

2009 Annual Meeting Abstracts

Lipid Oxidation and Quality

MONDAY

MORNING

LOQ 1: Prediction and Evaluation of Shelf Life

Chair(s): C. Hall, North Dakota State University, USA; and S. Zhou, Kellogg Company, USA

Prediction of Oxidative Stability of Food Products: Facts, Consideration and Challenge. Shane Zhou, Kellogg Company, 235 Porter Street, Battle Creek, MI 49016, USA

Development of rancid odor in food products during storage is the primary mode of failure in many food products, particularly those with low water activity and high content of unsaturated fatty acids. The removal of trans fat from food products significantly increases the chance of shelf life instability due to lipid oxidation. Food industry is hardly relying on the understanding of lipid oxidation in food matrixes to predict shelf life due to matrix complexity. Facts, consideration and challenge of lipid oxidation in foods will be the subjects of discussion in this presentation.

Challenges in Predicting Shelflife of Oil-based Products. K. Hrnčirik, Unilever R&D, Vlaardingen, The Netherlands

Shelf-life of food is usually related to the safety and quality. Shelf-life of fat-based products (e.g. margarines, dressings) is usually determined by the outbreak of the formation of undesirable (rancid) off-flavor which develops as a consequence of oxidation of polyunsaturated fatty acids. As the determination of shelf-life is time-consuming and expensive, a substantial effort has been spent by food industry to predict the shelf-life by developing methods that speed up the process of product deterioration under controlled conditions. The main purpose of shelf-life prediction is to estimate the shelf-life of food products without carrying out direct storage test, which leads to the substantial shortening of the product development process. This speech deals with main challenges related to the prediction of shelf-life of fat-based products. Some examples from the industrial R&D environment are shown to demonstrate the importance of shelf-life prediction in the product innovation.

Evaluation and Prediction of the Stability and Shelf Life of Ganache Chocolate Filling. F. Depypere, K. Dewettinck, Ghent University, Gent, Belgium

The health trend towards sugar reduction and/or substitution has evolved parallel to the increase in stability problems and decrease in shelf life of confectionary products. It is therefore yet common practice to add alcohol and/or polyols. Little, however, is known about the relationship between the dose and the resulting shelf life extension when using alcohol or polyols. Besides lowering water activity, these components also exhibit extra anti-microbiological activity. This work therefore aims to quantify the relationship between the dose of alcohol-polyol and the shelf life extension. Besides effects on microbiology, also the relationship between the dose of alcohol-polyol and the resulting texture and sensory effects were assessed. A model ganache made from 65% dark chocolate and 35% cream was produced. Firstly ganaches produced with sugar versus maltitol containing chocolate were compared. Additionally, up to 5% alcohol, 10% glycerol and 20% sorbitol was added. Effects on water activity, pH, hardness, taste and the development of xerophile moulds and osmophilic yeasts were investigated. Compared to the model ganaches, a longer shelf life was obtained for ganaches with alcohol-polyol. Taking also the sensory and texture aspects into account, an optimisation of the dose of alcohol-polyol was performed.

Prooxidant Mechanisms of Oleic Acids in Stripped Soybean Oil-in-Water Emulsions. Thaddao Waraho¹, Maria Rodriguez-Estrada², David McClements¹, Eric Decker¹, ¹University of Massachusetts, Amherst, MA, USA, ²University of Bologna, Bologna, Italy

Free fatty acids are prooxidants in bulk oils. The prooxidant role of free fatty acids in food dispersions was studied by

adding oleic acids to soybean oil-in-water emulsions. Previously formed oleic acid hydroperoxides were removed prior to emulsions formation. Addition of oleic acids (0 to 5.0% of oil) to the emulsions increased both lipid hydroperoxides and headspace hexanal formation with increasing oleic acid concentration increasing oxidation rates. Oleic acid also made the surface charge of the emulsion droplet more negative indicating that oleic acid was concentrating at the lipid-water interface. At pH 8.0, the emulsion containing oleic acid had the highest oxidation rate and lowest emulsion droplet charge. When pH was decreased from 8.0 to 4.0, the surface charge of the droplet became over 10-fold more less negative and the lag phase of lipid oxidation increased from 1 day (pH 8.0) to over 10 days. These data indicate that when oleic acid was negatively charge it concentrated at the interface of oil-in-water emulsion droplets and accelerated lipid oxidation. When the pH of the emulsion was less than the pKa of the carboxylic acid, the protonated oleic acid did not change the emulsion droplet charge and did not accelerate lipid oxidation.

Radical Scavenging Activity of Lipophilized Products from Lipase-catalyzed Transesterification of Flaxseed Oil with Cinnamic and Ferulic Acids. W.S. Choo¹, E.J. Birch², ¹Monash University Sunway Campus, Petaling Jaya, Selangor, Malaysia, ²University of Otago, Dunedin, New Zealand

Lipase-catalyzed transesterification of flaxseed oil with cinnamic and ferulic acids using Novozym 435 was conducted to evaluate whether the lipophilized products provided enhanced antioxidant activity in the oil. The lipophilized products were identified using Electrospray Ionization-Mass Spectroscopy and were examined for their free radical scavenging activity toward 2,2-diphenyl-1-picrylhydrazyl (DPPH?) in ethanol and ethyl acetate. The esterification of cinnamic acid and ferulic acid with flaxseed oil resulted in significant increase and decrease in the free radical scavenging activity, respectively. Lipophilized ferulic acid was a better free radical scavenger as compared with lipophilized cinnamic acid and extended the naturally-occurring antioxidant capacity of the flaxseed oil. Lipophilized cinnamic acid did not provide much enhanced radical scavenging activity in the flaxseed oil as the presence of natural hydrophilic antioxidants in the oil had much greater radical scavenging activity. The choice of solvent for the DPPH? assay is found to be critical in evaluating the free radical scavenging activity of substrates of differing polarity.

Evaluation of Oxidative Stability in Food Emulsions with EPR Spectroscopy. U. Nienaber, C. Shawl, Kraft Foods, Glenview, IL, USA

Metal-catalyzed lipid autoxidation is one of the most prominent deterioration modes in food emulsions. Since lipid autoxidation involves a radical mechanism, electron paramagnetic resonance (EPR) spectroscopy is a useful tool to monitor the formation of radicals during the initial reaction stages. A spin trap compound is used with incubation to generate levels of stabilized radicals high enough for detection. Products such as mayonnaise and salad dressings can be evaluated for their relative oxidative stability. Examples are presented to illustrate the pro-oxidant and anti-oxidant effect of various food ingredients and additives. The main advantage of this method is that samples can be analyzed at ambient or mildly elevated temperatures and without the need for time-consuming storage studies.

Phenomenological Models of Lipid Oxidation and Other Complex Reactions. M. Micha Peleg, University of Massachusetts, Amherst, MA USA

During isothermal lipid oxidation at relatively high temperatures, the peroxide concentration frequently peaks, while at relatively low temperatures, it only slowly rises. These are two different manifestations of single process kinetics where peroxides formation and degradation happen simultaneously, but on different time scales. A phenomenological mathematical model, comprising a decay factor superimposed on an accumulation term can describe both scenarios and help to identify a transition between them. The two model's components have characteristic time constants, shortened by raising the temperature, and 'rate parameters' that increase with temperature. The model's mathematical structure, and the magnitude of its coefficients, both depend on the particular system. However, regardless of the chosen expressions, if the degradation characteristic time falls within or just beyond the experiment's duration, a peak peroxide value will be observed. The peak's height and shape will then largely depend on the model's other parameters. If the degradation characteristic time is far outside the time of the experiment, no peak peroxides will be recorded. The chosen mathematical model need not be unique and no detailed knowledge of the oxidation mechanisms is required for its formulation. However, different model versions might be needed to accounts for scenarios where the oil is already oxidized to some extent at the beginning of the experiment or where the peroxides appear 'de novo'.

Novel Spice Extracts with Multi-antioxidant Properties and their Effect on Extending Shelf Life in Complex Food Systems. R. Nahas, P. VanAlstyne, A. Uhlir, G. Reynhout, J. McKeague, T. Jones, 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 such as emulsions. Seventeen different spices and vegetables were extracted purposely to optimize the overall antioxidant capacity. Initial evaluation was performed using the DPPH and the ferrozine assays to determine the fundamental components of the antioxidant activity and an overall polarity screening test. Furthermore, the antioxidant potency was examined in three different food models consisting of oil, emulsion and aqueous systems. Subsequently, the most promising extracts were tested in three different foods.

Antioxidant Activity of Natural Compounds Optimized by Response Surface Methodology. C.D. Capitani, P.B. Botelho, M.M. Carrapeiro, I.A. Castro, Department of Food and Experimental Nutrition, Faculty of Pharmaceutical Sciences, University of São Paulo, São Paulo, São Paulo, Brazil

The objective of this study was to explore the synergism on antioxidant activity of natural compounds for further application in food oxidative stability. Three hydrosoluble compounds (x_1 = caffeic acid, x_2 =carnosic acid and x_3 =glutathione) and three liposoluble compounds (x_1 = quercetin, x_2 =rutin and x_3 =genistein) were mixed according to a centroid simplex design. Radical scavenger and antioxidant activity of the mixtures were analyzed by Ferric reducing antioxidant power (FRAP) and Oxygen radical absorbance capacity (ORAC) methodologies and also applied in an oxidized emulsion prepared with linoleic acid (LAOX). Cubic polynomial models with predictive capacity were obtained only when the mixtures were submitted to the LAOX methodology ($y = 0.56 x_1 + 0.59 x_2 + 0.04 x_3 + 0.41 x_1 x_2 - 0.41 x_1 x_3 - 1.12 x_2 x_3 - 4.01 x_1 x_2 x_3$) for hydrosoluble compounds and to the FRAP methodology ($y = 3.26 x_1 + 2.39 x_2 + 0.04 x_3 + 1.51 x_1 x_2 + 1.03 x_1 x_3 + 0.29 x_2 x_3 + 3.20 x_1 x_2 x_3$) for liposoluble compounds. The models optimization suggested a mixture containing 47% caffeic acid + 53% carnosic acid or a mixture containing 67% quercetin + 33% rutin as potential synergistic combinations to be further evaluated in a food matrix.

