LIPID OXIDATION AND QUALITY

LOQ 1a: Antioxidant Mechanism and Activity

Chairs: Fereidoon Shahidi, Memorial University of Newfoundland, Canada; and Zhuliang Tan, DSM Nutritional Products, Canada

Antioxidant Activity and Mechanism of Action of Natural Extracts: Their Impact on Color and Lipid Stability in Meat Products S.P.J. Namal Senanayake*, *Camlin Fine Sciences, USA*

Maintaining the appearance and red color are very important to retail shelf-life of fresh meat products. If the meat is dark or discolors early, then consumers will not purchase the meat. Improved color stability results in fewer pulls, discounts and discards due to discoloration. One opportunity to improve color stability in fresh meats is to supplement meat products with naturally-derived antioxidants. The goal of this study is to investigate the effect of plant-based extracts such as those derived from acerola cherry, rosemary and green tea on color and oxidative stability of fresh ground beef products. In addition, the effect of these natural extracts on oxidative stability of cooked meat products during storage will also be evaluated. Antioxidant mechanism of action that are associated with each natural extract will also be discussed.

Antioxidant Mechanism of Natural Phenolics on Scallop Adductor Muscle During Drying and Storage Dayong Zhou*[1], Hongkai Xie[2], Fereidoon Shahidi[3], and Beiwei Zhu[4],*[1]Dalian Polytechnic University, China; [2]National Engineering Research Center of Seafood, China; [3]Memorial University of Newfoundland, Canada; [4]College of Food Science & Technology, Dalian Polytechnic University, China*

Objective The present work investigates the effect of natural antioxidant, tea polyphenols (TP) and antioxidant of bamboo leaves (AOB), against lipid oxidation in scallop's adductor muscle during the drying process and storage and demonstrates their in situ antioxidant mechanism. Methods used: The distribution of antioxidant in the scallop adductor muscle and their action in chelating metal ions and quenching of free radicals was examined in situ. Meanwhile, POV, TBARS, AV, and contents of TAG, FFA, PC, PE, protein carbonyl, total phenols, phospholipase, lipases and lipoxygenase (LOX) were determined. Furthermore, the effects of the natural phenolics on the shelf life of dried scallop adductor muscle were predicted by Arrhenius model. Results Using an in vivo imaging system, it was found that AOB could diffuse into the adductor muscle upon marinating, efficiently retarded lipid oxidation during the drying and storage process. The in situ antioxidant mechanisms of AOB as well as TP included quenching of free radicals as detected by electron spin resonance, chelating metal ions determined by confocal laser scanning microscopy and inhibiting LOX. Upon marinating with AOB and TP, the contents of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in adductor muscle decreased by less than 8% instead of >28% (without antioxidants) during the drying process. The shelf lives of AOB- and TP-treated dried adductor muscle were more than 1.70-fold than that of dried control adductor muscle. Conclusions Overall, the antioxidants efficiently maintained the high nutritive value of adductor muscle in terms of its lipid components during drying and storage.

Influence of Antioxidants on Oxidation Pathways Zhehan Jiang*, Suzanne M. Budge, and Wei Xia, *Dalhousie University, Canada*

While lipid oxidation pathways have traditionally focused on hydroperoxides and

their scission products, there is increasing interest is describing alternative pathways, proceeding through production of alcohols and epoxides. However, there has been little attention devoted to the effects of antioxidants on these pathways. In this study, we focus on the qualitative and quantitative analysis of epoxy and hydroxy fatty acids produced during oxidation of a single triacylglycerol, trilinolein, in the presence and absence of α-tocopherol, to better understand the diversity of products produced and the rates of their formation. Previous research suggested that while α-tocopherol has a well-known antioxidant effect at low concentrations, it may also function as a prooxidant at high concentrations. To address this, α-tocopherol was added to trilinolein at two concentrations (0.1% and 2% by mass) and compared to a control sample without added tocopherol. All the samples were heated at 30 °C with aliquots removed for analysis every 3 days in a 15-day experimental cycle. Samples were transmethylated with sodium methoxide, separated into epoxy and hydroxy fractions with solid-phase extraction, and derivatized to trimethylsilyl ethers to mask hydroxide groups. Gas chromatography-mass spectroscopy (GC-MS) was used to identify the epoxy and hydroxy components in each fraction, while GC with flame ionization detection was used for quantitative analysis. Preliminary data clearly showed that epoxy fatty acids did not form in both tocopherol treated samples (0.1% and 2%), while hydroxy fatty acids were present in greater concentrations in the samples having the higher α-tocopherol concentration. Coupled with rates of formation, these data will help elucidate the importance of alternative pathways in triacylglycerol oxidation.

Stability and Stabilization of Edible Oils: Role of Endogenous Antioxidants and Phenolipid Addition Fereidoon Shahidi*, *Memorial University of Newfoundland, Canada*

Edible oils are prone to oxidation and this is generally dictated by their fatty acid composition and degree of unsaturation as well as their positional distribution in the triacylglycerol molecules, minor components present, and storage conditions. This study examined the role of minor components on the stability of selected oils by stripping them from the samples. While stripped oils were generally less stable than their unstripped counterparts under Schaal oven conditions, the reverse was true under fluorescent light. In addition, selected phenolipids were tested for their antioxidant efficacy. Both the structural characteristics of the phenols as well as the nature of the acyl group determined their efficacy. Finally, the phenol moieties of phenolipids was released, at least partially, upon simulated digestion and hence exerting their potential health effects.

LOQ 1b / PRO 1b: Effect of Processing on Lipid Oxidation in Oils and Fats and Lipid-containing Foods
Chairs: S.P.J. Namal Senanayake, Camlin Fine Sciences, USA; and Sean Liu, USDA, ARS, USA

Effects of Modified Phosphatidylcholine on Physical and Oxidative Stability of Omega-3 Delivery 70% Oil-in-Water Emulsions Betül Yesiltas*[1], Ann-Dorit Moltke Sørensen[2], Pedro J. Garcia-Moreno[2], Sampson Anankanbil[3], Zheng Guo[4], and Charlotte Jacobsen[2],[1]*National Food Institute, Technical University of Denmark, Denmark;* [2]*Technical University of Denmark, Denmark;* [3]*Dept. of Engineering, Aarhus University, Denmark;* [4]*Aarhus University, Denmark*

The objective of this study was to investigate the effects of modified phosphatidylcholine (PC) with different alkyl chain lengths (C14 and C16) and covalently attached caffeic acid on the oxidative and physical stability of high fat 70% fish oil-in-water emulsions. It is hypothesized that 1) modified PC improves the physical stability of emulsions when used in combination with sodium caseinate (CAS) and soybean PC, by its high surface activity as a surfactant, and that 2) modified PC enhances oxidative stability due to the attachment of caffeic acid to the glycerol backbone of PC, which brings the antioxidant in the vicinity of oil-water interface. Physical stability of the emulsions were analyzed using droplet size, viscosity, zeta potential, interfacial tension, and protein content in the aqueous phase. Peroxide value, changes in tocopherol content and secondary volatile oxidation products were determined to evaluate oxidative stability. Results showed that the physical stability of the emulsions was improved with increasing concentrations of added modified PCs. Modified PC C14 showed higher physical stability compared to modified PC C16 by providing smaller oil droplets and higher viscosity as well as higher zeta potential. On the other hand, oxidative stability was higher for the emulsions produced with modified PC C16; increased concentration of modified PC C16 led to a decrease in formation of primary and secondary oxidation products. Modified PCs in combination with CAS and soybean PC thus improved the physical and oxidative stability of 70% fish oil-in-water emulsions compared to emulsions produced with only CAS as an emulsifier.

Effect of Maillard Reaction Conditions on Physicochemical Properties and Oxidative Stability of Microencapsulated Chia Oil Vanesa Y. Ixtaina[1], Bernd W.K Diehl[2], Claudia N. Copado[1], and Mabel Tomás*[1],[1]*CIDCA (CONICET-UNLP), Argentina;* [2]*Spectral Service AG, Germany*

Chia oil presents a very high content of PUFAs, which are very susceptible to lipid oxidation. Some techniques, such as microencapsulation, have been developed to protect this type of oils. Many studies showed that Maillard reaction products (MRPs) have anti-oxidative properties and can be used as wall material for microencapsulation. The objective of this study was to characterize the physicochemical properties of microencapsulated chia seed oil MRPs, as wall material, obtained by different heat treatments. Chia O/W emulsions were composed by NaCas, lactose, and chia oil (10, 15 % wt/wt). The aqueous phase was heated at different temperatures (60 and 100°C) for 30 min to promote the MRPs formation. Then, the microcapsules were obtained by spray-drying the emulsions. All the systems showed high microencapsulation efficiency (~99%). The moisture content and water activity (aw25ºC) of microcapsules ranged between 0.020-2.998 % (d.b.) and 0.243-0.470, respectively. In terms of oxidative stability, the accelerated oxidative test (Rancimat) and the peroxide values (PV) revealed a very significant influence of the heat treatment, with the highest induction time (ti)

and the lowest PV for microcapsules obtained from emulsions with 15% content oil and aqueous phase submitted to heath treatment of 100°C, 30 min.

