

2010 Annual Meeting Abstracts

Lipid Oxidation and Quality

MONDAY

MORNING

LOQ 1: Stability of Omega-3/Omega-6 Lipids in Emulsions and Microemulsions

Chair(s): C. Jacobsen, Technical University of Denmark, Denmark; and S.J. Yoo, Martek Biosciences Corp., USA

Lipophilized Phenolics as Antioxidants in Fish Oil Enriched Food Systems. A.-D.M. Sørensen, N.S. Nielsen, C. Jacobsen, DTU Food, Kgs. Lyngby, Denmark

Food products containing long chain omega-3 PUFA are highly susceptible to oxidation, which causes undesirable flavors and loss of health beneficial fatty acids. Many omega-3 enriched food products on the market are oil-in-water emulsions. According to the so called "polar paradox", polar compounds work better as antioxidants in bulk oil, whereas lipophilic compounds are better antioxidants in emulsions. Phenolics have in general shown to possess antioxidative properties, which depend upon their structure i.e. number and location of -OH groups. However, many of these compounds are polar. Our hypothesis is that lipophilization of such polar phenolic compounds may improve their efficacy in fish oil enriched food systems. Our study aimed at evaluating rutin and dihydrocaffeic acid and their esters as antioxidants in o/w emulsion model system and milk enriched with fish oil. Moreover, the effect of the chain length of the fatty acid was investigated. The effect of the compounds was evaluated by determination of primary and secondary oxidation products. Further, these findings were combined with antioxidant assay and partitioning studies. Preliminary data showed that the lipophilization improve the antioxidative effect depending on the system, and that the chain length influenced the efficacy of the lipophilized compounds.

Stability of Food Emulsions Enriched with Stearidonic Acid (18:4, n-3). R.S. Wilkes¹, D. Welsby², ¹Monsanto Company, St. Louis, MO, USA, ²Solae, St. Louis, MO, USA

Attempts to broaden the use of omega-3 oils in foods using conventional sources have been limited by the extreme oxidative instability of these oils in food applications. Stearidonic acid (SDA) is an omega-3 intermediate between α -linolenic acid (ALA) and eicosapentaenoic acid (EPA). Its relative stability against oxidation permits its incorporation into common foods without compromising flavour and shelf-life. The very large surface areas of droplets in the non-continuous phase of food emulsions present particular oxidative challenges to food formulators. This study presents data from food emulsions containing SDA-enriched soybean oil when compared to similar emulsions containing fish and algal oils. Models chosen for experimentation were salad dressings and mayonnaise representing w/o emulsions, and margarine spreads representing o/w emulsions. Results from sensory evaluations presented here show that SDA enriched soybean oil shows great promise as a readily metabolisable form of omega-3 fatty acid for use in these applications.

Micellar Catalysis in Lipid and Hydrocarbon Oxidation. O.T. Kasaikina, A.A. Golyavin, D.A. Krugovov, E.A. Mengele, Z.S. Kartasheva, L.M. Pisarenko, Semenov Institute of Chemical Physics, Moscow, Russia

Cationic surfactants have been found to form mixed micelles together with amphiphilic hydroperoxides (ROOH) and catalyse decomposition of hydroperoxides and H₂O₂ into free radicals. By means of NMR, interphase surface tension measurement, dynamic light scattering binding of ROOH and surfactants was studied. The results obtained open new fields of cationic emulsifiers application such as: i) creation of binary catalytic nanoinitiators of free radicals being effective at mild temperatures; ii) creation of soft catalysts for liquid phase oxidation based on cationic surfactants and transient metals; iii) creation of nanocomposites by means of radical polymerization of vinyl monomers initiated by colloid heterogeneous system hydroperoxide/nanodispersed filler being hydrophobized with cationic surfactants. This effect gives a new sight on the mechanism of known bactericide properties of cationic surfactants as well.

Antioxidant Activity of a Synthesized Palmityl Ester of Carnosic Acid. A. Prasad, C. Hall III, North Dakota State University, Fargo, ND, USA

The objective of this research was to increase the lipophilicity of carnosic acid by converting it into a fatty acid ester such as palmitic acid ester and to evaluate its antioxidant activity in emulsion type food system (e.g. corn oil emulsion). The route chosen for the derivitization of the carnosic acid involved conversion of carnosol via a ring opening leading to the formation of methyl 7-isopropyl-5,6-dimethoxy-1,1-dimethyl-1,2,3,4,4a,10a-hexahydrophenanthrene-4a-carboxylate (1). The ester group in 1 was reduced into alcohol using metal hydride reagents yielding (7-isopropyl-5,6-dimethoxy-1,1-dimethyl-1,2,3,4,4a-10a-hexahydrophenanthren-4a) methanol (2). Esterification of 2 with palmitic acid under basic condition using suitable acylating reagent gave 7-isopropyl-5,6-dimethoxy-1,1-dimethyl-1,2,3,4,4a,9,10a-hexahydrophenanthren-4a-yl)methylpalmitate (3). Further reduction of double bond in 3 was accomplished by standard hydrogenation protocol to give 7-isopropyl-5,6-dimethoxy-1,1-dimethyl-1,2,3,4,4a,9,10a-octahydrophenanthren-4a-yl)methylpalmitate (4). On deprotection of methoxy group in 4 yields the desired derivative (5,6-dihydroxy-7 isopropyl-1,1-dimethyl-1,2,3,4,4a,9,10,10a-octahydrophenanthren-4a-yl)methyl palmitate.