A Brief History of the Oxidation of Fats and Oils. Earl G. Hammond, Pamela White, Iowa State University, Ames, Iowa, USA

A historical journey about lipid oxidation and some of the people who provided the foundation that we often cite without reference today. We will start with the demonstration that oxidizing lipids take up oxygen (~1800), proxy tests for lipid oxidation (1900-1951), tests for peroxides (1930s), the demonstration that hydroperoxides were the first product (1933), demonstration of attack α to the double bond (1942), diene conjugation in polyunsaturates (1946), the kinetics of chain reactions and the mechanism of phenolic antioxidants (1946), the structures of hydroperoxy oleate, linoleate and linolenate, the identification of major scission products and flavor compounds, and we will end with the role of singlet oxygen in initiation reactions.

AFTERNOON

LOQ 2 / PHO 2.1: Oxidation and Antioxidation of Neutral and Polar Lipids

Chair(s): J. Winkler-Moser, USDA, ARS, NCAUR, USA; and T. Wang, Iowa State University, USA

The Role of Plasmalogen Phospholipid in Transition Metal-induced Lipid Oxidation. G. Wang, T. Wang, Iowa State University, Ames, IA, USA

Plasmalogen is a glycerophospholipid that is found in animal tissues (heart, brain, and sperm) and bacteria. It contains a vinyl ether bond instead of an ester bond in the sn-1 position. It has been shown that both in vivo and in vitro plasmalogen contributes to the delayed or inhibited lipid oxidation, especially for polyunsaturated fatty acids in the presence of transition metal ions. This is assumed to be a direct interaction of transition metal with the enol ether double bond. In our study the interaction of plasmalogen and transition metal ions was investigated in an emulsion

system. Our first aim was to evaluate how plasmalogen lipid oxidation happens in the absence/presence of each transition metal, e.g., copper and iron at different concentrations. Also, individual transition metal binding with enol ether bond will be evaluated under different pH levels (3 and 7). Our second aim was to investigate if different polyunsaturated fatty acids respond differently to plasmalogen in the presence of transition metal with respect to lipid oxidation as evaluated by peroxide value and thiobarbituric acid reactive substance. Our study offers insights on the antioxidant application of plasmalogen in food systems.

Investigations into Exploiting the Synergy of Lecithin with Natural-Source Antioxidants to Replace Synthetics.
B. Sebree, Archer Daniels Midland Co., USA

Lecithin and its fractions have been studied for years as a synergist to primary natural sourced antioxidants to the inhibition of oxidation in oils. Olcott and Vander Veen (1963) evaluated lecithin fractions, while Brandt et al (1973) studied the pro- and antioxidant activity of phospholipids. Brandt ascribed antioxidant activity of phospholipids to 1) the regeneration of phenolic antioxidants and 2) complexation of pro-oxidant metals. The aim of this work was to attempt to exploit synergism of lecithin and well known chelators to enhance the activity of natural-sourced antioxidants to the point where they could be a viable alternative to synthetics. Primary antioxidants studied were mixed tocopherols, rosemary extract and green tea extract. A wide range of oil/fat systems were studied via the OSI-I instrument - tallow, lard, poultry fat, fish oil, DAG oil and a variety of vegetable oils. Success was very dependent upon the fat system being treated, but in most cases the use of lecithin in preparations enhanced antioxidant activity. Green tea extract was directionally more effective in most fat, as opposed to rosemary extract. Mixed tocopherols showed generally synergistic activity in conjunction with both green tea and rosemary extracts in a large number of the fat systems.

Oxidative Stability of Polyunsaturated Phospholipids. A. Takenaka, Y. Mizuno, M. Hosokawa, K. Miyashita,
Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan

The nutritional importance of n-3 long chain highly-unsaturated fatty acids (HUFA) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) has been proven beyond any doubt through research works across the globe. However, due to their high degree of unsaturation, EPA and DHA are much more susceptible to oxidation. On the other hand, they are relatively stable to oxidation in marine biological systems. In biological systems a large amount of EPA and DHA are present as phospholipids (PL) in the membrane. The present paper made clear the stability of HUFA as PL form with special reference to its synergistic activity tocopherol. EPA and DHA in PL were much more stable to oxidation under the presence of tocopherol than those in triacylglycerols. The mechanism responsible for the synergy of tocopherols and PL would be related to the involvement of amino group of PL in the enhancement of the antioxidant activity of tocopherols and regeneration of tocopherols. Furthermore, when fish oil was oxidized with synthesized phosphatidylcholine (PC) and phosphatidylethanolamine (PE) having saturated and unsaturated fatty acids under the absence or presence of tocopherol, unsaturated PC and PE promoted fish oil oxidation without tocopherol. On the contrary, unsaturated PE showed synergistic antioxidant effect with tocopherol, while PC had little effect.

The Effect of Canola Oil Extracted from Pre-heated Seed on the Oxidative Stability of Oil-in-Water Emulsion Systems. A. Richards^{1,2}, P. Fagan^{1,2}, C. Ceccato^{1,2}, ¹CSIRO Food Futures National Research Flagship, Werribee, Victoria, Australia, ²Food Science Australia, Werribee, Victoria, Australia

There is a push within the food industry to move towards 'clean labeling' on food products. Therefore there is a need to identify and validate natural sources of antioxidants that provide equal or better protection towards oxidative deterioration than that currently used in the market place. The oxidative stability of canola oil can be improved through pre-heating of the seed. In this investigation, the effectiveness of canola oil extracted from pre-heated seed in stabilizing tuna oil-in-water emulsion systems against auto-oxidation was examined in comparison to (a) canola oil from non-treated seed, and (b) a selection of commonly used antioxidants. Oxidative deterioration is a significant problem within the food industry. EPA and DHA are both n-3 FA and the main component to undergo oxidation within tuna oil resulting in the formation of secondary oxidation products responsible for the fishy taste and smell. Results will be presented.

Antioxidative Activities of Mushroom (*Flammulina velutipes*) Extract Added to Bigeye Tuna Meat: Dose-dependent Efficacy and Comparison with Other Biological Antioxidants. Toshiaki Ohshima, Bao Huynh N. D. , Tokyo University of Marine Science and Technology, Tokyo, Japan

The ability of a hydrophilic extract prepared from edible mushroom (*Flammulina velutipes*) to stabilize fresh color of bigeye tuna (*Thunnus obesus*) meat was evaluated to compare it with certain other antioxidants. The fresh color shelf life of bigeye tuna meats, to which were added as 1, 3 or 5 mL of mushroom extract to 100 g of minced bigeye tuna meat, prolonged ice storage by more than 2, 4 and 6 days, respectively, in comparison with the control tuna meat without mushroom extract. Retarding oxidation of lipid in the tuna meat by the addition of 5 mL of mushroom extract to 100 g of minced bigeye tuna meat was more effective than adding ascorbic acid sodium salt (500 ppm) or α -tocopherol (500 ppm). The color changes significantly correlated with lipid oxidation as well as metmyoglobin formation in the tuna meat. These results clearly showed that the mushroom extract is a potential antioxidant which has ability to stabilize fresh color of tuna meat during ice storage.

Enhancement of Oxidative Stability of Canola Oil with Canola-derived Phenolic Antioxidants. C.

Wijesundera^{1,2}, P. Fagan^{1,2}, A. Richards^{1,2}, C. Ceccato^{1,2}, ¹Food Science Australia, Werribee, Victoria, Australia, ²CSIRO Food Futures National Research Flagship, Werribee, Victoria, Australia

Canola has the highest phenol content among commercial oilseeds. Ethanolic extracts of canola seed have been shown to possess strong antioxidant activity. During commercial canola oil extraction, where the seed is only heated to 75-100°C prior to oil extraction, very little of the canola phenolics is transferred to the oil. Heat treatment of the seed at higher temperatures (145-165°C) has been shown to increase the amount of phenolic compounds transferred to the oil, and also the oxidative stability of the crude oil. The increased oxidative stability has been attributed, at least in part, to 2,6-dimethoxy-4-vinylphenol (DMVP), which is derived from phenolic precursors occurring in canola seed. However, DMVP is almost completely removed during commercial oil refining. A practical way to utilize the antioxidant potential of DMVP is possibly to blend refined oil with relatively small amounts of crude oil extracted from high heat-treated canola seed. Experimental data on the relative oxidative stabilities of various blends will be presented.

TUESDAY

AFTERNOON

LOQ 3: Nutraceutical and Specialty Oils

Chair(s): M. Eskin, University of Manitoba, Canada; and F. Shahidi, Memorial University Newfoundland, Canada

Novel Lipids and Antioxidant Systems. F. Shahidi, Y. Zhong, Z. Tan, Department of Biochemistry, Memorial University, Canada

Novel lipids may be classified as those that may render specific physico-chemical properties or nutritional value in terms of their physiological function in foods and supplements. However, many such lipids, including structured lipids, that include omega-3 polyunsaturated fatty acids ((PUFA) are oxidatively unstable and require stabilization . Thus effective antioxidants / antioxidant systems may be required to achieve this goal. These antioxidants may be of synthetic or natural origin or could be modified to improve their solubility characteristics in different media. In addition, PUFA and other bioactive liposoluble products may be attached covalently to phenolic antioxidants in order to improve their stability or to render synergistic and multiple health effects. The presentation will provide examples where PUFA such as docosahexaenoic acid (DHA) are esterified to biomolecules to produce a range of products that may improve health and reduce disease risk.