Impact of Ratios of Polyunsaturated and Saturated Fatty Acids on Oxidation Kinetics in Oil/Water Emulsions Raffaella Inchingolo[1], D. Julian J. McClements[2], Eric A. Decker[2], and Mitchell D. Culler*[2],[1]*University of Massachusetts, USA;* [2]*University of Massachusetts Amherst, USA*

Recently, demand for clean-label food products has necessitated new strategies for preventing lipid oxidation as consumers become skeptical of synthetic antioxidants. One potential strategy is to dilute more easily oxidized, unsaturated fatty acids with more oxidatively stable oils, thereby decreasing oxidation by increasing the time needed for fatty acid free radicals to diffuse to and oxidize other fatty acids. This strategy has proved effective in bulk oils but not oil-in-water emulsions. The effect of diluting fish oil with increasing concentrations of medium chain triglycerides (MCT) on oxidative stability of oil-in-water emulsions was investigated using thiobarbituric acid reactive substances assay (TBARS), lipid hydroperoxides, and head-space aldehydes. Dilutions up to 1:20 of fish oil in MCT were found to extend the lag phase of lipid oxidation markers from 1 to 5 days in oil-in-water emulsions stabilized by Tween 80. To verify that the dilution was effective, two emulsions were prepared, one with fish oil and the other with MCT, and the 2 emulsions were blended to have the same fish oil:MCT ratios. The same protective effect was not observed when the oils were in separate droplets, indicating dilution is responsible for the protective effect. Emulsions containing high oleic sunflower oil were also examined as a more commonly used oil in food production. The protective effect was again demonstrated in mixed emulsion droplets, but not when the oils were in isolated droplets. These results indicated that dilution with more stable lipids presents an effective strategy to delay lipid oxidation in food emulsions systems.

Effective Prevention of Oxidative Deterioration of Fish Oil by the Combination of Amine-compounds and General Antioxidants Mariko Uemura[1], Masashi Hosokawa[1], Kazuo Miyashita*[1], Ai Iwashima-Suzuki[2], and Hiroaki Kubouchi[2],[1]*Hokkaido University, Japan;* [2]*Megmilk Snow Brand Co. Ltd., Japan*

EPA and DHA, abundant in fish oil, are known to have significant biochemical and physiological effects primarily linked to improvement of human health, especially cardiovascular and brain health. However, the incorporation of fish oil into foods and beverages is often challenging as fish oil is very easily oxidized and can cause undesirable flavors. In the present study, we demonstrate the successful prevention of volatile formation in fish oil oxidation by amine-compounds. Several kinds of amine-compounds such as butylamine, stearylamine, and spermine could show antioxidant activity and this activity increased with increasing the number of amine groups. In addition, their antioxidant activity synergistically increased in the presence of general antioxidants such tocopherols, hydroxytyrosol, and carnosic acid. For example, the volatile formation was completely inhibited by the combination of spermine and α-tocopherol up to 5000 hr after incubation of purified fish oil triacylglycerol at 50°C. On the other hand, amine-compounds having hydroxyl group(s) had no antioxidant activity without any general antioxidants, while they showed a strong antioxidant activity in the presence of tocopherols. The most likely mechanism for the antioxidant activity of amine-compounds is the formation of antioxidants by the amino-carbonyl reaction between the amine group

and the carbonyl group of aldehydes, which are formed in a very early stage of the fish oil oxidation.

Determination of Lipid Oxidation Parameters in Solid Non-oil Matrices and the Impacts on the Pet Food Industry B.J. Bench*, *Tyson Foods, USA*

Most pet food products consist of rendered animal protein meals and fats as one of the major building blocks in pet food diets. As pet food ingredients start to degrade via the lipid oxidation phenomenon it undergoes changes affecting odor, flavor, nutritional quality and palatability. Several parameters can be measured as means of determining oxidative stability and shelf-life of rendered protein meals and finished pet food products. In pet food products containing oils and fats, peroxide value is a popular oxidative stability measurement. However, it is not possible to use peroxide value alone to judge the actual quality of rendered protein meals because hydroperoxides decompose readily during storage. To avoid misinterpretation of peroxide values, it is crucial to understand the oxidation history of the meal samples, which can be determined using other indicators such as p-anisidine values, hexanal and/or 2,4-decadienal contents, as well as TOTOX ("total oxidation") values. p-Anisidine values, headspace volatile aldehydes, specifically, the hexanal and/or 2,4-decadienals, and TOTOX values are not commonly utilized to assess lipid oxidation in these products. Ultimately, correlating these analytical parameters to companion animal palatability will provide guidance on what pet ingredient and food manufacturers can utilize to determine lipid oxidation.

LOQ 2a: Oxidation and Antioxidants in High Protein Foods

Chairs: Michelle Peitz, Archer Daniels Midland Co., USA; and David Johnson, Kalsec Inc., USA; and Minwei Xu, North Dakota State University, USA

Increasing Oxidative, Microbial and Color Stability of Fresh Meats: Mechanism and Application Min Hu*, *DuPont Nutrition & Health, USA*

Meat products are easily oxidized and spoiled. It is critical, therefore, to prevent spoilage bacteria growth and maintain the quality attributes of fresh meats such as flavor, color and texture. Clearly, natural antioxidants like ascorbic acid, green tea extract and rosemary extract can greatly inhibit lipid oxidation and maintain red color of fresh ground meats. Some antimicrobials can not only inhibit microbial growth but maintain the red color of fresh meats. Further, adding the blend of natural antioxidants and antimicrobials could be more efficacious in increasing oxidative, microbial and color stability of fresh meats. However, the mechanisms of these antioxidants and antimicrobials to increase the oxidative, microbial and color stability have not been completely elucidated. In-depth research on the mechanism would help develop new antioxidant and antimicrobial products, thus extending the shelf life of fresh meats. In this presentation, we will discuss possible mechanisms: (1) how natural antioxidants such as polyphenols and ascorbic acid effectively maintain the cheery red color and prevent lipid and pigment oxidation; (2) how some of antimicrobials keep red color of fresh meats, and (3) how the blend of antioxidant and antimicrobial extend red color, inhibit lipid oxidation and spoilage bacterial growth in fresh meats, effectively, and how antioxidant and antimicrobial work together to fight hydrogen peroxide and reduce heme pigment metmyoglobin and MbFe(IV)=0 to oxymyoglobin, as well as prevent lipid oxidation in fresh meats.

Maillard Reaction Products as Antioxidants in a Muscle Model System: Effect of pH and Tocopherol Ling Liu, Jie Yin, and Mark P. Richards*,*University of Wisconsin-Madison, USA*

Effects of Maillard reaction products (MRPs) as inhibitors of hemoglobin-mediated lipid oxidation were evaluated in washed cod muscle (WCM) and washed turkey breast muscle (WTM) during storage at 2°C storage. MRPs were prepared by reacting equimolar glucose with lysine at 110°C for 2 h. The cooled solution was used immediately or stored at 4°C compared to -20°C prior to use. MRPs were added at 75-900 µmol/kg washed muscle (as a dilution of the glucose and lysine concentration in the heated mixture). Bovine hemoglobin (Hb) was added to promote lipid oxidation at 44 µmol heme/kg washed muscle. pH values examined were 5.6 and 6.6. Lipid peroxides and thiobarbituric acid reactive substances (TBARS) were used as markers of primary and secondary lipid oxidation products, respectively. Alpha tocopherol was measured by high pressure liquid chromatography with fluorescence detection. MRPs strongly inhibited Hb-mediated lipid oxidation in WCM (p

Pea Protein Isolate/Gum Arabic Glycation Improves the Oxidative Stability of Oil-in-Water Emulsions Bingcan Chen*, *North Dakota State University, USA*

The current work presented the feasibility of modifying pea protein via glycation to produce a dual effect food ingredients. Pea protein isolate (PPI) was glycated with gum Arabic (GA) under variable incubation time. The properties and functionalities of modified PPI was characterized by SDS-PAGE, FT-IR, and SEM. The physical properties and the oxidative stability of corn oil-in-water emulsions stabilized by modified PPI was examined. We found the emulsions prepared by modified PPI

had smaller particle size, higher surface charge, and stronger steric hindrance to prevent the droplets against environmental stresses. The emulsion oxidation kinetic study indicated that the modified PPI formed a barrier that prevents the transition metal from interacting with hydroperoxides, thus enhancing the oxidative stability of emulsion.

LOQ 2b Special Session to Honor Dr. Michael Eskin's 50 Years of Research in Fats and Oils
Chairs: Michelle Peitz, Archer Daniels Midland Co., USA; and David Johnson, Kalsec Inc., USA; and Minwei Xu, North Dakota State University, USA

Mustard and Canola-Derived Canolol: Challenges and 0pportunities. Usha Thiyam-Hollander, *Food and Human Nutritional Sciences, University of Manitoba, Canada*

Canolol extracted from mustard and canola has been the focus of our research for the last ten years. Multiple substrates namely seed, crude oil, distillates, protein, and the by-product press cake were investigated for canolol and related products. While it has been shown to have potent antioxidant properties, it is limited for commercial use unless it can be produced in adequate amounts. Scale-up production is limited due to potential structural-alteration and degradation. These structure-production challenges and proposed pathways drawn from the literature and our multiple projects will be addressed in this paper. An improved method for the production of canola will require heat, enzymes and pressurized treatment and will be presented as well. It is evident that canolol has considerable potential as an antioxidant. Our work over the past ten years was conducted in collaboration with Dr. N.A.M Eskin.

The Ramblings and Raps of an Aging Lipid Chemist. N.A. Michael Eskin, *University of Manitoba, Canada*

I have been privileged to spend the last 50 years of my professional career at the University of Manitoba in Winnipeg, Canada. It wasn't too long after my arrival that I found myself part of an incredible team that established canola oil as a viable commercial product. Later work dealt with a variety of interesting problems that presented themselves including sedimentation. At the same time I developed a simple colorimetric method for measuring rancidity based on hydroperoxides which required 500 mg of oil and some 40 years later used the Iatroscan to develop a method for measuring rancidity requiring only micrograms of oil. Parallel work on a mucilage from yellow mustard recently showed it had strong emulsifying properties as well as antioxidant activity. Current work on canola with Dr. Usha Thyam-Hollander is focussed on canolol, the subject of the next presentation. The lipid raps are a fairly recent development with the first one presented at the AOCS Conference in California in 2012 with several other released since then including the latest one on fat-soluble vitamins.

