytosterols with Triacylglycerols as a Delivery System to Reduce Plasma Cholesterol. D. Franchetti* and N. Acevedo, Iowa State University, Ames, IA, USA.

Phytosterols have been known to reduce blood cholesterol levels. Fully hydrogenated soybean oil (FHSO), liquid soybean oil (SO), and free-phytosterols (FPS) were melted and co-crystallized upon cooling. Stigmasterol, beta-sitosterol, and a 1:1 weight ratio of stigmasterol and beta-sitosterol were used. Results from oil loss over time show when phytosterols are added, oil loss decreases compared to the control. The added phytosterols showed desirable oil loss values of 4 to 8%, which are comparable to commercial shortening. G' and yield stress values of 200 to 800 Pa suggest the enriched FPS fats fall within the range of spreadability acceptable for bakery purposes. Polarized light microscopy images show that both stigmasterol and beta-sitosterol crystallized in star-like clusters of needles. Co-crystallization of FPS with the FHSO and SO was confirmed from a lack of phase separation in PLM and the absence of endothermic peaks from the pure phytosterols in DSC.

EAT 5/S&D 5.1: Suspensions, Emulsions, and Foams

Chairs: S. Ghosh, University of Saskatchewan, Canada; and A. Ramchandran, University of Toronto, Canada

Microbeam X-ray Diffraction of Pickering Fat Crystals at the Oil-water Interface. D. Rousseau*[1], S. Ueno[2], K. Sato[2], and G. Mazzanti[3], [1]Ryerson University, Toronto, ON, Canada, [2]Hiroshima University, Higashi-Hiroshima, Japan, [3]Dalhousie University, Halifax, NS, Canada.

Synchrotron microbeam small angle X-ray diffraction (μ-SAXD) was used to probe surfactant and triacylglycerol (TAG) molecular arrangement at the oil-water interface of water-in-oil emulsions stabilized with glycerol monostearate (GMS) and fully hydrogenated canola oil (HCO). The μ-SAXD experiments permitted spatial analysis of the polymorphic structure and orientation of surfactant and TAG lamellar planes at different positions around the periphery of the dispersed aqueous droplets. There were 2 key findings from this study: i) the lamellar planes of crystalline GMS were highly aligned at the oil-water interface and ii) GMS templated HCO crystallization, resulting in oriented HCO crystals that extended well into the continuous oil phase. Overall, these findings provided further evidence of the interfacial orientation of surfactants at the oil-water interface and their role on interfacial templating of TAGs.

Fabrication of Reduced Fat Products by Controlled Aggregation of Lipid Droplets. B.C. Wu*[1], B. Degner[2], and D.J. McClements[1], [1]Department of Food Science, University of Massachusetts Amherst, Amherst, MA, USA, [2]ConAgra Foods, Omaha, NE, USA.

The creation of high quality reduced-fat food products is challenging because the removal of fat adversely affects quality attributes, such as appearance, texture, and flavor. This study investigated the impact of pH- or calcium-induced droplet aggregation on the microstructure and physicochemical properties of model mixed colloidal dispersions containing 2 wt% protein-coated fat droplets and 4 wt% modified starch (hydroxypropyl distarch phosphate). DIC and confocal microscopy showed that the aggregation state of fat droplets dispersed within the interstitial region between the starch granules can be altered by modulating the inter-droplet electrostatic interactions using either pH adjustment or calcium addition. Systematically controlling pH and calcium concentration can

modulate the microstructure of the mixed colloidal dispersions and obtain a system with a high yield stress and apparent viscosity and other desirable properties. This study has important implications for fabricating reduced fat food products with desirable sensory attributes such as sauces, dressings and deserts.

Application of the HLD and NAC Models to Predict the Size and Stability of Emulsions. S. Kiran* and E. Acosta, University of Toronto, Toronto, ON, Canada.

Emulsions represent surfactant encapsulated droplets of one medium (oil or water) dispersed throughout the other. These mixtures are of growing interest across various applications such as the design of agricultural, coating, crude oil, foodstuff, paint, and pharmaceutical products owing to their tailorable size and stability. It has been demonstrated by a number of past researchers that the above emulsion properties are a function of the underlying phase behavior of related microemulsions (μEs). The first objective of this work is to therefore illustrate how the measured size and stability of emulsions formulated with sodium dihexyl sulfosuccinate (SDHS), toluene, and water vary across a Type I-Type III-Type II phase behavior scan. To do so, the hydrophilic-lipophilic deviation (HLD) model is used to help guide formulation changes. The second objective of this work is to in turn predict the measured size and stability of these emulsions. This is accomplished with the aid of the net-average curvature (NAC) model.

Experimental Investigation of Sub-micron Water Droplet Formation in Bitumen Froth. R. Sonthalia*[1], A. Ramachandran[1], and S. Ng[2], [1]Department of Chemical Engineering & Applied Chemistry, University of Toronto, Toronto, ON, Canada, [2]Edmonton Research Centre, Syncrude Canada Ltd, Edmonton, AB, Canada.

Processes such as centrifugation and inclined settling are currently used to achieve the separation of water and solids from bitumen froth in the oil-sands industry. They are, however, ineffective in removing sub-micron water droplets, which can form a significant fraction of the residual water content in bitumen after separation. The aim of our project is to understand the mechanisms of formation of sub-micron-scale water droplets, and to suggest remedies to mitigate their production. Our current focus is to assess if the combination of hydrodynamics and interfacial composition/properties could be leading to small droplets. Preliminary experiments were performed in a co-flowing device with a aqueous-bitumen system. We observed the tip streaming of fine threads (<2um diameter) of the core fluid that produced sub-micron droplets for capillary numbers less than the critical value for primary drop breakup. This implies that there could be mixing conditions where drops could tip stream to produce sub-micron droplets, but not break up. We will also discuss results from a systematic study that is currently exploring the effects of viscosity ratio, bitumen weight fraction and concentrations of asphaltenes and naphthenates.

Impact of Droplet Size and Emulsifier Concentration on Nanoemulsion Gelation. V. Erramreddy and S. Ghosh*, University of Saskatchewan, Saskatoon, SK, Canada.

We show that liquid nanoemulsions (NE) stabilized with ionic emulsifier can be transformed into viscoelastic gels by reducing droplet size. 40wt% canola oil-in-water NE were prepared with different amount of sodium dodecyl sulfate (SDS) or Tween 20 by high-pressure homogenization. During homogenization viscosity of SDS NE progressively increased as the droplet size decreased and beyond a critical droplet radius (65-90 nm), the liquid NE transformed into viscoelastic gel. The yield stress and elastic modulus of the nanogels increased with SDS concentration until 15 times the critical micelle concentration, thereafter decreased steadily till it became liquid beyond 25 times CMC. The repulsive electric double layer on the nanodroplet surface significantly increased the effective oil phase volume fraction such that the nanodroplets kinetically jammed to provide elastic behavior. NE prepared with non-ionic Tween 20 did not show any elastic behavior, as no repulsive barrier was formed. At intermediate concentrations of SDS, depletion attractions by micelles in the continuous phase further improved nanogels' elastic behavior, while at higher concentration SDS micelles acted as depletion stabilizer and their overall charge screened the repulsive interactions among the nanodroplets, leading to gel breakdown. The NE gels possess great potential for use in low fat foods.