Effect of Emulsifiers and Physical Structure on Lipid Oxidation in Omega-3 Emulsions. A.F. Horn, N.S. Nielsen, C. Jacobsen, DTU Food, Kgs. Lyngby, Denmark

The body of evidence supporting health beneficial effects of long-chain omega-3 polyunsaturated fatty acids has increased over the last decades. Consequently, the interest in fish oil-enriched foods has also increased. However, addition of these highly unsaturated fatty acids to foods also adds the challenge of lipid oxidation. In order to limit lipid oxidation and the consecutive development of unpleasant off-flavours, the manner in which the fish oil is introduced to the food product should be carefully considered, e.g. an emulsion could be used as delivery system for the omega-3s. The aim of this study was therefore to compare lipid oxidation in fish oil-in-water emulsions made by the use of different emulsifiers, i.e. sodium caseinate, whey protein isolate, soy lecithin and two milk phospholipids. Results showed that emulsions made with phospholipid based emulsifiers oxidised more than neat oil, whereas emulsions made with protein based emulsifiers generally oxidised less than neat oil. The protective effect of proteins might be caused by several factors such as the physical structure of the interface and a possible metal chelating effect. Moreover, due to the much lower lipid content, the protein based emulsifiers, may be less susceptible to lipid oxidation compared to the phospholipid based.

Kinetics in Oxidation of Marine ω -3 Fatty Acids in Heterophasic Systems. I. Storrø¹, R. Mozuraityte¹, A. Carvajal¹, V. Kristinová², T. Rustad³, ¹SINTEF Fisheries and Aquaculture, Trondheim, Norway, ²Brno Univ. of Technology, Brno, Czech Republic, ³Norwegian University of Science and Technology, Trondheim, Norway

Marine n-3 fatty acids are healthy but highly susceptible to oxidation. To reduce and control this oxidation, knowledge of the functions of antioxidants is crucial, but the effect of the pro-oxidants is also important and is often overlooked. To study the effect of pro- and anti-oxidants we have developed a simple system consisting of marine phospholipids as liposomes in a buffer, a pro-oxidant and if necessary an antioxidant. The rate of oxidation is measured by the consumption of dissolved oxygen and is continuously monitored, giving kinetic data for the oxidation. Kinetic data for the oxidation of n-3 fatty acids by the pro-oxidants ferric and ferrous ions and haemoglobin will be presented, as well as the data on the effect of the concentration of pro-oxidants, oxygen, lipids, selected chelators and ions in addition to some natural antioxidants. The conclusion from this study is that the effect of the antioxidant clearly depends upon the pro-oxidant active in the system. For example EDTA completely inhibits Fe-mediated oxidation, but has no effect on haemoglobin mediated oxidation. Caffeic acid acts as a strong pro-oxidant in Fe-mediated oxidation, but acts as antioxidant in the haemoglobin mediated oxidation. This study might cast some new light on the controversy of the effect of antioxidants.

Impact of Phospholipid Reverse Micelles on the Physical and Chemical Properties of Bulk Oil. B.C. Chen, D.J. McClements, E.A. Decker, Department of Food Science, University of Massachusetts, Amherst, MA, USA

The oxidation of lipid yields both primary and secondary oxidation compounds e.g. hydroperoxides, malondialdehyde(

MDA), 4-hydroxynonenal (4-HNE), et al, which produce undesirable biological effects. Inhibition or suppression the lipid oxidation in food matrices are of great crucial for human beings. Many studies demonstrated that lipid oxidation can vary strongly depending on the systems in which they have been stayed. Some indirect evidences demonstrate the highly possibility that oxidation in bulk oil occurs in the interface of the in situ association colloid in the bulk oil microenvironment. In order to fully understanding the oxidation in bulk oil, reverse micelle which might be one of the in situ association colloids in bulk oil have been formed by dioleoyl phosphatidylcholine(DOPC) which is the main phospholipids in bulk oil with stripped soybean oil (SSO). Interfacial tension and spectromicroscopy measurement showed the critical micelle concentration (CMC) of DOPC in stripped soybean oil at room temperature is around 650 micro M. Besides, the physical properties of this novel reverse micelle were studied by Micro differential scanning calorimetry (DSC) and small angle X-ray scattering (SAXS). The fabrication and completely characterization of this structure will help better understanding lipid oxidation in bulk oil system.

AFTERNOON

LOQ 2: Specialty Antioxidants

Chair(s): F. Shahidi, Memorial University of Newfoundland, Canada; and J. Gerde, Iowa State University, USA

Novel Antioxidants in Food Preservation and Health. F. Shahidi, Department of Biochemistry, Memorial University of Newfoundland, St. John's, NL, Canada

Antioxidants from natural sources are the focus of much attention not only for their efficacy in food preservation, but to a large extent for their beneficial health effects rendered by a variety of mechanisms beyond their traditional antioxidant potential. Phenolic and polyphenolic compounds are amongst the most important group of antioxidants for natural resources from acting as free radical terminators. In this connection, hydrophilicity and lipophilicity (HC) of the compounds of interest, their balance (HLB), and hence their incorporation into different food systems or their reaching of cells and membrane sites is of utmost importance. This presentation discusses the importance of structural effects of phenolics and their modified counterparts and their HP effects in food preservation and in rendering health beneficial effects in both in vitro and in vivo studies.