ANA 2c / LOQ 2c: Chemical and Sensory Methods to Predict Food Stability

Chairs: J. David Pinkston, Archer Daniels Midland Co., USA; and Lan Ban, Kemin Food Technologies, USA

The Effect of Rosemary Extract and Phospholipase A2 on the Color Stability and Lipid Oxidation of Fresh Pork Sausage James Whalin*, Ling Liu, and Mark P. Richards, *University of Wisconsin-Madison, USA*

The objective of this study was to determine if a combination of rosemary extract (RE) and phospholipase A2 (PLA2) could stabilize color and limit lipid oxidation in pre-rigor pork sausage as well or better than synthetic (Syn) antioxidants. We hypothesized the combination of PLA2 and RE would stabilize color and lipid better than either PLA2 or RE individually and as well as synthetic antioxidants. Sausage was manufactured from sows within one hour post-exsanguination. Sausages were stored in the dark at -20°C (up to 245 days) prior to light display for nine days of refrigerated storage. Color stability was measured based on redness. Peroxide values (PVs) were measured spectrophotometrically and headspace hexanal were measured via gas chromatography (GC) as markers of lipid oxidation. Sausage with RE and RE+PLA2 exhibited better color stability than the synthetic antioxidants. However, the synthetic antioxidants had less lipid oxidation as measured by headspace hexanal. RE and PLA2 had lower PV than RE alone at one time point of cold storage. In conclusion, RE and PLA2 decreased lipid oxidation (compared to RE) and enhanced color stability (compared to Syn) and offer an alternative to synthetic antioxidants in pork sausage.

The Effect of Volatile and Non-volatile Degraded Products on the Performance of Frying Oil Junmei Liang*[1], Fuhuan Niu[2], and Yuan Rong Jiang[3], *[1]Wilmar (Shanghai) Biotechnology Research & Development center Co., Ltd, China; [2]Wilmar (Shanghai) Biotechnology Research & Development center Co., Ltd; [3]Wilmar Biotechnology R&D Center (Shanghai) Co., Ltd., China*

Frying is a very popular food preparation method in both food and catering industry. Deep fried food is always popular by their special flavor, delicious taste and crispy texture in the surface of fried food. Frying oil is one of the most important factor affecting the fried food quality and sensory. During deep frying, different reactions happened including autoxidation, polymerization and degradation. Both the volatile compounds and non-volatile compounds formed during frying. These compounds affect both the sensory of fried food and the quality of the frying oil. In this presentation, the detailed composition in the polar compounds will be analyzed, including both volatile compounds and the non-volatile polar compounds include free fatty acids, diglycerdies, oxidized triglycerides mono, dimers and polymers. The difference of the composition in degraded compounds with different frying oils will be compared. By compared the degraded products in the different oils, the effect of fatty acids profile will also be discussed. The effect of the total polar compounds composition of the frying oil on the sensory and quality of the different frying oil will be discussed.

Improvement of Flavour and Stability of High-oleic Sunflower Oil by Onion Frying Chang Chang*, and Xingguo Wang,*Jiangnan University, China*

High-oleic sunflower oil has been received more attentions by its prolonged stability and positive impacts on low-density lipoprotein cholesterol, but flavour qualities of its fried foods and itself were not satisfactory. The objective of this study was to improve sensory characteristics of high-oleic sunflower oil with an advantageous oxidative stability by onion

frying. Aroma compounds formed in high-oleic sunflower oil during the processes of heating and onion frying were investigated, as compared with palm oil and soybean oil. Onion frying developed four times more volatiles in the high-oleic sunflower oil than the simple heating process. Other than aldehydes, hydrocarbons, alcohols, and ketones resulting from lipid oxidation, onion frying also brought furans, furanones, furfurals, and phenols into the frying oils via Maillard reaction of amino acids with reducing sugars and aldehydes. In comparison with palm oil and soybean oil, high-oleic sunflower oil exhibited the highest flavour intensity after continuous frying of 16 h at 160 °C, especially on some representative volatiles [e.g., 2-n-octylfuran, dihydro-5-pentyl-2(3H)-furanone, and furfural]. Moreover, total polar compounds and fatty acids profiles of the heated and onion fried oils were comparatively studied. A great loss of flavonoids in onions took place during frying to effectively prevent oxidative deterioration of the oils by inhibiting the formation of polar compounds and trans fatty acids under deep frying. In conclusion, sensory quality of high-oleic sunflower oil was significantly optimized by onion frying with an unignorable bonus on oxidative stability under frying conditions.

Correlation of Oxidative Shelf-life to Test Conditions and Physical Stability of Antioxidants Chia-Yu F. Shen*, Kristen Robbins, and Lan Ban,*Kemin Food Technologies, USA*

Oxidative stability of foods and beverages is related to their intrinsic physical and chemical properties. Effective and clean-labeled antioxidants are strongly demanded by market-driven customers to improve the unsatisfactory oxidative stability. Antioxidants have been fast screened by accelerated tests, including oxidative stability index (OSI), Oxipres and elevated temperature storage stability. However, those accelerated tests may not truly reflect the antioxidants performance. In this study, selected antioxidants were evaluated in bulk oil and a low moisture food by OSI and Oxipres respectively. Those accelerated tests were compared to ambient storage condition which monitored oxidative byproducts and sensory change. The study reveals interesting observations. First, accelerated tests cannot reflect the actual antioxidants performance in foods. The combination of rosemary extract and ascorbic acid performed the best in improving shelf-life in biscuits, but Oxipres showed tocopherols the best. The discrepancy possibly came from different antioxidants chemical stability. Second, physical stability is crucial for ascorbic acid in extending bulk oils shelf-life which cannot be captured by OSI. Third, only ambient oxidative byproducts well-correlated to ambient sensory evaluation. Abusive storage conditions resulted in poor correlation between the two. In summary, sensory acceptance scores well-correlated to chemical markers in biscuit at ambient condition, and the physical stability of an insoluble antioxidant closely correlated to its shelf-life extension capabilities. Limited correlation was seen between highly abusive acceleration tests (Oxipres and OSI) and actual antioxidant performance in extending oxidative shelf-life in food systems.

Evaluation of Oxipres™ Apparatus to Study Oxidative Stability and Antioxidant Activity Cindy Tian*,*Kalsec, Inc., USA*

When studying the stability of oils and oil containing foods, accelerated tests are regularly used, where the rate of oxidation is enhanced either by using higher temperature or by addition of prooxidants. Oxipres™ apparatus, which shares similar principle as the ASTM Oxygen Bomb method, provides a fast way to examine stability of diverse applications compared to other methods such as Accelerated Shelf Life Testing (ASLT) and Oxidative Stability Index (OSI). As a preliminary

work to develop an Oxipres™ system to screen natural antioxidants, different matrices were studied to determine the optimum condition for each. Bulk oil, salty cracker, cookie, and dressing were selected to represent different food types in terms of different oil, protein, sugar and water content. Testing conditions including temperature, oxygen pressure, and sample size were studied. Temperature showed the biggest impact on induction time, whereas O2 pressure and sample size affected various matrices differently. All above factors also showed influence on the oxidation rate and total oxygen consumption. Initial work on the development of model systems for screening antioxidant activities will also be discussed.

ANA 3c / LOQ 3a: Advanced Analytical Techniques for Lipid Oxidation

Chairs: Matthew Fhaner, University of Michigan-Flint, USA; and Rick Della Porta, Pepsico/Frito-Lay, USA

New Method for the Investigation of Oxidation Stability of Fats, Oils and Complex Food Products Carolin Edinger*, *Anton Paar ProveTec GmbH, Germany*

The quality of fats and oils strongly depends on their oxidation stability. In this contribution a new method for evaluating the oxidation stability of fats and oils by determining the induction period is introduced. Under accelerated conditions (elevated temperature and pure oxygen pressure) a sample of 5 mL/4 g is examined in a sealed stainless steel test chamber. Typical conditions of the method are temperatures between 80 °C – 140 °C and an initial oxygen pressure of 700 kPa. These conditions initiate a rapid oxidation process, which is monitored by recording the pressure until a predefined pressure drop. It was found that the elapsed time until the pressure drop is directly related to the oxidation stability of the sample. Correlation and precision studies demonstrate the method's effectiveness. Due to the defined oxygen volume in the closed test chamber, the oxygen consumption can be calculated. Furthermore, we observed Arrhenius behaviour with regard to the applied temperature, enabling the user to determine the activation energy of a specific oxidation process. Beneficially, the oxidation stability of complex food products can be investigated since even solid samples can be measured without prior sample preparation. The significantly reduced measurement time and a high repeatability of the method represent its major advantages, allowing for quick and direct measurement of the oxidation stability for research, process and test bench control.

Analysis of Polar Compounds Generated during Thermal Process of Oils and its Biochemical Function Evaluation Chen Cao*, Yongjiang Xu, and Yuanfa Liu, *Jiangnan University, China*

Objectives: during thermal process of oil, a wide variety of chemical reactions occur, which lead to the formation of kinds of compounds with high molecular and polarity, for instance oxidize triglycerides (ox-TG), oxidized triglycerides dimer (TGD), oxidized triglycerides oligo (TGO), diacylglycerol and some free fatty acids. The analysis of polar compounds generated during thermal process of oils and its biochemical function evaluation are necessary. Methods: we used HPLC, LS-MS to separate and analyze the polar compounds, established saturated – unsaturated fatty acids systems to investigate the connections between the final products and the fatty acids composition. Studied their biochemical functions in vitro and in vivo. Results: 1. The polar compounds in the frying oil can induce gene mutation and chromosome variation. At the same time, the intake of polar compounds interferes with the metabolism of lipid, causing liver function damage and affecting the health of the body. 2. The results of cell experiments showed that the toxicity of oxidized triglycerides in polar compounds was greater than others. 3. New types of fatty acids, such as epoxy fatty acids and hydroxyl fatty acids, are produced during the frying process. By the ESR method, the thermal oxidation mechanism of the frying oil is explored to explain the complex reaction process in the frying system. Conclusions: this study help us to have a better understanding of polar compounds generated during thermal process of oils.