Trends in Structuring Edible Emulsions with Pickering Fat Crystals. D. Rousseau*, Ryerson University, Toronto, ON, Canada.

This presentation proposes a new

microstructure-based nomenclature to delineate three classes of fat-based Pickering stabilizers: Types I - III. Type I stabilization results from the solidification of lipids at the droplet surface during cooling of freshly-formed emulsions either via interfacial crystallization, as is commonly observed with high-melting, oil-tending surfactants, with the crystal morphology of the resulting fat crystals consisting of mono- or multilayers, individual crystals or even spherulites. Type II stabilization involves the diffusion or migration of previously-formed micro or nano-scale crystals or particles towards the oil-water interface, with possible species being TG crystals or lipid particles. Emulsion formation and stabilization with Type II species may arise due to the inherent surface activity of the crystal/particle or may require the use of a surfactant layer to aid in emulsification and particle adsorption. Finally, Type III stabilization consists of micron or nano-scale droplets encased within crystalline shells significantly larger than the droplets themselves. These spheroidal crystalline assemblies form due to combined surfactant-TG molecular compatibility (as per Type I above) and shear cooling in a micro-confined environment, the result being agglomerated fat crystal microstructures containing encapsulated droplets.

Formulation of Lipopeptide Biosurfactant Mixtures for Dispersing Oil Spill in Seawater. W. Rongsayamanont*[1,6], S. Soonglerdsongpha[2], O. Pinyakong[3,6], C. Tongcumpou[4,6], D.A. Sabatini[5], and E. Luepromchai[3,6], [1]International Postgraduate Programs in Environmental Management, Graduate School, Chulalongkorn University, Patumwan, Bangkok, Thailand, [2]Environmental Research and Management Department, PTT Research and Technology Institute, Ayutthaya, Thailand, [3]Bioremediation Research Unit, Department of Microbiology, Faculty of Science, Chulalongkorn University, Patumwan, Bangkok, Thailand, [4]Environmental Research Institute, Chulalongkorn University, Patumwan, Bangkok, Thailand, [5]Schools of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK, USA, [6]Center of Excellence on Hazardous Substance Management (HSM), Chulalongkorn University, Patumwan, Bangkok, Thailand.

This study aimed to formulate a biocompatible (low toxicity) oil dispersant by mixing lipopeptide biosurfactant, synthetic surfactant and electrolyte. The lipopeptide biosurfactant was produced by *Bacillus* sp. GY19 using waste glycerol and palm oil as substrates. The biosurfactant was found to be relatively hydrophobic since it could lower interfacial tension values against hexadecane better than toluene. In addition, the biosurfactant was stable under a wide range of temperature, alkalinity, and electrolyte concentrations and was not toxic to brine shrimp, vegetable seed and PAH-degrading bacteria. To improve its surface activity, the lipopeptide biosurfactant was mixed with 0.1-2 % of various synthetic surfactants and/or electrolytes. Biosurfactant mixtures lowered the IFT values of hexadecane and toluene to the range of 0.07-0.46 mN/m when the concentrations of additives increased. The oil dispersion efficiency of various biosurfactant mixtures were later investigated with synthetic seawater and a local seawater sample. When compared with a commercial dispersant, the mixture of lipopeptide, Triton X-100 and K_2HPO_4 dispersed Oman light crude oil and fuel oil at 100% in both seawater samples. Consequently, lipopeptide biosurfactant mixtures have a potential for lowering IFT and showed a great promise for use as an oil spill dispersant.

N-alkylimidazole as CO_2-swithable Surfactant. Z. Zheng*, M. Chai, L. Bao, and W. Qiao, Dalian University of Technology, Dalian, Liaoning, China.

Due to global environmental pollution and rich carbon dioxide as a friendly solvent, CO_2-swithable surfactants as a kind of functional surfactant are more attractive. We found that functionalized N-alkylimidazoles (amidine group existed in the imidazole ring) show the similar switchablity compared with long chain alkyl amidines. In the present work, we focus on the switchablity of four N-alkyl imidazole compounds synthesized in our lab. They can be reversibly transformed from uncharged to charged species by exposure to carbon dioxidec, reflecting in the repeatedly conductivity increase-decrease cycle in their aqueous solution under alternatively CO_2/N_2 stimuli. The emulsion prepared by CO_2-induced imidazole can be stable for more than 5 hours, and be broken by bubbling N_2 for 20 min. The cycle of emulsion-demulsion can be repeated at least 5 times.

Structure Parameter: Modeling Ice Cream Meltdown Test. M.M. Warren* and R.W. Hartel, University of Wisconsin-Madison, Madison, WI, USA.

A structure parameter has been developed to model the relationship between partially-coalesced fat globules and meltdown rates of ice cream.

Commercial vanilla ice cream products were analyzed for their fat content, degree of partial coalescence, mean ice crystal and air cell size, and overrun. The conventional meltdown test, where ice cream melts on a mesh screen, was also studied to measure meltdown rate and percent change in height. The foam that remains atop the mesh screen (Top) after the meltdown test provides great insight into structural elements that affect the behavior of ice cream. The structure parameter was developed utilizing the Top of the meltdown test. Fat destabilization level of the melted ice cream, as determined by the relative number of clusters to initial emulsion droplets, did not predict the drip-through or stand-up properties of the ice cream products. However, the structure parameter (Top cluster density) predicts the behavior (drip-through and stand-up properties) of ice cream products. This parameter accounts for size and number of partially coalesced fat globules and the volume they occupy. By understanding and controlling partially-coalesced fat in ice cream, the structure parameter can model, control, and predict the behavior of ice cream products.

EAT 5.1: General Edible Applications Technology

Chairs: M.A. Rogers, State University of New Jersey, USA; and K. Miyashita, Hokkaido University, Japan

Effect of Milk Sphingolipids on Lipid Metabolism. I. Yamauchi[1], M. Shiota[2], M. Hosokawa[1], and K. Miyashita*[1], [1]Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan, [2]Megmilk Snow Brand Co Ltd, Kawagoe, Japan.

Dairy products are most likely to be major source of milk phospholipids (PL) and milk sphingolipids (SL). Both polar lipids have been reported to show several health beneficial effects such as memory improvement, antimicrobial activity, anti-inflammatory effect, protection against gastric ulceration, and improvement of lipid metabolism; however, the detail mechanism for the physiological effect of these PL and SL has not yet been made clear. In the present study we evaluated the effect of milk polar lipids on the lipid metabolism of obese-model mouse (KK-A^y), especially focusing on milk SL. Milk SL was separated from total lipids of butter serum by liquid-liquid distribution, lipase hydrolysis treatment, and silicic acid column chromatography. Animal experiment showed that 1% milk SL supplementation significantly reduced plasma cholesterol and triacylglycerol levels as compared with control. Moreover, blood glucose of mice fed 1% milk SL was significantly lower than that of the control. Hepatic triacyglycerol level also decreased significantly by milk SL feeding. Although there was no significant difference in the fatty acid composition of all dietary lipids, decrease in the ratio of 18:1n-9 to 18:0 and the increase in 22:6n-3 (DHA) were significantly found in the liver lipids of the mice fed milk SL.