Brown Seaweed Lipids as Rich Source of Omega-3 and Omega-6 Polyunsaturated Fatty Acids with Functional Carotenoid, Fucoxanthin. N. Sasaki, K. Sugiyama, M. Hosokawa, K. Miyashita, Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan

Although seaweeds have been thoroughly explored for their hydrocolloids, their lipids are often ignored due its low

content. However, it has been reported that lipid content of some seaweeds was over 5% of dry algal matter. Moreover, waste matters from the industrial production of seaweed phycocolloids contain lipids as a major component. In this presentation, we report chemical and physiological properties of brown seaweed lipids as source for nutraceuticals and functional foods. We found that some seaweed species belonging to *Sargassum* showed higher lipid levels (5-10%) caught in Japan. Most abundant lipid class of the *Sargassum* was glycolipids, having 18:4n-3, 20:5n-3, and 20:4n-6 as major fatty acids. The extracted seaweed lipids also showed the higher content of functional carotenoid, fucoxanthin, and other high value lipid compounds such as fucosterol and polyphenols. Our previous studies showed the several physiologically important functions of fucoxanthin, including anti-oxidative, anti-cancerous, anti-obesity, anti-diabetes, and other properties. Anti-obesity and anti-diabetic effects of fucoxanthin, synergistically increased with omega-3 highly unsaturated fatty acids contained in brown seaweed lipids. Synergistic effect was also found between fucoxanthin and seaweed polyphenols.

Specialty Omega-3 Lipids in Food and Supplement Application. Jaroslav A. Kralovec, Ocean Nutrition Canada Ltd., Canada

It has been suggested that supplementation with omega-3 fatty acids, particularly eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), could moderate excessive omega-6 mediated inflammatory processes, prevent or slow down the progress of immune, inflammatory and vascular disease, and ease major depression. Therefore omega-3 fatty acids are important components of a balanced diet and, not surprisingly, they have an established position as science-backed nutritional supplements and ingredients of functional foods. Fish oils are the best sources of EPA and DHA, the two most bioactive omega-3 fatty acids, and seal oil is a good source of structurally related docosapentaenoic acid (DPA, 22:5n-3). However, there are other omega-3 fatty acids and lipids that have demonstrated important health benefits, and alpha-linolenic acid (ALA, 18:3n-3), the essential omega-3 fatty acid, a major components of flax seed oil and other plant sources, is the most researched one. Stearidonic acid (20:4n-3) has been a focus of biological assessment by a number of research groups and has recently received a great attention due to the research involving transgenic plants. Other omega-3 fatty acids are also currently studied by various groups. A large number of natural oils from different sources composed of different lipid classes, and various delivery technologies developed by us or others, including emulsions, spray dry emulsions and microencapsulation, are on the market. This is a very dynamic field and this presentation will feature the most recent products and technologies.

Nutraceutical Lipid Components in the North American Wild Rice. R. Przybylski¹, D. Klensporf-Pawlik³, F. Anwar², M. Rudzinska³, ¹Department of Chemistry & Biochemistry, University of Lethbridge, Lethbridge, Canada, ²Department of Chemistry, University of Agriculture, Faisalabad, Pakistan, ³Institute of Food Technology of Plant Origin, Poznan University of Life Sciences, Poznan, Poland

Content and composition of fatty acids, sterols, tocopherols and γ -oryzanol in wild rice (*Zizania palustris*) grown in the North America were compared to regular brown rice (*Oryza sativa* L.). The content of lipids in wild rice averaged at 0.9%, compared to 2.7% in regular brown rice. Lipids of wild rice comprised mainly of linoleic and linolenic acids, found at 36% and 26%, respectively. In wild rice lipids the average contributions of palmitic, stearic and oleic acids were: 16.2 %, 1.2 % and 14.5 %, respectively. Wild rice lipids contained very high amounts of sterols, ranged from 70 g/kg to 145 g/kg of lipids. The main sterols found were: campesterol, β -sitosterol, Δ^5 -avenasterol and cycloartenol. The amounts of γ -oryzanol ranged from 459 to 730 mg/kg in wild rice lipids. Tocopherols and tocotrienols amounts were growing location dependent and ranged from 3682 and 9378 mg/kg to 251 mg/kg and 224 mg/kg, respectively. The α -isomer was the most abundant among tocopherols and tocotrienols. The results of the present study showed that wild rice lipids contain high amounts of nutraceuticals with proven positive health effects.

Gamma Linolenic Acid Oils: Processing and Opportunities. N.A.M. Eskin, University of Manitoba, Winnipeg, Manitoba, Canada

The literature reports that many herbaceous plants contain a high content of gamma-linolenic acid (GLA, 18:3n-6) in their seed oils. However, only borage (*Borago officinalis*) and evening primrose (*Oenothera biennis*) are produced commercially as sources of GLA. GLA has considerable potential as a nutraceutical so that these specialty oils have become important sources. Since both seed oils are highly unsaturated GLA, the traditional high-temperature solvent

extraction process has undesirable effects on the quality of the end products. This paper will review the application of cold-pressing for the production specialty oils.

Increasing the Oxidative Stability of Bioactive Lipids by Nanolamination and Other Techniques. Eric A. Decker, D. Julian McClements, Atikorn Panya, Department of Food Science, University of Massachusetts, USA

Many bioactive lipids could be used as functional food ingredients if they can be added to the food in a manner in which they are physically and oxidatively stable. Since most foods are primarily composed of water, these bioactive lipids must be added in the form of a lipid dispersions. Numerous techniques exist to form physically stable lipid dispersions but the oxidative stability of lipid in these dispersions varies widely. One of the main prooxidative factors that promote the degradation of bioactive lipids is iron. Therefore, an effective strategy to increase the oxidative stability of bioactive lipids is to control the reactivity of iron. Engineering lipid dispersions to control iron reactivity generally utilizes technologies that inhibit interactions between iron and the dispersed lipids. This can be accomplished by directing biopolymers onto the surface on the emulsion droplets or liposomes where they will inhibit prooxidative metals-lipids interactions. Such techniques can substantially improve the chemical stability of bioactive lipids thus increasing their applications in functional foods.

Germ Oil Processing: Challenges and Opportunities. N. Dunford, Oklahoma State University, USA

The germ of a cereal constitutes about 2-3% of the grain and can be separated in a fairly pure form during the milling operation. The bran and endosperm content of commercial germ may vary with the extent and sophistication of the milling operations. In mills with no special germ separation equipment germ recovery yields are usually very low. Ideally germ should be stabilized within a few minutes after removal from the kernel. Stabilization inactivates the enzyme lipase that causes rapid hydrolysis of triacylglycerides. Most of the oil present in the grain is found in the germ fraction of the cereal. For some cereals such as rice, corn and wheat, oil has economic significance. The lipid content of the germ varies with the grain type. Even though a small amount of germ oil is commercially extracted from other grains such as oats and barley the most important commercial germ oils are from rice, corn and wheat. In general germ oil has a significantly higher concentration of unsaponifiables compared to other vegetable oils. The bioactive components of cereals are usually associated with the germ, bran and oil fractions and concentrated in the unsaponifiable fraction of the oil. Plant germ oils of high nutritional quality can be obtained from cereal grains. Germ oil processing presents a challenge because of the high content of biologically active heat labile components. Mechanical oil extraction rather than organic solvent extraction is preferred for recovering germ oil that will be used in specialty products and health foods. Physical refining methods improve retention of these compounds in the final product. High purity products enriched in health beneficial bioactive compounds are obtained by utilizing supercritical fluid technology for extraction, refining and fractionation of germ oil. Currently plant germ oils, except corn germ oil, are produced for specialty markets in the U.S. However increasing consumer demand for healthy food products may change the market trends in the future.

Diacylglycerol Oil: Evidence Supporting a Role in Weight Loss. P. Jones, University of Manitoba, Canada.

WEDNESDAY

MORNING

LOQ 4: Monitoring the Effect of Natural Products on Lipid Oxidation

Chair(s): R. Nahas, Kalsec Inc., USA; and A.D.M. Sørensen, DTU Aqua, Denmark

Effect of Fish Oil Concentration and Emulsifier on Lipid Oxidation in Fish Oil Enriched Mayonnaise. A.D.M. Sørensen, N.S. Nielsen, C. Jacobsen, DTU Aqua, 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 omega-3 PUFA. Most food products consist of a complex matrix, and several factors might influence their oxidative stability. Previous studies of fish oil enriched mayonnaise and salad mayonnaise have showed different results with respect to oxidative stability. The observed differences in stability seem to be related to differences in the total fat level and level of fish oil. Previous studies have also suggested that pH and emulsifier significantly influenced lipid oxidation in mayonnaise (80% fat). Therefore, the present study aimed at evaluating 3 different concentrations of fish oil and the influence of emulsifier type on lipid oxidation in fish oil enriched light mayonnaise (40% fat) during storage (20°C). The emulsifiers evaluated were egg yolk and milk protein. Moreover, the influence of storage temperature (20°C and 2°C) on oxidation was evaluated. Lipid oxidation was assessed by determination of the concentration of peroxides, volatile oxidation products and sensory profiling. At high fish oil concentration milk protein as emulsifier resulted in more oxidation than mayonnaise with egg yolk. As expected, higher fish oil concentrations and higher temperature increased the oxidation rate.