Electrochemistry as an Analytical Tool for Monitoring Antioxidant and Omega-3 Fatty Acid Levels during Degradation Matthew Fhaner*, *University of Michigan-Flint, USA*

Electrochemical methods have been utilized for investigating antioxidant systems due to fast analysis times, low cost, direct quantitative

capabilities, and useful limits of detection and linear range. Specifically, voltammetric methods such as square-wave voltammetry (SWV), provide a direct correlation between analytical signal and analyte concentration making it possible to monitor antioxidant levels during degradation of lipid products. Our group has worked to correlate voltammetric oxidation currents of antioxidants with changes in lipid profile of omega-3 fatty acids as monitored via gas chromatography with flame ionization detection (GC-FID). Over a three week degradation study, sesamol, rosemary extract, and butylated hydroxytoluene were supplemented into stripped commercial fish oil and exposed to elevated temperatures. Antioxidant levels were assessed via SWV oxidative peak currents while two specific fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), were monitored using GC-FID. It was determined that SWV does not act as a predictive tool for how well an antioxidant species will protect a specific fatty acid. SWV was successful in providing insights as to the rate of antioxidant depletion over the course of the study, albeit no significant difference was observed between the antioxidants used. An unexpected finding was that SWV was able to monitor oxidation peaks for EPA and DHA and this data mirrored that of the well-established GC-FID FAME method that was run in parallel to SWV studies. The results suggest SWV may fit a niche need for real-time analysis of antioxidant levels and potentially fatty acid quality in commercial and industrial applications.

Application of Flow Cytometry as Novel Technology in the Study of Lipid Oxidation in Oil-in-Water Emulsions Peilong Li*[1], D. Julian J. McClements[2], and Eric A. Decker[2],[1]*Dept. of Food Science, University of Massachusetts, Amherst, USA;* [2]*University of Massachusetts Amherst, USA*

The body of literature on the impact of emulsion particle size on oxidation rates is unclear. This could be because emulsions are typically polydisperse and the oxidation rate of individual droplets is impossible to discern. Flow cytometry is a technique for studying individual cells and their subpopulations using fluorescence technologies. It is possible that individual emulsion droplets could also be characterized by flow cytometry as a novel approach for studying lipid oxidation. Typical emulsion droplets are too small to be visualized by flow cytometer so emulsions were prepared to have droplets > 2 µm; weighting agent and xanthane gum were added to minimize creaming during storage. A radical-sensitive lipid-soluble fluorescence probe (BODIPY 665/676) was added to the lipid used to prepare the emulsion so that the susceptibility of individual emulsion droplets could be determined. The results showed that in a polydisperse emulsion system, small droplets were oxidized faster than large droplets. Using mixtures of emulsions with and without prooxidants, it was possible to see the transfer of prooxidants between droplets, a process that is influenced by surfactant and salt concentrations. For example, surfactants micelles can transport prooxidants to neighboring non-oxidized droplets when surfactant concentration was higher than critical micelle concentration (CMC). Transfer of prooxidants was promoted by adding salt which could be attributed to the effect of salt on CMC. This study showed the good potential for applying flow cytometry on oxidation of individual emulsion droplets.

LOQ 3b: Specialty Oils: Phytochemicals, Extraction and Oxidative Stability

Chairs: Hong-Sik Hwang, USDA, ARS, NCAUR, USA; Ignacio Vieitez, UdelaR, Uruguay; and Alex Kripps, Caldic USA, USA

Supercritical Fluid Extraction of Black Sesame Seeds and Study of the Functional Properties Obtained in Comparison with the Extraction by Soxhlet Method Ignacio Vieitez*[1], Florencia Jorge[1], Elena Dutto[1], Lucia Velazco[1], and Cecilia Abirached[2],[1]*UdelaR, Uruguay;* [2]*PEDECIBA Química, Dept. de Ciencia y tecnología de los Alimentos, Universidad de la República, Uruguay*

Sesame is an important oilseed due to its high lipid content. This seed contains 40-50% of lipids (mainly polyunsaturated lipids). In the present study, the extraction with supercritical fluids using CO2 as a solvent was evaluated in order to obtain functional additives in black sesame seeds, and compared to Soxhlet method, which is one of the conventional procedures used for lipid extraction. Supercritical extractions were performed in a laboratory scale system. Extractions were performed with the following operating conditions: 40ºC, 300 or 400 bar, average CO2 flow of 0.5 sL/min and alternatively, some extractions were done in the presence of 10% wt (related to CO2) of ethanol as co-solvent. To evaluate the antioxidant power of the different extracts obtained, they were added to purified sunflower oil (p-SFO) stripped off from natural antioxidants, at different concentrations (1 and 5%). Induction period (IP) of the oxidation process was determined by an accelerated oxidation method at 100ºC (Rancimat equipment). Also, the content of total phenols (Folin-Ciocalteu method) and total tocopherols (HPLC) were determined, as well as fatty acids composition (GC). When the p-SFO was added with 5% with the extracts obtained at 40°C/ 400bar or 40°C/400bar/co-solvent (10%), its RIP (IP relative to that of the starting p-SFO= 1.5 h) was 2.0 or 3.0, respectively. The use of ethanol as co-solvent in the supercritical extraction allows obtaining an increase in the yield and content of total phenols, for each extraction condition. Additionally, an increase in the IP is also observed.

Development of pulse protein-polyphenol conjugates for improved oxidative stability of flaxseed oil-in-water emulsions Saakshi Parolia[1], Rick Green[2], Michael Nickerson[3], and Supratim Ghosh*[3],[1]*University of Sasatchewan, Canada;* [2]*POS Bio-Sciences, Canada;* [3]*University of Saskatchewan, Canada*

The objectives of the present work were to develop lentil proteins isolate (LPI) and plant polyphenol conjugates, determine their structural and functional characteristics and use them to prepare flaxseed oil-in-water emulsions for improved oxidative stability. Polyphenols are potent antioxidants, and when complexed to proteins at the oil droplet interface, could contribute to enhanced stability of flaxseed oil emulsion compared to when the proteins and the polyphenols were used separately. The interaction between the polyphenols (quercetin, ellagic acid) and LPI was achieved by a grafting method where the degree of conjugation was higher for quercetin compared to ellagic acid. FTIR results showed a change in the secondary structure of the conjugated protein. A reduction in surface hydrophobicity and intrinsic fluorescence for the conjugates compared to the control indicated potential polyphenol binding to the aromatic amino acids of the proteins. Antioxidant capacities, estimated using the DPPH scavenging and FRAP assays, were found to be higher for the conjugates compared to the pure polyphenols. The flaxseed oil emulsions prepared with the conjugates had similar long-term stability compared to the emulsion prepared with LPI. The peroxide and p-anisidine values of flaxseed

oil were significantly lower in the emulsions stabilized with the conjugates compared to LPI alone and when the pure polyphenols were added directly to the emulsion aqueous phase. The presence of polyphenols at the oil-water interface by conjugating them with LPI was better at preventing lipid oxidation in emulsions compared to when they were present in the bulk phase.

Physicochemical Characteristics and Bioactivities of Black Raspberry Seed Oil Keum Taek Hwang*[1], Hee Jae Lee[2], Taehwan Lim[2], and Hana Jung[2],*[1]Seoul National Univeristy, Korea; [2]Seoul National Univeristy, South Korea*

Black raspberry (*Rubus occidentalis*) seed oil (BRSO) can be a potent functional ingredient due to its unique fatty acid composition and rich tocopherol content compared to other vegetable oils. Black raspberry seeds accounted for about 50% in the dried berry and contained more than 17% crude oil. BRSO was high in polyunsaturated fatty acids (PUFA) including about 57% linoleic and 29% α-linolenic acids. Total tocopherols in the BRSO extracted by hexane were 175 mg per 100 g oil, in which γ-tocopherol was the most, followed by α-tocopherol and δ-tocopherol. It was investigated how dietary BRSO intake affected inflammation and lipid profile through animal studies. When male C57BL/6 mice (5 weeks old) were fed high-fat diet having 50% calories from lard and 10% from BRSO for 12 weeks, mRNA expressions of NF-κB-associated pro-inflammatory markers were down-regulated and anti-inflammatory markers were up-regulated. Similar results were observed when C57BL/KsJ-*db/db* mice (6 weeks old) were fed AIN-93G diet with BRSO substituted for soybean oil for 10 weeks. In both cases of high-fat diet-induced obese and *db/db* mice, BRSO supplements shifted hepatic fatty acid composition toward a decrease in n-6/n-3 PUFA ratio. BRSO may also lead to inhibit lipogenesis and promote lipolysis via up-regulation of PPARα and down-regulation of SREBP-1c. These results suggest that BRSO have beneficial bioactivities and applicability to food industry.

Effects of Deacidification Methods on High FFA Containing Oils Obtained from Sea Buckthorn Berry Longkai Shi*, Ruijie Liu, Ming Chang, Qingzhe Jin, and Xingguo Wang,*Jiangnan University, China*

High free fatty acid (FFA) containing sea buckthron oil (SBO) was deacidified using five different methods and the impacts of deacidification on acid value, phytochemical and free radical scavenging capacity of the SBO were evaluated. Although deacidification of oil using solvent extraction and alkali refining exhibited excellent deacidification efficiencies (89.21% and 98.95%, respectively), low oil yields as well as high neutral lipid and minor component losses were observed. In contrast, amidated, molecular distilled and esterified SBO showed not only satisfied acid value, but also low loss of the neutral lipid. Especially, the enzymatic deacidification methods (amidation and esterification) showed nearly 100% of oil yield using ethanolamine and glycerol as the acyl acceptors, respectively. Further, the enzymic deacidified oils and molecular distilled oil exhibited higher retention rates of the micronutrients and antioxidant capacities compared to the crude SBO. This is the first time that multiple deacidification methods have been used to neutralize the FFA of the high acid SBO, and the obtained results hold the potential to be applied industrially in the future.