Effect of n-3 PUFA-rich TG on Lipid Metabolism of Diabetic/Obese Mice. M. Hosokawa*, Hokkaido University, Hakodate, Hokkaido, Japan.

n-3 polyunsaturated fatty acids are health functional fatty acids. We prepared n-3 PUFA rich triglyceride (PUFA-TG) containing 5.0% EPA, 19.8% DPA and 47.0% DHA by enzymatic reaction and examined the effect on lipid metabolism on diabetic/obese mice. PUFA-TG suppressed body weight and white adipose tissue weight gain. In mice fed PUFA-TG, hepatic fatty acid synthase activity decreased and hepatic ACO activity increased. Their lipid metabolism regulated by PUFA-TG was stronger than those of fish oil. Further, PUFA-TG increased UCP1 mRNA expression in white adipose tissue. These result suggests that PUFA-TG is highly functional lipid regulating lipid metabolism in diabetic/obese mice.

Understanding Acylglycerol Polymorphism from the Stereochemical Perspective. R.J. Craven* and R.W. Lencki, Department of Food Science, University of Guelph, Guelph, ON, Canada.

Determining the mechanism behind acylglycerol polymorphism has challenged researchers for more than 150 years. The development of the stereochemical perspective has undoubtedly led to a more complex view of lipid crystallization behavior. On the other hand, this new perspective also provides simple, plausible mechanistic solutions for many nagging research problems. For example, it has recently been reported for some pure triacylglycerols that the racemic mixture crystallizes

first in the alpha form under conditions where the corresponding pure enantiomer crystallizes directly into the beta-prime form. Research has established that the alpha form is a solid solution and that the beta-prime form is a conglomerate (mechanical mixture of crystals of pure enantiomer). Accordingly, the enantiomer readily forms crystals of pure enantiomer (beta-prime form) from the melt whereas chiral resolution into crystals of pure enantiomer is required to obtain the beta-prime form from the racemic mixture melt. Evidently, kinetics favor formation of the solid solution (alpha form) over chiral resolution (beta-prime form) for the racemic mixture. This and several other mysteries will be addressed in the presentation.

Structures in Liquid Triglycerides. G. Mazzanti* and L. Lin, Dalhousie University, Halifax, NS, Canada.

The measurement of small and wide angle scattering patterns of liquid triglycerides were compared with NMR diffusivity measurements. Both methods indicate the presence of structural entities that are of a multimer nature. Based on the volume of these multimers it has been possible to estimate the approximate number of single molecules in each one, as a function of temperature and type of triglyceride. The results from the combined NMR and scattering methods are consistent with the multimer model that was postulated in 2013 based on x-ray scattering data.

Aggregation in Complex Triacylglycerol Oils: Coarse-grained Models, Nanophase Separation, and Aggregation. B. Quinn[1], T. Gordon[2], A.G. Marangoni[3], F. Peyronel[3], C.B. Hanna[2], and D.A. Pink*[1,3], [1]St. Francis Xavier University, Antigonish, NS, Canada, [2]Boise State University, Boise, ID, USA, [3]University of Guelph, Guelph, ON, Canada.

We modelled an edible oil comprising solid triacylglycerol (TAG) fats, essentially insoluble in a multi-component liquid TAG oil in order to understand the process of oil-binding capacity. Acevedo and Marangoni showed that solid SSS forms crystalline nanoplatelets (CNPs). Pink *et al*. modelled CNP aggregation in triolein (OOO), predicted they would aggregate into TAGwoods and that TAGwoods would form fractal structures. This was confirmed by Peyronel *et al*. Here we model CNP aggregation in a complex oil such as a cottonseed oil-OOO mix. We assume that highly-anisotropic CNPs are formed, that oil nanophase separation (MacDougall et al. 2012) takes place at CNP surfaces on a time-scale rapid compared to other motion, and that CNPs become coated with a permanent layer of liquid oils. The CNPs are represented by arrays of spheres that form rigid flat structures, as done elsewhere. These objects can move laterally and rotate. The spheres interact via the attractive van der Waals interaction, together with a soft repulsive interaction. The nanoscale coating serves to keep the model CNPs apart. We use Monte Carlo computer simulation to discover the aggregation characteristics, and compute static structure functions from which we predict X-ray intensities as functions of the oil nanoscale coatings.

Fat Mesocrystal Networks Studied Using Ultra Small Angle X-Ray Scattering. F. Peyronel*[1], A. Marangoni[1], and D.A. Pink[1,2], [1]University of Guelph, Guelph, ON, Canada, [2]St. Francis Xavier University, Antigonish, NS, Canada.

Ultra Small Angle X-Ray Scattering (USAXS) has proven to be a useful technique to study the structure of fat crystal networks at length scales in the range 0.02 μm to 20 μm. The structure of tristearin-cottonseed oil-triolein and tristearin-shea butter-high oleic sunflower oil ternary systems was characterized in terms of the size of structural units (R_g) and the spatial distribution of mass (fractal dimension). The amount of solids was 5% and 15%, while the ratio among the two liquid oils where 1:4 and 3:2. The R_g for the smallest length scale gave values between 40 nm and 150 nm, confirming the presence of nanoplatelets (NP). The R_g values for the larger length scale, gave values between 180 nm and 500 nm. The fractal dimension of the aggregation of NP gave fractal dimensions of either ~1 or in the range between 1.7 and 2.

This work emphases a nondestructive technique, USAXS, which can be efficiently used to characterize *in situ* 3-D structures. These results should help understand the oil binding capacity of complex systems by studying the values of the fractal dimension obtained.

The Effect of Emulsifiers on the Physical Properties of the Candelilla Wax Organogels. M. Sánchez-Becerril[1], A. Marangoni[2], J.D. Pérez-Martínez*[1], and J.F. Toro-Vazquez[1], [1]Universidad Autónoma de San Luis Potosí, San Luis Potosí, SLP, México, [2]University of Guelph, Guelph, ON, Canada.

Candelilla wax (CW) in safflower oil can develop organogels in a wide range of temperature. CW organogels functional properties can be modified by

addition of emulsifiers without changing the CW melting behavior and crystal microstructure. Effects of emulsifiers in fat crystal networks have been associated to changes in the CW inter-crystal interactions, more likely by a change in the number and proportion of permanent and transient junction zones in the crystal network. Within this frame work, we investigate the effect of saturated monoglycerides or PGPR in the thermal properties, crystalline structure, microstructure, and thixotropic behavior of organogels developed with CW (0.5%-8%) and safflower oil. At the studied conditions, CW crystallization was not significantly affected by PGPR, while the crystallization of CW and MG in safflower oil occurred independently. At 25°C, 1% CW organogels with an emulsifier concentration of two times the critical micelle concentration showed a structural recovery over 90% (measured as the percentage ratio of G' value before and after shearing), but the recovery decay to a less than 4% for organogels with 3% CW or higher.

