PROCESSING

BIO 1.2a/PRO 1a: Advances in Enzyme Processing Technologies

Chairs: Long Zou, Bunge Oils, USA; and Leslie Kleiner, Roquette Americas Inc., USA

Unique Phospholipase Degumming Enzyme Michael E. Spampinato*, *DSM Inc., USA*

As an oilseed processor you are faced with the continued challenge of improving output and reducing costs whilst remaining environmentally friendly. Our Purifine 3G enzymes can make a big difference to your oilseed extraction process, crushing the seeds more effectively, hiking your yields, increasing the value of your meal, all leading to a boost in your profit margins. These enzymes work as catalysts to break phospholipids into water-soluble and oil-soluble fragments breaking the emulsion formation and making degumming easier." " Support Areas to Example: • Higher oil yields thus more profit: • How Purifine 3G works • Higher meal value, reduced protein dilution • Easy to integrate, consistent results • First-time right performance

New Enzymatic Process Improves the Yield in Alkaline Refining of Vegetable Oils Hans Christian Holm, and Per Munk Nielsen*, *Novozymes A/S, Denmark*

Use of enzymes in the degumming process is accepted in the vegetable oil processing. The effect of the enzymes is first and foremost to obtain a highest possible yield, but also to help assuring a good quality of the refined oil. The known processes use different types of enzymes. In the water degumming process extra yield is obtained by a treatment with phospholipase C/A, and in acid refining use of phospholipase type A is the typical solution. In the alkaline refining process, the phospholipids are removed from the oil by a water degumming and the caustic treatment. This comes with a yield loss. We have identified a new way of operating the alkaline refining process by integrating a phospholipid hydrolysis into the process line. It has been possible to design an alkaline refining process where the enzyme treatment with phospholipase C fits in, and results in a significant yield increase. The process includes following steps: an acid chelating, pH adjustment, enzyme reaction, alkaline treatment, separation, and washing. The process will be presented with the documentation for the yield improvement compared to a typical chemical refining process.

Enzymatic Interesterification. Chris Dayton, Bunge, USA

Kinetic Modelling of Enzymatic Saccharification of Soy Molasses Ashwin Sancheti*, and Lu-Kwang Ju, *University of Akron, USA*

Soy molasses is a low-value stream generated in the soybean industry. It is primarily composed of stachyose and sucrose. The enzymatic hydrolysis of soy molasses produces a rich feedstock composed mainly of monomeric sugars glucose, galactose and fructose, which can be used for multiple biotechnological applications such as arabitol production by *Debaryomyces hansenii* and fatty acid synthesis by engineered *Escherichia coli* (collaboration with Drs. Ka-Yiu San and George Bennett of Rice University). The enzyme used was produced by *Aspergillus niger* using soybean hulls as substrate. The objective of this study was to model and optimize the enzymatic hydrolysis of stachyose and sucrose in soy molasses, using a semi-mechanistic, multi-reaction network to describe the kinetic profiles of reactants, intermediates and products measured by the HPLC-RI analysis. The model predicted monomeric sugar release with

reasonable accuracy and can help in formulating the optimized cocktail of enzymes to produce by adjusting *A. niger* fermentation conditions. Results showed that the enzyme composition impacts the reaction pathways, leading to different profiles of intermediates and side products. The interactions among different assayed enzyme activities will be discussed in the presentation.

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

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

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

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

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

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

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

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

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

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

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

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

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

PRO 2: Expert Insights in Seed and Oil Processing Technologies

Chairs: Gijs Calliauw, Desmet Ballestra Group, Belgium; and William Younggreen, Alfa Laval Inc., USA

Deodorizer Energy Use – How Low Can We Go? Alan R. Paine*, *Desmet Ballestra, Belgium*

Since the 1970s heat recovery and the increased use of refrigerated vacuum equipment has led to a dramatic reduction in the amount of energy used in edible oil refineries. But there is scope for further reductions especially when it comes to thermal energy. Deodorization is the biggest energy user in a refinery. The energy consumption of the most economical deodorizer vacuum systems has been reduced to below that usually used to heat the oil making the heating energy an obvious target for improvement. We will show, using well established heat transfer calculations, that there is a good economic case for using substantially more heat recovery area in deodorizers than is commonly installed. These ideas can be applied to a wide range of deodorizer designs and to both new installations and retrofits. As a bonus the presentation will include explain ways of improving the efficiency of existing deodorizers with little or no capital expense.