LOQ 4a: Development of Novel Antioxidants

Chairs: John Sander, Kemin Agrifood, USA; Min Hu, DuPont Nutrition & Health, USA; and Yu Zhao, Penn State University, USA

Enzyme Assisted Extraction of Antioxidant Ingredients from Seaweeds Sabeena Farvin Koduvayur Habeebullah*[1], Zainab Al-Sattari[2], Sakhina Al-Haddad[2], Saja Fakhraldeen [2], Surendraraj Alagarsamy[2], and Faiza Al-Yamani[2], *[1]Environmental and Life Science Research Center, Kuwait Institute for Scientific Research, Kuwait; [2]Kuwait Institute for Scientific Research, Kuwait*

Enzymatic pre-treatment has been considered as a novel and an effective way to release bound compounds from seaweeds. In the present study, antioxidant activities of enzymatic extracts from eleven species of seaweeds collected from Kuwait coast were evaluated using four in-vitro assays. The seaweeds were enzymatically hydrolyzed to prepare water-soluble extracts with five carbohydrate degrading enzymes (Viscozyme, Celluclast, AMG, Termamyl and Ultraflo) and three proteases (Neutrase, Flavourzyme and Alcalase). In general, cabohydrases were good in extracting radical scavenging compounds and proteases were useful in extracting compounds with iron chelating activity. Antioxidant rich seaweed extracts could be obtained when S. boveanum, M. pericladose, C. cornuta, Cladophora sp are hydrolysed with viscozyme, alcalase, neutrase and ultrafo. Whereas antihypertensive rich seaweed extract could be prepared from M. pericladose and Cladophora sp by digesting with alcalase and neutrase respectively. The fractionation of these extracts revealed that the phenolic rich fractions were resposible for the antiradical and reducing power, where as the protein and polysaccharide rich fractions were resposible for iron chelating activity. The anti-hypertensive properties are mainly due to protein rich fractions. Thus we can make tailor made seaweed extracts with specific properties by using enzymes. The interesting results will be presented in the conference.

Opposite Antioxidative Activity Variation of Soluble Free and Soluble Bound Phenolic Compounds during Yellow Pea Germination Minwei Xu*, and Bingcan Chen, *North Dakota State University, USA*

Germination is an effective process to improve the antioxidative activity of phenolic compounds in pulse seeds. This research aims to study the dynamic change of antioxidative activity of soluble phenolic compounds during yellow pea germination and unveil the mechanism based on phenolic composition and molar mass. After germination, soluble free and soluble bound phenolic compounds were extracted and their antioxidative activities were evaluated in both in vitro and in stripped soybean oil (SSO)-in-water emulsion system. Liquid chromatography coupled with electrospray ionization quadrupole time-of-flight mass spectrometry (LC-ESI-QTOF-MS) and size-exclusion chromatography with multiangle-light-scattering and refractive-index detection (SEC-MALS-RI) were employed to analyze the phenolic composition and molar mass, respectively. Antioxidative activity of soluble free phenolic compounds increased in both oxygen radical absorbance capacity (ORAC) and SSO-in-water emulsion system, while that of soluble bound phenolic compounds decreased with germination. Coupled with the chemometric analysis, phloridzin (4), quercetin (9), hesperetin (14), glyzaglabrin (15), and pinocembrin (16) were speculated as the pivotal phenolic compounds responsible for the hydrogen donating capacity. In addition, decreased molecular weight accompanied with the decrease of antioxidative activity in SSO-in-water emulsion system that testified steric

hindrance theory: moieties of soluble bound phenolic compounds have protective and dual antioxidative effect.

Structural determination of polyphenols bound to hemoglobins: Mechanisms of anti-oxidative and pro-oxidative effects Jie Yin, Mark P. Richards*, Wenjing Zhang, and Craig Bingman,*University of Wisconsin-Madison, USA*

The objectives were to determine i) the crystal structure of hemoglobins that form covalent adducts with polyphenols, and ii) relate structural aspects of adducts to oxidative properties of hemoglobin. Caffeic acid and epigallocatechin gallate (EGCG) were reacted with bovine, porcine, trout and turkey hemoglobin (Hb). Electrospray-ionization mass spectroscopy was used to determine adduction(s) of polyphenols to alpha and beta chains of Hb. Protein crystallography was used to determine the three-dimensional structure of protein-polyphenol adducts. Changes in lipid oxidation capacity were assessed by measuring Hb auto-oxidation, heme dissociation, ferryl Hb formation, and Hb-mediated lipid oxidation in washed muscle. Caffeic acid and EGCG bound at Cys130 of the H-helix in turkey Hb alpha chains. Caffeic acid bound at Cys93 of the F-helix in bovine and porcine Hb beta chains. Adduction increased Hb auto-oxidation whereas heme dissocation and ferryl Hb formation were decreased. The Hb-EGCG adduct more effectively inhibited lipid oxidation compared to the Hb-CA adduct. Structural evidence suggested enhanced access of solvent to the distal heme pocket of Hb-CA to explain increased Hb auto-oxidation and decreased access of solvent to the proximal pocket to explain decreased heme dissociation. Electron transfer from bound polyphenol to O2 liganded to the heme-iron can contribute to the increased auto-oxidation of Hb-CA while electron transfer to the heme iron may explain the decreased ferryl Hb formation in Hb-CA. Covalent bonding of polyphenols to hemoglobins represents a novel mechanism by which plant-based antioxidants can affect oxidative processes in muscle foods.

Impact of Intrinsic Chemical Properties and External Emulsion State on Antioxidant Performance in Food Emulsions Yvonne Gildemaster*, Joan Randall, and Lan Ban,*Kemin Food Technologies, USA*

Chelating agents such as EDTA sequester metal ions, whereas many phenolic compounds serve as free radical scavengers. EDTA is cost effective, however, there is a negative image due to its synthetic origin, non-biodegradable nature, and being a possible environmental hazard. In this study both intrinsic and external factors were evaluated, which might influence the performance of an antioxidant molecule. In the first study, the chemical and electrochemical properties of EDTA and plant extracts were evaluated for their different modes of action. Chelating assay and cyclic voltammetry were used to examine EDTA and natural plant extracts in vitro. Electron paramagnetic resonance (EPR) was used in ranch dressing matrix to assess free radical accumulations over time. The second study was designed to identify if different physical properties of food emulsions, such as emulsion stability and droplet size distributions, are correlated with the efficacy from the same treatment. The performance of the ingredients was evaluated in real time in ranch dressings that had the same composition but different emulsion states. From both studies, common plant extracts (rosemary, green tea and spearmint extracts) were used to compare to EDTA. Results have confirmed earlier hypotheses that EDTA was able to both chelate and alter redox potential of Fe(II)/Fe(III) pair, while natural plant extracts didn't have significant chelating capabilities in acidic foods, and performance was largely driven by their

free radical scavenging capabilities. In addition, the physical state of the emulsion affected the antioxidant performance to some degree regardless of their mode of action.

Mechanistic Investigation and Efficacy of Polar Antioxidants to Stabilize Bulk Oil David R. Johnson*, Laura Lafond, Xin Tian, and Nora Yang, *Kalsec Inc., USA*

Consumer perceptions over synthetic food antioxidants have led the food industry to seek alternative natural solutions to prevent lipid oxidation in bulk oil systems. Natural antioxidant strategies, such as rosemary extract, provide some protective effect to stabilize oil. However, rosemary extract alone falls short of reaching the efficacy of synthetic antioxidants, such as TBHQ. To achieve antioxidant stability that rivals that of TBHQ in bulk oil, polar antioxidants (such as ascorbic acid or green tea extract) can be used. Combining these polar extracts with rosemary extract can produce even greater antioxidant protection. In this study, the mechanistic actions of how ascorbic acid and rosemary interact to stabilize oil was investigated. Results suggest that ascorbic acid can reduce oxidized rosemary components (e.g., carnosic acid quinone) back to their reduced forms (i.e., carnosic acid), which may further extend the oxidative stability of oil systems. The efficacy of another polar antioxidant, green tea extract, was also investigated using an oil delivery system. Oil-dispersible green tea was tested alone and in combination with rosemary extract, to stabilize bulk oil, frying oil, and bulk oil that was then used in a baked good application. Analysis by oxidative stability index (OSI), peroxide value (PV), total polar compounds (TPC), and headspace aldehydes (hexanal) showed a protective effect of oil dispersible green tea that in some cases matched that of TBHQ. Overall, results suggest that incorporating polar antioxidants into bulk oil can provide enhanced oxidative protection and may be related to free radical scavenging or antioxidant regeneration.

[Canceled] Physicochemical properties of black bean protein hydrolysates and their antioxidant activities in oil phase Zhaojun Zheng*[1], Yuanfa Liu[2], Yongjiang Xu[1], Chen Cao[1], and Jinwei Li[1],[1]*Jiangnan University, China;* [2]*School of Food Science and Technology, State Key Laboratory of Food Science and Technology, Jiangnan University, China*

LOQ 4b: Frying Oils: Industry Perspective and Novel Solutions
Chairs: Shawn Pan, Bunge North America, USA; Cindy Tian, Kalsec, Inc., USA; and Chandra Ankolekar, Kemin Industries Inc., USA

Practical Application of Amino Acids as Natural Antioxidants for Frying Hong-Sik Hwang*[1], Jill Moser[1], Kenneth M. Doll[1], Mayuresh Gadgil[2], and Sean Liu[3],[1]*USDA, ARS, NCAUR, USA;* [2]*Bradley University, USA;* [3]*USDA, ARS, USA*

Our previous study showed that amino acids were excellent natural antioxidants for frying oils. We conducted further studies on their activities, especially, for their practical application. Antioxidant activities of amino acids was compared to synthetic antioxidant, tert-butylhydroquinone (TBHQ), and leading commercial natural antioxidants including tocopherols and rosemary extract in soybean oil at 180 ºC. Sensory impact and labeling will also be discussed. Factors affecting their activities such as lipophilicity, basicity, effect of side chains and other functional groups, and chelation of metals will be discussed. We found that, in general, higher lipophilicity, higher basicity, and longer alkyl chain increased the antioxidant activity of an amino acid although there were some exceptions. The chelation of metals by an amino acid and antioxidant activity of secondary products produced by reactions between an amino acid and oxidation products, which were known to be important factors for its activity, did not play critical roles at frying temperatures. Peptides and protein hydrolysates have drawn interest as potential natural antioxidants for frying. We compared their antioxidant activities with amino acids. Although protein hydrolysates and dipeptides also showed strong antioxidant activity in soybean oil at 180 ºC, their activities were not as strong as some single amino acids.