Formation and Structural Characterization of Lecithin-based Organogels Made with Vegetable Oil. D. Rousseau*[1] and M. Bodennec[2], [1]Ryerson University, Toronto, ON, Canada, [2]Ecole Nationale Supérieure de Chimie, de Biologie et de Physique, Bordeaux, France.

We developed food-grade thermoreversible oleogels consisting of canola oil, commercial lecithin and deionized water. Lecithin concentrations ranging from 10-30 wt% lecithin and water contents of 0.1-10 wt% were investigated in a partial binary phase diagram. The gels developed were optically opaque, self-supporting and thermo-reversible with gel-sol transitions at ~ 50-60 °C. Confocal and light microscopy revealed a 3D entangled network composed of worm-like microfibres generated upon addition of water. Small-angle X-ray diffraction analysis revealed the formation of a hexagonal supramolecular arrangement at d = 52 Å corresponding the centre-to-centre distance between neighbouring reverse micellar lecithin tubules. Upon the gel-sol transition, this d value increased to 67 Å where it remained constant till 95 °C. In parallel, the long-range order parameter (L) decreased from ~ 1200 Å to ~ 350 Å in the sol state. The proposed self-assembly mechanism for these gels is based on the packing of hexagonal tubules parallel to the axis of fibres. The gel network formed due to branching and rejoining of bundles of the lecithin fibres at junction zones.

Rheology Behavior of Ethyl Cellulose/Canola Oil Based Oleogels. M. Davidovich-Pinhas*, S. Barbut, and A. Marangoni, University of Guelph, Guelph, ON, Canada.

Ethylcellulose-structured oleogels have been recently shown to have a wide range of applications in food, cosmetics and pharmaceuticals. The current research aims to characterize the rheological behavior of ethylcellulose/canola oil oleogel systems. The effect of EC molecular weight and concentration on small deformation rheological behavior was characterized. Temperature sweep experiments using different cooling/heating rates were used to analyze the sol-gel transition. Hysteresis was detected in all samples where a higher cross-over temperature was detected during the heating compared to the cooling. Cooling and heating rates did not affect this cross-over temperature. The storage modulus (G') increased with increasing polymer molecular weight and concentration. In addition, an increase in G' with decreasing in cooling/heating rate was detected for low molecular weight samples (13-18kDa). The effect of molecular weight and concentration on the gelation temperature was determined using frequency sweep experiments at different temperatures. A decrease in gelation temperature with a decrease in polymer molecular weight was detected. These results provide a first insight to the ethyl cellulose/canola oil gelation process. Such insight could potentially contribute to the understanding of the gel behavior under shear which is crucial to further processing applications.

EAT-P: Edible Applications Technology Poster Session

Chairs: M.A. Rogers, State University of New Jersey, USA; and G. Cherian, Kellogg North America Co., USA

1. **Oleogels - Lyotropic Mesophases - TernaryPhase Diagrams and Structural Characterization.** Y. Nemirovsky*, A. Aserin, and N. Garti, Hebrew University of Jerusalem, Jerusalem, Israel.

The food industry have strong interest in replacing saturated triglycerides or margarines in our diet. We are studying oleogels formulated from ternary mixtures of surfactant, oil, solvent (s) and cosolvent (c) in order to increase significantly the gel properties with minor influence on the isotropic region at 25 and 37°C. The structural aspects were studied by cross polarized light microscopy (CPLM), powder X-ray scattering (PXRD), small angle X-ray scattering (SAXS), differential scanning calorimetry (DSC) and rheology measurements. Results from surfactant, solvent, oil and cosolvent system along dilution line 8:2 wt% 1:0, 3:1 and 1:1 s:c , showed formation of reversed hexagonal (H_{II}) mesophases. Rheology measurements revealed visco-elastic properties of lyotropic liquid crystals and, addition of cosolvent to the system, resulted in a decrease in the elasticity, plasticity and complex viscocity. The present study indicates the existence of ternary promising oleogel systems as fat replacers for the food industry.

2. **Key Physical and Microstructural Properties Underlying Roll-in Shortening Functionality.** Br. Macias-Rodriguez* and A. Marangoni, Food Science Department, University of Guelph, Guelph, ON, Canada.

Roll-in shortenings are stiff but very plastic fats tailored to laminate dough layers and resist high pressures during the manufacture of puff pastries. A major problem associated with these products is their high content in unhealthy saturated and trans fatty acids. Therefore, this study is aimed to compare 4 roll-in shortenings (randomly selected) in terms of their TAG composition and functionality. Functionality is defined by physical (yield stress , melting profile and solid fat content) and microstructural (crystal array and size) attributes. The foregoing properties were determined using dynamic rheology, differential scanning calorimetry (DSC), pulsed nuclear magnetic resonance (p-NMR) and powder x-ray diffraction (XRD) respectively. Preliminary results demonstrated yield stress in the range of 500-1000 Pa for all shortenings. DSC and p-NMR measurements revealed similar melting behavior and approximate fat content of 10-50%. Powder XRD spectra supported the existence of both ß and ß' polymorphism. Based on the current findings, more systematic investigation is needed to identify an "optimal" attribute-composition combination and achieve our ultimate goal of designing healthier roll-in shortenings.

3. **Lipase-catalyzed Transesterification of High Stability Algal Oil with Ethyl Esters Derived from Palm Stearin and Fully Hydrogenated Soybean Oil.** C. O'Sullivan* and A. Marangoni, University of Guelph, Guelph, ON, Canada.

Solvent-less 1,3-specific lipase-catalyzed transesterification was used to synthesize a cocoa butter-like fat using either high stability algal oil (HSAO) or high oleic sunflower oil (HOSO), and ethyl esters derived from palm stearin (PS) and fully hydrogenated soybean oil (FHSO). HSAO is a unique high oleic acid microalgal oil with extremely low linoleic acid content.

The performance of ethyl esters as acyl donors was compared with that of carboxylic acids to find the ideal reagent type for the reaction.

The triglyceride reaction product was separated from free fatty acids, MAGs and DAGs by fractionation and solid phase extraction.

The solid fat content and melting profile of the product, as measured by pulse NMR and DSC, were comparable to those of cocoa butter. Powder XRD also demonstrated similar polymorphic behaviour. Further analysis by HPLC showed the product to have similar TAG distributions to cocoa butter.

In future studies, the yield of cocoa butter-like fat will be examined by optimizing transesterification reaction conditions: enzyme load, substrate ratio, reaction temperature and time. A comparison between HSAO (0.1% 18:2) and HOSO (10% 18:2) as transesterification reagent will also be conducted.

4. **Effect of Tripalmitin Crystallinity on Emulsion Lipid Digestion.** S. Huynh* and A.J. Wright, University of Guelph, Guelph, ON, Canada.