Monitoring Oxidation of Fish Oil Emulsions Containing Fructose and Sorbitol, using SPME and Peroxide Values. J.C. Sullivan¹, S.M. Budge¹, M. St-Onge², ¹Dalhousie University, Halifax, NS, Canada, ²Ascenta Health Ltd., Dartmouth, NS, Canada

Fish oil emulsions provide a novel way to supply long chain polyunsaturated fatty acids, primarily EPA and DHA. However, these fatty acids are highly unstable and prone to oxidation, and antioxidants must be used to control the rate of oxidation. Here we investigate the use of fructose and sorbitol as antioxidants. Solid phase microextraction (SPME) headspace analysis coupled with GCMS was used to monitor oxidation products of fish oil emulsions containing varying levels of fructose and sorbitol. Peroxide values were also measured. Preliminary results with emulsions suggest that the antioxidant effect of sorbitol is greater than that of fructose. The sweetness of sorbitol is less than that of fructose, allowing more of the sugar to be used without having negative impact on the sensory qualities of the emulsion.

Assessing French Fry Quality by Sensory Evaluation and the Electronic Nose. M. Aliani, N.A.M. Eskin, D. Ryland, K. Loewen, S. Siddhu, University of Manitoba, Winnipeg, Manitoba, Canada

Studies have shown that diets high in trans fats can lead to increased risk for heart disease. Research has suggested that products fried in oils with increased oleic and decreased linolenic acid content are similar in stability and sensory quality compared to the hydrogenated high trans counterparts. Quality of the fried product depends on a number of factors including the appropriate temperature and time for frying. The objective of this work was to determine the effect of temperature/time (T/t) on the discontinuous batch frying (240 batches) of French fries for 105 hours (7 hrs/day for 15 days) in high oleic/low linolenic canola oil using commercial fryers. Sensory evaluation and electronic nose were employed to investigate the effect of three T/t combinations on French fry quality. Significant differences were found between the three T/t conditions for fried oil, sweet and overcooked aromas; potato, fried oil and overcooked flavors. For all attributes, 172°C/240 sec was significantly different ($p < 0.05$) than 186°C/165 sec. All conditions showed significant differences for overcooked aroma and flavor. Correlations between overcooked aroma and flavor attributes and electronic nose sensor response calculated by partial least squares analysis were 0.66 and 0.65 respectively.

Effect of Polydimethyl Siloxane Concentration on Fatty Acid and Tocopherol Degradation in Soybean Oil at High Temperature. J.A. Gerde, E.G. Hammond, P.J. White, Dept. of Food Science and Human Nutrition Iowa State University, Ames, Iowa, USA

The most accepted mechanism for polydimethyl siloxane's (MS) protection of oil is that its surface accumulation prevents oxygen diffusion into the oil. Soybean oil containing 100, 50, 25, 10, and 5 ppb of MS and a control (no MS) were heated at 180 °C for 48 hr. The calculated amount needed for a surface monolayer of MS is 25 ppb. Both higher and lower concentrations than 25 ppb were tested. Fatty acid composition and tocopherol concentration were monitored. Slopes of the linear change in the ln (18:2/16:0) were calculated. For 50, 25, and 10 ppb MS inflection points were observed in these plots. The greater the MS concentration, the later the inflection point occurred, and for 100 ppb no inflection point occurred within 48 hr. At 5 ppb MS, the slope was not significantly different from that of the control. The slopes after the inflection points for 25 and 10 ppb were not different from that of the control. The

smaller the MS concentration, the faster the degradation of gamma and delta-tocopherol. For all treatments gamma-tocopherol degraded faster than delta, possibly because delta spares the gamma analog. A decrease in the oil's surface oxygen concentration was observed when 100 ppb MS was added, demonstrating that MS indeed acts as an oxygen barrier.

Oxidative Stability of Natural Canola Oil Body Emulsions. C. Wijesundera^{1,2}, Z. Shen^{1,2}, M Golding^{1,2}, S Oiseth^{1,2}, ¹Food Science Australia, Werrbee, Victoria, Australia, ²CSIRO Food Futures National Research Flagship, Werribee, Victoria, Australia

Oil bodies extracted from canola seed can potentially be used to prepare natural and functional food emulsions without added emulsifiers or antioxidants. Oil bodies were extracted from roasted (165 °C, 7 min) and unroasted canola seed by an aqueous extraction process which consisted of a series of steps including maceration, filtration, centrifugation and washing with water. The oil bodies from the unroasted canola seed contained 41.85±0.61% lipid, 44.43±0.08% moisture, 7.15±0.04% protein, 1.15±0.01% ash and 5.42% other matter. The corresponding values for the oil bodies from roasted canola seed were similar: 42.17±0.58%, 42.58±0.09%, 8.82±0.22% , 1.15±0.01% , and 5.28% respectively. Particle size distributions within oil in water emulsions (6.7% w/w, pH 6.8) prepared from oil bodies extracted from roasted and unroasted seed were similar and unimodal with d32 values of 4.92 and 5.09 micron respectively. However, confocal light scanning microscopy showed significant differences between the emulsions prepared from oil bodies extracted from unroasted and roasted seeds. The latter exhibited more globular and discrete oil droplets (particle size approximately 3 micron) than the former. Differences in chemical properties and oxidative stability will also be presented.

Optimization of the Oxidation of Methyl Linoleate Monolayers to Yield Useful Products. H. Liu, E.G. Hammond, Food Science and Human Nutrition, Iowa State University, Ames, IA, USA

Methyl linoleate spread as a monolayer on silica gel oxidizes rapidly to hydroperoxides and epoxy compounds. We wished to examine this process as a means of making useful products. The methyl linoleate was oxidized at various temperatures between 35°C and 60°C. A temperature of 50°C was optimum for the production of epoxylinoleate, but the yield was ~20%. Unpublished work in Aziz Tekin's laboratory has shown that copper and iron addition increases the amount of scission products during surface oxidation. We found that a treatment of the silica gel with sodium citrate and ethylenediaminetetra- acetic acid markedly increased the yield of epoxy linoleate during surface oxidation. The effect of vanadium addition to increase the epoxy yield also will be reported.

Changes in Lipids and Fatty Acid Profile of *Migaki-Nishin* (Dried Herring Fillet) During Drying. A.K.M. Azad Shah¹, Chikara Tokunaga², Hideyuki Kurihara¹, Koretaro Takahashi¹, ¹Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan, ²Kyowa Hakko Food Specialties Co., Ltd., Ibaraki, Japan

Migaki-nishin is a traditional dried fish product in Japan. Herring lipids are susceptible to deterioration by oxidation and hydrolysis during drying. This study was conducted to investigate the changes in lipids and fatty acid profile of *migaki-nishin* during drying. Lipids were extracted from herring fillets on different drying stages to determine lipid oxidation, lipid composition and fatty acid profile. Peroxide value and carbonyl value of the lipids were significantly increased ($P < 0.05$), which revealed that lipid oxidation occurred in *migaki-nishin* during the drying period. Marked increase in free fatty acids, with decreases in triglyceride and phospholipid content were observed in proportion to drying time. This result suggested that hydrolysis of triglyceride and phospholipid might take place, caused by lipases or phospholipases. The decreases in polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), were observed in the total lipids and phospholipid fraction. In addition, significant increase in PUFAs especially DHA was found in the free fatty acid fraction. These results suggest that during drying period lipid oxidation was not only occurred but also lipolysis predominantly released DHA, which might have a contribution to the characteristic taste of *migaki-nishin*.

Thermo-oxidation of β -Sitosterol and Campesterol in Vegetable Oils. M.F. Ramadan¹, A -M. Lampi², V. Piironen², ¹Biochemistry Department, Faculty of Agriculture, Zagazig University, Zagazig 44511, 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 oxides (POP) and the amount of unoxidized sterols (PS) using GC-MS method. Vegetable oils with different fatty acid and tocopherol profile (corn, sunflower, blended, palm, and rapeseed oils) were used. The highest amount of PS was found in rapeseed oil (768.7 mg/100g). The major PS in oils were β -sitosterol and campesterol. Upon heating, 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. The rate of oxidation after 8h of heating recorded the highest level in rapeseed oil (about 35 times higher than the initial amount) followed by corn oil and sunflower oil, respectively. At the end of heating experiment, the highest amount of total oxides was found in rapeseed oil (250.5 μ g/g) followed by sunflower oil (246.5 μ g/g). 7-Ketositosterol, followed by 7 β -hydroxysitosterol, 5,6-epoxy derivatives and 7 α -hydroxysitosterol were the main POP induced during heating. In addition, it was also noted that POP measured do not account for all the PS losses and a clear gap was found during heating.

Preparation of Sunflower Oil Based Products Using Curcuminoids. Sameera Rege, Shamim Momin, Dipti Narayan Bhowmick, Dept. of Oils, Oleochemicals and Surfactants Technology, Institute of Chemical Technology, N.P. Marg, Matunga(E), Mumbai, India

Reported literature shows curcuminoids present in the dry rhizome of turmeric have a wide range of biological and pharmacological activities such as antioxidant, anti-inflammatory and anticarcinogenic effects. Curcuminoids contain three main components, namely curcumin, demethoxycurcumin and bisdemethoxycurcumin. Curcuminoids in edible oils show pro-oxidant activity. In the present work, the separation of three components and application of curcuminoids as antioxidant with other natural antioxidant have been reported. The observations indicate curcuminoids do not show pro-oxidant effect when blended with other natural antioxidant. Further, the oil-based products have been prepared and studied for stabilizing curcumin using additive. The stability study of the product was also conducted. It has been proved that turmeric is not toxic even at higher doses. Hence, higher amount of curcumin can be incorporated in the product. Curcuminoids have been separated into three components using column chromatography. As curcuminoids have wide range of biological and pharmacological activities, the work has been taken up.