The Advantage of Adsorbent Treatment in Snack Foods Frying Oil Application Joby Ulahanan*,*Crystal Filtration Co., USA*

The advantage of Adsorbent treatment in snack foods frying oil application. Objective / Hypothesis There are different types of vegetable oil and animal fat used in frying oil application. The finished products range from different types of snacks foods (for example chips, nuts etc..). One of the major problems facing in snacks foods industries is oil degradation due to an increase in the free fatty acids and other undesired components. This article provides an overview of the advantage of adsorbent treatment in snack foods frying oil application and reduction in free fatty acids. Method Used The oil quality parameters like free fatty acids and peroxide are measured using the Foodlab analysis system. Results Vegetable oil and edible oil samples were collected from a different industrial application. Before the adsorbent treatment, free fatty acid and peroxide of oil samples were measured. The oil sample was heated in Lab scale pilot R&D set up. The adsorbent used in these trials was up to 2% of the weight of cooking oil. After 10 minutes of reaction & mixing time, started filtration. Then measured free fatty acids and peroxide. The free fatty acids reduced 60-75% and peroxide reduced 5-15% for the selected oil samples Conclusion Adsorbent treatment in snacks foods frying oil application is economical and extends the life of cooking oil.

Capturing the Value of Fry Life Extension Through High Oleic Oils Susan Knowlton*, *DuPont Company, Pioneer, USA*

High oleic oils, compared to their conventional counterparts, offer food service establishments many benefits not the least of which is the extension of fry life. High oleic oils are resistant to oxidation and therefore do not break down as quickly as oils that have higher amounts of polyunsaturated fatty acids. When oils oxidize, polymeric materials resulting from

oxidation accumulate in the oil and ultimately coat the surfaces on which they come in contact. Sensory changes also result ultimately leading to unpalatable food prepared in the degraded oil. Restaurants have a difficult time knowing when to change out their fry oils due to the lack of a universal standard in the US. Many choose to change out their oils based on color or a weekly management schedule. In contrast, many European countries impose limits based on a measurement of 'total polars' through legislation. Tests for 'total polars' exist but the equipment, complexity, or cost is often beyond the means of a typical restaurant establishment. This session will discuss work to date on developing a simple, inexpensive test to measure total polars in fry oils.

High Oleic Soybean for Frying Tammy Bratton*, *Bunge Loders Croklaan, USA*

High oleic soybean oil has been in testing market for over decades. This research is studying its pros and cons for frying and providing basics for further improvement of high oleic soybean.

Achieving Desired Shelf Life for Fried and Baked Products Monoj K. Gupta*,*MG Edible Oil Consulting International, Inc., USA*

Achieving desired shelf life in fried and baked products is one of the major goals of the food industry. Modern day products are distributed through the warehouse and then appear on the shelves of the super markets or convenience stores. Depending on the mode of product distribution and delivery system in a company, it may take anywhere from days to weeks, or even months before the product appears on the store shelf. Companies which have store-door delivery capability and district or distribution warehouses of their own can control the time it takes from the day of production to the day the store receives them. The companies that use distributors for their products, generally suffer from the delay in the delivery of the product and sometimes, the product may have only a fraction of the remaining time specified on the product code date by the time the product is purchased and consumed. In addition, the distribution system cannot guarantee the high-temperature exposure the product might be exposed to during storage and transit. Oxidized and rancid flavor in the product can develop due to degradation of the oil used in frying or baking. The oil degradation can also come from the ingredients that contain natural lipids in them. The consumer may complain about the bad product flavor. One statistic about the customer complaint is that 1 out of 100 consumers, who have experienced bad flavor in the product and found it unacceptable flavor, would contact the product manufacturer. Remaining 99 consumers may just switch to another brand of the same product. This paper addresses the basic factors that can affect product shelf life and offer some remedies that could be applied by the manufacturers of the product to improve the shelf life of the same.

LOQ-P: Lipid Oxidation and Quality Poster Session
Chair: Scott Bis, Kemin Industries Inc., USA

1. **Determination of Triacylglycerol Oxidation Mechanisms using Liquid Chromatography-tandem Mass Spectrometry.** Shunji Kato*[1], Naoki Shimizu[2], Yurika Otoki[1], Junya Ito[2], Masayoshi Sakaino[3], Takashi Sano[4], Takahiro Eitsuka[2], Teruo Miyazawa[5], and Kiyotaka Nakagawa[1], *[1]Tohoku University, Japan; [2]Food and Biodynamic Chemistry Laboratory, Graduate School of Agricultural Science, Tohoku University, Japan; [3]Innovation Development Section, J-OIL MILLS, INC., Japan; [4]J-Oil Mills, Inc.., Japan; [5]Food and Biotechnology Innovation Project, New Industry Creation Hatchery Center (NICHe), Tohoku University, Japan*

Objective Triacylglycerol (TG), the main component of edible oil, is oxidized by thermal- or photo-oxidation to form TG hydroperoxide (TGOOH). Since excessive amounts of TGOOH and its subsequent oxidation products cause not only the deterioration of oil quality but also various toxicities, controlling the oxidation of edible oils is essential. Thereby understanding oxidation mechanisms that cause the formation of TGOOH is necessary. Since isomeric information of lipid hydroperoxide provides insights about oil oxidation mechanisms (e.g. auto- and photo-oxidation), we analysed TGOOH isomers in various oil such as canola oil, rice bran oil and fish oil. **Methods** We first determined the most suitable TGOOH molecular species for the evaluation of each oil oxidation mechanisms using Q1 mass scan, product ion scan or neutral loss scan. As necessary, authentic references of the target TGOOH isomers were prepared from diacylglycerol and fatty acid hydroperoxide isomers. Discrimination of TGOOH isomers were carried out by collision induced dissociation of sodiated TGOOH ion ($[M+Na]^+$). Oxidized oil were diluted with hexane, and analysed by LC-MS/MS (MS/MS/MS). **Results and Discussion** In this study, reliable TGOOH analysis were achieved by MS/MS (MS/MS/MS) analysis and authentic references, in the level of molecular species/geometrical isomers. And it was demonstrated that photo- and auto-oxidation products were characteristically detected in photo-oxidized oil and thermal-oxidized oil, respectively. These method is valuable in the understanding of oil and food oxidation mechanisms, and may be applied to the development of useful methods for food production. 1) S. Kato et al., npj Science of Food, 2 (2018).

2. **Effect of Furan Fatty Acids and 3-methyl-2,4-nonanedione on Light-Induced Off-Odor in Soybean Oil.** Takashi Sano*[1], Ryo Okabe[1], Maiko Iwahashi[1], Jun Imagi[1], Toshiro Sato[1], Eiichiro Fukusaki[2], and Takeshi Bamba[3], *[1]J-Oil Mills, INC., Japan; [2]Osaka University, Japan; [3]Kyushu University, Japan*

Objective: Soybean oil is one of the most widely consumed vegetable oils. However, under photooxidative conditions, this oil develops a beany and green off-odor through a mechanism that has not yet been elucidated. In this study, the effect of furan fatty acids and 3-methyl-2,4-nonanedione (3-MND) on odor reversion in soybean oil was investigated. Methods: Synthesized furan fatty acid (F3 acid, 96% purity), 3-MND (>99.0% purity) and 3-hydroxy-3-methyl-2,4-nonanedione (3-hydroxy-3-MND, 95.9% purity) were used in this study. These chemicals were added into canola oil, and photo oxidized under a fluorescent lump. The oils were assessed by sensory evaluation and analyzed using GC/MS following our previous protocol. In most experiments, pure soybean oil was used as a positive control. Results: The intensity of the off-odor was found to increase with increasing amounts of F3 acid, and the concentration of 3-MND was also found to

increase. While the addition of 3-MND to canola oil produced a slight off-odor, the intensity of the off-odor was much greater following light exposure. We found that the off-odor was increased with increasing amounts of 3-hydroxy-3-MND. Further, the concentration 3-hydroxy-3-MND in soybean oil was found to increase during storage, paralleled that of 3-MND. Conclusions: Our findings suggest that the observed off-odor was likely attributable to the furan fatty acids present in the oil through the generation of 3-MND. In addition, 3-hydroxy-3-MND, which is derived from 3-MND, was identified for the first time in light-exposed soybean oil and shown to be one of the compounds responsible for odor reversion.

3. **The Antioxidant Effect of Licorice Root Extract in Retarding Lipid Oxidation in High Oleic Canola Frying Oil and Comparison to Rosemary Extract.** Brandon Williams*[1], Jane Whittinghill[2], and Rachael Miller[1], *[1]ICL Phosphate Solutions, USA; [2]ICL Food Specialties, USA*

The objective of the study was to investigate the effectiveness of licorice root extract (LRE) on the oxidative stability of high oleic canola oil upon repeated frying and comparison to rosemary extract (RE). French fries were fried in canola oil once every week for 3 weeks. A control oil, a 500 ppm LRE oil and a 500 ppm RE oil were used in the study. After frying, oil samples were collected and analyzed after frying for oxidative stability using the Rancimat, free fatty acid, hexanal, peroxide value and p-anisidine value. A hedonic scale was used to determine the effect of the antioxidants on the sensory quality of the French fries. The results show that LRE is more effective in controlling oxidation during frying when compared to RE at the same usage level. The improvement on oxidative stability over the control oil was significantly higher using 500 ppm of LRE (265%) in the frying oil than with 500 ppm RE (174%). PV and p-anisidine values were significantly lower in the LRE oil than in control but comparable to RE. However, sensory analysis conducted on the French fries by 10 panelists showed significant differences in the score with LRE receiving higher liking scores and higher preference than the RE French fries. LRE contains potent antioxidants useful in frying oils to improve their oxidative stability under repeated frying without any effect on the oil as well as sensory quality of French fries.