A better understanding of the interplay between TAG crystallinity and the processes of digestion is

needed. The purpose of this study was to determine the impact of TAG crystallinity on digestibility using undercooled liquid and crystalline emulsions exposed to an *in-vitro* model simulating upper GIT digestive conditions. Modeled after Bonnaire et al. (JAFC, 2008, 56;3791), 10wt% tripalmitin oil-in-water emulsions ($d_{3,2}$~0.115nm) with 0.9wt% sodium dodecyl sulfate (SDS) were prepared by hot homogenization (M110-EH, 69MPa, 3 passes), cooled to 37°C (undercooled droplets) or to 0°C for 15 min and then 37°C (solid droplets, beta form). Samples were then exposed to conditions representative of gastric (pepsin=3.2mg/mL, pH=2, 1h @37°C) and duodenal (pancreatin=5mg/mL, bile=8mg/mL, phospholipids=5mM, pH=6.5, 2h @37°C) environments. Melting and re-crystallization profiles revealed interactions between TAG and SDS. The addition of digestive fluids led to increases in particle size, particularly for the liquid droplets. The rate and extent of lipolysis was greater for the liquid vs crystallized emulsion (50 vs 30%, P<0.05). Exposure to digestive conditions led to beta polymorph formation in the undercooled emulsion droplets. Therefore, TAG crystallinity impacted and was impacted by digestive lipolysis. The influence of specific digestive factors was investigated.

5. **A Rheological Evaluation of Structured O/W Emulsions for Laminating Fat Applications.** A.I.E. Blake* and A. Marangoni, University of Guelph, Guelph, ON, Canada.

Controlled stress small deformation rheology was used to evaluate the mechanical properties of a unique structured O/W emulsion, with the elastic modulus and yield stress taken as performance indicators. These parameters were compared to those of a commercial lamination fat in an effort to modify the original version of this structured emulsion to extend its application as a shortening alternative to a laminating fat, typically used in danishes, croissants, and puff pastries. Laminated bakery products can be 1/3 fat, for which reason the reduction of fat conduct for these products is nutritionally desirable. More specifically, the effect of water content, monoglyceride chain length and concentration, oil type, and the addition of oil-phase and water-phase additives on these rheological parameters was evaluated, with the goal being to increase the elastic modulus and yield stress of the original emulsion by a factor of 10^3 Pa and 10^1 Pa, respectively. The addition of wax at greater than 10% (w/w), the use of palm oil, the use of C-18 monoglyceride at 6%(w/w), and 4% (w/w) for C-22 monoglyceride molecules proved to be effective modifications capable of achieving the required rheological characteristics while providing valuable insight on the limitations and constraints of this o/w emulsion as a roll-in shortening.

6. ***In vitro* Digestive Stability, Lipolysis, and Bioaccessibility of an Algal Oil-containing Lecithin-stabilized Emulsion.** X. Lin*[1], Q. Wang[2], W. Li[3], and A. Wright[1], [1]University of Guelph, Guelph, ON, Canada, [2]Guelph Food Research Centre - Agriculture and Agri-Food Canada, Guelph, ON, Canada, [3]Manchester Metropolitan University, Manchester, UK.

Emulsification, which can be impacted during digestion, facilitates oil hydrolysis by digestive lipases and the subsequent lipid solubilization in the aqueous micellar phase (i.e. lipid bioaccessibility). Our objective was to investigate the effects of emulsification on algal oil digestion and DHA bioaccessibility using an *in vitro* digestion model. The oil/water emulsion (50:44:6 oil:water:lecithin, mean droplet diameter = 395 ± 0.001 nm) was prepared using a microfluidizer. Digestions were conducted in a shaking water bath at 37oC for 1h in simulated gastric fluid (pH 1.6 or 4) and then 3h in simulated duodenal fluid (pH 6.85). Bulk oil and an oil-lecithin-water mixture were studied for comparison. The emulsion was destabilized at gastric pH 1.6, with subsequent slow fatty acid release in the duodenal stage. The structure of the emulsion treated at gastric pH 4 remained intact. Under this condition, while the extent of fatty acid release was not increased, initial lipolysis proceeded more quickly and DHA bioaccessibility was higher than that from the bulk oil, the mixture and the destabilized emulsion ($p<0.05$). Therefore the presence of an intact emulsion at the start of duodenal digestion, while not impacting the extent of lipolysis, did impact the rate of lipolysis and DHA bioaccessibility.

7. **The Effect of Ultrasound on Crystallization of Cocoa Butter in Sugar-free Dark Chocolate.** E. Dibildox-Alvarado and N. Murillo Hernández*, Universidad Autónoma de San Luis Potosí, Facultad De Ciencias Químicas, Lab. Biopolímeros, San Luis Potosí, SLP, Mexico.

The use of low-frequency (20 kHz)/high-intensity ultrasound (HIU) was proved in sugar-free dark chocolate (SFDC) as a complementary method to the tempering process, in order to enhance the

cocoa butter (CB) crystallization as the main chocolate´s component. As preliminary experiments pure CB was studied, this and SFDC samples were evaluated through calorimetric, polarized light microscopy, texture and X-ray diffraction studies. CB samples were crystallized with and without HIU application at two intensity levels (80 and 200 W/cm^2) and at two effective sonication times (5 and 10 seconds). All HIU treatments had a significant effect on the crystals generated (e.g., smaller size and greater quantity) as compared with a non-sonicated control sample. The application of 200 W/cm^2/5 s was selected for SFDC sonication because it contributed to the smaller crystal diameter and higher number of crystals in CB. The SFDC sonocrystallized showed crystals with a diameter of 37 mm (25% less than in a non-sonicated sample) and developed a solid crystal lattice (990 g_f vs 880 g_f) and a higher melting temperature (32.66 °C vs. 30.65 °C).The X-ray analysis in SFDC showed crystals in the form b_2^V. The present results indicate that HIU is an efficient tool for crystallization of fats.

8. **Characterization and Storage Stability of Spread Margarine Using Enzymatically Interesterified Fat Blend.** E. Dibildox-Alvarado and R.J. Flores Ruedas*, Universidad Autónoma de San Luis Potosí, Facultad De Ciencias Químicas, Lab. Biopolímeros, San Luis Potosí, SLP, Mexico.

It this work we studied spread margarines formulated with enzymatically interesterified fat blend (MarIEE) and were compared with homologues prepared with physical fat blend (MarF) during their storage. The MarIEE and MarF were prepared under the same process, storage at 5°C and 25°C and then studied in function of time. First the oil blend used in each margarine (IEEB and FB respectively) was characterized. The results of iodine value and fatty acid composition showed that during enzymatic interesterification there were no changes in comparison to the traditional fat blend, on the contrary, free fatty acids (FFA) in the interesterified blend were higher. Also, it was observed that the IEEB had an oxidative stability index 50% less than the FB. In thermal characterization, higher crystallization and melting temperatures were obtained in MarIEE than in MarF (i.e., 6.69 °C vs. 3.28 °C for crystallization temperatures). In both margarines, the levels of peroxide value and FFA increased at higher storage temperature (25°C) and showed no significant difference (P>0.05) at 5°C. Finally, from the separation analysis phase, it was concluded that the only non-stable margarine was the MarF stored at 25°C.