Application of Natural Extracts in Margarines and Spreads. Namal Senanayake, Jerry Erdmann, Cathy Dorko, Danisco USA Inc, New Century, Kansas, USA

The use of natural extracts, such as those from rosemary and green tea, to combat oxidative rancidity is generating increased interest with consumer concerns over the use of synthetic antioxidants. Natural extracts are of importance because they have the advantage of being labeled as spices or natural flavors. Rosemary (*Rosmarinus officinalis* L.) has been reported to contain certain bioactive compounds including, carnosic acid, carnosol, rosmanol, rosmariquinone, and rosmaridiphenol, which may be as effective as synthetic antioxidants in various foods. Tea (*Camellia sinensis* L.) and its phenolic constituents (epigallocatechin-3-gallate, epicatechin-3-gallate, epicatechin, and epigallocatechin) are also reported to have antioxidant activity and have potential for use in several food products. The presentation will discuss the antioxidant activities of rosemary and green tea extracts, and their ability to extend the storage shelf life of various food products.

Enzymatic Synthesis of Novel Phytosteryl Caffeates and their Antioxidant Activity. Z. Tan, F. Shahidi, Department of Biochemistry, Memorial University of Newfoundland, St John's, NL, Canada

Phytosterols have attracted much attention in recent years due to their health benefits. While most of the research has focused on the free phytosterols and phytosteryl esters of fatty acids, less research has explored phytosteryl esters of phenolic acids. Caffeic acid and its derivatives are widely distributed in the plant kingdom. Although present in trace amounts, they possess a broad spectrum of biological activities, including antioxidant, anti-inflammatory, antibacterial, anti-carcinogenic, and anti-HIV properties, among others. A novel method was successfully developed for enzymatic synthesis of phytosteryl caffeates (PC) through an intermediate which was first chemically produced and subsequently esterified with phytosterols through alcoholysis with lipase as a catalyst and using a mixed solvent system. The structures of the PC were confirmed by infrared (IR) and HPLC-MS/MS. The antioxidant activity of PC was higher than that of the starting material and the intermediate in all assays employed including ORAC, DPPH radical

scavenging capacity and β -carotene-linoleate model systems. The results indicated that they had a good potential to be used as food antioxidant. Research is progressing on evaluation of other biological activities of PC in order to shed light on their potential beneficial health effects.

Modified Tea Catechins in Oxidation Control. Y. Zhong, F. Shahidi, Memorial University of Newfoundland, St. John's, NL, Canada

Epigallocatechin gallate (EGCG), the major polyphenol in green tea leaves, is known as a powerful antioxidant by inhibiting oxidative deterioration of foods and protecting against oxidative stress-mediated diseases. However, the antioxidant effectiveness of EGCG in liposoluble media is limited due to its hydrophilic nature, which also hinders its cellular absorption in vivo through the lipid membrane. Esterification of EGCG with long chain saturated and polyunsaturated fatty acids (PUFA) provides a useful means to improve its lipophilicity and hence the bioactivities in certain environments. Moreover, the health beneficial omega-3 PUFA component may provide additional perspectives for food and health applications. Thus, ester derivatives of EGCG with stearic (SA), eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids were synthesized. The antioxidant activity of EGCG esters was evaluated in food and biological model systems. Oxidation was inhibited to a greater extent by the esters than by EGCG in a β -carotene/linoleate emulsion and in cooked pork. All ester derivatives exhibited protective effects against LDL-cholesterol oxidation and DNA scission superior or similar to that of EGCG. These results suggest that the ester derivatives of EGCG may be used as potential lipophilic alternatives to EGCG for food and medicinal applications with improved functional and physiological properties.

Influence of Filtering of Cold Pressed Berry Seed Oils on their Antioxidant Profile and Quality Characteristics. V. Van Hoed¹, I. Barbouche^{1,3}, N. De Clercq², K. Dewettinck², M. Slah³, R. Verhé¹, ¹Ghent University, Department of Organic Chemistry, Ghent, Belgium, ²Ghent University, Department of Food Safety and Food Quality, Laboratory of Food Technology and Engineering, Ghent, Belgium, ³University 7th November of Carthage, National Agronomical Institute of Tunisia (INAT), Tunis, Tunisia

The quality, composition and color of eleven oils from 6 different berries were evaluated before and after filtering the cold-pressed oils. The filtering did not lead to significant compositional or quality differences, except a significant lighter appearance of the oil due to seeds removal. Due to their high insaturation, the peroxide and p-anisidine values were high in all oils. However the high tocopherol content protected the oils during the Oil Stability Test (significant correlation; $r = 0.803$; $p = 0.003$). Tocopherol contents between 138 mg/kg (kiwi seed oil, filtered) and 1639 (blackberry seed oil, non-filtered) mg/kg were found. Phenolic compounds, identified and quantified by HPLC, ranged from 90 mg/kg (blackberry seed oil, filtered) to 15,810 mg/kg (strawberry seed oil, filtered). Surprisingly, no correlation could be found between the quantified phenolic compounds and the oxidative stability of the oils, suggesting that in these oils the tocopherols were the main antioxidants protecting the lipids during storage.

