2010 Annual Meeting Abstracts

Edible Applications Technology

MONDAY

MORNING
EAT 1: Lipid Crystals and Structural Properties in Food
Chair(s): N. Garti, Hebrew University of Jerusalem, Israel; and S. Narine, Trent University, Canada

The Immobilization of Free Liquid Oil in Food Products - Principles and Applications. A. Marangoni, Dept. of Food Science, University of Guelph, Guelph, ON, Canada

Immobilization of free oil in foods, animal feeds and cosmetics remains one of the greatest challenges in food materials science. The problem of oil binding has become even more significant due to the pressure to replace solid fat with liquid oil in order to reduce both the saturated and trans fatty acid content in our foods. Several strategies exist for this purpose including the inclusion of small (2-4%) amounts of fully hydrogenated oils, high melting monoglycerides, waxes, or fatty acid-fatty alcohol mixtures. More recently, more sophisticated strategies have included the use of organogelators which form self-assembled fibrillar networks at very low concentrations (0.5-2%), such as 12-hydroxystearic acid, ricinoelaidic acid and phytosterol-oryzanol mixtures. Here we also report on the use of a biopolymer to form macromolecular oil gels at concentrations greater than 5% w/w. The principles and applications of some of these technologies will be reviewed and the limitations discussed.

The Spherulite Structures of Palm Olein. Satoru Ueno, Naomi Ohgi, Kiyotaka Sato, Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan

In this study, the spherulite structures of palm olein were measured by using poralized optical microscope (POM), DSC and synchrotron radiation microbeam X-ray diffraction (SR-micro-XRD). Three types of samples were examined; pure palm olein, palm olein added 2 wt% tripalmitin (PPP) and palm olein added 2 wt% monopalmitoylglycerol (MP). We crystallized them as thin plates and measured them by above methods. The major results are as follows; for the POM measurement, (i) all samples crystallized as spherulites with some special slow cooling, (ii) the crystallization of spherulites of samples added PPP and MP were promoted, and for the SR-micro-XRD measurement, (iii) the spherulite structures of pure palm olein appeared with a random orientation in all local areas of the spherulite, on the other hand, the spherulites of the palm olein with PPP were crystallized having four parts; the PPP-rich randomly oriented double-chain length inner core, the PPP-rich better oriented double-chain length outer core, the palm olein-rich random oriented double-chain length inner peripheral region and the palm olein-rich random oriented triple-chain length outer peripheral region. According to these results, the additives, especially PPP, play as the crystal seeding in crystallizing the spherulite of palm olein.

Characterization of the Polymorphic Forms and Liquid State of Cocoa Butter by Raman Spectroscopy. Serge Bresson[1], Derick Rousseau[2], [1]Laboratoire de Physique des Systèmes Complexes, Université Picardie Jules Verne, Amiens, France, [2]Department of Chemistry and Biology, Ryerson University, Toronto, Ontario, Canada

Raman spectroscopy was used to distinguish the differences in the molecular organization of the polymorphs as well as the liquid state of cocoa butter, with emphasis placed on the evolution of the ester carbonyl stretching (1800-1700 cm^{-1}), along with complementary analysis and comparison of the Raman-active C-C (1200-1000 cm^{-1}) and C-H (3000-2700 cm^{-1}) vibrational modes. The ester carbonyl stretching region permitted polymorphic discrimination due to significant differences in the number of modes, their relative frequencies and their full-widths at half-maximum. The C-C stretching modes, which provided insight into the *trans/gauche* content, were polymorph-dependent. C-H stretching generally increased with polymorph stability, indicating the dominance of symmetric C-H methylene vibrations as the cocoa butter TG crystal lattices became more ordered. Cocoa butter polymorph identity was

confirmed with DSC and x-ray diffraction. Overall, Raman spectroscopy provided confirmation of existing structural models in the literature.

Bulk and Microstructural Effects of Anisotropic Colloid Adsorption at Emulsion Interfaces. P.T. Spicer[1], A.B. Pawar[1,2], R. Ergun[2], R. Hartel[2], [1]Procter & Gamble, USA, [2]University of Wisconsin, USA

The phenomenon of partial coalescence in emulsions is important both for its broad impact on food production as well as its interdisciplinary combination of research in wettability, surfactant adsorption, and rheology. Although the role of solid particles in partial coalescence is being elucidated, the phenomenon is not yet entirely understood. First a literature review is discussed that helps clarify the definition of partial coalescence by mapping it relative to a wide range of colloidal adsorption behavior. Systematic variation of colloidal microstructure at an oil-water interface using surfactants is then demonstrated using non-spherical colloids like rods and ellipsoids. Measurements of droplet interactions as a function of colloidal microstructure are then made using microfluidic devices to assess the magnitude of interfacial effects on flow and anticipate bulk effects on emulsion rheology.

Effects of Cocoa Butter Origin, Tempering Procedure, and Structure on Oil Migration Kinetics. S. Marty-Terrade[1], A. Marangoni[2], [1]Nestlé Product Technology Centre, Singen, Germany, [2]Dept. of Food Science, University of Guelph, Guelph, ON, Canada

The effects of cocoa butter (CB) origin, tempering procedure, and structure on oil migration kinetics were studied using a flatbed scanner followed by image processing and analysis. The oil migration rate (OMR) and migration distance (I10) of stained oil were determined in tempered and nontempered CBs. Tempered matrices had 10 to 50 times lower OMRs than nontempered CBs. In addition, the lag phase observed before significant oil migration was also significantly longer in tempered CBs (12 days vs 2 days in nontempered butters). Moreover, cocoa butter origin had a strong effect on OMR. Brazilian and Nigerian CBs had the highestOMRin both tempered and nontempered samples. Malaysian CB had the third highest OMR,but this effect was only significant in untempered samples. Finally, the lowest OMRs were found in Chinese, Ecuadorian, and Ivorian cocoa butters. The amount of oleic acid and triunsaturated triglycerides (UUU) was strongly correlated to OMR (the higher the UUU concentration, the lower the resistance to oil migration). However, the relationships between the permeability coefficients and structural factors (squared averaged particle size and crystalline domain size) suggest that the micro- and nanostructure of the material also play a significant role in the oil migration process.

Structuring of Organogels by Steroid-based Helixes in the Presence of a Dispersed Aqueous Phase. E. Flöter, A. Bot, Unilever R&D Vlaardingen, Vlaardingen, The Netherlands

Low molecular weight structuring agents that can serve as an alternative to crystallising triglycerides in edible oils have raised considerable interest in recent years. The requirement that potential structurants should at least hold the promise to be allowed in food applications is a severe limitation. Nevertheless, several systems have been identified, amongst which the class of γ-oryzanol + sterol organogelators.SA has been reported previously mixtures of γ-oryzanol and β-sitosterol are able to form transparent organogels in edible oils. Small-angle x-ray scattering was used to elucidate the microstructure of the building blocks of these organogels in sunflower oil.It was found that the plant sterol(ester)s form hollow tubules with a diameter of 7.2±0.1 nm. Tubules prepared with γ-oryzanol-rich structurant show the least bundle formation, and can be supercooled during formation most easily. The tubules vanish at the melting point of the gel, in agreement with the loss of structuring capacity as observed in earlier experiments.In order to establich in how far this structuring system is suited for emulsions system these were prepared, structured only by a mixture of sitosterol and oryzanol and without further emusifiers, containing 16 and 32% total sterol(esters)s on lipid phase and 10, 30 or 60% water. At 16% total sterol concentration, diffraction pattern only demonstrated the presence of sitosterol and oryzanol crystals, but not of tubules. At 32% total sterol concentration, the diffraction patterns revealed the presence of tubules next to the crystals of the individual compounds. However, the tubule structure was more complicated and changed during storage, revealing the formation of bigger structures in the emulsion over time. In the cooling stage of a temperature cycle, water droplets nucleate at the tip of the fibres that reappear as a consequence of crystallisation. In this contribution the effect of the presence of water to the structuring system at hand will be discussed.

Quantifying Oil Binding Capacity of Crystallized TAG networks. L. Bouzidi[1], S. Narine[1], T. Omonov[2], [1]Biomaterials Research Program, Departments of Physics & Astronomy and Chemistry, Trent University, Peterborough, Ontario, Canada, [2]Alberta Lipid Utilization Program, Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada

The structuring of organic phases has broad scientific and practical significance for a wide variety of industries such as the food, pharmaceutical, cosmetic and petrochemical. The nature of the structuring agents and the mechanisms through which structuring is achieved and evolves are crucially important for the design of specialized materials. Different structuring agents and strategies to provide structure have been proposed, some of which were successfully utilized. However, no universal method to measure or quantify the oil binding capacity (OBC) of structuring agents has been reported so far. Furthermore, the molecular mechanisms of assembly and network formation of systems capable of structuring organic phases are still insufficiently understood. In fact the base level of understanding and modelling required in order to really engineer better processes and products rather than rely on past experience, trial and error is lacking. We present a robust and reproducible method to measure accurately the oil binding capacity (OBC) of structuring fats. The method was validated using two oil/hard fat model systems, i.e. fully hydrogenated canola oil in CO (FHCO/CO) and fully hydrogenated soybean oil in CO (FHSO/CO). The mixtures were crystallized from the melt at three different temperatures (15, 25 and 35 °C) and OBC was measured as a function of time. Crystal structure, melting behavior, microstructure, and solid fat content of these systems in relation to the OBC of the solid fat network have been investigated using X-ray diffraction (XRD), differential scanning calorimetry (DSC), polarized light microscopy (PLM), and low resolution pulsed nuclear magnetic resonance (pNMR) techniques, respectively. We have also investigated colligative effects and found that the two systems demonstrate a typical dilution effect.