4. **Influence of Margarine and Oil Composition on Phytosterols, Fatty Acid Profile and Quality Parameters at High Heating Temperatures.** Jallah Smith[1], Peace C. Asuzu[2], Anh T.L Nguyen[3], Benjamain M. Bougouneau[4], Samuel A. Besong[5], and Alberta N A Aryee*[3], *[1]Delaware State University, USA; [2]College of Agriculture & Related Sciences, Delaware State University, USA; [3]Delaware State University, USA; [4]Dept. of Human Ecology, Delaware State University; [5]Dept. of Human Ecology, College of Agricultural Sciences, Delaware State University, USA*

Repeated heating of oils and margarines at elevated temperatures produces decomposed compounds which can affect; sensory, nutritional and health properties. This study investigated the effect of heating on oxidative stability and sterol content of njangsa seed oil (NSO), bush mango oil (BMO), soybean oil (SBO), coconut oil (CCO), their derived margarines: BMO and NSO (BN), BMO and SBO (BS), CCO and NSO (CN), CCO and SBO (CS), and commercial margarines: blue bonnet and land O'Lakes. The tested margarines and oils were heated up to 20 and 120 min, respectively at 130, 170 and 210oC. Changes in free fatty acid (FFA), peroxide value (PV), anisidine value (ρ-AV), fatty acid composition and sterols content; stigmasterol, sitosterol and campesterol were determined titrimetrically, spectrophotometrically and using GC-FID.

Higher increase in FFA content in oils and margarines containing higher amount of polyunsaturated fatty acids (PUFA) were observed than in highly saturated counterparts. Generally, there was an increase in PV with increasing temperature. Oils with higher proportions of linoleic acid had a higher ρ-AV at the end of heat treatment. Higher TOTOX values were seen in oils with a higher proportion of PUFA. A decrease in sterol content was observed in all tested oils and margarines with increasing temperature, with a greater reduction in stigmasterol content compared to β-sitosterol. This result suggest that the level of saturation and oxidative stability may better predict oil behavior and properties during heating and provide valuable information on the selection and utilization of these oils and margarines in product development.

5. **Oxidative Stability of Spray-dried Microencapsulated Chia Seed Oil with the Addition of Antioxidants.** Elizabeth Hoffmann[1], Claudia N. Copado[2], Vanesa Y. Ixtaina*[2], and Mabel Tomás[2], *[1]CIDCA, Argentina; [2]CIDCA (CONICET-UNLP), Argentina*

Chia seed oil has a high content of polyunsaturated fatty acids (PUFAs), giving it nutritionally beneficial qualities, although determining its high susceptibility to oxidative deterioration. The microencapsulation and the addition of natural antioxidants are alternatives to protect this oil during its processing and storage. The objective of this work was to study the physicochemical characteristics and the oxidative stability of chia seed oil microencapsulated with different antioxidants (rosemary extract, rosemary and chamomile extracts blend, ascorbyl palmitate) by spray-drying using inlet/outlet temperatures of 170/90°C, and sodium caseinate and lactose as wall material. The microencapsulation efficiency and the moisture content were >98% and <4% d.b., respectively. SEM micrographs showed that the microcapsules were spherical, without cracks. Some of the particles presented concave and shriveled surfaces. The powder dispersibility was measured by changes in the obscuration as a function of time. Samples analyzed at t=0d recorded a steeply increase in the obscuration with the agitation time up to ~1.5 min, after which it reached a constant value. At t = 0, the microencapsulated chia oil presented a ti=12.7h, being seven times greater than that of the bulk oil. The addition of the antioxidants increased the ti of the microencapsulated chia oil. Regarding the PV evolution, only the addition of ascorbyl palmitate maintained the PV under the limit acceptable after 100 d of storage (25°C, darkness, HR 33%). Thus, microencapsulation by spray drying of chia oil with ascorbyl palmitate addition could protect this oil against lipid oxidation during the processing and storage.

6. **Antioxidative Polyphenols of Canola Meal: Effect of High Pressure, Temperature and Solvents.** Usha Thiyam, Michael Eskin, and Ruchira Nandasiri* ***(Lipid Oxidation and Quality Division Student Travel Grant Winner)***, *University of Manitoba, Canada*

Canola meal, a by-product of the edible oil-pressing is a rich source of phenolic and antioxidant compounds. However, its application in the food and feed sector is still limited in part due to greener, sustainable and cost-effective extractability of phenolic compounds. Thus, use of high pressure and temperature, commonly associated with high extractability of phenolic compounds is investigated. Accelerated solvent extraction (ASE) uses high pressure and temperature to enhance extraction efficiency of antioxidant phenolics. Moreover, ASE could be studied to obtain structure-activity based antioxidant function against high pressure and temperature subjectively. This study evaluated the effect of

temperature (140, 160 & 180 oC) and pressure (1500 psi) on the extraction yield of phenolic compounds from canola meal relating to type of solvent (ethanol and methanol) and concentration of solvents (30%, 40%, 60% & 70% v/v). The highest extraction of phenolic compounds was obtained with 70% methanol (20.72 ± 1.47 mg SAE / g DM) and 70% ethanol (24.71 ± 2.77 mg SAE / g DM) at 180 oC temperatures. A similar trend was observed for the antioxidant activity of the extracts (FRAP, DPPH, ion chelation) as well as their total flavonoid content. The structure related antioxidant activity of the extracts examined increased with the increase in the percentage of the extracting solvent ($p > 0.05$). This study established ASE as an efficient green method for extracting of phenolic compounds from canola meal, which could apply towards the production of natural bioactive compounds from agricultural by-products.

7. **Prediction of Oxidative Stability in Edible Bulk Oils using Dielectric Constant Changes.**
HeeSun Na*[1], YunSik Woo[2], SeungBeen Jo[2], MiJa Kim[3], and JaeHwan Lee[4], *[1]Sungkyunkwan university, South Korea; [2]Sungkyunkwan University, South Korea; [3]Kangwon National University, South Korea; [4]Dept. of Food Science and Biotechnology, Sungkyunkwan University, Republic of Korea*

Dielectric constant (DA) in edible oils is affected by the degree of unsaturation in lipids and amphiphilic compounds. Presence of amphiphilic compounds and moisture affects the oxidative stability in oils. The objectives of this study was to determine the effects of amphiphilic compounds on the changes in the DA of edible oils. DA of seven edible oils with different degree of unsaturation were determined by TESTO 270™ and expressed as percentage unit. Fatty acid composition of oils was determined and oxidizability of oils was calculated. Monoacylglycerols (MAGs), oleic acid, linoleic acid, or soy lecithin were mixed with corn oil at concentrations of 0, 3, 6, and 9% (w/w) to determine the effects of the amphiphilic compounds on the DA. The moisture effects were evaluated using 5 different saturated salt solution. Unoxidized fresh oils showed a wide range of DA, from 8% for canola oil to 33% for flaxseed oil. As the content of MAGs, lecithin, and moisture increased, DA of corn oils increased at different rates, whereas addition of oleic and linoleic acids decreased DA of corn oil by 40%. DA showed a strong correlation with the percentage of unsaturated fatty acids ($R2 = 0.883$) in edible oils. Overall, DA of edible bulk oils is strongly correlated with the content of amphiphilic compounds, moisture content, and degree of unsaturation of fatty acids. DA could be a reliable parameter to predict the oxidative stability of edible oils.

8. **Antioxidant Effects on the Oxidative Stability in Bulk Oil Treated with Plasma Stress.**
HeeSun Na*[1], SeungBeen Jo[1], MiJa Kim[2], and JaeHwan Lee[3], *[1]Sungkyunkwan University, South Korea; [2]Kangwon National University, South Korea; [3]Dept. of Food Science and Biotechnology, Sungkyunkwan University, Republic of Korea*

Plasma is an ionized gas as the fourth state of matter. Plasma treatment is a promising non-thermal oxidative technique. Therefore, lipids with plasma stress may undergo oxidation. The objectives of this study were to determine the oxidative power of plasma treatment and to evaluate the antioxidant efficiency of selected compounds in plasma treated bulk oils. Stripped corn oils (SCOs) treated with plasma jet were compared with 60℃ or 100℃ treatment by analyzing conjugated dienoic acid (CDA). Tocopherol homologs in plasma treated SCO and medium-chain triacylglycerols (MCT) were determined by using HPLC-fluorescence detector. To evaluate the antioxidant capacities

in SCO, antioxidants including of TBHQ, alpha-tocopherol, sesamol, beta-carotene and EDTA were mixed with SCO at two concentrations of 10 and 300 µmol. CDA, p-anisidine value, and moisture content were determined. Degree of lipid oxidation by 10 min of plasma jet in SCO corresponded to 48 h of 60℃ and 2.5 h of 100℃. Stability of alpha-tocopherol in MCT treated with plasma jet was lower by 6 fold than those in SCO whereas 12 fold lower in case of gamma-tocopherol. Under plasma jet, SCOs added with TBHQ, alpha-tocopherol, and sesamol had significantly low values based on CDA (p sesamol> TBHQ> beta-carotene> EDTA in SCOs with plasma jet treatment. Moisture content in all samples decreased after plasma treatment. Plasma treatment is one of strongest oxidation stressor and TBHQ, alpha-tocopherol, and sesamol could control the lipid oxidation in bulk oil by plasma treatment.