Antioxidant Activity of Brown Seaweed Lipids. A. Widjaja-Adhi, S. Iwasaki, M. Hosokawa, K. Miyashita, Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan

Brown seaweed lipids, especially from Sargassaceae species, contain high level of antioxidants, namely, fucoxanthin, a characteristic carotenoid found in brown seaweeds, and phlorotannins, a largest group of polyphenols from seaweeds. Brown seaweed lipids also contain a large amounts of omega-3 highly unsaturated fatty acids such as 18:4n-3 and 20:5n-3. Thus, these brown seaweed lipids would be a good source of nutraceuticals and functional foods. In this presentation, we report the antioxidant activity of brown seaweed lipids. In vitro antioxidant activities of the organic solvent extracts varied with the solvent used and with the seaweed species, showing that not only phenolic compounds but also the combination effect with fucoxanthin contribute highly to the strong antioxidant activity of brown seaweed lipids. Brown seaweed lipid feeding to diabetes/obese model mouse significantly reduced the peroxidation level of the liver and abdominal white adipose tissue as compared with those of mouse fed control, although omega-3 highly unsaturated fatty acid content in the liver increased significantly in the mouse fed brown seaweed lipids. Fucoxanthin metabolites, fucoxanthinol and amorousixanthin A were detected in the liver and adipose tissue. These metabolites would be due to the protection of the highly unsaturated lipids against oxidation.

AFTERNOON

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-Ciocalteu 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. Hassanien¹, A.-M. Lampi², V. Piironen², ¹Agricultural Biochemistry Department, Faculty of Agriculture, Zagazig University, Egypt., ²Department 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 studied. 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 7 β -hydroxysitosterol, 5,6-epoxy derivatives and 7 α -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 Tabe^{1,2}, Margaretha

Jagerstad¹, Paresh C. Dutta¹, ¹Department of Food Science, Swedish University of Agricultural Sciences, Uppsala, Sweden, ²Food 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 Przybylski¹, Magdalena Rudzinska², ¹University of Lethbridge, Lethbridge, AB, Canada, ²Poznan 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 "heart-neutral" 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 decommo-ditized 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. Savvidou¹, M.G. Kontominas¹, A.K. Kiritsakis¹, A.V. Badeka², ¹Alexander Technological Education Institute of Thessaloniki, Greece, ²University 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%).

LOQ 3: Shelf Life Stability and Sensory Properties of Whole Grains and Cereal Products

Chair(s): U. Nienaber, Kraft Foods Inc., USA; and S.C. Liang, DuPont Applied BioSciences, USA

Protein Oxidation in Cereal Products: Footprint of Lipid Oxidation or Reflection of Processing Stress?. K.M. Schaich, Rutgers University, New Brunswick, NJ, USA

Electron paramagnetic resonance (EPR) and antibody surveys of a wide range of cereal products show that protein oxidation is surprisingly ubiquitous, resulting from both lipid oxidation and processing stresses such as heat and shear. What does the presence of protein oxidation imply? What does protein oxidation reveal about product history and how does protein oxidation affect food qualities? Processing damage involves high energy peptide and disulfide bond scissions and occurs over a finite period of time. In contrast, lipid co-oxidations are lower energy reactions occurring mostly, if not exclusively, on side chains; they develop continually during storage, mediated by lipid radicals, hydroperoxides, epoxides, and aldehydes, and generate products that mimic lipid rancidity. Importantly, these changes are seldom connected to lipid oxidation because reaction with protein removes lipid oxidation products from the system, and hence "rancidity" as commonly measured paradoxically can appear to be very low or even absent. Consequently, both protein and lipid oxidation should be monitored when assessing oxidative stability of food systems. This paper discusses patterns of cereal protein co-oxidation by lipids and identifies characteristic protein markers that provide footprints of lipid oxidation.

Key Antioxidants from Whole Grain Wheat Flours. M. Bunzel, C. Tyl, University of Minnesota, Department of Food Science and Nutrition, St. Paul, Minnesota, USA

An overview about antioxidants from whole grains with an emphasis on wheat will be given. Tocopherols and tocotrienols, carotenoids, phytic acid, hydroxycinnamic acids such as ferulic acid and p-coumaric acid, lignans, alkyresorcinols etc. are important antioxidants in whole wheat. Their contribution to oxidative stability of cereal products or to health beneficial effects is based on different mechanisms. The antioxidants are located in different tissues of the grain and their abundance is dependent on wheat variety and environmental factors. In addition, some of these antioxidants i.e. ferulic and p-coumaric acids are linked to partially insoluble cell wall polymers limiting their bioavailability. While the general groups of antioxidants are well-known, less information about ?key antioxidants? in whole grains is available. The concept of antioxidant-activity guided fractionation can be applied to determine those. This concept and its application to two wheat varieties will be briefly described.

Oxidative Stability of Processed Pea Flours. T Jeradechachai², C Hall III¹, M Tulbek², ¹North Dakota State University, Fargo, ND, USA, ²Northern Crops Institute, Fargo, ND, USA

Dry yellow pea flour has gained significant interest as a food ingredient due to its low glycemic index and non allergen label. Two processing methods, hydrothermal treatment and extrusion, were used to thermally treat whole and split pea flours to increase shelf life stability. Hydrothermal treatment was accomplished by roasting water soaked pea. Peas were roasted at 150°C, 170°C, and 190°C for 12.5 mins. The effects of different processing methods on pea flour color, volatile profile, fatty acid profile, enzymatic activities, and microbiological activities were investigated. Processed peas were darker than raw peas. Color of roasted whole peas at 150°C was the most acceptable (L= 72.49, a= +2.03, b=+20.91) and roasting at 190°C were the least acceptable (and L=64.87, a=+5.05, b= +20.34). Preliminary results indicate that roasting has a greater impact on color than extrusion. Preliminary results indicate that heat processing was beneficial in inhibiting oxidation. This presentation will provide information on the conjugated dienes, headspace volatiles and lipoxygenase activity of heat treated peas. The results provided useful information for pulse processing industry to process pulse flour using optimal conditions and to estimate product stability after processing.