Mechanisms of Oil Binding in Crystallized Networks of TAGS: Concept of Effective Critical Concentration. S. Narine[1], L. Bouzidi[1], T. Omonov[2], [1]Trent Biomaterials Research Program, Departments of Physics & Astronomy and Chemistry, Trent University, Peterborough, Ontario, Canada, [2]Alberta Lipid Utilization Program, Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada

We have measured the oil binding capacity (OBC) of two oil/hard fat model systems, i.e. fully hydrogenated canola oil in CO (FHCO/CO) and fully hydrogenated soybean oil in CO (FHSO/CO). The mixtures were crystallized at 25 °C, a temperature close to room temperature, to mimic real-world storage conditions. Using a wide range of hard fat weight fractions and several measurement times, we have measured the concentration of hard fat at which the solid fat network is stable and binds oil effectively (critical concentration). We have identified the mechanisms of oil migration/binding and established that oil migration occurs in different steps, each of which is characterized by different possible mechanisms, namely Fickian diffusion, molecular diffusion and capillary flow. The effective critical concentration was explained through these migration mechanisms.

AFTERNOON

EAT 2: Structured Solutions

Chair(s): D. Nakhasi, Bunge Oils Inc., USA; and F. Orthoefer, FTO Food Research, USA

Fatty Acid Chain Mismatch Optimization to Influence Bakery Shortening Functionality. D.K. Nakhasi, R.L. Daniels, J.W. Eartly, Oils; Division of Bunge North America, Inc., Bradley, IL, USA

Background: Food processors having solved the challenges of trans reduction in their products are increasingly investing resources to achieve enhanced organoleptic properties in products relative to mouthfeel, taste and texture. A critical component affecting organoleptic properties in most baked products is the shortening component. Food scientists traditionally utilize shortenings based on partial hydrogenation or blending to achieve the desired solid fat content (SFC) profile which in turn contributes to the organoleptic properties of the finished baked product. Higher SFC values contribute to a less desirable waxy mouthfeel, while lower SFC values contribute to more desirable organoleptic properties. Objective: The aim of this study was to investigate fatty acid chain mismatch optimization to

yield functional reduced trans shortenings with lower SFC profiles. Technology: The technology involves the utilization of fatty acid chain mismatches to yield a functional shortening with lower hard fat solids. This technology utilizes two different hard fat ratios. Examples are:PSP/SSS = 2.46PSP/SSS = 0.82Results: Analytical analysis indicates the comparability of solid fat content with low trans commercial product and Bake tests are directional similar as well.

Enzymatic Interesterification: Sustainable Solutions for the Bakery Industry. B. Johnson, Bunge North America, Inc., Bradley, IL, USA

With the movement of the baking industry away from the use of partially hydrogenated shortenings having high levels of trans fatty acids, the formulator has been presented with a number of options and challenges. Use of specially hydrogenated low trans shortenings, palm fractions and structuring fats have all proven to meet the formulators needs in specific applications. More recently, enzymatic interesterification has become a viable tool in the formulation of functional bakery shortenings.Enzymatic interesterification is a means of achieving functional bakery shortenings without partial hydrogenation. Benefits of enzymatic interesterification include: 1. Simplification, a migration to a more natural process, 2. Sustainability via good environmental stewardship due to less processing waste, 3. Efficiency in production via a continuous process and 4. Low trans with elimination of partial hydrogenation.

Lipase-catalyzed Synthesis of Omega-3 Vegetable Oils. F. Jovica, S.M. Budge, Dalhousie University, Halifax, NS, Canada

Triacylglycerol (TAG) molecules that have been modified to incorporate a new fatty acid (FA) or which have had a FAs position changed are considered structured lipids (SL). The synthesis of a SL through a controlled enzymatic process can potentially modify the nutritional properties of a food or can be used to change the physical properties of a fat or oil. Methods that incorporate omega-3 FAs into fats and oils are particularly important. Here the effects of temperature, reaction time, and substrate concentration on the incorporation of a short chain FA, decanoic acid (DA), and an omega-3 FA, alpha-linolenic acid (ALA), into a vegetable oil, cocoa butter (CB), were compared, using an immobilized enzyme derived from Rhizomucor miehei. Production of diacylglycerol (DAG) and monoacylglycerol (MAG) by-products was also monitored using high-performance liquid chromatography (HPLC). Preliminary results indicated that all variables tested had a significant effect on incorporation of DA and ALA into CB but that effects were not equivalent for the two FAs. Thus, DA is not an adequate model FA for the incorporation of ALA into CB. The crystallization properties of the CB modified with ALA were examined using differential scanning calorimetry (DSC) and solid fat content (SFC).

Processing EPA Oil from *Yarrowia lipolytica*: A New, Vegetarian Source for Omega-3 Fatty Acids. S-C Liang, B.D. Tyreus, C. R Powley, L. A. Belcher, D. E. Spahr, DuPont Applied BioSciences, Wilmington, DE, USA

Among the Omega-3 fatty acids, EPA and DHA are well recognized as two important PUFA's that deliver critical nutritional and health benefits. While DHA is recognized for brain and cognitive development, numerous health studies have shown that sufficient intake of EPA through regular diet or dietary supplement can promote heart health, help maintain proper immune function, and help maintain healthy cholesterol levels. Currently, North American diets are skewed towards high consumption of Omega-6 fatty acids with insufficient intake of long chain Omega-3 fatty acids such as EPA and DHA. DuPont has recently developed a vegetarian EPA-rich Omega-3 oil based on a fermentation process using the yeast *Y. lipolytica*. The EPA-rich Omega-3 oil is in the natural triglyceride form without the need for additional concentration steps such as molecular distillation and is naturally free of the environmental contaminants PCB's, mercury and lead. Encapsulated in vegetarian softgels, New Harvest^{TM} Omega-3 Fatty Acid Supplement delivers 600mg of EPA in every 1200 mg softgel. In this presentation, we will be sharing the process technology used for extracting and refining this novel, vegetarian-source EPA oil. Shelf life, toxicology and clinical results will also be presented to demonstrate the stability and safety of our product.

Structured Unique Phospholipids Gels - Technology and Application. S. Baseeth, B. Sebree, Archer Daniels Midland Co., Decatur, IL, USA

Liquid crystalline structures are generally well ordered structures that can hold a large number of active ingredients, yet restrict the diffusion of the active ingredients to facilitate a controlled release of the active ingredients. Lecithin organogels are clear, thermodynamically stable, vicsoelastic and biocompatible jelly-like phases typically composed of hydrated, purified phospholipids, an organic liquid and a gelling agent. Typically, the purified phospholipids used contain at least -80-95% phosphatidylcholine content to prepare the organogel. A limitation of earlier organogel formulation needs the use of very highly pure lecithin that is expensive and not easily obtained. The present study overcomes the obstacles of the prior art and discloses a more commercially viable method to make cubic, liquid crystalline phases at ambient temperature, with no high energy input and a low equilibration time in minutes or a few hours. Polarized light microscopy (PLM) was used to determine whether the composition formed a cubic phase. The cubic phase was also confirmed by Small Angle X-ray Scattering (SAXS). The gels were made for both food and personal care applications. The preparation, properties and applications of these structured phospholipid organogels will be discussed.

PHO 2 / EAT 2.1: Lipids in Nanotechnology I
Chair(s): S. Ali, Jina Pharmaceuticals, Inc., USA; M. Ahmad, Jina Pharmaceuticals, Inc., USA; and F. Orthoefer, FTO Food Research, USA

Micro/nanochannel Emulsification for Producing Monodisperse Emulsions Containing Lipids. I. Kobayashi[1], M. Nakajima[2,1], [1]National Food Research Institute, NARO, Tsukuba, Ibaraki, Japan, [2]University of Tsukuba, Tsukuba, Ibaraki, Japan

Monodisperse emulsions consisting of uniform droplets are dispersions useful for foods, pharmaceuticals, cosmetics, chemicals, etc. Microchannel (MC) emulsification, proposed by our group in the middle 1990s, is a promising technique to produce monodisperse emulsions with the smallest coefficient of variation of below 5%. Droplet generation for MC emulsification is very mild and does not require any external shear stress. Here we introduce recent developments in MC emulsification using lipids as an emulsion component. Initially designed MC emulsification chips composed of silicon grooved MC arrays with microgrooves and a terrace. Straight-through MC arrays with straight through-holes have been recently developed for large-scale production of monodisperse emulsions. MC emulsification can generate uniform droplets of refined soybean oil (RSO) with an average size of 2–200 μm, dispersed in a continuous aqueous phase. Straight-through MC arrays demonstrated a high productivity of uniform RSO droplets of 100 L m-2 h-1. Monodisperse oil-in-water and water-in-oil emulsions stabilized by phospholipids have been produced by MC emulsification. NC emulsification for producing submicron emulsions is also briefly introduced. This work was supported in part by the Food Nanotechnology project of MAFF, Japan.

Structured Lipids in Physical Structuring: Case Studies. Xuebing Xu, Aarhus University, Aarhus C, Denmark

We have knowledge that structured lipids, after chemical re-structuring, have better bioavailability or better delivery to specific parts of the body. The case for example for the structure containing omega-3 PUFA at the sn-2 position and medium chain fatty acids at the sn-1,3 positions has accumulated quite amount of evidence. When structured lipids are made in specific emulsion for animal model study, particularly in different emulsion structures, the delivery of omega-3 PUFA to the brain was found significantly different. This is some cases can improve 20-30% of bioavailability. A couple of other cases to use phospholipids as carrier of omega-3 PUFA for liposome formulation also showed the difference of bioavailability. This indicates the physical structure of bionutrients in intaking can give a different performance.

Milk Phospholipids Nanoliposome as Bioactive Compounds Carrier. B. Farhang, Y. Kakuda, M. Corredig, University of Guelph, Guelph, ON, Canada

Nano liposome technology has been considered as an effective technology in food industry for encapsulation and controlled release of nutraceuticals and bioactive compounds, as well as for enhancing their stability and bioavailability. Liposomes are mostly prepared with soy or egg phospholipids. This research focuses on the study of nano liposomes prepared from milk phospholipids. These have been shown to have significantly different physical and chemical characteristics than those traditionally prepared with soy . We have prepared different types of milk

liposomes via microfluidization. These nano liposomes would themselves be considered bioactive ingredients, because of the high content of Sphingomyelin present in the milk phospholipids. To characterize the encapsulating behaviour of the liposomes, we will use model hydrophobic and hydrophilic compounds, namely β-Carotene and Vitamin C. Preliminary results showed high incorporation efficiency for β-Carotene and a significant increase in the stability of vitamin C. These results suggest that there may be inherent advantages in the use of nano liposomes prepared from MFGM-derived phospholipids via microfluidization for the encapsulation of both hydrophobic and hydrophilic compounds, in addition to the nutritional benefits of the milk phospholipids per se.