9. **Towards the Understanding of the Candelilla Wax Phase Behavior, Interactions Among Some Representative Components.** J.D. Pérez-Martínez*, L.L. Serrato-Palacios, E. Dibildox-Alvarado, J.F. Toro-Vazquez, and M.R. Morales-Armenta, Universidad Autónoma de San Luis Potosí, San Luis Potosí, SLP, México.

The organogels development is a potential alternative for the reduction of saturated and *trans* fats in food systems. Candelilla wax (CW) is a mixture of alkanes, sterols, fatty alcohols, fatty acids and wax esters. It has been reported that n- hentriacontane, the major component of CW dominates the thermodynamic properties of the solid-liquid phase change. However, it is unknown what type of molecular and supramolecular interactions has with other major components such as long chain fatty acids or triterpene alcohols. Within this context, we studied the crystallization/melting of mixtures of n-hentriacontane (C31), melissic acid (MA) and betulin (Be). Melting of C31/MA showed a monotectic behavior for x_{C31} = 0.9-0.0. While a solid solution was observed for x_{C31} = 0.95-1.0. According to this, CW is dispersion of crystals highly concentrated in MA and C31. In the studied mixtures microcrystals were significantly smaller than those of the pure components, particularly the C31/MA mixture with 8:2 ratio produce a microstructure quite similar to CW. Evaporation of C31 and MA at temperatures below the melting point of Be (260°C) limited the phase diagrams development for C31-Be and MA-Be mixtures.

10. **Effect of Sucrose Esters on Crystallization Behavior of a Palm Oil-based Blend.** C. Chen[1,2], Y. Bi[1], T. Yang[2], and H. Zhang*[2], [1]School of Food Science and Engineering, Henan University of Technology, Zhengzhou, Henan Province, China, [2]Wilmar (Shanghai) Biotechnology R&D Center Co Ltd, Shanghai, China.

The object of this study is to study the effect of low-HLB (HLB=1) sucrose esters (SE) S-170, P-170, L-195 and ER-190 on crystallization behavior of a palm oil-based blend (palm oil/palm stearin=2/1) at room temperature. The crystallization rate, viscosity, morphology, hardness and melting behavior of blend crystallized at 25 °C with and without 1% SE were evaluated. Results showed that the similarity of fatty acids between blend and SE greatly affected

crystallization behavior. S-170 (70% stearic acid) and P-170 (70% palmitic acid) had similar fatty acids as blend, they accelerated crystallization rate, formed many finer crystals, increased viscosity and hardness, but decreased melting temperature by nearly 4 °C. On the contrary, L-195 (95% lauric acid) and ER-190 (90% erucic acid) had different fatty acids compared to blend, they delayed crystallization rate, decreased viscosity and formed rare and large crystals. L-195 increased sample hardness while ER-190 decreased, but they didn't significantly affect the melting temperature. In general, fatty acid compositions between SE and pure blend were similar, the acyl-acyl interactions were strong, and then nucleation was accelerated and rapidly formed tiny crystals. When they were dissimilar, weak interactions appeared and led to form large crystals.

11. **A Strategy for Detecting the Adulteration of Sesame Oil by the Combination of Modified Villavecchia Test and Triacylglycerol Profile.** W.J. Lee*[1], M.H. Lee[2], and N.W. Su[1], [1]Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan, [2]Department of Nutrition and Health Science, Chung Chou University of Science and Technology, Changhua, Taiwan.

In this work, Villavecchia test (official method of AOCS, Cb 2-40), a traditional method for detecting sesame oil in other edible oil, was used reversely to detect adulteration of sesame oil. This traditional test is based on that sesame oil's lignans, namely sesamol and sesamolin, can react with furfural to generate chromogenic products under acidic conditions. In the present study, we analyzed the contents of sesamol and sesamolin in various virgin sesame oils obtained from different varieties of sesame seeds, and meanwhile performed the Villavecchia test with each of these oils, which were diluted properly with solvent (hexane/ethyl acetate at 3:1 ratio, v/v) to obtain various levels of diluted oils. By means of evaluating the Villavecchia test results of these sesame oils and their corresponding sesamol and sesamolin contents, we concluded that Villavecchia test can be a promising method to apply in the judgment of the authenticity of sesame oil. On the other hand, by means of evaluating triacylglycerol profiles of genuine sesame oil, soybean oil and canola oil, we found that the unique triacylglycerol species presenting only in soybean oil (LLnL, OLnL and PLnL) and canola oil (OLnL and OLnO) could be used to judge the authenticity of sesame oil.

12. **Structured Lipids as Moisture Barriers in Food.** A. Purgianto*, Q. Duong, and F. Maleky, Ohio State University, Columbus, OH, USA.

Moisture migration between different phases in a food system is detrimental because it can damage the quality of food and shorten its shelf-life. As a solution, an edible lipid layer is often applied to limit moisture migration. The objective of this study was to evaluate the effect of lipid structure on moisture permeability of the layer. Laminar shear crystallization was used to modify fat crystal size and arrangement of two fat systems, cocoa butter and interesterified hydrogenated canola oil. Weight loss and moisture content of the crystallized fats were analyzed using periodical weighing and thermogravimetric analysis; and moisture permeability of the samples was calculated. The results showed that processing conditions and fat crystal network structure might affect moisture migration in different ways. These findings could be used by the industry to limit moisture migration and to prolong the shelf-life of food products.

13. **CLA-Rich Soy Oil Margarine Production and Characterization.** U. Shah*[1], A. Patel[2], D. Van de Walle[2], P. Rajarethinem[2], A. Proctor[1], and K. Dewettinck[2], [1]University of Arkansas, Fayetteville, AR, USA, [2]Gent University, Ghent, Belgium.

A heterogeneous catalysis method to produce 20 % conjugated linoleic acid (CLA)-rich food-grade soy oil in 2 h without solvents or gases was recently developed. The objective of this study was to produce and characterize CLA-rich soy oil margarine relative to a soy oil control and commercial margarine. CLA-rich soy oil was used to prepare margarine. The samples were characterized for firmness, rheology, thermal behavior, solid fat content (SFC) and microstructure and compared with a soy oil control and commercial margarine. The CLA-rich oil margarine firmness and rheological properties were similar to commercial margarine and provided a better texture relative to the soy oil control margarine. However, SFC, droplet size distribution and melting behavior of CLA-rich oil margarine were similar to control soy oil margarine and dissimilar to the commercial product. This suggests that hardness and rheological properties of margarine are not solely dependent on SFC and melting behavior. Lipid composition, polymorphism and microstructure differences in CLA-rich oil margarine may play an important role on the texture and rheological properties. A 7-g typical serving of

the CLA-rich oil margarine will provide 0.6 g CLA. Thus five servings will provide 3.2 g/day of CLA and 185 calories/day, which is well within the maximum recommended 700–980 fat calories/day.