Consequences of Lipid Degradation During Storage of Whole Grain Products. Devin Rose^{1,2}, Michael Dunn², Oscar Pike², ¹U.S. Department of Agriculture/Agricultural Research Service, Peoria, IL, USA, ²Brigham Young University, Provo, UT, USA

Whole grain products are nutritionally superior to their refined grain counterparts; however, the active enzyme systems and higher lipid contents of whole grain products make them particularly susceptible to rancidity. The free fatty acids produced by lipase during storage may induce detrimental changes in functional properties of whole grain products and contribute soapy flavors. Furthermore, free fatty acids may oxidize by autoxidation or through the action of lipoxygenase, leading to off-flavors and decreased nutritional quality. Manufacturers often stabilize whole grain products by using various procedures to denature lipase and lipoxygenase; however, it is important to use a mild treatment that does not change functional or sensory properties of the whole grain product and does not degrade antioxidants.

Shelf Life Stability and Sensory Properties of Whole Grains and Cereal Products. Sylvia De Long-Onak, Mark Sewald, General Mills, Golden Valley, MN USA

To optimize the sensory quality and rancidity limited shelf life of whole grain products, the starting point should be the quality of the grain. This entails developing pertinent grain specification; understanding both the natural variability of the grain and ingredient processing variability that can be expected. As the product is formulated, the desired shelf life must be achieved with the entire range of ingredient quality that can be reasonably anticipated given the grain specification. While ingredient and formulation are being optimizing, target processing conditions need to be established and maintained for optimal final product stability. To study this optimization process, storage tests on multiple lots of ingredient and final product need to be conducted to document the average and range and in product stability achieved through the range of ingredient quality and processing conditions. The general storage test protocols,

including the sensory and analytical measures used in these studies will be discussed. Several examples depicting, ingredient, processing, and packaging impacts on oxidative stability of whole grain products will be presented.

WEDNESDAY

MORNING

LOQ 4: Frying Oil Chemistry, Quality, and Nutrition

Chair(s): J. Moser, USDA, ARS, NCAUR, USA; and K. Hrncirik, Unilever R&D Vlaardingen, The Netherlands

Chemical Reactions in Oils During Deep-Fat Frying. Eunok Choe, Inha University, Incheon, Korea

Deep-fat frying produces desirable or undesirable compounds and changes the flavor stability and quality of the oil by hydrolysis, oxidation, and polymerization. Oxidation occurs at higher rate than hydrolysis. Dimers and polymers are also formed in the oil by radical and Diels-Alder reactions increasing the viscosity during deep-fat frying. Tocopherols, essential amino acids and useful fatty acids in foods are degraded during deep-fat frying. The reactions in deep-fat frying depend on the factors such as replenishment of fresh oil, frying time and temperature, initial oil quality and frying oil composition, composition of food materials to be fried, type of fryer, antioxidants, and oxygen concentration. High frying temperature, repeated frying, high contents of free fatty acids, polyvalent metals, and highly unsaturated fatty acids of oil decrease the oxidative stability and flavor quality of oil during deep-fat frying. Antioxidants such as tocopherols decrease the oil oxidation, but they become less effective at frying temperature due to faster degradation. Lignan compounds in sesame oil are more stable than tocopherols at frying temperature, therefore they are more effective antioxidant in deep-fat frying.

Oxidative Changes in Fat-based Products in Cooking Applications. K. Hrncirik, Unilever R&D, Vlaardingen, The Netherlands

The development of products designed for modern cooking is clearly driven by the trend to offer the consumer enhanced nutritional benefits. This is reflected by the implementation of several (re-)formulation steps, namely the reduction of saturated fat and fortification with relevant nutrients (especially essential fatty acids, vitamins). However, cooking, and in particular frying, may lead to a certain decrease of the nutrients present in the cooking (frying) medium affecting nutritional value of cooked (fried) food. In this study the changes in lipid substrate (fatty acid composition, polymerised triglycerides, etc.) were monitored in several cooking products (liquid margarines, stick margarines, oils) during potato pan-frying and cake baking. The findings of the study are presented and discussed in the context of the dietary implications.

***CANCELED* Application of Rapeseed Oils for Frying Processes.** K. Franke

Using Biotechnology to Improve the Health and Functionality of Edible Oils. Susan Knowlton, DuPont Company, USA

Biotechnology has been used extensively to improve plant performance for farmers. Some examples include herbicide tolerance, pest resistance, and drought tolerance. However the development of consumer-related traits to improve the composition of food has begun and these products are beginning to make their way into the marketplace. This paper will review these quality traits with particular focus on those that are directed at improving oil composition and the challenges related to their delivery to food manufacturers and ultimately the consumer. A particular focus on high oleic soybean oil, its functional and nutritional properties as well as its commercial status will be discussed.