Lecithin-based Self-Emulsifying Oral Delivery Systems. J. Chu, E. Acosta, University of Toronto, Toronto, ON, Canada

Lipid-based formulations have been used to improve the oral bioavailability of hydrophobic drugs. The lipid-based, self-emulsifying drug delivery system (SEDDS) shows potential in improving oral bioavailability of poorly water soluble drugs. We developed alcohol-free SEDDS formulated with lecithin, linkers, and food-grade additives. The linker system is comprised of sorbitan monooleate, a lipophilic linker, decaglyceryl caprylate/caprate and PEG-6-caprylic/capric glycerides which are hydrophilic linkers. Ethyl caprate was the carrier oil for lipophilic nutraceuticals beta-sitosterol and beta-carotene. A ternary phase diagram was generated to investigate the phase behaviour. Mixtures of surfactants/ linker in aqueous medium and surfactants/ linker in oil medium were titrated with oil and aqueous components respectively to determine the dilution lines, isotropic regions, and phase transitions of microemulsion structures. Microemulsion preconcentrates were formulated which could be incorporated into pharmaceutical or other applications. The diluted preconcentrates form self-emusified drug delivery systems with drop sizes ranging from 100-250 nm. The equilibrium uptake and permeation of the oil phase (containing the drug) through a membrane was evaluated using a Flow-Thru Dialyzer system.

Phenolipids: Novel Phenolics Enriched Lecithin for Functional and Pharmaceutical Applications. M.F.R. Hassanien, Agricultural Biochemistry Department, Faculty of Agriculture, Zagazig University, Egypt.

Phenolipids results from the reaction of phospholipids with the selected phenolics in a nonpolar solvent. They are lipophillic substances freely soluble in nonpolar solvents (in which the hydrophilic moiety was not), and moderately soluble in fats. Liposomes, unlike Phenolipids, are formed by mixing water-soluble substances with phospholipids without forming chemical bonds. This difference results in Phenolipids being much better absorbed than liposomes or individual phenolic compounds. Preparation of Phenolipids is recently described by complexing querectin with soy lecithin [1]. Phenolipids exhibited novel antioxidant properties in a triolein model system stronger than individual lecithin or querectin. The goal of this work was to optimize preparation of different structured Phenolipids and to study antioxidant properties of new Phenolipids. Phenolipids are anticipated to play a vital role in efficient herbal drug delivery of a broad spectrum of protective phytochemicals. After selection of potential phytochemicals from medicinal plants, Phenolipids can be developed for various therapeutic uses like cardiovascular, anti-inflammatory and anticancer activities. Moroever, Phenolipids are anticipated to show their potential in cosmetics as anti-skin ageing agents and for the use of other nonpathogenic skin conditions. [1] Ramadan MF (2008) Food Science and Technology-LWT 41: 581-587

TUESDAY

AFTERNOON
EAT 3: Food Emulsions and Dispersed Systems
Chair(s): L. Sagalowicz, Nestle Research Center, Switzerland; and R. Campos, Mars Chocolate NA, USA

Pre-freezing of Emulsifier-Fat Complex During Interfacial Heterogeneous Nucleation in Oil-in-Water Emulsion. Kiyotaka Sato, Sachiko Murakami, Satoru Ueno, Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan

In-situ optical microscopic observation, DSC and synchrotron radiation X-ray diffraction experiments have unveiled

pre-freezing of emulsifier-fat complex during interfacial heterogeneous nucleation in oil-in-water emulsion. As the oil phase, semi-solid fat of palm mid fraction (PMF) was employed and distilled water including a solid-type emulsifier (polyglycerine palmitic acid ester) was employed as the aqueous phase. As a comparison, liquid-type emulsifier, polyoxyethylene sorbitan monooleate (Tween 80) and solid-type hydrophobic emulsifier, sucrose palmitic acid ester, were employed as the emulsifier and the additive, respectively. We found that pre-freezing occurred at the oil-water membrane at the temperature far above the crystallization temperature of PMF during slow cooling process of the O/W emulsion. Further cooling caused the crystallization of PMF. Such a pre-freezing was not observed when liquid oil was employed as the oil phase. This means that the pre-freezing was due to the formation of emulsifier-fat complex in which high-melting fraction of PMF may be included. The pre-freezing phenomena may cause the interfacial heterogeneous nucleation in oil-in-water emulsion, which has recently been observed with a microbeam X-ray diffraction technique by our group.

Delivery Systems in Emulsions. Laurent Sagalowicz, Nestlé Research Center, Vers-Chez-Les-Blanc CH-1000 Lausanne 26, Switzerland

One challenge in the development of functional foods is to guarantee the efficacy of a given bioactive compound incorporated in the food matrix. The poor solubility or the fast degradation in aqueous systems is a barrier, which needs to be overtaken through the use of appropriate delivery systems. Classical encapsulation systems, obtained by spray-drying of carbohydrates, dissolve in aqueous media and therefore alternative delivery systems need to be designed. In the present contribution we will compare various delivery systems and discuss their advantages and limitations in emulsion based products. At the end, we will focus on self assembly structures (micelles, vesicles, reversed bicontinuous cubic phases, reversed microemulsion...) and see how one can use their specific features to deliver benefits to food products. In mesophases, the presence of large surface interface areas, ensures spontaneous solubilisation of high concentration of active elements of various physico-chemical characteristics. In addition, sub-micrometer scale domains ensure fast molecular exchanges. Those properties can be exploited for many functionalities, such as control of bioavailability of nutrients, solubilisation of crystalline molecules, control of chemical reactions and controlled release. In particular, it will be shown that self assembly structures can control or modify bioavailability and solubilisation of nutrients. They can also control the aroma partition coefficients between an emulsion and a gas phase resulting in more sustained release of amphiphilic and lipophilic aromas.

Comparative Analysis of Structuring Effects of Different Lecithins on Palm Oil-based Blends. S. Danthine[1], S. Delacharlerie[1], E. Floter[2], [1]University of Liège Gembloux Agro-bio Tech, Gembloux, Belgium, [2]Unilever, Vlaardingen, The Netherlands

Lecithin?s are emulsifiers frequently used in crystallized emulsions such as margarines. The sensorial properties of this kind of structured emulsions are determined, among other factors, by the fat crystal network obtained by crystallization of triacylglycerols hard-stocks. When lecithins are used, they can modify this network structure.The purpose of the present work was to determine the effects of some selected commercial lecithin?s from different sources (soybean, sunflower, rapeseed?), in their native state or hydrolysed form, on the crystallization behaviour of fat blends made of palm oil. Addition of all the studied lecithin?s preparations (rapeseed, sunflower and native or hydrolyzed soybean) to the fat blends had a significant influence on the hardness measured by texture analyzer. This influence was depending on the type of lecithin, the lecithin concentration, the storage duration and temperature and the blend composition.Lecithin?s influenced also the crystal morphology, and the polymorphism, while SFC was not changed by lecithin addition. Lecithin?s effect seems to depend on their composition. All these observations could be explained by considering the kinetic of the mechanism and studying the role of adsorption phenomena and the sintering effect.

Mechanism of Partial Coalescence and the Role of Tempering. R. Ergun[1], R.W. Hartel[1], P. Spicer[2], A. Pawar[1,2], [1]Food Science Department, University of Wisconsin-Madison, Madison, WI, USA, [2]The Procter & Gamble Co., Cincinnati, OH, USA

Partial coalescence is important in various food applications. It has been hypothesized that partial coalescence is caused by an extension of fat crystals through the oil/water interface of one globule, which then penetrates another one and causes a clustering effect. However, there is not sufficient experimental data to test this hypothesis. It has also

been shown that tempering is significantly important for partial coalescence to occur, but its role has not been thoroughly explained. We examined fat crystal orientation at the oil/water interface in oil-in-water emulsions as a function of surfactant concentration and tempering conditions. The experiments were designed to test the hypothesized mechanism of partial coalescence and explain the role of tempering. The results with milk fat in water emulsions show that an increase in sodium dodecyl sulfate (SDS) and addition of decanol? a co-surfactant? to the system increases the number of emerged crystals, but does not always lead to partial coalescence. On the other hand, when sodium caseinate was used as a surfactant there were no crystal penetration yet we observed increased degree of partial coalescence. Also, emulsions with different surfactants required different cycling temperatures to partially coalesce. The results suggest that the mechanism of partial coalescence may be different than the hypothesized one.

Optimization of Sucrose Laureate Stabilized Water-soluble Phytosterol Nanodispersion. Wai Fun Leong[1], Yaakob Che Man[1], Oi Ming Lai[2], Kamariah Long[4], Misni Misran[3], Chin Ping Tan[1], [1]Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia., 43400 Serdang, Selangor, Malaysia, [2]Department of Bioprocess Technology, Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia, [3]Department of Chemistry, Faculty of Science, University of Malaya, 50603, Kuala Lumpur, Malaysia, [4]Malaysian Agricultural Research & Development Institute (MARDI), P.O. BOX 12301, 50774 Kuala Lumpur, Malaysia

Phytosterols are functional lipid well-known for their cholesterol lowering effect. Mounting evidence suggested that phytosterols posses anti-carcinogenic effect. However, phytosterols fortification is limited to high-fat food products attributable to their water insoluble nature. This work focused on the optimization of parameters involved in the production of sucrose laureate stabilized water-soluble phytosterol nanodispersion. Response surface methodology (RSM) was employed to model and optimized four independent parameters, namely phytosterol, P(2-10%w/v) and sucrose laureate, L(0.5-1.5%w/v) concentrations, homogenization cycles, C(1-5 cycles) and pressure, Pr(20-80MPa). All response, namely particle size(PS), polydispersity index(PI) and %phytosterol retention(%Ph) were well fit by a quadratic model. The optimized parameters were 5.5% of P, 1.0% of L, 3 C, and Pr of 37MPa. The responses for the optimized condition were PS of 3nm, PI of 0.590 and %Ph of 90.4%. The chi-square test showed that the experimental values of PS, PI and %Ph agreed with the predicted value at ($P<0.05$). The produced phytosterol nanodispersion is predicted to have a better bioavailability and greater health effect owing to the small nano-size phytosterol in dispersion. It can be apply to a wide range of food products including low-fat and low-calories food products.