AFTERNOON

LOQ 5: General Lipid Oxidation and Quality

Chair(s): C. Hall, North Dakota State University; and U. Thiyam, University of Manitoba, Canada

Rapid Method to Determine the Free Fatty Acid Content in the Whole Grain Flour. Bin Zhao¹, Ning Zhou¹, Tim Hansen¹, Clifford Hall³, Hui Li⁴, ¹Kraft Foods, Inc., East Hanover, NJ, USA, ²Kraft Foods, Inc., Glenview, IL, USA, ³North Dakota State University, Fargo, ND, USA, ⁴Bruker Optics Inc., Billerica, MA, USA

Grain germ and bran represent a substantial portion of the grain, the nutritional quality of whole-grain products is superior, but increasing their utilization is not without pitfall. The levels of storage lipids commonly lead to rancid problems when bran and germ enzymes are not inactivated or when the lipid components of which about 65% consists of polyunsaturated fatty acids is not removed by defatting. It's also a challenge to determine the free fatty acids (FFA) content in whole grain flour rapidly from the quality control point. Two rapid methods have been investigated compared with traditional method. Traditional method (AACC 02-01A or AOCS Ba 3-38 and AOCS Te 2a-64) involved the oils extraction with solvent, solvent evaporation, and titration. Since the oil content is low in the whole grain, it needs a larger amount of whole grain flour and solvent to get enough oil for titration, it is very labor extensive procedure. One new rapid method included whole grain flour mixing with extraction solvent, then titration, but without solvent removal. Another new method was near-infrared reflectance spectroscopic method. The calibration curve was developed according the FFA value of 16 whole grain flour samples which were measured from traditional method. The data from these two new methods were consistent with data from traditional method.

The Influence of De-oxygenation on the Quality of Linseed Oil. Mikkel Nordkvist¹, Frank Pudel², Krause Thomas², Ludger Brühl³, Bertrand Matthäus³, ¹ISO-MIX A/S, Ishøj, Denmark, ²Pilot Pflanzenöltechnologie Magdeburg e.V., Magdeburg, Germany, ³Max Rubner Institut, Münster, Germany

The oxygen content of edible oils and fats can be significantly reduced by de-oxygenation using the ISO-MIX rotary jet head system. The de-oxygenation process is performed by circulating oil from the bottom of a tank via a pump and re-injecting it into the bulk liquid through the nozzles of an ISO-MIX rotary jet head (RJH) mixer. The RJH is equipped with 4 nozzles which are rotating around two axes ? driven by the inlet pressure of the fluid ? in such a way that the liquid jets sweep the entire tank volume. Stripping gas in the form of e.g. nitrogen is added on the pressure side of the pump and distributed in the tank by the RJH which is responsible for breaking down bubbles and consequently giving a larger specific surface area than would result if the gas was blown directly into the tank, thereby giving good mass transfer. The influence of the de-oxygenation process on the formation of oxidation products and the sensorial properties of linseed oil was investigated. Linseed oil was produced under industrial conditions, de-oxygenated, stored, analysed and evaluated, and compared to results for untreated oil. Besides storing a set of samples at room temperature, results were obtained using the accelerated Schaal oven storage test.

Antioxidant Effect of a Partially Purified Water Extract from Flaxseed. V. Barthelet, K. Waszkowiak, Canadian Grain Commission, Winnipeg, MB, Canada

The water-soluble partially purified flax seed extract containing approximately protein, water-soluble carbohydrates (polysaccharides) and some phenolic compounds (mainly SDG) was prepared from defatted ground flax. A model system (emulsion system) with commercial flax oil was used to study the antioxidant potential of the prepared flax extract. All oxidations experiments were performed at 40°C in a temperature controlled cabinet under UV light. Flax oil oxidation was assessed by monitoring the first step (conjugated diene and peroxide content) and the second step of oxidation processes. An emulsion blank with no added flax extract or antioxidant plus two controls (with 0.01% BHT and 0.12% GSH) were run simultaneously with the flax protein extract. Multifactor analyze of variance (ANOVA) showed a significant influence of incubation time and substances added into emulsion system ($P < 0.05$) on value all oxidation parameters, i.e. conjugated diene, peroxide and aldehyde value. It was found that changes in all oxidation parameters (diene, peroxide and aldehyde contents) as a function of time were best described by an exponential growth equation, with correlation coefficients (R^2) for each equations greater than 0.92 (in some case was in the 0.97-0.99 range).

Lipophilisation of Phenolic Acids and its Impact on their Antioxidant Properties in Emulsified and Cellular Media. L.J. Lopez-Giraldo¹, M. Laguerre¹, J. Lecomte¹, M.C. Figueroa-Espinoza¹, J. Weiss², E.A. Decker², C. Wrutniak-Cabello³, G. Cabello³, P. Villeneuve¹, ¹CIRAD UMR IATE, Montpellier, France, ²Dept of Food Science, University of Massachusetts, Amherst, MA, USA, ³UMR DCC, INRA SupAgro, Montpellier, France

Phenolic acids generate a large interest due to their antioxidant effect. However, their implementation in lipid systems is difficult and can lead to a decrease of their efficiency. To solve this issue, one can adjust their polarity by the grafting of aliphatic chains. First the synthesis of chlorogenate and rosmarinate fatty esters was carried out. For chlorogenic acid, the best results were obtained using a two-steps strategy involving a preliminary esterification with methanol followed by an enzymatic transesterification of methyl chlorogenate, with alcohols of 4-16 carbon chains. Rates of transesterification and final conversion yields were higher than that of direct esterification. For rosmarinic acid, only the direct esterification in leads to satisfactory yields. Then, the antioxidant capacity of lipophilized derivatives was evaluated in an emulsified system by a new methodology based on the absorption properties of tung oil. For in vivo systems, we employed cellular lines of fibroblasts, characterized by an important production of endogenous oxidative species. Results showed that maximum antioxidant capacities for chain length of 12 and 8 carbons were observed for esters of chlorogenic and rosmarinic acid, respectively using the CAT assay. Same chain length optimum activity was found with the in vivo system.

High Temperature Antioxidant Activity of Plant Leaves (*Laurus nobilis L.*, *Rosmarinus officinalis*, *Origanum majorana*) Ethanolic Extracts and Essential Oils in Vegetable Oil. Imen Kahouli, Francoise Nadeau, Khaled

Belkacemi, Paul Angers, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec , Canada

In order to improve the quality of vegetable oils used for thermal processing of foods without using synthetic antioxidants, we evaluated antioxidant activity of *Laurus nobilis* L., *Rosmarinus officinalis*, *Origanum majorana* extracts and their essential oils, and compared their activity with that of butylhydroxytoluene (BHT). Essential oil extraction was carried out by hydrodistillation of lyophilized and powered plant material. Compositions were determined by gas chromatography coupled with mass spectrometry. Then, it was found that the essential oils were respectively rich in p-menth-1-en-8-ol acetate (31%), eucalyptol (40,7%) and terpinen-4-ol (45,3%). Ethanolic extracts were obtained by maceration, and total phenolic content was estimated by the Folin-Ciocalteu method. Canola oil enriched with 1% (w/v) antioxidant was heated at 120 °C in open vials, and changes in unsaturated fatty acid composition were monitored daily for 5 day periods, by gas chromatography. The results show a significant antioxidant effect of ethanolic plant extracts compared to BHT. Efficacy was highest for *L. nobilis*, extract, followed by *R. officinalis* and *O. majorana* extracts, respectively. Antioxidant was lowest for BHT under the conditions used.

Sinapic Acid Derivatives and Tocopherols in Canola Seeds Grown in Western Canada. R. Khattab, M. Eskin, M. Aliani, U. Thiyam, University of Manitoba, Winnipeg, Manitoba, Canada

A number of different varieties of canola will be compared for the presence of sinapic acid derivatives and tocopherols. Methanolic extracts from the seeds, meals and press cakes of each variety will be determined by HPLC. The importance of sinapic acid derivatives and tocopherols are related to their antioxidant properties.

Effect of alpha-Tocopherol Level on the Oxidation of Trioctadecadienoin. Shane Zhou¹, Jamie Zhang², Linglu Zhou², Walt Erhardt², ¹Kellogg Company, 235 Porter Street, Battle Creek, MI 49016, USA, ²Battle Creek Area Math and Science Center, 765 Upton Ave, Springfield, MI 49037, USA

The effect of alpha-tocopherol concentration on the oxidation of trioctadecadienoin was investigated by the addition of alpha-tocopherol ranging from 50 ppm to 6400 ppm and by storing the samples at 40°C and 60°C, respectively. The oxidation of trioctadecadienoin was monitored by measuring the formation of conjugated dienes, an indicator of hydroperoxide formation. Headspace secondary oxidation products, pentane and hexanal, were also monitored during storage. Comparing with the control, alpha-tocopherol effectively inhibited trioctadecadienoin oxidation at all concentration levels. At both storage temperatures, higher conjugated diene levels were found to be associated with increased alpha-tocopherol content. However, higher concentrations of alpha-tocopherol resulted in longer induction periods based on the formation of both conjugated dienes, and headspace pentane and hexanal. In general, increase in alpha-tocopherol concentration led to lower headspace pentane and hexanal content, especially when increasing alpha-tocopherol from 1600 ppm to 3200 ppm .