14. **Use of Fully Hydrogenated Soybean Oil Micronized Apply in Palm Oil/Sugar System.** M.C.C.N. Mascarenhas*, M.C. Chiu, and L.A.G. Goncalves, Faculty of Food Engineering–UNICAMP, Campinas, São Paulo, Brazil.

Palm oil (PO) has characteristic of slow crystallization process. To obtain an appropriate consistency used in PO/sugar systems is necessary a technological process such as the use of seeds. Fully hydrogenated oils are used as seeds to modulate PO crystallization. The aim of this study was produce fully hydrogenated soybean oil (FHSO) micronized by microemulsion technique and apply in PO/sugar system (50/50). The FHSO micronized were produced with FHSO/water (30/70) and 0.3% lecithin. The microemulsion was produced by homogenization at 70°C, crystallization under stirring (0.7°C/min), separation and drying at room temperature. The FHSO micronized was applied in PO/sugar system and the effects on crystallization were evaluated through solid fat contain (SFC) at 25°C (RMN), polymorphism (X-ray diffraction), texture (25 °C) and microstructure (Polarized Light Microscope–PLM). The results of SFC were similar between samples (FHSO micronized and melted). The PO polymorphism (form ß') was maintained for both samples. The texture of PO/sugar system with FHSO micronized was higher than with FHSO melted stored for 2 days and similar for 1 month that can be related with nucleation and growth rate of PO crystals. Thus, fully hydrogenated oils micronized as seeds can be useful for technological adjustments on crystallization of PO.

15. **Rheological Properties of Sugarcane Wax Organogels Under Different Cooling Rates.** J. Rocha* and D. Barrera-Arellano, Department of Food Technology, Faculty of Food Engineering, State University of Campinas - UNICAMP, Campinas, São Paulo, Brazil.

The use of organogels as fat replacers for food products has shown a great potential at the last few years. The concern about the rheological properties of organogels produced under different processing conditions, lead to studies of how the changes on process; for example temperature rate leads to different behaviors. The objective of this study was to determinate changes on complex module (G*) and apparent viscosity (η*) of organogels produced using sugarcane wax as structuring agent and soybean oil as solvent under two different cooling rates. Temperature sweeps were performed under two conditions (3 and 10°C/min) for melting and crystallization. It was possible to observe that the higher values of G* were obtained using 3°C/min; 11878.26 Pa and 1633.73 Pa for 10°C/min. The same behavior were observed for η?*; 1891.33 and 260 Pa.s at 3 and 10°C/min respectively. It was also observed that the organogelation temperatures changed comparing both cooling rates. Based on that results it is possible to observe that organogels developed under slower cooling rates presented higher mechanical resistance, probably due to better organization of the tridimensional network as result of lower supercooling.

16. **Prediction of Crystallization Parameters in Fat Formulations by Neural Networks.** R.K. Garcia* and D. Barrera-Arellano, University of Campinas, Campinas, São Paulo, Brazil.

In the last years we have used artificial neural networks (ANN) to define the proportions of each base in the formulation of fat product with defined characteristics. This technology offers different formulations with same solid fat content (SFC) however has been observed that these may differ in their crystallization behavior. In this work were obtained blends with different proportions of each fat base from a SFC desirable, and was performed the prediction of crystallization parameters. The ANN were trained for predict induction, medium, and final crystallization times, as well maximum SFC to 25°C for blends formulated by two ANNs: ANN1 (soybean basestocks) and ANN2 (soybean/palm basestocks). Examples of blends were used for verification of ANN learning, and SFC of a filling fat was used as solicited profile. For the blends suggested by ANNs were presented values of crystallization parameters *predicts* and it were experimentally determined. The *predicted* and *determined* values for crystallization parameters were very similar (relative error < 0,21). The soybean blends present resembling crystallization behavior, whereas products formulated with soybean and palm/kernel palm fat based present some differences in crystallization parameters even having similar SFC. The ANN showed high ability to predict crystallization parameters. Supported by: Cnpq

17. **Analysis and Characterization of Oleogel Consisting of Beta-sitosterol and Gamma-oryzanol in Soy Oil.** Z. Nguyen* and N. Acevedo, Iowa State University, Ames, IA, USA.

This study reports on the formation and analysis of soy oil organogels composed of ß-sitosterol (BS) and γ -oryzanol in ratios ranging from 10-20%. The sample with 2% γ -oryzanol and 18% ß-sitosterol showed promise as a desirable substitute for hydrogenated oils due to better gelation properties. A decrease in oil loss was associated with increase in γ -oryzanol content. Thus, γ -oryzanol is an important factor in oil binding capacity. The effects of cooling rate on gel crystal size and firmness were studied. Gel properties based on rheological measurement were dependent on cooling rate. Organogel hardness (G') significantly increased with the increase of cooling rate (0.9°C/min to 1.4°C/min), suggesting that a desired macroscopic functionality could be achieved by controlling cooling rate and amount of gelling agent. Polarized light microscope images showed that organogels with higher ratios of ß-sitosterol contain needle-like crystals, while those with lower ratios are represented by flower-like clusters. This research reveals that a small amount of ß-sitosterol-γ-oryzanol organogel may replace a large amount of hardstock fats containing *trans* or saturated fatty acids. The organogel consisting of 4% γ -oryzanol and 16% ß-sitosterol showed no phase separation up to 3 months at room temperature, carrying physical properties of potential use by the food industry.

18. **Effect of High Intensity Ultrasound and Cooling Rate on the Crystallization Behavior of Beeswax in Edible Oils.** S. Jana* and S. Martini, Utah State University, Logan, UT, USA.

The objective of this study was to evaluate the effect of wax concentration (0.5 and 1%), cooling rate (0.1, 1 and 10 °C/min), and sonication on the crystallization behavior of beeswax (BW) in six different edible oils. Samples were crystallized at 25 °C with and without the use of high intensity ultrasound (HIU). Crystallization behavior was monitored for a period of 7 days. Higher wax concentrations resulted in faster crystallization and in a more turbid sample. When samples were crystallized at slow cooling rate (0.1 °C/min) phase separation was observed due to crystals' sedimentation. This behavior was not observed in samples crystallized at faster cooling rates (1 and 10 °C/min). Results showed that HIU induced the crystallization of 0.5% BW samples and delayed phase separation in sunflower, olive, soybean, and corn oil; while it didn't affect BW crystallization in safflower and canola oils. Similar effects were observed in 1% samples where the crystallization behavior was affected by HIU in canola, soybean, olive, and safflower oils. HIU did not affect crystallization of 1% BW in corn or sunflower oils. In general HIU changed the morphology and size of the BW crystals. Small needle-like crystals were usually associated with a lower degree of phase separation.

19. **Antioxidant Activity Evaluation of Phenolipids Synthesized from Protocatechuic Acid.** C. Grajeda-Iglesias[1], E. Salas[2], B. Baréa[3], P. Villeneuve*[3], and M. Figueroa-Espinoza[1], [1]Montpellier SupAgro, Montpellier, France, [2]Universidad Autónoma de Chihuahua, Facultad de Ciencias Químicas, Chihuahua, Chihuahua, Mexico, [3]CIRAD, Montpellier, France.