Effects of Frying Condition on Physicochemical Properties of Palm Olein-Olive Oil blends. Mahsa Naghshineh, Abdul Azis Ariffin, Hasanah Mohd Ghazali, Hamed Mirhosseini, Abdulkarim Sabur Mohammad, Sadra Tabassi, Universiti Putra Malaysia, Srikembangan, Selangor, Malaysia

The main objective of present study was to investigate the effect of frying conditions namely frying time and type of frying oil on physicochemical properties of palm olein-olive oil blends (POo: Oo, 75:25 and 50:50 w/w) compared to pure palm olein (100% w/w). The frying of French fries was performed in duplicate at 180 ± 5 °C for 5 consecutive days. The physicochemical properties of frying media namely fatty acids composition (FAC), iodine value (IV), free fatty acid (FFA) and color were considered as response variables. The results indicated the physicochemical properties of pure palm olein (100% w/w) were significantly ($p < 0.05$) influenced by partial replacement of olive oil (Oo) with palm olein. In all the samples, iodine value (IV) decreased during frying. This could be explained by the destruction of double bonds induced by oxidation and/or polymerization. There was a significant ($p < 0.05$) positive correlation between FFA and color. Besides the frying performance improvement of palm olein, the present work suggested that the partial replacement of palm olein with olive oil provided the oil blends with more desirable functional properties for the human health due to the high proportion of monounsaturated to polyunsaturated fatty acid.

Recent Possibilities in the Analysis of Used Frying Oils. M.C. Dobarganes¹, G. Márquez-Ruiz², J. Velasco¹, S. Marmesat¹, ¹Instituto de la Grasa (CSIC), Sevilla, Spain, ²Instituto del Frío (CSIC), Madrid, Spain

In this lecture, the most recent techniques applied for the quantitation of the new compounds formed during frying are presented. Given the complex mixture of alteration compounds formed during heating of oils at frying temperatures, quantitation of groups of compounds has been shown to be more practical than specific analysis of individual structures. High-performance liquid-chromatographic techniques, mainly based on the molecular size of the new compounds formed, enable rapid determination of total oligomeric compounds, while a previous separation by adsorption chromatography of the less polar compounds, i.e., intact triglycerides, allows the determination of oxidized, polymerized and hydrolytic compounds. Methodologies applied directly to the fat or to its simpler derivatives - fatty acid methyl esters - are described and applications discussed. At present, a more detailed quantitation of the main oxidized fatty acyl groups included in glyceridic molecules is feasible. In this context, quantitation of short-chain compounds, originally attached to the glyceridic backbone, resulting from hydroperoxide breakdown, as well as epoxy, keto and hydroxy fatty acyl groups by capillary gas-liquid chromatography, is detailed. Finally, present possibilities of high-temperature gas chromatography for determination of oxidized fatty acids and dimers are commented.

Investigation of Frying Oil Quality Using VIS/NIR Hyperspectral Analysis. A. Yavari¹, M. Hamed¹, S. Haghbin², ¹Tehran University, Tehran, Iran, ²Tehran University, Tehran, Iran, ³Bioengineering Research Institute, Rasht, Iran

Traditional chemical methods of analyzing frying oil quality are time-consuming and not amenable to on-line measurement. The main objective of this study was to evaluate quality changes of heated oils based on visible/near infrared spectral analysis using a hyperspectral radiometer. The reflectance spectra of the heated oils were analyzed within the range 400 - 1,750 nm. Acid value, total polar component, and viscosity of oil samples were used as indicators of different quality levels of oil. Partial least squares calibration models were developed for quantitative evaluations of these parameters. The R² and root mean square error for each prediction were calculated to assess the prediction capability of calibration models. The study demonstrated that using the established calibration models, quality parameters could be predicted with R² values over 0.92.

Development of Novel Antioxidants for Frying Application. F. Aladedunye, Y. Catel, R. Przybylski, University of Lethbridge, Lethbridge AB Canada

Frying is the most often used preparation method for many foods. Oxidative degradation during frying is the most important process where some detrimental components are formed. We developed novel antioxidants which reduced oxidative degradation and improved frying stability of oil and offer better quality frying products. Those antioxidants significantly lower formation of polar components and polymers in oils during frying. Some of them work very effectively in preventing polymerization of triglycerides and sterols. These new antioxidants combine nutraceutical components present in oils and oilseeds.

Effect of Polydimethylsiloxane (MS) on 4-Hydroxynonenal (4HNE) Formation in Frying Oil. J.A. Gerde, E.G. Hammond, P.J. White, Dept. of Food Science and Human Nutrition Iowa State University, Ames, Iowa, USA

Soybean oil containing 100 and 25 ppm MS and a control with no MS were heated at 180°C in a crystallizing dish for 48 hr. The calculated amount of MS for a surface monolayer was 25 ppb. Fatty acid composition and concentrations of tocopherol and 4HNE, a reportedly highly toxic compound formed in frying oils, were monitored periodically. Slopes of the linear change in the ln (linoleate/palmitate) were calculated. For 100 and 25 ppb MS, inflection points were observed in these plots, and for 100 ppb MS plot, the inflection point occurred later than that for 25 ppb. The slope after the inflection point for the 25 ppb plot did not differ from that of the control. For 100 ppb MS, degradation of γ - and δ -tocopherol was slower than for the 25 ppb and control treatments. For all treatments γ -tocopherol degraded faster than δ . The 4HNE concentration increased faster in the control than in the 25 ppb MS treatment. For both the control and 25 ppb MS treatments, a maximum concentration of 4HNE was observed. For the 100 ppb treatment, the increase in 4HNE concentration was much slower than for other treatments, and 4HNE did not reach a maximum during the experiment. Thus, the practice by many oil manufacturers of adding MS to oils to extend frying life, also may provide important human health benefits.