Value Addition of Sunflower Oil Using Natural Antioxidant. Sameera Rege, Shamim Momin, Dipti Narayan Bhowmick, Dept. of Oils, Oleochemicals and Surfactants, Institute of Chemical Technology, N.P. Marg, Matunga(E), Mumbai, India

Edible oils provide essential fatty acids like linoleic and linolenic acids, which are converted into vitamins and hormones in the human body. These vitamins and hormones are responsible for various activities in our body. Also these essential fatty acids protect our body mainly from cardiac diseases. These essential fatty acids are not produced in our body naturally. They have to be consumed through the food such as soybean, linseed, sunflower oils. Such oils are not stable and get oxidized, which lowers their nutritive value and affects the flavor and taste. These oils are supplied by adding synthetic antioxidants such as BHA, BHT, TBHQ etc. But their safety has been questioned. Hence, it is the need of an hour to search for the safer and more efficient natural antioxidants to be used in food industry. Owing to the high content of essential fatty acids, sunflower and soybean oils are used in abundance as edible oils in India and other countries. Hence, in the present research work, we carried out the studies related to the stability of sunflower oil using natural antioxidants such as spices, curcumin, kalonji oil. Throughout the stability study, all the samples were analyzed for Peroxide Value, p-Anisidine Value, Totox Value and Conjugated Diene and compared with the control sample, i.e., oil without antioxidant and oil with synthetic antioxidant.

Chair(s): J. Barren, Kalsec Inc., USA

Oxidative Stability of Fish Oil Incorporated with Apple Skin Extract under Accelerated Conditions.

Naciye Erkan, H.P. Vasantha Rupasinghe, Nova Scotia Agricultural College, Truro, NS, Canada

Omega-3 polyunsaturated fatty acids (PUFA)-enriched fish oil (1.1% linolenic acid, C18:3 n-3; 61% eicosapentaenoic acid, C20:5 n-3; 4.3% docosahexaenoic acid, C22:6 n-3) was evaluated for its oxidative stability, with or without two apple skin extracts (ASE), using Rancimat. Accelerated oxidation of fish oil was performed at different temperatures (50-110 °C) using a gas flow rate of 20 L/h. Due to the high percentage of PUFA, the fish oil was highly sensitive to oxidation and the induction times (IT) were less than 0.4 h at and above 90 °C. Thus, the IT values obtained at temperatures between 50-80 °C were used to estimate the storage stability of fish oil at 20 °C. Interestingly, when fish oil was incorporated with ASE at 400 mg total phenolics/L, the estimated IT was 115 h at 20 °C, which was 2.5- fold greater than fish oil without any antioxidants (control). The ability to protect fish oil by incorporation of ASE was found to be similar to that of the incorporation of synthetic antioxidants, butylated hydroxytoluene (BHT) and alpha-tocopherol, at the concentrations of 200 and 400 mg/L, respectively. Results indicate that the potential exists for use of ASE as a naturally sourced antioxidant against lipid oxidation.

Inhibition of Oxidation of Omega-3 Polyunsaturated Fatty Acids and Fish Oil by Quercetin Glycosides.

Gwendolyn M. Huber¹, H.P. Vasantha Rupasinghe¹, Fereidoon Shahidi², ¹Nova Scotia Agricultural College, Truro, NS, Canada, ²Memorial University of Newfoundland, St John's, NL, Canada

The antioxidant properties of naturally occurring flavonols, quercetin glycosides, were examined and compared to the common food antioxidants butylated hydroxytoluene (BHT) and alpha-tocopherol. Antioxidants were incorporated into selected polyunsaturated fatty acids (PUFA) or fish oil in aqueous emulsions and bulk oil systems. The effectiveness of quercetin was similar to or greater than quercetin glycosides in inhibiting lipid oxidation in the oil-in-water emulsion systems when oxidation was induced by heat, light, peroxy radical or ferrous ion. In bulk fish oil, C-3 glycosylation enhanced the antioxidant activity of quercetin. The effectiveness of quercetin and its glycosides was greater than that of alpha-tocopherol in the emulsions. Quercetin and quercetin-3-O-glucoside exhibited greater antioxidant activity than BHT in bulk fish oil; however, the reverse was observed in the emulsions of omega-3 PUFA and fish oil systems in agreement with the polar paradox theory. The effectiveness of quercetin and its glycosides was greater than alpha-tocopherol in emulsions.

Effect of Green Tea Extract on the Quality of Ground Beef Patties.

J. Wassergord, Danisco, New Century, KS, USA

Rosemary extracts are commonly used as a natural flavor in meats including ground meat systems such as ground beef patties. A benefit of using rosemary extract in meats is inhibition of oxidation including reduction of warmed over flavors in pre-cooked meats and color retention in raw meat. In this research, the oxidative protection of green tea extracts was evaluated in ground beef systems to determine efficacy versus the more commonly used natural extract, rosemary. Ground beef patties were made using 20% fat ground beef, with the addition of rosemary extract and green tea extract at comparable activity levels. The patties were MAP packaged in an 80% oxygen, 20% carbon dioxide environment and held at 32-35°F for 22 days. The samples were tested during storage for color stability using a Minolta colorimeter, and for aldehyde development using the SafTest method. Equivalent activity was demonstrated between the rosemary extract and green tea extract treatments in this application. Color was significantly improved for all rosemary and green tea extract treatments compared to development of browning in control samples. Aldehyde levels of the control samples increased significantly throughout storage indicating development of oxidation; whereas, all rosemary and green tea extract aldehyde levels remained low.

Content of Phytic Acid, Condensed Tannins, Chlorophyll, and Carotenoids in Canola.

L. Lin, E. Goldberg, U. Thiyam, University of Manitoba, Winnipeg, Manitoba, Canada

Phytic acid, condensed tannins, chlorophyll and carotenoids of canola seeds are important minor compounds in canola. Content of the phytic acid, condensed tannins, chlorophyll and carotenoids estimated using rapid spectrophotometric assays are examined. The content varies in substrates examined such as seeds, meals and press cakes. The variations are important when profiling these minor compounds which are important as potential antioxidants.

Oxidative Stability of Corn Oil with Elevated Tocotrienols.

D. Dolde¹, T. Wang², ¹Pioneer, A DuPont Company, Johnston, Iowa USA, ²Iowa State University, Ames, Iowa USA

Tocotrienols and tocopherols (tocols) are a group of eight natural, plant produced, homologs that are exploited for their ability to quench free radicals therefore delay onset of oxidation of lipids. Corn oils with elevated concentrations of tocotrienols were evaluated for primary and secondary oxidative products under accelerated conditions. Peroxide values and oxidative stability indexes (OSI) were measured in both a model system of stripped oil spiked with individual tocols at various concentrations from 100 to 5,000 ppm and crude oil extracted from modified corn overexpressing homogentisic acid geranylgeranyl transferase containing greater than 5,000 ppm total tocol. In the model system, alpha tocopherol and tocotrienols were less effective antioxidants with increasing concentration and promoted lipid hydroperoxide formation at concentrations above 700 ppm. Secondary oxidation as measured by OSI induction period was inhibited by all tocols evaluated. The OSI induction time increased, but the inflection point of the OSI curve was less acute as tocol concentration increased. In the crude corn oil, the antioxidative effects of high tocotrienols was minimal compared to an unmodified control crude and may have been masked by other endogenous compounds. In bulk oils, the antioxidative properties of tocotrienols were similar to their corresponding tocopherols.

Stability of Sausage Added With an Extruded Mixture Containing Soy Proteins and Pectin as Emulsifying Agents.

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A fractional factorial design (2^{5-2} III) was applied to evaluate the effect of a new emulsifier prepared with soy proteins and pectin on sausage quality changes after 60 days of storage at 4°C. The selected factors were: type of emulsifier (raw or extruded), emulsifier concentration (3.3 or 3.5%), freeze/thaw cycles (0 or 2), extra addition of ice (0.0 or 0.5 %), and cassava starch concentration (0.0 or 2.0%). Responses such cooking loss, oxidation measured by PV and TBARS, hardness, color, pH, water activity (aw) and sensory characteristics were compared with those of a commercial sausage used as control after 0, 30, and 60 days of storage. All parameters significantly changed among the samples during each period of storage, suggesting the influence of at least one of these 5 factors on the evaluated responses. The results showed that extrusion improved the emulsifying proprieties of the mixture containing soy proteins and pectin when applied in a meat emulsion evaluated after 60 days of storage. Sausages made with the extruded mixture at 3.3% retained 0.5% of additional water in the formulation, without any appreciable sensory difference compared to control.

Antioxidant Activity of Extract from Distiller's Dried Grain Oil.

J.K. Winkler-Moser, S.F. Vaughn, USDA, ARS, NCAUR, Peoria, IL, USA

A distillate was obtained by molecular distillation of oil extracted from distiller's dried grains (DDG). The dried distiller's grains distillate (DDGD) contained phytosterols, steryl ferulates, tocopherols, tocotrienols, and carotenoids. DDGD was tested for its impact on the oxidative stability index (OSI) at 110°C of soybean, sunflower, and high-oleic sunflower oils, as well as the same oils that were stripped of their natural tocopherols and phytosterols. In addition, the impact of added DDGD on the stability of stripped sunflower oil during an accelerated storage study conducted at 60°C was also determined. DDGD (0.5-1% w/w) had little impact on the OSI of soybean, sunflower, and high-oleic sunflower oil, but at levels of 0.1 to 1% it significantly increased the OSI for stripped soybean, sunflower, and high-oleic sunflower oil in a dose-dependent manner. DDGD also delayed peroxide value, conjugated diene, and hexanal

formation during accelerated storage of stripped sunflower oil. The antioxidant activity is likely due to the combination of tocopherols, tocotrienols, and steryl ferulates.