9. **Effects of Sesamol on the Oxidative Stability of Canola Oil-based Organogels with Beef Tallow.** SeungBeen Jo*[1], Heesun Na, Seungmi Hong, MiJa Kim[2], and JaeHwan Lee[3], *[1]Sungkyunkwan University, South Korea; [2]Kangwon National University, South Korea; [3]Dept. of Food Science and Biotechnology, Sungkyunkwan University, Republic of Korea*

Organogels are organic liquids entrapped by organogelators through 3-dimensional networks. The addition of antioxidants in organogels is required because of the high degree of unsaturation in organogel which accelerates lipid oxidation. Sesamol is one of the lignans present in sesame and used as an antioxidant. The objective of this study was to evaluate the effects of sesamol in mixture of beef tallow and canola oil-based organogel at 100°C and ultraviolet (UV) irradiation.

Organogel was prepared using canola oil and 10% (w/w) beeswax and 40 ppm (w/w) of sesamol was added to the organogel. Beef tallow was mixed with organogel in 4:6 proportion, with (BTWS) or without (BTWOS) sesamol. To determine the oxidative stability, headspace oxygen content, conjugated dienoic acid (CDA) value, and p-anisidine value (p-AV) were measured by using GC/TCD and spectrophotometer.

After 3 days at 100°C treatment, the headspace oxygen content of BTWS was significantly higher than beef tallow by 2 times ($p<0.05$) whereas those of BTWOS was the lowest. This pattern was also observed in CDA value and p-AV. In addition, under the UV irradiation, BTWS showed the highest oxidative stability which was almost 2 times better than beef tallow and BTWOS based on headspace oxygen content and p-AV. Overall, sesamol showed strong antioxidant capacity in the mixture of organogels and beef tallow. Therefore, sesamol could be a good antioxidant in meat products containing organogels with high content of unsaturated fatty acids.

10. **Influence of Oil Type on Epoxy Fatty Acid Formation in Repeated Deep-frying of Potatoes.** Ru Shen*[1], Jingyi Meng[2], Claire Schane[2], Tilo Lamken[2], William G. Helferich[2], and Nicki J. Engeseth[2], *[1]University of Illinois, USA; [2]University of Illinois at Urbana-Champaign, USA*

Repeat-utilization of frying oil results in frying oil deterioration and undesirable compound formation. Epoxy fatty acids have been used as an indicator in toxicological evaluation of lipids. The objective of this research was to determine formation of monoepoxy fatty acids (MEFA) in oils and foods during repeated deep-frying of potatoes. Frying experiments were conducted with potato strips, 100 cycles at 180ºC in three oils: soybean oil (SO), refined palm olein (RPO) and stearin (RPS). Oil and foods were analyzed from different cycles. Six MEFA were quantified using solid phase extraction and GC characterization, Repeated exposure to frying led to dramatic

increases of oil MEFA: RPS>RPO>SO. After 100 cycles, MEFA in RPS, RPO, SO were 5656.11, 4138.11 and 1779.81 mg/kg, respectively. Compositional distribution of MEFA in TAFOs was directed by the original oil composition and altered significantly over time. Epoxy stearate comprised the majority of MEFA for RPS and RPO and epoxy oleate for SO. Over the course of repeated frying of food, the ratio of trans MEFA to total MEFA in RPS, RPO and SO increased from 33.72, 0 and 0% to 66.38, 60.22% and 45.79 %, respectively. Oil quality impacted the food being fried directly: MEFA accumulation in potatoes was greater when fried in RPS (496.21 mg/kg food) than RPO (312.12 mg/kg food) and SO (119.28 mg/kg food) at 100 cycles. Epoxy fatty acid formation was highly dependent upon the type of frying oil being utilized. Monounsaturated oil accumulated MEFA to a greater extent than polyunsaturated oil.

11. **Antioxidant Performances and Emulsifying Activity of Corn Gluten Meal Hydrolysate in Oil-in-Water Emulsions.** Yanting Shen*[1] ***(Lipid Oxidation and Quality Division Student Travel Grant Winner)***, Ruijia Hu[2], and Yonghui Li[1], *[1]Kansas State University, USA; [2]Kansas State University, Grain Science and Industry, USA*

Corn gluten meal (CGM) is a protein-rich co-product generated during corn wet milling. In this study, corn gluten meal was hydrolyzed using enzyme (Neutrase) for 1 and 3 hours, respectively, to obtain antioxidative protein hydrolysates (CGMH), which could be a potential antioxidant to retard lipid oxidation in various food products. Our objective was to evaluate emulsion properties (e.g., emulsion turbidity, stability, particle size, microstructure, zeta-potential, and partition) and oxidation stability (e.g., POVs and TBARS) of oil-in-water emulsions containing different types (1 and 3-hour hydrolysates) and amount (0, 1, 2.5 and 5 mg/ml) of CGMH. The results showed that the emulsions with CGMH had significantly improved oxidative stability than the control based on both TBARS and POV analysis. The 3-hour hydrolysate had slightly better antioxidant performances in emulsion than the 1-hour hydrolysate. The emulsion with 5 mg/ml CGMH had the most effective inhibition on lipid oxidation. The emulsion turbidity of 1-hour hydrolysate at 2.5 mg/ml had lower value than other emulsions, and overall, the turbidity for 3-hour hydrolysates had slightly higher value than that with 1-hour hydrolysate. Addition of CGHM did not affect emulsion morphology and droplet sizes. Zeta potential analysis showed that emulsions with 1-hour hydrolysate had more negative charges with better emulsion stability than that with 3-hour hydrolysate at the same pH. In conclusion, the CGMH was able to inhibit lipid oxidation and reduce the formation of TBARS and POVs and could be a potential functional antioxidant for food emulsion applications.

12. **Proximate Composition, Fatty Acids Profiles and Nutritionally Valuable Minerals of 10 Industrial Hemp Seeds Varieties.** Minwei Xu* and Bingcan Chen, *North Dakota State University, USA*

Due to its nutritional properties, industrial hemp(Cannabis sativa L.) has been reconsidered as a valuable specialty crop for both humans and domesticated animals in Canada and European countries during the last decade. As a result, industrial hemp seeds and hemp seeds food products have become available to the general public in these countries.In the current study, 10 varieties of industrial hemp grown in North Dakota in 2017 were analyzed for their proximate composition, nutritional minerals, and fatty acid profiles. The findings from this study could help industry identify the industrial hemp variety with greater quality for food application.

13. **Aroma Characteristics of Fried Onion Prepared by Palm, High-oleic Sunflower, and Soybean Oils Frying.** Chang Chang* and Xingguo Wang, *Jiangnan University, China*

Onion frying has shown great interest to household cooking because of intensive flavour and nutritional value provided by the onion; however, aroma characteristics of fried onion are still unclear to hinder their prevalence in food industry. The objective of this research was to examine changes of the flavour profiles in fried onion in response to oil frying (e.g., palm, high-oleic sunflower, and soybean oils at 0-16 h continuous frying), and to determine key aroma compounds of fried onion-like odour. Flavour profiles (e.g., aldehydes, alkanes, alkenes, alcohols, amines, furans, furfurals, furanones, ketones, organic acids, and sulfur-containing compounds) were identified using headspace solid phase microextraction (HS-SPME) combined with gas chromatography-mass spectrometry (GC-MS) and -olfactometry (GC-O). Overall, palm, high-oleic sunflower, and soybean oils frying at 8 h quantitatively and qualitatively generated more volatiles on the fried onion, especially aldehydes and sulfur-containing compounds. Therefore, fried onions treated by palm, high-oleic sunflower, and soybean oils (at 8 h) were carried forward to investigate key aroma compounds of fried onion flavour. Findings indicated that the fried onion flavour mostly resulted from the combination of 3-methyl butanal and 2-propen-1-thiol in all fried onion. High-oleic sunflower oil and soybean oil fried onion were identified more oily by (E)-2-decenal and (E,E)-2,4-decadienal whereas 4-ethyl-3-nonen-5-yne contributed to the more intensive fried onion flavour from palm oil. Of the fried onions studied, 2-propen-1-thiol and 3-methyl butanal were most promising key aroma compounds attributed to fried onion flavour, which was also affected by oil type.

14. **Effect of Sinapic Esters Derivatives on the Oxidative Stability of Omega-3 Fatty Acids Enriched Emulsions** Inar A. Castro[1], Bruno Baréa[2], Pierre Villeneuve[3], Tayse Tayse Ferreira da Silveira*[4], and Letícia Maeda Cajaíba[4],[1]*University of Sao Paulo, Brazil;* [2]*CIRAD, France;* [3]*UMR IATE, CIRAD, France;* [4]*University of São Paulo, Brazil*

Oil-in-water (O/W) emulsions are important delivery systems of omega-3 fatty acids (n-3 FA), however, the high chemical instability of n-3 FA still challenges food producers. Lipophilization of phenolic compounds with different chain lengths is a strategy used to increase their hydrophobicity and enhance their antioxidative effectiveness in O/W emulsions. However, other factors such as the electrical charge of the emulsifier and emulsion pH play a role in the development of lipid oxidation. In the present approach, we investigated interaction effects between chain length increase of sinapic acid esters derivatives (C4, C8 and C12), different emulsion pH (3.0 and 7.0) and emulsifier charge (positively or negatively charged) using a factorial design 24. The O/W emulsions were enriched with echium seed oil (Echium plantagineum), which contains 40% of n-3 FA in its fatty acid composition. Malondyaldehyde (MDA) and volatiles (2,4-heptadienal and 2,4-decadienal) were measured as responses. The results demonstrated that an increase in the chain length improved the oxidative stability of the emulsions (lower MDA and volatiles formation) only when negatively charged emulsifiers were used at low pH (3.0), suggesting that lipophilization could be more useful to protect from oxidation emulsion-based foods presenting these characteristics, such as salad dressings. Therefore, our findings demonstrate the importance of studying these factors in conjunction in order to optimize emulsion formulations for maximum oxidative protection of n-3 FA.