Endogenous Minor Components and Frying Stability of Oil. F. Aladedunye, R. Przybylski, University of Lethbridge, Lethbridge AB Canada

Oils used for frying contain variety of minor components which from their chemical structure can be involved in triacylglycerides degradation. Those components has been isolated from different oils and separated by chemical composition. Purified triacylglycerides were used to assess how minor components affect frying stability of oils. Sterols group affected positively or negatively triglycerides oxidative degradation defined by composition of these components. Sterols isolated from rice bran oil protected triglycerides from oxidative degradation and extended frying life of oil. Different tocopherols isomers offered different protection for oil during frying. Some of minor components act as synergistic components and improve protection of oil. Results of this work showed how important are minor components in frying stability of oils.

Effect of Natural Steryl Ferulates on Frying Oil Degradation. J.K. Moser, K.A. Rennick, USDA, ARS, NCAUR, Peoria, IL, USA

Steryl ferulates are found naturally in the hull of grains such as wheat, rye, corn, and rice. They consist of a plant sterol esterified to ferulic acid. The steryl ferulates from corn and rice differ in the sterol constituent. Corn steryl ferulates have a much higher percentage of saturated sterol constituents, which are more stable to oxidation and heat than unsaturated sterols, which constitute the majority of rice steryl ferulates. The objective of this study was to determine the ability of the steryl ferulates to prevent oxidation and polymerization of oil used for frying, and to also compare the heat stability of the steryl ferulates from corn and rice. Corn and rice steryl ferulates acted similarly in protecting oils from degradation, depending on the concentrations added and the study conditions. Corn steryl ferulates were slightly more heat stable compared to the rice steryl ferulates. These results suggest that steryl ferulates may be useful natural compounds for the protection of frying oils.

AFTERNOON

LOQ 5: General Lipid Oxidation and Quality

Chair(s): C. Hall, North Dakota State University, USA; and B. Zhao, Kraft Foods Inc., USA

Novel Vegetable and Spice Extracts with Unique Antioxidant Potential as Natural Food Preservatives in Complex Systems. R. Nahas, G. Reynhout, A. Uhlir, P. VanAlstyne, J. McKeague, Kalsec, Inc., Kalamazoo, MI, USA

Several natural antioxidant blends were developed to create multifunctional antioxidant systems that can prolong shelf-life of complex food matrices. Initial evaluation was performed using the DPPH and the ferrozine assays to determine the fundamental components of the antioxidant activity and the potency was examined in various foods by the conjugated dienes and hydroperoxides determination coupled with GC. Subsequently, the most promising extracts were tested in real foods and beverages.

Delay of Oil Oxidation Using Rosemary Extract, Increasing Shelf Life. Terese O'Neill, Rodger Jonas, PL Thomas,

Morristown, NJ, USA

Three oils and two fats commonly used in consumer goods, were tested in a 5 day heat study, testing natural and synthetic antioxidants. Induction time was delayed by using 1ppm of Rosemary extract versus other more commonly used antioxidants, such as BHT, BHA and mixed tocopherols. Graphed results will show the improvement of the induction time. The rosemary extract has a very low flavor profile and can be used in frying oils, baked goods, and snacks to increase shelf life and meet consumer demands for a cleaner label.

Synergistic Antioxidant Effect from Combination of Herb Extracts. H. Ge, T. Doering, The Dial Corporation, A Henkel Company, Scottsdale, AZ, USA

Many herbs are known to have good anti-oxidant properties. They can be incorporated into skin care products to retard skin aging by scavenging excess free radicals in skin cells. In this study, at least 20 herb extracts frequently used in the Traditional Chinese Medicine (TCM) were screened on their anti-oxidant activities by Oxygen Radical Absorbance Capacity (ORAC) assay. The top 5 herb extracts with good activities are Ginger root, Licorice root, Honeysuckle flower, Kudzu root and Sophora flower. The anti-oxidant activities from the combinations of the top 5 extracts with various concentrations were tested. 7 combinations out of 10 show synergistic antioxidant effect.

Stability of Stearidonic Acid Enriched Soybean Oil Through the Shelf-Lives of a Broad Range of Processed Foods. S. Lee, B. Lambach, X. Pan, C. Lucak, D. Welsby, Solae, St Louis, MO, USA

Stearidonic acid (C18:4, SDA) is an omega-3 essential fatty acid, and it is biosynthesized from α -linolenic acid (ALA) by the enzyme Δ 6-desaturase. Research has shown that SDA is effectively converted to eicosapentaenoic acid (C20:5, EPA). Soybeans producing oil enriched with 20% SDA which can be an omega-3 source have been developed, and incorporated into a variety of food applications (baked cereal bars, dairy drinks, clinical nutritional beverages and frankfurters) to examine oxidative stability in food systems. Formulas for each food application were developed to deliver 375 mg of SDA per serving. Samples were evaluated by trained panelists (descriptive profiling) and consumers (consumer acceptance), and fatty acid profile was analyzed. Results showed that SDA enriched soybean oil can be added at this level with no significant impact on sensory attributes, compared to controls. These results suggest that SDA enriched soybean oil can deliver physiologically active levels of omega-3 fatty acids in a broad range of processed foods without negatively impacting eating quality.