A number of phenolic compounds are extracted industrially from plants, since they are considered to have an important antioxidant capacity, to be used as dietary supplements or to be incorporated in cosmetic and pharmaceutical formulations. Some examples of them are phenolic acids like caffeic, *p*-coumaric, vanillic, ferulic, and protocatechuic acid.

Protocatechuic acid can be found in many edible and medicinal plants, like the *Hibiscus sabdariffa* flower. It is known to act as a potent antioxidant, and to have preventive effects in carcinogenesis and cardiovascular diseases, as well as analgesic and anti-inflammatory properties. Unfortunately, its character hydrophilic limits its utilization in lipid-rich matrices, like those found in food and cosmetic products. To counterbalance this disadvantage, the grafting of a fatty alcohol to the phenolic moiety, has demonstrated to be a good strategy, resulting in a new lipophilized active molecule.

In the present work we present the results of the protocatechuic acid esterification with fatty alcohols of various chain lengths (C4 to C18). A comparison between the chemical and the enzymatic lipophilization has been made, as well as the measure of the antioxidant capacity using the conjugated autoxidizable triene (CAT) assay of the new obtained phenolipids.

20. **Crystallization of Triglycerides Under Shear in a Narrow Gap.** T. Tran* and D. Rousseau, Ryerson University, Toronto, ON, Canada.

The effects of shear-cooling of model solid

fat/liquid oil systems on the microstructures and crystallization kinetics was investigated. Fully hydrogenated canola oil (FHCO) and canola oil (CO) were used as the solid and liquid phases, respectively. Samples were cooled at various cooling rates (0.2 to 5.0 ºC/min) and shear rates (0, 500, 1000, and 2000 s^{-1}) and characterized via polarized light microscopy and rheology. In the absence of shear (0 s^{-1}), FHCO crystallized into fractal three-dimensional networks. Upon shearing, HCO crystallized into distinct domains with ovoid structures. The size and microstructure of the crystal ovoids were shown to be dependent on cooling rate, shear rate, crystallization temperature, and time. An optimal cooling rate of 1.0 ºC/min was observed. Lower shear rates resulted in larger, more irregularly-shaped crystal ovoids while higher shear rates promoted the formation of more numerous smaller spherical crystals. The simultaneous action of both cooling and shear were required for crystal ovoid formation, with shear having a greater impact. The apparent viscosity of the systems decreased with increasing shear. The results demonstrated that cooling and shear rates may be manipulated to tailor crystal morphology.

21. **Practical Considerations of Using High Intensity Ultrasound in a Low Saturated Shortening.** H. Zhong[2], J. Lee[1], Y. Ye[1], K. Allen[1], and S. Martini*[1], [1]Utah State University, Logan, UT, USA, [2]Glanbia R&D Center, Twin Falls, ID, USA.

The objective of this research was to evaluate the effect of sonication of a low-saturated shortening on some practical food applications such as oxidation stability, chemical composition, and quality of baked products. Our research shows that HIU did not affect early stages of oxidation (PV < 10 mEq/mg) of the shortening. Crystals formed using sonication had a higher (a = 0.05) T_{on} (44.8 ± 0.1 °C vs. 49.4 ± 0.7 °C), the same T_p (52.1 ± 0.5 °C vs. 53.1 ± 0.1 °C) and higher enthalpy (39.2 ± 2.4 °C vs. 27.8 ± 1.2 °C) compared to the non-sonicated. No significant differences were found in the chemical composition or the polymorphism of the sonicated and non-sonicated crystals. Sonicated and non-sonicated shortenings were used to formulate cakes, cookies and pie crusts. Sonicated shortenings significantly (a = 0.05) decreased cake batter and cookie dough density resulting in taller cookies with lower spreads. In addition, cookies formulated with sonicated shortening showed lower water activity. Pie crusts formulated with the sonicated shortening were taller and softer. These results show that sonication can be used to change the physical properties of a shortening without affecting its chemical and oxidative properties. These changes in the physical properties of the shortening are translated in changes in the quality of baked products.

22. **Non-hydrogenated Crystallization Improver for Confectionery Applications.** K. Bhaggan, H. Manson, and J. Werleman, IOI Loders Croklaan BV, Wormerveer, The Netherlands.

Crystallization improvers are added to fats and oils in order to initiate or facilitate crystallization process. These components can be described as being high melting triacylglycerols with a melting point of 55°C to 70°C.

High-melting triacylglycerols are the standard crystallization promoters. However, the most functional of these are produced by fully hydrogenating oils. Fully hydrogenated fats need to be labelled as hydrogenated and many retailers and consumers avoid foods with that label. In terms of non-hydrogenated, high-melting triacylglycerols the only one that has been commercially available, is the less functional palm stearin.

A non-hydrogenated high-melting triacylglycerols that closely matches these functionalities and is produced using modern oil processing techniques has been developed. It is particularly targeted at the confectionery market, enabling faster crystallization and because it structures the crystalline phases, it maintains product characteristics longer and minimizes the degree of oiling-out on the surface of chocolate spreads on storage. It enables food manufacturers to produce according to the demands of today's consumer – as natural as possible, with clean ingredient list.

This non-hydrogenated crystallization agent has the full functionality needed for use in confectionery coatings, fillings and chocolate spreads.

23. **Promising Cultivar of Soybean for the Yield of Oil and Protein in Khyber Pakhtunkhwa-Pakistan.** M. Usman*, A. Rehman, M. Shakeel, and N. Ullah, Foundation for Rural Development, Peshawar, KPK, Pakistan.

Research work conducted on the yield of oil and protein consisted of two varietal trials with 10 promising varieties of Soybean during Kharif 2012 in Pakistan in order to select the most promising, high

and stable yielding cultivar for the yield of oil and protein on hectare basis. The seed was inoculated with a commercial strain of TAL-379.
The data revealed that variety Kharif-93 gave the highest seed yield of 2620kg/ha, followed by Wahab-93 (2015kg/ha) and Ajmeeri (1765kg/ha) however, the lowest yield of 780kg /ha was obtained from variety Weber. The maximum oil and protein content were found in Weber (22.5%) and Kharif-93 (45.30%) but due to increase in seed yield, a progressive increase in the yield of oil (522.69kg/ha) and protein (1186.86kg/ha) were found in Kharif-93, followed by variety Wahab-93 (405.01kg/ha) and (902.72kg/ha), variety Ajmeri (354.74kg/ha) and (767.77kg/ha).

Being leguminous crops, it improves the fertility and productivity of the soil and it also help the growers to avoid the indiscriminate use of fertilizer which will save a large amount of foreign exchange on the import of edible oils and fertilizer up to 2.611 billion dollars and 340 million dollars respectively.

It is, therefore, suggested that soybean varieties Kharif -93 and Wahab-93 are recommended for commercial cultivation in KPK - Pakistan with regard to the yield of oil and protein on hectare basis.