Molecular Interactions Responsible for Oil Gelation as Studied by Vibrational Spectroscopy. T. Laredo, A. G. Marangoni, University of Guelph, Guelph, ON, Canada

Structuring of vegetable oils is a promising way to diminish the amount of saturated fats in foods. This novel strategy is based on the gelation of the oil by means of a biopolymer, namely, ethylcellulose (EC). The resulting gels have a wide range of properties depending on the type of oil used and the amount of EC in them. These properties have been characterized through rheology. However, the molecular mechanism of gelation for this type of systems is not known, especially because of the non-aqueous nature of the samples. Vibrational spectroscopy has provided a way to study the specific interactions occurring between the polymer and the solvent and between the polymer strands. Through Attenuated Total Internal Reflection (ATR) and Raman spectroscopy we have been able to determine that the structuring of the triglycerides is mostly a conformational effect of the components of the sample rather than due to a chemical interaction between them. This work has provided great insight regarding the molecular interactions responsible for the formation of the macromolecular network that structures the oil. The conclusions drawn from this work will allow for the a priori assessment of oils suitable for gelation, depending on the application of interest.

EAT 3.1 / LOQ 3.1: Antioxidants in Omega-9 Oils
Chair(s): F. Orthoefer, FTO Food Research, USA; and U. Thiyam, University of Manitoba, Canada

Retention of Sinapic Acid and Canolol after Oven and Microwave Pre-treatment of Canola Seeds. Usha Thiyam, Rabie Khattab, Schyamchand Mayengbam, University of Manitoba, Winnipeg, MB, Canada

Among oilseeds, canola has the highest content of phenolic compounds, mainly sinapic acid derivatives. Effect of toasting canola seeds, prior to oil extraction, using both conventional and microwave (with and without steam) ovens on the phenolic content of oils and defatted residues was investigated. Seeds were toasted at 160, 180 and 200 C for 10, 15 and 20 min in both the convection oven and the microwave oven at different power stages; with and without steam. Phenolic profile of both oils and residues before and after toasting was investigated using the RP-HPLC-DAD. Total phenolic content was determined using Folin-Ciocalteau assay as well as HPLC DAD. For the defatted residues, toasting under different conditions did not impact sinapic acid (SA) content but decreased the total phenolics (TP) and sinapine (SP). Toasting altered the phenolic profile of the oil. profile of the oil, before and after toasting the seeds will be presented.

Effect of Canolol (4-vinylsyringol) on the Oxidative Stability of Canola Oil. B. Matthäus, Max Rubner-Institute, Münster, Germany

Rapeseed contains high amounts of phenolic compounds, mainly derivatives of sinapic acid, but only a small part can be found in virgin rapeseed oil, since the compounds remain in the press cake. During heating of the raw material, by roasting or as a result of the pressure during pressing in a screw press sinapic acid reacts to 2,6-dimethoxy-4-vinylphenol (vinylsyringol or canolol) which is described in literature as a very strong antioxidant component. This compound shows good oil solubility and passes over into the oil during pressing. In the present work canolol was measured together with the tocopherols by HPLC and detected by fluorescence detector. Virgin rapeseed oils contain below 100 µg canolol/g oil, while in rapeseed oil from roasted or heated seeds remarkable higher values can be found. Higher amounts of canolol in rapeseed oil strongly improve the oxidative stability of the oil in the Rancimat test at 120°C, but also the storage stability of rapeseed oil is remarkable improved by the presence of canolol. The presentation discusses the results of the investigation on the effect of canolol on the oxidative stability of edible oils.

Oxidation of β-sitosterol and Campesterol in Vegetable Oils Upon Heating. M.F.R. Hassanien[1], A.-M. Lampi[2], V. Piironen[2], [1]Agricultural Biochemistry Department, Faculty of Agriculture, Zagazig University, Egypt., [2]Department of Applied Chemistry and Microbiology, University of Helsinki, Latokartanonkaari 11, P.O. Box 27, FIN-00014, Helsinki, Finland

The aim of this study was to measure the oxidation of endogenous β-sitosterol and campesterol in vegetable oils during heating at 180 ˚C for different periods (1, 4 and 8h) by analyzing the formation of phytosterols (PS) oxidation products (POP) and the amount of unoxidized PS using GC-MS method. Vegetable oils with different fatty acid and tocols profile (corn, sunflower, blended, palm and rapeseed oils) were studies. Upon heating, the total PS content decreased in all oils and the lowest degree of PS deterioration was found in corn oil, while blended oil recorded the highest degree. Generally, heating resulted in deterioration and/or decrease in the total β-sitosterol and campesterol amounts, wherein the highest decrease was measured after 8h of heating in blended oil (24.3%) followed by sunflower oil (19.2%), while corn oil recorded the lowest degree of deterioration accounting for only 12%. At the end of heating experiment, the highest amount of total oxides was found in rapeseed oil (250 µg/g) followed by sunflower oil (246 µg/g) and blended oil, respectively. 7-Ketositosterol, followed by 7β-hydroxysitosterol, 5,6-epoxy derivatives and 7α-hydroxysitosterol were the main POP induced during heating. It was also noted that POP measured do not account for all the PS losses and a clear gap was found during heating.

Evaluation of Phytosterol Oxidation in High Oleic Vegetable Oils During Heating. Elham Tabee[1,2], Margaretha Jagerstad[1], Paresh C. Dutta[1], [1]Department of Food Science, Swedish University of Agricultural Sciences, Uppsala, Sweden, [2]Food and Drug Department, Ministry of Health and Medical Education, Tehran, Iran

Phytosterols are natural components in food with plant source and due to their structure; phytosterols are susceptible to oxidation and formation phytosterol oxidation products (POPs). The levels of POPs in fried foods have attracted interest in recent years because of their possible harmful health effects. In first part of this review, the results of a study showing that after heating at 180°C for up to 12 h, the levels of POPs increased in high oleic rapeseed oil, palm olein and refined olive oil. In addition, it was demonstrated that the addition of 0.2% α-tocopherol to refined olive oil decreased POPs formation significantly during heating compared with other oils. In another part of the study, the quality characteristics of French fries prepared at 180°C in palm olein and refined olive oil in five batches at 1-hour

interval showed a higher amount of POPs in French fries prepared in refined olive oil. However, all other frying quality parameters tested, such as total polar compounds, *p*- anisidine value and free fatty acids, were significantly higher in French fries prepared in palm olein than in those prepared in refined olive oil. Although expensive, but refined olive oil with added α-tocopherol can be good oil for preparing fried potato products.

Effect of Saturated/Unsaturated Fatty Acid Ratio on Physicochemical Properties of Palm Olein-Olive Oil Blend. Mahsa Naghshineh, Abdul Azis Ariffin, Hasanah Mohd Ghazali, Hamed Mirhosseini, Abdulkarim Sabur Mohammad, Sadra Tabassi, Universiti Putra Malaysia, Srikembangan, Selangor, Malaysia

Although blending polyunsaturated oil with more saturated or monounsaturated oils have been studied extensively, there is no similar information regarding the partial replacement of palm olein with olive oil. Therefore the main objective of this study was to investigate the effect of olive oil (OO) partial replacement (0, 25, 50, 75, 90 and 100% w/w) on chemical stability of palm olein oil (POO). The physicochemical properties of samples namely iodine value (IV), peroxide value (PV), anisidine value (AV), TOTOX value (total oxidation value, TV), free fatty acid (FFA), cloud point, color and viscosity were considered as response variables. Apart from FFA, all the response variables were significantly ($p < 0.05$) influenced by type and concentration of oil. The oil blend containing 10% (w/w) POO and 90% (w/w) OO showed the highest significant ($p < 0.05$) TV (6.10); whereas the blend containing 90% (w/w) POO and 10% (w/w) OO exhibited the least significant ($p < 0.05$) TV (2.41). This study indicated that the chemical stability of oil blend significantly ($p < 0.05$) enhanced with increasing the proportion of polyunsaturated/monounsaturated fatty acid.

Changes in Sterols and Formation of Oxysterols During Oil Processing. Roman Przybylski[1], Magdalena Rudzinska[2], [1]University of Lethbridge, Lethbridge, AB, Canada, [2]Poznan University of Life Sciences, Poznan, Poland

Phytosterols are the main minor components present in all vegetable oils. Chemical structure of phytosterols is similar to cholesterol and these compounds are degraded by oxidation in similar way. Oil processing caused degradation of sterols and formation of oxidized derivatives of these components. Each step of processing affected differently sterols and the amount of oxyphytosterols formed. During refining the majority of oxyphytosterols were formed, which were removed during bleaching. Further reduction in these components was observed during deodorization however the last step also cause formation of new oxidative derivatives of phytosterols and increased amount in finished oil.Oil processing by-products also contained important amount of sterols and their oxidation derivatives.