Purification of Oleate Esters from High-Oleic Soybean Oil (HOSO) by Low Temperature Crystallization.

H. Liu, E.G. Hammond, T. Wang, Food Science and Human Nutrition, Iowa State University, Ames, IA, USA

High purity oleate esters can decrease the melting points and improve the oxidative stability of lubricants. High oleic soybean oil (HOSO) was esterified to butyl and isopropyl esters respectively. After subjected them to a two-step crystallization at reduced temperatures, the percentage of oleic acid in the HOSO was increased from 83.2% to 92.5%. Saturates decreased to less than 2.2%, but polyunsaturates percentage remained almost unchanged.

Online Automated Oxidation of Low Molecular Weight Organics and FAME's Coupled to GC/MS for Product Identification.

R. Burgett, A.E. Brown, A.L. Forks, D.L. Sparks, T.L. Benson, W.E. Holmes, R. Hernandez, Mississippi State University, MS State, MS, USA

In this study, a novel analytical technique was developed for monitoring organic oxidation mechanisms and elucidating product information. Current oxidation systems, such as the Rancimat, allow for rapid oxidation detection in fats and oils; however, they do not provide information on the oxidation mechanism or product formation. The system used for this work was comprised of a Varian 3600 GC equipped with a Saturn 2000 MS. The mass spectrometer allowed for electron impact and chemical ionization modes to aid in oxidation product identification. Multi-port valves were added to the GC to allow manipulation of oxygen to flow into a temperature-controlled microreactor. The valve system purged the oxidant prior to GC analysis, preventing damage to the column stationary phase. In this work, well-studied FAME's such methyl oleate and methyl palmitate, as well as low molecular weight organics such as toluene, 1-decene, and tetralin were oxidized to determine the efficacy of the technique. Typical oxidation products such as alcohols and aldehydes have been identified for these compounds. This research has the potential for profound impact on the food science and renewable fuels industries.

Changes in Tocopherol Content in Frying Oils and Aged Fried Food.

K. Warner, USDA, NCAUR, Peoria, IL USA

Fatty acid composition of oils has a significant influence on oil fry life and storage stability of fried food. Naturally occurring constituents such as tocopherols also have a positive effect on oil stability, but tocopherol levels may change during frying. Therefore, knowing how tocopherol contents change during frying and storage of fried foods could provide information on inhibiting oil deterioration. Our objective was to measure tocopherol types and amounts in oils used for frying french fried potatoes or potato chips. Oils with wide ranges in fatty acid compositions were tested including sunflower, mid oleic sunflower, high oleic sunflower, soybean, low linolenic soybean, high oleic soybean, and cottonseed oils. Tocopherols decreased with increasing frying time. In soybean oil with low frying deterioration of 8% total polar compounds (TPC), losses of tocopherols were 26% for gamma, 14% for alpha and 8% for delta. However, soybean oil with 18% TPC lost 72% gamma, 46% alpha and 30% delta. Fatty acid composition of the oil had a significant effect on loss of the tocopherols in oils. When sunflower oil was used for 10 hours of frying at 180C, it lost 25% alpha and 19% gamma; however, no tocopherols remained in high oleic sunflower oil.

Interesterification of Anhydrous Milk Fat with Rapeseed and/or Linseed Oil: Oxidative Stability.

J-M Giet, M. Aguedo, S. Danthine, M. Paquot, A. Thomas, M. Vandenbol, P. Thonart, J-P Wathelet, C. Blecker, G. Lognag, FUSAGx, Gembloux, Belgium

Blends of anhydrous milkfat (AMF) and linseed oil (70/30), and AMF, rapeseed oil (RO), linseed oil (LO), 70/20/10, were submitted to enzymatic interesterification (IE), as reported in : Enrichment of anhydrous milk fat in polyunsaturated fatty acid residues from linseed and rapeseed oils through enzymatic interesterification. The oxidative stability of the starting blends, the interesterified (IE) blends and IE blends with 50 ppm added α -tocopherol antioxidant was studied. Samples were stored in open flasks at 60°C, 25°C and 4°C, and periodically submitted to peroxide, p-anisidine, TBA value determination and UV measurement at 232 and 268 nm. The analysis of volatiles compounds was realized by SPME for the samples stored at 60°C. Peroxides appeared to be the only significant

oxidation products after 12 weeks storage at 4°C. As expected, the binary blends were more sensitive to oxidation than the ternary blends. Interesterification appeared to produce variable effects on the oxidation stability of fat mixture, depending on composition and temperature (beneficial effect on BB, at both 25°C and 60°C, and a rather neutral effect on TB).

Antioxidant Capacity and Phenolics Content from Different Peppers (*Capsicum annuum* L.).

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The fruit of pepper (*Capsicum annuum* L.) is considered an important source of phenolic compounds with antioxidant capacity. Recent studies show that consumption of pepper can prevent cardiovascular diseases, neurological disorders and cancer. Therefore, the aim of this work was evaluate the antioxidant properties of five types of peppers (Anaheim, Bell, Caribbean, Jalapeño and Serrano). Phenols and flavonoids were quantified, and the total antioxidant capacity of different peppers by the methods of chelation of free radicals 2,2'-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-Azino-bis (ABTS) was evaluated. Also the main phenolic compounds by HPLC were identified. The results showed that phenols content was between 275.75 ± 6.44 and 518.82 ± 28.05 mg/100 g fresh pepper, for Jalapeño and Caribbean, respectively. The levels of total flavonoids were found between 250 ± 19.42 and 310.85 ± 17.30 mg/100 g, with the highest levels for Anaheim, Caribbean and Serrano. Bell and Caribbean showed the highest percentage of inhibition of DPPH (90.74 ± 0.61 and 92.33 ± 0.22). These extracts showed the highest levels of gallic acid, catechin, epicatechin, and luteolin. Serrano and Caribbean showed the highest inhibition of ABTS radical. The results obtained showed that the studied peppers represent a potential as source of natural antioxidants with antioxidant capacity.

Investigation into the Utility of the Food Stability Analyzer for Assessing Oxidative Stability of Various Food/Feedstuffs.

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Lipid oxidation occurs when fats and oils experience various degenerative reactions which result in the formation of free radicals and reactive oxygen. These products of oxidation cause offensive flavors, odors, colors, textures and a reduction in nutritional content, resulting in undesirable consumer perception. The OSI-I, widely used by industry, measures the conductivity of volatile compounds formed during lipid oxidation. However it is not able to test food systems other than oil or high oil containing products. The Food Stability Analyzer (FSA or OSI-II) can be used to analyze the effects of whole food systems (proteins, acids, water, etc) on the oxidative stability of their lipid system. The instrument measures the rate of oxygen absorption from the headspace of sample vial and quantifies the degree/rate of oxidation. When the rate of oxygen consumption increases, an inflection point is calculated as an OSI value. A variety of food products were tested, including salad dressings, Margarine, butter, pet food, cakes/cookies and more. The only negative for the instrument was that for each product type the test method had to be developed or modified.

The Impact of Heat on Toxic HNE Formation in Imitation and Natural Cheeses.

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The formation of 4-hydroxy-2-trans-nonenal (HNE), a toxic secondary lipid peroxidation product, was investigated in heat treated imitation cheeses (IC), made from vegetable oils, and natural cheeses (NC). The cheese samples were baked at 204°C for 30min and 1hr, and at 232°C for 30min. The baked cheeses were homogenized with hexane and the extracts were reacted with 2,4-dinitrophenylhydrazine (DNPH) reagent overnight. The DNPH hydrazones, including HNE, were extracted with methanol:water (75:25) and dichloromethane, and prepurified on silica gel TLC. Quantification of HNE was conducted by HPLC. The HNE formations were higher in IC than in NC in both temperatures. HNE concentrations were 8.5 times higher in IC than in NC after 30 min of heat treatment at 204°C and 4.7 times higher at 232°C. When heating time was continued at 204°C for one hour in both cheeses the HNE continued to increase. HNE concentration was 7.5 times larger in IC and 13.6 times more in NC at 232°C than 204°C for the same heating time of 30 min. Since IC are made with vegetable oils which contains much higher level of linoleic acid, a precursor for HNE, than dairy fat it is not surprising that in heat treated IC HNE formation is higher than in NC.

Pecan nut [*Carya illinoensis* (Wangenh.) C. Koch] - Antioxidant Properties of Shell Infusion.

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Pecan nut processing results in a relatively high volume of shell (40 to 50%) that can constitute an alternative source of compounds with high antioxidant capacity. In the south of Brazil, Pecan nut shell is used for infusion, but there are no studies related to the presence of compounds with possible positive effects. Thus, the objective of the present work was to determine the total phenolic compound and condensed tannin contents of Pecan nut shell infusion and to evaluate the in vitro antioxidant activity of Pecan nut shell infusion through ABTS [2,2'-azino-bis-(3-ethylbenzotiazoline-6-sulphonic acid)] and DPPH (2,2-diphenyl-1-picrylhydrazyl) systems. The total phenolic content ranged from 116 to 167 mg GAE/g and the condensed tannin content was between 35 and 48 mg CE/g. The antioxidant activity varied between 1112 and 1763 $\mu\text{mol TEAC/g}$ in the ABTS system. In the DPPH method, the antioxidant activity was from 305 to 488 mg TEAC/g (30 minutes reaction) and from 482 to 683 mg TEAC/g (24 h reaction). The results indicated high phenolic content and antioxidant activity of Pecan nut shell infusion. Support: CAPES and DIVINUT.