Composition and Antioxidant Activities of Selected Species of Seaweeds from the Danish Coast. Koduvayur Habeebullah Sabeena Farvin, Susan Løvstad Holdt, Charlotte Jacobsen, National Institute of Food (DTU-FOOD), Technical University of Denmark, B. 221, Søtofts Plads, DTU, DK-2800 Kgs., Lyngby, Denmark

In the present study, composition and antioxidant activities of 16 species of seaweeds obtained from Danish coasts consisting of 8 brown seaweeds, 2 green seaweeds and 6 red seaweeds were determined. Ethanol or water were used as extraction solvents. The antioxidant activities were determined by employing four in vitro established systems such as antioxidant activity in liposome model systems, 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity, reducing power and metal chelating activity. The brown algae consisting of *Fucus* sps and red algae *Rhodomela* showed multiple antioxidant activities among the sps tested. All *Fucus* sps showed high content of total phenolics in water extracts whereas in ethanolic extracts *Rhodomela* had the highest content followed by *Fucus* sps. Data on individual phenolic compounds revealed by HPLC show that both water and ethanolic extracts contained high amounts of gallic, gentisic and protocatechuic acids. In addition, ethanolic extracts of some sps contained trace levels of caffeic acid and all water extracts showed trace levels of chlorogenic acids. As the phenolic content of the extract did not correlate well with antioxidant activity, the antioxidant activity might be due to some other compounds in the extracts and this needs further investigation.

Role of Plasmalogen in Lipid Oxidation. Guang Wang, Tong Wang, Iowa State University, USA

The role of ethanolamine plasmalogen extracted from bovine brain (BBEP) in maintaining oxidative stability of bulk soybean oil and liposome made with egg phospholipids (PL) was studied. In a purified soybean oil (PSO), the addition of 200 and 1000 ppm BBEP promoted lipid oxidation in a rate of 0.037 and 0.071 whereas soy lecithin (SL) added in

the same amount showed a similar trend to the PSO Blank which had an oxidation rate of 0.025. The PSO with BBEP was susceptible to cupric ion-catalyzed oxidation, in that the oil was oxidized much faster than the PSO with SL and cupric ion. In commercial soybean oil (CSO) with the presence of tocopherols, SL at 1000 ppm acted synergistically as an antioxidant with the natural tocopherols, but addition of BBEP accelerated lipid oxidation, as evidenced by the oxidative stability index (OSI) test. In the egg PL liposome, the BBEP had a fast breakdown of the lipid hydroperoxides, consequently promoted more thiobarbituric acid-reactive substances (TBARS) formation. The PL oxidation in the presence of copper in the liposome was not affected by the BBEP, which indicates that the hypothesis of ethanolamine plasmalogen (EthPm) chelating cupric ion as the antioxidation mechanism was not supported. The addition of cumene hydroperoxide to the egg PL liposome promoted lipid oxidation as indicated by a fast development of PV and TBARS. However, the result with cumene hydroperoxide failed to differentiate the effect of BBEP and SL, and their concentration on lipid oxidation. Based on the observations from this study, we conclude that EthPm is not an antioxidant but rather a pro-oxidant in bulk lipid system, and it has no significant antioxidant effect for PL oxidation in the liposome.

Fatty Acid Profile and Antioxidant Properties of Mangosteen Seed. Amonrat Thanonkaew¹, Akkasit Jongjareonrak², ¹Research Unit of Local Southern Thai Foods, Department of Food Science and Technology, Faculty of Technology and Community Development, Thaksin University, Phapayom, Phatthalung, Thailand, ²Nutraceutical and Functional Food Research and Development Center, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Mangosteen seed oil was extracted from the seed waste of a fruit industry in Southern Thailand. The mangosteen seed oil contained a great content of stearic acid (C18:0, 54.88%), cis-9-octadecanoic acid (C18:1 n-9, 19.53%), cis-9,12-octadecadienoic acid (C18:2 n-6, 18.37%) with less amount of palmitic acid (C16:0, 5.92%), arachidic acid (C20:0, 0.62%) and cis-9,12,15-octadecatrienoic acid (C18:3 n-3, 0.12%). The antioxidant activities of mangosteen seed were also determined in comparison with peel and flesh extracts. Among all extracts, peel extract had higher total phenolic content, DPPH-, ABTS-, superoxide anion-radical scavenging activity and ferric reducing antioxidant power than those of seed and flesh extract, respectively. In addition, the antioxidant activities of extracts were increased in the dose dependent manner. Furthermore, seed extracts exhibited the synergistic effect with trolox, ascorbic acid and gallic acid toward all antioxidant activities assays. Therefore, mangosteen seed could be an alternative source for oil and antioxidant extraction for using in food and/or nutraceutical purposes.

Effect of Natural Antioxidants on the Oxidative Stability of Chia Seed Oil. V. Y. Ixtaina^{1,2}, S. M. Nolasco², M.C. Tomás¹, ¹Centro de Investigación y Desarrollo en Criotecología de Alimentos (CIDCA - CONICET La Plata-UNLP), La Plata, Buenos Aires, Argentina, ²Facultad de Ingeniería, Dto. de Ingeniería Química (TECSE), Universidad Nacional del Centro de la Provincia de Buenos Aires (UNCPBA), Olavarría, Buenos Aires, Argentina

Chia seed oil exhibits a high susceptibility to lipid oxidation, due to its high level of PUFAs (