High Oleic/Low Sat Soybean for Food and Industrial Uses. T. Ulmasov, Monsanto, St. Louis, MO

Most industrialized countries recognizing the risks of trans-fat have adopted policies strictly regulating its presence in food supply. Today, almost 4 years after introduction of regulation in US, food companies are still struggling to find a cost-effective solution to the trans-fat problem. Using combination of biotechnology (RNAi) and traditional breeding, Monsanto was able to develop high-yielding soybean varieties containing increased (>70%) oleic acid, <3% of linolenic acid, and reduced (5-7% vs. 15% in normal soybean) saturated fat. This profile results in significant improvement in oxidative stability over low linolenic oils introduced in 2005. This oil is ideal for heavy-duty frying applications, providing an abundant and inexpensive supply with saturated fat content lower than can be found in most vegetable oils. It will also find its use in industrial applications, making it a preferred feedstock for biodiesel and lubricants. For applications that require solid fat Monsanto is developing soybeans with elevated stearate. Stearate, considered by many to be a â??heart-neutralâ? saturated fat is capable of providing texture and other solid fat functionality in such applications as baking and margarine spreads. We believe that future soybean market will be decommoditized with several types of trait-enhanced oils serving the needs of different market segments.

The Effect of Blending Frying Oils on French Fry Quality. N.A.M. Eskin, M. Aliani, D. Ryland, K. Loewen, S. Siddhu, University of Manitoba, Winnipeg, MB, Canada

The objective of this work was to determine the effect of high oleic canola oil (HOCO) and regular canola oil (RCO) blends on the discontinuous batch frying (240 batches) of French fries for 105 hours (7 hours per day for 15 days) in commercial fryers. Sensory evaluation and electronic nose were employed to investigate the effect of 100%

HOCO/0% RCO; 90% HOCO/10% RCO; 80% HOCO/20% RCO on French fry quality. After 15 days of frying all of the oil blends contained polar components below the 25% limit. For fried and overcooked aromas; fried, overcooked and bitter flavors the 80/20 blend was significantly different ($p<0.05$) than the other two blends as measured by eleven trained panelists. Degree of browning and textural attributes showed no significant differences for the three blends. Correlation between overcooked flavor and electronic nose sensor response calculated by partial least squares analysis was 0.57. Adding 10% RCO to a HOCO blend appeared to produce French fries that were not deemed significantly different from those fried in 100% HOCO.

Aroma Profiles of Greek Olive Oils from Different Olive Cultivars and Geographical Origins. T.S. Savvidou[1], M.G. Kontominas[1], A.K. Kiritsakis[1], A.V. Badeka[2], [1]Alexander Technological Education Institute of Thessaloniki, Greece, [2]University of Ioannina, Greece

Olive oils from healthy fruits from different Greek olive cultivars and geographical areas were used for the present study. Fruits were collected at the optimum maturity stage and similar storage and processing conditions (temperature, malaxation time etc) in the olive processing mill were applied. Quality parameters such as free acidity, peroxide value, absorbance coefficient values at 232 and 270, and total phenols were determined. Aroma components of oil samples using solid phase micro-extraction (SPME) and gas chromatography (GC) mass spectroscopy techniques, were analyzed.Quality parameter values showed that all olive oil samples were extra virgins. More than 70 compounds were identified from the volatile fraction of all the samples, belonging to aldehydes, ketones, esters, alcohols and hydrocarbons.In all oil samples, the most representative C6 compounds were aldehydes, with E)-Hex-2-enal to be the most predominant. Oil samples obtained from the same olive cultivar, cultivated in different geographical areas contained different percentage of aldehydes, alcohols and esters.Olive oils from the cultivar Koroneiki, from different geographical areas, showed the highest percentages of C6 esters (24%) compared to the oil of other olive cultivars which showed lower percentage (3,7%).

WEDNESDAY

MORNING
EAT 4: Crystalline Properties of Fats
Chair(s): N. Widlak, ADM Cocoa, USA

Physical Analysis of Mixing Phase Behavior of POP/POS/SOS. Kiyotaka Sato, Mari Sasaki, Satoru Ueno, Hiroshima University, Higashi-Hiroshima, Hiroshima, Japan

Ternary mixing behavior of POP/POS/SOS has been analyzed by using very pure samples with an aim to precisely clarify the mixing behavior of the three triacylglycerols (TAGs) near the concentration ratio range of cocoa butter. DSC and synchrotron radiation X-ray diffraction methods were applied to observe the occurrence of miscible or eutectic mixing behavior both in metastable and most stable polymorphic states of the mixtures with different concentration ratios of the three TAGs. The following results were obtained.(1) The binary mixtures of POP/SOS and POP/POS revealed miscible and eutectic behavior, depending on the ratio of the two main components. However, SOS/POS mixtures were miscible at the whole concentration ratios.(2) At the concentration ratio of POP/POS/SOS=22/46/32 (CB ratio), which is quite close to the ratio of three TAGs in cococa butter, metastable and most stable polymorphs revealed miscible mixtures, and their polymorphic transformation behavior was quite similar to that of cocoa butter.(3) With increasing concentration of SOS from the CB ration, the ternary mixtures became eutectic. By contrast, miscible nature was increased with increasing concentration of POS.The present study may provide much more clear insights into the mixing behavior of cocoa butter constructing TAGs, and useful information for material design of cocoa butter equivalent fats production.

Monitoring Crystal Size, Morphology and Polymorphism by Ultrasonic Spectroscopy in Cocoa Butter. F. Peyronel[1], A. Shukla[2], A. Prakash[2], R. Hone[3], I. Neeson[3], A. Marangoni[1], [1]University of Guelph, Guelph, Ontario, Canada, [2]The University of Western Ontario, Canada, [3]VN Instruments Ltd., Canada

The crystallization process of tempered and un-tempered cocoa butter was monitored in real time using an Ultrasonic workstation from VN Instruments (Brockville, ON, Canada) which uses the Synthetic ImpulseTM technique. This data processing method provides high resolution spectral characterization of the extremely attenuative solid/liquid mixtures present in a crystallization process . It is known that as fat material solidifies the attenuation of the sound waves changes significantly and is a strongly dependent on the frequency used. The speed of sound also tends to increase when the material solidifies. The formation of the crystalline structure of a material causes the ultrasonic waves to both scatter and be absorbed through the volume of the material. By monitoring crystallization in the range of frequencies from 500 Khz to 5 MHz, it was possible to detect differences between tempered and untempered cocoa butter. Results of these observations will be presented together with analytical data on cocoa butter structure using pulsed magnetic resonance (p-NMR), X-Ray diffraction, polarized light microscopy and differential scanning calorimetry (DSC). These results show that this technique is powerful enough to detect changes in the structure and morphology of Cocoa Butter under different treatments.

Effect of Laminar Shear and Crystalline Orientation on Fat Crystal Network's Nano-structure. Farnaz Maleky, Alejandro G. Marangoni, University of Guelph, Canada

The effects of laminar shear and crystalline orientation on nano-structure of fat crystal network and its physical properties were quantified. Scanning Electron Microscopy (SEM) gave us the possibility to observe the whole sample and analyze both internal and surface structure of the network. At the nanoscale, the lamellar orientation of TAGs and crystalline domain size were studied by Small angle X-ray System (SAXS) analysis. Both techniques show that laminar shear affects crystal morphology, domain size and porosity of the system.Moreover, monitoring thermal properties and elasticity modulus illustrates the effects of this crystallization process on physical properties of the samples. Crystal orientation and the aggregation behavior were all affected by laminar shear, which in turn affected the mechanical response of the fat, including hardness and stiffness (shear storage modulus, yield force). This translated also to change in food product attributes and functionality.

Isothermal Crystallization Kinetics of Palm Oil in Blends with Palm-Based Diacyglycerol. Amir Hossein Saberi[1], Lai Oi-Ming[1,2], [1]Department of Bioprocess Technology, Faculty of Biotechnology and Biomolecular Sciences, University Putra Malaysia, Serdang, Selangor, Malaysia, [2]Institute of Bioscience, University Putra Malaysia, UPM, 43400 Serdang, Selangor, Malaysia, Serdang, Selangor, Malaysia

Crystallization kinetics of palm oil (PO) in presence of different concentrations (2, 5, 30, 50%) of palm-based diacylglycerol (PB-DAG) were investigated over different ranges of crystallization temperatures. Addition of 30 and 50% of PB-DAG (High concentrations) increased drastically the melting point as well as crystallization onset of PO despite having similar fatty acid compositions. Individual comparison of induction time (IT), Avrami exponent (n), Avrami constant (k) and half-time of crystallization (t1/2) of blends classified under various groups based on supercooling similarity, showed that addition of 5% of PB-DAG in most of the supercoolings significantly ($P<0.05$) reduced nucleation rate as well as crystal growth velocity of PO as reflected in its significantly higher IT, k and t1/2. Although the presence of 2% of PB-DAG was found to have inhibitory effect on PO crystallization, this effect was not significant ($P>0.05$). Also, Mode of crystal growth attributed to n was changed only in presence of 5% of PB-DAG. On the other hand, high concentrations of PB-DAG were found to significantly ($P<0.05$) reduce IT as well as t1/2 and also increase k suggesting their promoting effects on nucleation and crystallization rate of PO even with the same supercoolings. In addition, they changed crystal growth mode of PO.

Ultrasound Doppler based in–line Viscosity and Solid Fat Profile Measurement of Fat Blends. P. Wassell[1,2], J. Wiklund[3], M. Stading[3], G. Bonwick[2], C. Smith[2], E. Almiron-Roig[2], N.W.G. Young[1,2], [1]Dansico A/S, Multiple Food Applications, Brabrand, Århus, Denmark, [2]University of Chester, Environmental Quality and Food Safety, Chester, Great Britain, [3]SIK—The Swedish Institute for Food and Biotechnology, Göteborg, Sweden

Removal and reduction of saturated fats from foods is becoming increasingly prevalent within the food industry. Populations across the globe are being gradually educated about high inclusion levels and dietry affects of saturated

fats. Removing total saturates however, requires novel solutions in terms of maintaining fat blend structure and functionality. A method for in-line rheometry combining the Doppler-based Ultrasound Velocity Profiling (UVP) technique, with Pressure Difference (PD) measurements, commonly known as UVP–PD, has recently been developed and validated. The method gives directly the 1D–solution to the Navier-Stokes equations and allows measurements not possible with common rheometers such as in–line determination of rheological properties and radial velocity profiles in real time. Furthermore, it offers non-invasive investigation, to correlate the speed of sound to solid fat content under real time dynamic shear conditions and compare with the standard NMR based method.