Effect of Ethanol Concentration on Polyphenol Content and Antioxidant Capacity of Plant Extracts: *Andrographis paniculata*, *Centella asiatica*, and *Orthosiphon stamineus*.

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This study was aimed to investigate the effect of ethanol concentration (0-100%, v/v) on the extraction of selected plants. Polyphenol content (total phenolics content, TPC, total flavonoids content, TFC and condensed tannins content, CTC) and antioxidant capacity (by ABTS radical scavenging assay (ABTS) and DPPH radical scavenging assay (DPPH)) were evaluated. The maximum yields of TPC and TFC of *O. stamineus* were obtained with 40% ethanol. While, the highest yield of TPC of *A. paniculata* and *C. asiatica* as well as TFC of *C. asiatica* were exhibited at 60% ethanol. However, the highest CTC exhibited by *A. paniculata*, *O. stamineus* and *C. asiatica* was extracted with mono-solvent system. For the antioxidant capacity, crude 80% ethanol extract of *A. paniculata*, *O. stamineus* and *C. asiatica* had the highest ABTS radical scavenging capacity. Positive correlations were observed between the TPC and DPPH in *O. stamineus* extract. For *A. paniculata* and *C. asiatica* extracts, TFC was positively correlated to DPPH. The results demonstrated that the composition of polyphenol content with varying degree of hydroxylation, glycosylation and methoxylation lead to structural diversity which contribute to variation in the level of antioxidant capacity in these plants.

Thermal Oxidation of Vegetable Oils and the Formation of Nonpolar Lipophilic Aldehydes.

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When heated at frying temperature, highly unsaturated vegetable oils undergo thermal oxidation resulting in the formation of a variety of polar and nonpolar aldehydes. In the present experiment, the nonpolar lipophilic aldehydes and related carbonyl compounds (NPC) in heated and unheated oils of varying degrees of unsaturation were identified and measured. Samples of coconut, olive, corn, soybean, and cod liver oils were heated at 185°C and the heated and unheated oils were analyzed by HPLC after conversion to 2,4-dinitrophenylhydrazones. The individual aldehydes were identified by co-chromatography with pure standards. The identified compounds were butanal, 2-butanone, pentanal, 2-pentanone, hexanal, hexenal, 2,4-heptadienal, 2-heptenal, octanal, 2-nonenal, 2,4-decadienal, decanal, and undecanal. The major NPC found in the heated oils was 2,4-decadienal, which increased with increased unsaturation of the oils. The unheated oil samples contained mostly short chain carbonyl compounds, primarily 2-butanone and 2-pentanone; after heating these highly volatile compounds were found in much smaller amounts due to volatilization. Unlike headspace GC methods, this HPLC method measures the presence of the partially volatile compounds that remain in the oil sample.

Oxidative Stability of Virgin Coconut Oil for Deep-Fat Frying.

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Comparative study of refined bleach and deodorized (RBD) palm olein, RBD coconut oil and virgin coconut oil (VCO) for frying of potato chips was undertaken at 170°C for five consecutive days. The samples were then analyzed for iodine value (IV), peroxide value (PV), free fatty acids (FFA) content, viscosity, color index, specific extinction, E1%1cm at 233 and 269nm, fatty acid composition and % total polar material (%TPM). In terms of oxidative stability, VCO was found to be the least susceptible to oxidative deterioration during deep-fat frying compare to RBD palm olein and RBD coconut oil. However, its used as deep-fat frying oil at temperature above 170° is not recommended. Due to the polarity structure of VCO, total polar material determination may not be a suitable parameter for oil quality measures.

Effect of Chemical Randomization on Positional Fatty Acid Distribution and Oxidative Stability of Omega-3 Oils.

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Omega-3 fatty acids have attracted much attention with respect to their biological significance and health benefits in recent years. The current interest in omega-3 oils includes improvement of their oxidative stability in order to prevent quality deterioration. Thus, addition of antioxidants, or using novel processing techniques to stabilize oils are among the methods employed by the food industry to protect omega-3 oils from oxidation. In this work, seal blubber oil and menhaden oil were modified through chemical randomization. The effect of randomization on the stability of the original oils and their randomized counterparts was analyzed by comparing conjugated dienes and TBARS values after accelerated oxidation at 60°C for 4 days. Positional distribution of fatty acids was determined by gas chromatography. The data obtained indicated that polyunsaturated fatty acids were redistributed more evenly among the terminal (sn-1, sn-3) and middle (sn-2) positions in the randomized oils when compared with their unrandomized counterparts. However, stability of the randomized oils was affected to different degrees, depending on the storage time.

Effects of Spice Oleoresins on the Oxidative Stability of Soybean and Groundnut Oil Blend.

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Several spice oleoresins including mustard, black pepper, white pepper, turmeric, ginger, paprika, capsicum were chosen to study the effects of antioxidant activity on the blend of soybean and groundnut oil. Oil samples were stored for 15 days at 60°C for oxidation study. Progression of oxidation was monitored by peroxide value, acid value, weight gain, P-anisidine value, conjugated diene. Synergistic study of these oleoresins with tocopherol, l ascorbyl palmitate and TBHQ were carried out. Attempts were also made to investigate the synergistic effect of combination of these oleoresins. Results showed that ginger was most effective antioxidant than any other spice oleoresin, synergism has been observed between all these oleoresins with l-ascorbyl palmitate. An optimum combination of l ascorbyl palmitate and tocopherol with these oleoresins could immensely improve the oxidation stability of oil. This present study also revealed that with increase health awareness and preservative free approach of the consumers towards the oils, addition of natural spices such as ginger and mustard in oil can be used at household level and may become an economical, partial replacement for synthetic antioxidants.

Catalytic Decomposition of Hydroperoxides in Mixed Micelles with Ionic Surfactants.

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The kinetics and mechanism of hydroperoxides decomposition in the presence of surfactants have been investigated by means of NMR, GC-MS, UV and IR spectroscopy, DLS and kinetic approaches. Hydroperoxides (ROOH) are the primary products of lipid oxidation. ROOH were shown to decrease the surface tension and to form mixed micelles together with known surfactants (S): direct micelles are formed in water solution and reversed micelles in organic media. Mixed micelles sizes depend on the S nature and change in the range 1-200 nm, so mixed micelles can be named as self-organized nanoreactors in which active polar substances such as ROOH, metal compounds, phenols,

amines, etc are concentrated. Cationic surfactants (S+) were found to catalyze ROOH decomposition into free radicals. Binary systems {nROOH mS+} can be used as lipophilic initiators for radical polymerization and other chain radical processes at low temperature. Contrary to S+, some anionic surfactants (S-) were found to catalyze nonradical decomposition of ROOH. Sodium dodecylsulfate (SDS) catalyzes the decomposition of alkylaromatic hydroperoxides into phenol and corresponding carbonyl compound. Because phenol is an acceptor of free radicals, the alkylaromatics (ethylbenzene, cumene, etc.) oxidation is completely inhibited in the presence of SDS.

Oxidative Stability of EPA and DHA - Effect of Tocopherol Isomers.

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Polyunsaturated fatty acids such as EPA and DHA are rapidly becoming a part of one of the vital bioactive components in some food products around the globe. Fish oil containing these essential fatty acids is added in a variety of food commodities in different forms. Flavour volatiles generated by the rapid oxidation of these highly unsaturated fatty acids contribute to a variety of off-flavours in food-grade fish oils as well as food products containing them. Therefore, it is imperative to prevent the oxidation of these oil products to improve their quality. Antioxidants are commonly added to retard the oxidation of PUFA in fish oil. Phenolic antioxidants such as tocopherol are commonly used in a variety of unsaturated oils as well as food products containing them. The storage stability of EPA and DHA in the presence and absence of tocopherols was studied and the stability indices such as peroxide value (PV), p-anisidine value (p-AV), conjugated di-enes and oxidative stability index (OSI) were monitored. These stability indices as well as sensory properties of fish oil deodorized with different tocopherol isomers were also monitored. This presentation will contribute some information on the effect of different levels of tocopherol on the oxidative stability of EPA and DHA as well as the effect of tocopherol isomers (α , γ , and δ) on the oxidative stability of PUFA in fish oil.

Improved International Dairy Federation Method for the Determination of Peroxide Values to Evaluate Oxidation of Microencapsulated Polyunsaturated Fatty Acids.

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The International Dairy Federation (IDF) method is commonly used to estimate peroxide values for evaluation of lipid oxidation. The IDF method requires a large amount of sample and several steps are used to extract raw materials before colorimetric assays, which may be obstacles for small sample quantities. In this work, we were interested in estimating peroxide values of fish oil encapsulated in corn zein. We modified the IDF method by selecting an appropriate solvent mixture that was able to completely dissolve microcapsules. A ternary mixture of 1-butanol, isopropanol, and water was screened for the capability of dissolving microcapsules and a 100: 100: 50 (v/v/v) proportion of 1-butanol: isopropanol: water was identified as the optimum condition. By dissolving microcapsules, the detection limit was improved to 0.010 mequiv peroxide/kg oil, in contrast to 0.050 mequiv peroxide/kg oil when the IDF method was used. The amount of sample needed was only about 0.010-0.015 g. The modified IDF method also showed very good precision and accuracy. Our approach required a small amount of sample, reduced sample preparation steps, and eliminated experimental errors due to sample extraction. These advantages are important for lab-scale research projects to evaluate oxidation of products such as polyunsaturated fatty acids.