Nanoscale Modifications of Fat Crystal Networks. N.C. Acevedo, A.G. Marangoni, University of Guelph, Guelph, Ontario, Canada

The structural attributes of a fat crystal network play a significant role in the properties of fat-structured foods. For the past years most of the research on the structure of fats has been directed towards elucidating the microstructural scale within the range of 1 to 100μm. However the nature and organization of the nanoscale in fat crystal networks has not been characterized and no systematic studies have been performed in this area. Blends of non-interesterified (NI) and chemically interesterified (CI) tristearin and triolein were prepared. The materials were crystallized non-isothermally at different cooling rates, and isothermally in the presence and absence of laminar shear. Studies were carried out by cryo-TEM microscopy, and X-ray diffraction. The results indicate that fat mesocrystals are composed of individual asymmetric nanoplatelets. Nanoplatelet dimensions decreased as the supersaturation increased, ranging from 400x160x35 to 150x60x30nm. Platelet sizes in CI blends were smaller than those in NI. Fast cooling rates induced a decrease of approximately 50 % in platelet length and width and 12% in thickness, relative to slow cooling rates. Crystallization under shear induced a decrease of around 40% in platelet length and width and 10% in thickness. Trough the rational engineering of the nanoscale, the macroscopical properties of fat products can be modified to obtain the desired functionality.

Use of High Stearic High Oleic Sunflower Oil in Enzymatic Interesterification for CBE Application. E. Dubinsky[1], I. Jachmanian[2], M.A. Grompone[2], [1]Eduardo Dubinsky & Associates, Argentina, [2]Universidad de la Republica, Uruguay

The acidolysis of High Oleic Sunflower Oil with stearic acid has been described in the literature. There are also some patents including this process connected with this process and its use for the manufacture of Cocoa Butter Equivalents (CBE) and Cocoa Butter Improvers (CBI).A theoretical model for enzymatic interesterification of High Stearic High Oleic sunflower Oil was developed and will be presented using a restricted random approach. The use of this modified Sunflower Oil gives 2 advantages regarding the High Oleic Sunflower Oil: 1) An increase in the StOSt content in the interesterification products 2) An increase in productivity providing that the maximum yield of SOS is reached with lower concentrations of Stearic Acid or Stearic Esters.The first experimental results in the lab, confirming this expected improvements, will be presented.

Fat Bloom in Compound Coatings. Adam Lechter[1], Neil Widlak[2], Wan Yi Tammy Tam[2], Dawn Sikorski[2], [1]ADM Cocoa, Milwuakee, WI, USA, [2]ADM Research, Decatur, IL, USA

Plam kernel oil is widely used as a compound coating in the confection industry. If not processed or stored properly palm kernel based coatings may bloom, resulting in an undesirable appearence on the product's surface. This paper will review the lipid composition and physical properties of bloomed fat formed on a variety of palm kernel based compound coatings.

Experimental Validation of the Modified Non-Isothermal Avrami Model for 1D Fibrillar, 2D Platelet and 3D Spherulitic Crystal Growths. R. Lam, M.A. Rogers, University of Saskatchewan, Saskatoon, SK, Canada

Originally, the Avrami model was developed to describe crystallization kinetics under isothermal conditions for polymers. Due to the majority of industrial crystallization processes utilizing non-isothermal cooling profiles an understanding between non-isothermal crystallization kinetics and the macroscopic properties of the network is crucial. Numerous non-isothermal crystallization conditions for 12-hydroxystearic acid (1-d fibre), stearic acid (2-d platelet),

and trihydroxystearic acid (3-d spherulites) were fitted using the modified-Avrami model to calculate the dimensionality of growth, n, the apparent growth rate constant (kapp), and induction time (t). Different methods of measuring crystal growth were assessed using calorimetry, rheology, infrared spectroscopy and microscopy. Depending on the techniques employed, similar results were obtained for the dimensionality of growth, n. The apparent growth rate constant (kapp) shows the importance of reaction limited and diffusion limited crystallization kinetics which are differentiated using the non-isothermal Avrami model.

An Extraction Method for the Removal of the Fat Phase in Chocolate. A. Coutouly[1], S. Hodge[2], D. Rousseau[2], [1]ENSBANA, Université de Bourgogne, Esplanade Erasme, Dijon, France, [2]Ryerson University, Toronto, ON, Canada

Microstructurally, chocolate consists of cocoa particles, sugar crystals and milk powder (if present) dispersed in a continuous cocoa butter fat phase. Much like industrial concrete, the fat phase in chocolate acts as the cement holding these dispersed particulates in place. The purpose of this investigation was to develop an extraction method to remove the cocoa butter fat phase whilst leaving the dispersed particulate network intact. Three parameters were evaluated: i) the method of addition of small amounts of water (up to 4 wt%) to the chocolate during its preparation; ii) the contact method of a solvent (petroleum ether) with the fat phase, and iii) the duration of fat phase extraction. The addition of 2-4% water was necessary to retain the structure of the backbone particulate network during extraction. Absence of water generally resulted in dispersed particulates that fell apart, suggesting that the water aided in particle-particle sintering and network preservation. Water in the form of a fine water-in-oil emulsion was the most efficient means of addition. Optimal fat extraction and structure retention was achieved with a solvent capillary/vapour phase method. Extraction times upwards of 24 h were necessary to extract sufficient cocoa butter from the chocolate for proper particulate network analysis. Finally, characterization with scanning electron microscopy confirmed the adequacy of the developed extraction method.

AFTERNOON
EAT 5: General Edible Applications
Chair(s): B. Farhang, University of Guelph, Canada; and G.R. List, Retired, USDA, ARS, NCAUR, USA

Degumming Revisited. A.J. Dijkstra, Consultant, Dijkstra-Tucker, St Eutrope-de-Born, France

It is time to revisit the degumming process. Twelve years ago, when I presented a paper with the same title at the 89th AOCS Annual Meeting & Expo held in Chicago, I reported that ?enzymatic degumming raises more questions than it answered?. On the other hand, when trying to look into the future, I also mentioned membrane degumming and that the use of phos¬pholipase C might offer yield advantages. To put these remarks in perspective, I will start my presentation by reviewing some phosphatide chemistry and explain how the various degum¬ming processes work, what their advantages and disadvantages are, and when to use which. As is only to be expected, I will also highlight some unresolved issues. For instance the mechanism by which non-hydratable phosphatides are removed with the soapstock during alkali refining has never been elucidated. After this introduction, I will review recent developments. These are mainly concerned with the use of various phospholipidolytic enzymes that can not only be used to remove phosphatides from triglyceride oil but also to recuperate acylglycerols from the gums resulting from a degumming process. It will become clear that no single one degumming process is ideal for all circumstances encountered in industry. For oils with a low phosphatide content such as palm oil and the lauric oils, the dry degumming process will remain the best preparation for the subsequent physical refining process. Oils with a high phosphatide content - and that excludes water-degummed oils processed in stand-alone refineries- may profit from an enzymatic treatment because of yield advantages. Which enzyme or combination of enzymes to use will be discussed in more detail.

Physical and Structural Case Study of Low *trans* Shortenings for Improved Performance in Icing Applications. M. Peitz, Archer Daniels Midland Co., USA

In today's world of low trans alternatives, options for icing shortenings that provide the same mouth feel and performance as their traditional partial hydrogenated counterparts, with a 0 trans label claim, has been an issue. This study looks at the impact of emulsifiers and/or beta prime tending fat addition to promote the ideal crystal structure to

retard post hardening of the finished product while still providing ideal workability, functionality, and sensory characteristics. Fat systems discussed are enzymatically interesterified soybean oil (EIESBO) with the addition of enzymatically interesterified palm kernel oil (EIEPK) and/or fully hydrogenated cottonseed oil (FHCSO), and/or distilled monoglyceride, and/or mono and diglycerides. The development of viscosity and functionality over time will be related to the properties of each formulation. Results show that the addition of EIEPK and fully hydrogenated cottonseed oil made the greatest impact on the final product by retarding post hardening while still providing the most satisfactory mouth feel and functionality over time.

Fry Studies Utilizing a Novel Low Saturate High Oleic Soybean Oil. R. Wilkes, L. Jurado, Monsanto Company, St. Louis, MO, USA

Since the implementation of mandatory trans fatty acid labeling in consumer products, and subsequent local foodservice bans, a range of trans fat solutions have been adopted to replace partially hydrogenated fats. Second generation oilseeds are being developed which address stability, and flavor concerns foodservice operators and food companies have been facing. A new high oleic, low saturated, low linolenic soybean has been developed that has approximately 75% oleic acid, 15% linoleic acid, 3% linolenic acid and 6 % total saturated fat. Dietary assessments demonstrate this new oil reduces trans fats without impacting essential fatty acid intake when replacing partially hydrogenated oils (PHOs) and liquid oil blends developed as substitutes for PHOs. Fry studies were conducted over an extended fry time of 120 hrs for French Fries and chicken. Results demonstrate improved fry life and stability of the oil compared to other soybean oil alternatives. Sensory analysis confirmed acceptable flavor for both French Fries and chicken fried in this oil. Analytical results showed that low trans fat levels were maintained, and saturated fat content in both French Fries and fried chicken were reduced. Use of a high oleic, low saturate, low linolenic soybean oil provides the opportunity to maintain low trans fat levels, reduce saturated fat, and improve fry performance.

Formulation of Zero trans, Low Saturated and Nutritious Rate of Omega 9,6,3 Semi-solid Fat for Production of Muffins and Cupcakes. F. Madadnoee[2], M.R. Modalal[1,2], F. Karami [1,2], [1]Kesht va Sanaat Shomal, Sari, Mazandaran, Iran, [2]Mahidasht Agri-Industry and Vegetable Oil Manufacturing, Kermanshah, Iran

In the first part of a 3-phase applied research we successfully eliminated trans fatty acids from all our products. Keeping the saturated fat at low level in production of trans free products is challenging. In the second phase we formulated a low saturated semi-solid fat with approximately the same melting point of high saturated shortenings to be used in production of Muffins and cupcakes. The new formulation has already replaced the high saturated shortening by consumer companies. The shelf life, color, texture and taste of muffins and cupcakes were evaluated by sensory panel and revealed superiority of the new product in all tested attributes over conventional products. In the third phase to keep the balance of three unsaturated fatty acid, omega9,6 and 3, we raised the ratio of omega 9 and 3 and lowered the ratio of omega6, by changing the type of blended liquid oils. Formulated fat were used in production of muffins, cupcakes as well as cookies in both small scale confectioneries and industrial scale manufacturing. Results of the sensory analysis showed preference towards the new formulation. The fatty acid composition of the formulated semi-solid fat is; Total saturated fatty acids 14±1%, omega9, 54±3%, omega 6, 25±2, omega 3, 7±1 and omega 6/omega 3, 3-4 and slip melting point 37 C.

Comparison of Oil, Interesterified Soy Shortening, and a Monoglyceride Structured Shortening Alternative on Wheat Dough Rheological Properties and Starch Pasting. Brittany Huschka, Carolyn Challacombe, Alejandro G. Marangoni, Koushik Seetharaman, University of Guelph, Guelph, ON, Canada

Monoacylglycerol-stabilized oil in water emulsion (MAG gel) is a recent advance in the development of alternate shortening that is free of trans fats, and low in saturated fat. However, the behaviour of MAG gels in dough systems has not been investigated. We investigated the effect of MAG gel at different levels (6-24%) in hard (HWF) or soft (SWF) wheat flour dough to dough with oil or interesterified soy shortening (IE Soy). Dough mixing and water absorption were evaluated using a Farinograph. Gluten behavior was measured using a Gluten Peak Tester (GPT); and pasting characteristics were measured using a micro-viscoamylograph (MVAG). Dough development times were similar between the MAG gel and IE Soy, but Farinogram curve characteristics were similar between MAG gel and oil. The trend for torque development in the GPT was similar between MAG gel and IE Soy, exhibiting delayed gluten

aggregation, whereas oil exhibited earlier gluten aggregation. Following heating and cooling in the MVAG, starch interaction with the monoglyceride component of MAG gel appeared to be the dominating factor resulting in an increased pasting temperature and a second viscosity peak during cooling. These results suggest that further evaluations are necessary to effectively use MAG gels in baked product systems.

Performance of Hybrid Triacylglycerides During Frying and Storage of Oil. Roman Przybylski, Eliza Gruczynska, University of Lethbridge, Lethbridge, AB, Canada

Antioxidants are the main protectants of oils during frying and storage. New antioxidants to improve performance during frying and storage were developed in the form of hybridized triacylglycerols, where antioxidative components were implemented. Those novel triacylglycerols improved significantly frying stability of standard oil. The amount of polar and polymerized components was significantly lowered extending fry-life of oil and producing fried products with improved quality and enriched in antioxidants. Those hybrids also improved storage stability of oil by reducing oxidative degradation and extending shelf-life of the product. Developed hybrid triglycerides contain natural components usually present in vegetable oils.

Research and Development of Micro Algae Food Ingredients. Michael Golembieksi, Solazyme, South San Francisco, CA, USA

Solazyme has developed a unique technology platform that utilizes microalgae to produce renewable triglyceride oils in standard fermentation facilities quickly, efficiently and at large scale. These oils are rich in heart-healthy unsaturated fats, contain no trans fat or cholesterol, are shelf stable and are composed of a variety of valuable fatty acid profiles. The oils are also high in antioxidants and other valuable nutrients, including phospholipids, tocopherols, tocotrienols, sterols and carotenoids. Solazyme?s researchers have demonstrated that when used in full or partial replacement of full-fat lipids (eggs, butter, oil) in a wide variety of formulated food products, significant reduction in calories, saturated fat, and cholesterol can be achieved, coupled with the addition of valuable micronutrients and dietary fiber. In addition to nutritional improvement, the products also provide a number of functional benefits such as enhanced sensory qualities in low-fat formulations and improved moisture retention in challenging applications such as gluten-free recipes.Solazyme?s development of its algal food ingredient platform addresses consumer demands for natural food ingredients that provide great taste and outstanding sensory attributes, while offering a healthier nutritional profile when compared to the use of conventional lipid sources.

Edible Applications Technology Posters

Chair(s): N. Garti, Hebrew University of Jerusalem, Israel

Effect of Shear on the Crystallization of Fat Blend.
Makoto Shiota, Miki Konno, Ai Iwasawa, Tomoyuki Isogai, Leo Tanaka, Mototake Murakami, Snow Brand Milk Products Co., LTD., Kawagoe, Saitama, Japan

The consumption of low-trans fat foods, which contain more palm oil, is increasing in recent days compared with fat products containing partially hydrogenated oil. The physical properties of margarine and shortening containing large amount of palm oil such as consistency and plasticity are determined largely by triacylglycerol composition and crystallization behavior. However, the impact of shear for processing these products on the crystallization behavior during storage has not been fully understood. In this study, the effect of shearing of the palm oil based blend (P-Fat) and fat blend containing partially hydrogenated fat (H-Fat) on the polymorphic structure under thermal thawing between 5 and 20°C every 12h during storage were compared. The X-RD peak of β form of P-Fat increased in intensity with increasing of the storage period, and the diffraction peak intensity of β form of P-Fat prepared with shear after 40 days storage was lower than that of without shear. On the contrary, the polymorphic transformation of H-Fat from β′ to β was not observed. The electron microscope observation revealed the differences of the tri-dimensional organization of the crystals between with and without shear step. These results suggest that appropriate shear enable us to control the physical properties of palm oil based fat foods.

Oil and Fatty Acid Content Among Diverse Sesame Genetic Resources.
J.B. Morris, M.L. Wang, USDA, ARS, Griffin, GA, USA

Sesame, Sesamum indicum contains oil used for salads, cooking while the seeds are used on hamburger buns, candies, and are used to make tahini. Sesame oil is known to reduce cholesterol due to the high polyunsaturated fat content in the oil. Oil content ranges from about 40 to 63% among sesame accessions (samples) worldwide. However, the U.S. sesame collection has limited oil and fatty acid content information. One thousand two hundred and twenty nine sesame accessions are conserved at the USDA, ARS, Plant Genetic Resources Conservation Unit, Griffin, GA. The objectives of this study are to determine oil and fatty acid content and if correlations occur among eleven sesame accessions regenerated in Georgia, U.S. for various morphological features, oil content, and fatty acids. Seed reproductive data will be analyzed after mature seeds have been harvested. Gas chromatography (GC) will be used to analyze fatty acid composition while oil content will be determined using nuclear magnetic resonance (NMR) from these sesame seeds. Morphological data, seed yield, fatty acid analysis, and oil content will be determined after all sesame plants have completed their growth cycles. High oil producing sesame genotypes will be produced and will offer breeders and geneticists valuable germplasm for cultivar development.

Stability and Bioaccessibility of Beta Carotene Encapsulated in Poloxamer 188 and Tween 20 Stabilized Canola Oil Emulsions Versus Canola Stearin Solid Lipid Articles.
S. Langmaid, C. Trujillo, A.J. Wright, University of Guelph, Guelph, ON, Canada

Solid lipid particles (SLP) can be used to encapsulate lipophilic molecules for improved stability and enhanced bioavailability. Canola stearin (CaSt) SLP and canola oil (CO) emulsions with either Poloxamer 188 (P188) or Tween 20 (T20) with and without 0.1 wt% β-carotene (BC) were produced by high pressure homogenization. The influence of encapsulation on SLP properties and BC stability and bioaccessibility was determined. Droplets and particles with D4,3 in the range of 130nm and monomodal distributions were produced for all systems at 9 and 10 % P188 and T20, respectively. The presence of BC did not alter SLP polymorphic or melting behavior. Losses of BC in the emulsions were significantly higher than for the crystallized SLP ($P<0.05$) as well as with T20 versus P188 ($P<0.05$). BC losses of at least 51% were observed for all systems by 90 days storage at 4 and 20 C in a dark and oxygen-free environment. Differences in BC stability between P188 and T20 SLP may be related to polymorphism and surface coverage. While the P188 systems contained only the β polymorph from Day 1 onwards, the T20 SLP contained both β' and β polymorphs up to Day 90. Bioaccessibility experiments using an in vitro model of digestion revealed differences between the samples related to a liquid versus solid matrix and between the emulsifiers.

Synchrotron X-Ray Diffraction Characterization of Crystallizing Triglycerides.
M. Li, G. Mazzanti, Dalhousie University, NS, Canada

Triglycerides are known to crystallize in three main polymorphic forms; α, β? and β, with the structural form dependent on environmental and processing crystallization conditions such as temperature, cooling rate and shear rate. Binary mixtures of pure triglycerides (Trialurin, Trimyristin) in non-crystallizing oil (Triolein) were used as test samples, which comprises of Trialurin and Trimyristin in a ratio of 7 to 3, diluted with 60% or 40% Triolein. 40%7L3M was cooled at 10˚C/min from the melt at 60˚C down to temperatures of 14˚C, 16˚C, 18˚C, respectively; while 60% 7L3M was cooled at 10˚C/min from the melt at 17, 20˚C, and 23˚C. Both of the fat samples were left to crystallize at each end temperature both statically and under shear rates of 800, 80, and 8s-1. Time-resolved X-ray diffraction was performed at the National Synchrotron Light Source (Brookhaven National Lab, US) to detect the whole crystallization processing at both the small angle (SAXD) and wide angle (WAXD). X-rays are used to image crystals based on the constructive interference of scattered diffracted x-rays from different layers to create a detectable signal. By translating the image results into curve ones, it assigns the peaks to particular polymorphic forms and resolves ambiguous cases of polymorph identity. Obvious phase transitions were observed and different polymorphs were identified and compared to that of literature from SAXD and confirmed using WAXD.

Effect of Evaporation Conditions on Physicochemical Properties of Sodium Caseinate-stabilized Astaxanthin Nanodispersions Prepared by Using Emulsification-evaporation Method.
Navideh Anarjan, Chin Ping Tan, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

In this study, sodium caseinate-stabilized astaxanthin nanodispersions were prepared by using emulsification-evaporation method. Response-surface methodology was employed to study the effect of evaporation conditions, namely the applied temperature (16-66°C), frequency of rotation (0-200 rpm) and evaporation time (1-11 min) on the average particle size, polydispersity index and astaxanthin concentration of the prepared nanodispersions. Second-order polynomial regression models expressing the astaxanthin nanodispersion properties as functions of the evaporation variables were significantly ($p < 0.05$) fitted, with acceptable coefficient-of-determination values. Among three studied evaporation parameters, the frequency of rotation had the most significant effect on all studied responses. A multiple-optimization procedure showed that the optimum conditions for temperature, frequency of rotation and evaporation time were 47°C, 94 rpm, 9 min, respectively, with composite desirability equal to 0.736. Under these optimum conditions, no significant ($p > 0.05$) differences between the experimental and predicted values were observed, confirming the suitability of the regression models relating the independent and response variables studied.

The Effect of Nanoscale van der Waals Interactions on the Mechanical Properties of Fats.
F. Peyronel, A. Marangoni, University of Guelph, Guelph, Canada

Knowledge of the Hamaker coefficient for mixtures of solid fats and oils provides valuable information regarding the strength of intercrystalline interactions and thus the mechanical strength of the material. There are different approaches for the calculation of this Hamaker coefficient, a classical, a semiclassical or a quantum dynamical approach. Our latest effort in our laboratory was to focus on the quantum dynamical approach, by using the non-retarded approximation to the Lifshitz theory. This approximation requires the knowledge of the static dielectric constant and the refractive index in the visible region for both, the fat and the oil. Using this method, the Hamaker coefficient was calculated for a series of fats across several oily media. The values obtained were compared to the Hamaker coefficient obtained by using both the fractal model developed in our laboratory, and a semiclassical approach. A brief discussion about the pros and cons of these three ways of calculating the Hamaker coefficient will be presented

Extraction of Essential Oils from Natural Feedstocks Using Supercritical Fluid Extraction.
Kenneth James, Supercritical Fluid Technologies, Newark, DE, USA

Supercritical fluid technology (SFE) is especially attractive for extraction of naturally occurring essential oils. Extraction and fractionation can be accomplished simultaneously in the high pressure process. SFE is useful to produce oils of standardized concentration of active ingredients, and products of much higher concentration (higher yields and purity) and quality (with less creation of artifacts), than possible by conventional chemical engineering unit operations such as liquid/liquid extraction, steam distillation, mechanical micronization. Phase equilibrium experiments are carried out to determine the preliminary processing conditions in which the compound of interest solubilizes and precipitates from the supercritical fluid. This information can then be utilized to give a "starting point" to the extraction and separator processing conditions and insight to a commercial scale supercritical fluid extraction system. This poster illustrates the selection of operating conditions to maximize both essential oil yields utilizing several examples.

Edible Oil Polymer Organogels as Fat Substitutes in Comminuted Meat Products.
A.K. Zetzl, A.G. Marangoni, S. Barbut, Dept. of Food Science, University of Guelph, Guelph, Ontario, Canada

Comminuted meat products such as bologna, or coarsely ground meat products such as sausages, can contain fat contents in excess of 20%, half of which is saturated. Due to increased awareness of the numerous deleterious health effects of saturated fatty acids on human health, there has been a move to develop a novel fat structuring method that can mimic the textural properties of saturated animal fat, while maintaining a healthier fatty acid profile. Polymer organogels appear to be a promising solution as they are predominantly composed of highly unsaturated oils. An organogel can be defined as an organic liquid entrapped within a thermo-reversible, three-dimensional gel network. The polymer ethylcellulose can be used to gel oil at concentrations below 10%. The performance of the organogel in meat batters resembled that of the beef fat and was very different to the performance of oil in meat batters. Preliminary trials using differential scanning calorimetry have been completed in an attempt to understand the interactions between liquid oils, saturated animal fat, and the ethylcellulose gel and meat proteins. Lipid-protein-gel interactions were also studied using a variety of microscopy techniques to better understand the functionality of the gel in comminuted and

coarsely ground meat batters.

Using Multilayer Emulsion Technique to Protect Omega-3 Fish Oil from Oxidation.
Dongming Tang, Sylvie Cloutier, Clint Brooks, Ocean Nutrition Canada Ltd., Dartmouth, NS, Canada

Omega-3 fish oil rich in polyunsaturated fatty acid is sensitive to oxidation, so various microencapsulation methods have been employed to protect it from oxidation. The multilayer emulsion or layer-by-layer emulsion technique is a novel encapsulation technique and draw a lot of interest of researchers recently from both academic and industrial world.This study investigated the process of using multilayer emulsion technique and a combined method of multilayer emulsion and complex coacervation to encapsulate Omega-3 fish oil. The encapsulated Omega-3 fish oil samples made by both methods were spray-dried and tested for their capability to protect the Omega-3 oil from oxidation. The results clearly showed that the multilayer emulsion method significantly improved the oxidative stability of encapsulated Omega-3 fish oil for both emulsion and complex coacervation method, which is illustrated by longer induction period, lower free oil, and better sensory data. This work showed that the multilayer emulsion technique can be added on top of the current microencapsulation techniques and broaden the application of the encapsulated Omega-3 oils by selecting and composing different inner and outer layers of shell materials.

Characterization and Encapsulation of Pytochemical-rich *Hylocereus polyrhizus* Seed Oil.
Hong Kwong Lim, Jamilah Bakar, Chin Ping Tan, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

Hylocereus polyrhizus (red-skinned pitaya with red flesh) seed oil can serve as a potential new source of essential oil. As a by-product of pitaya juice processing, the tiny black pitaya seeds (size < 1.0 mm) contained 18.33% of oil and showed a high degree of unsaturated fatty acid content. Linoleic, oleic, and palmitic acids were the major fatty acids in the pitaya seed oil (PSO). Total tocopherol content in PSO was 43.50 mg/100 g, whilst abundance of β-sitosterol was also found in PSO. Most commonly found phenolic compounds such as p-hydroxybenzoic, vanillic and protocatechuic acids were identified by liquid chromatographic analysis. In addition, spray-drying technique was used to encapsulate PSO. Sodium caseinate/ maltodextrin DE10 as wall material was homogenized with PSO to form an O/W emulsion and spray-dried into an encapsulated lipid powder. Shelf-life stability test: active oxygen method by Rancimat and Schaal oven test were conducted. The result reveals that sodium caseinate/ maltodextrin DE10 can be used to protect PSO from oxidation and increase the shelf-life of PSO.

Hard Stock from Enzymatically Interesterified Hard Palm Stearin: Characterization and Potential Application in *trans* Free and Low SAFA Solid Fat Formulations.
Noor Lida Habi Mat Dian[1], Fatihanim Mohd Nor[1], Miskandar Mat Sahri[1], Lai Oi Ming[2], [1]Malaysian Palm Oil Board, Kajang, Selangor, Malaysia., [2]Universiti Putra Malaysia, Serdang, Selangor, Malaysia

Enzymatic interesterification (EIE) of palm stearin (IV14) (POsIV14) and canola oil (CO) blend in 1:1 ratio was conducted in a continuous packed-bed reactor operating at 70°C. Immobilized lipase (Thermomyces lanuginosa) was used as catalyst. The POsIV14/CO blend is high in trisaturated (S3) triacylglycerols (TAGs), i.e., PPP (37.0%) and PPS (2.9%) (P =palmitic and S =stearic acids). This blend is fully solid and hard at ambient temperature and fully melted at about 60°C. EIE softened the blend, as indicated by its slip melting point (SMP), solid fat content (SFC) and DSC melting profiles. Softening of the blend was due to the reduction in the S3 TAGs content. The interesterified (IEed) blend was then blended with palm kernel and canola oils in various ratios (according to Design Expert ternary mixture design) in order to study the potential usage of the IEed blend as hard stock for trans free and low saturated fatty acids (SAFA), preferably < 30%, solid fat formulations. Statistical results (based on SMP, SFC and fatty acid composition) indicated that it is possible to formulate such products using the IEed POsIV14/CO blend as hard stock.

Crystallization Behaviors of Diacylglycerols.
K. Saitou, Y. Mitsui, J. Moriwaki, M. Shimizu, N. Kudou, Y. Katsuragi, Kao Corporation, Human Health Care Research Center, Health Care Food Research Laboratories, Sumida-ku, Tokyo, Japan

For use of fatty materials as food products, it is important to know crystallization behaviors of them, which affect storage stability, texture, and suitability for processing. There are many studies about crystallizing properties of

Triacylglycerols (TAGs), but on the other hand, little is known about those of diacylglycerols (DAGs), especially of multi-component mixtures of DAGs. In the present study, thus, the crystallization behaviors of DAGs were examined. First, we investigated the components in the fat crystals developing when DAG-rich oil, made of a vegetable oil, was cooled. In the early stages of crystallization, levels of DAGs containing one or two saturated fatty acids (SS or SU) were high in the fat crystals, and then, DAGs of two unsaturated fatty acids (UU), mostly in the 1,3-isoform, became the major components in the crystals. Next, using purified 1-palmitin-3-olein (1,3-PO) and 1,3-diolein (1,3-OO) as representative SU and UU in the DAG-rich oil, crystallization behaviors of binary mixtures were investigated by differential scanning calorimetry (DSC). DSC analysis showed that the crystallization temperature of 1,3-OO was shifted to higher temperature by addition of 1,3-PO. These results suggested that, in the crystallization processes of DAGs, SS and SU crystallized at first, and this was followed by the loading of UU on the crystals.

Technical Program