An Experts' Insight in the Separation-Technology for Degumming and Neutralization Processes Birger Horns*, *GEA Group, Germany*

Centrifugal separation technology is a well proven and established technology in vegetable oil processing. Suppliers provide a wide range of different machine types with several features to adjust the machine according to actual process conditions. A good knowledge of these features is essential to operate a centrifuge always with best possible results regarding oil quality, yield and chemical consumption. Beside the above mentioned, energy consumption and efficiency becomes more and more important and can be influenced with actual features as well. This presentation will give an insight in special capabilities of different machine types, separation principles, influencing parameters and how to use the available features.

Degumming and Neutralization of Vegetable Oils with Hydrodynamic Cavitation: A Long Term CFC™ Experience Review Paul Bloom*[1], Inmok Lee[1], Peter Reimers[2], and Darren J. Litle[2],[1]*Archer Daniels Midland Co., USA;* [2]*Arisdyne Systems, Inc., USA*

The introduction of hydrodynamic cavitation to conventional refining processes has been proven to increase oil yield and reduce or eliminate refining aids such as acid, caustic soda, washing water, silica and or bleaching clay, while at the same time achieving lower amounts of phospholipids, soaps and free fatty acids in the oil. Yield improvements of 0.3% and in some cases greater than 1% have been demonstrated. The real benefits of hydrodynamic cavitation will be reviewed from multiple refinery experiences.

Reducing Wastewater in a Solvent Extraction Plant Matthew Ducharme*, *Crown Iron Works, USA*

The Crown Zero Effluent Discharge System (ZED) is designed to eliminate wastewater from your solvent extraction plant. In the ZED system, wastewater is concentrated in specially-designed pressure vessels and converted to steam for recycle use in the extraction plant. While the system is designed to eliminated wastewater from the extraction plant, client savings may come from several system advantages and benefits. My presentation will include descriptions of the process flow diagram (PFD), footprint layout, features, benefits, and plant operating cost savings.

White Flake Desolventization, Feedback from the Field and New Applications such as Palm Kernel and Citrus Fiber Richard W. Ozer*, *Crown Iron Works, USA*

White Flakes is a generic term describing hexane extracted oilseeds such as soy, canola, or sunflower that have been desolventized at low temperature to preserve protein value. Gentle desolventization of non-traditional oilseeds creates the possibility of a whole new range of products such as SPC, Canola & Sunflower Protein Isolate for the Food & Feed industry. While the majority of the traditional applications have been for high protein oilseeds, Flash Desolventization has proven to be an effective method to desolventize previously hard to desolventize products such as Palm Kernel and other fibers. This paper will discuss the standard approach to desolventization of traditional products then report on feedback from the field. The paper will then discuss the adaptations that make it possible to desolventize more difficult fibers such as palm kernel, citrus, etc.

Adsorbents, Filter Aids, Reagents and Their Synergy to Maximize Frying Oil Life Li-Chih Hu*[1], Andrew Oh[2], and David Gittins[3], *[1]Imerys Performance Minerals, USA; [2]Imerys Performance Minerals, United States; [3]Imerys Filtration Minerals Inc., USA*

Life extension of used frying oil provides high value to food industry. With adequate treatment, one may achieve high and stable frying oil quality, and minimize oil loss and waste disposal. The key to extending the life of frying oil is removal of free fatty acid, fatty acid salts as well as polar impurities from the oil. In this study, we report the oil life extension with "Active Adsorbent - Filter Aid" (AAFA), which is an optimized combination of reagent, adsorbent and filter aid minerals. We will discuss about the role and compatibility of components, different types of formulations and their optimal application, as well as composition-performance relationships. Similar purification strategy can also apply to refining of high free fatty acid of raw edible oils, and end-of-life used cooking oil treatment as biodiesel feedstocks.

PRO 3: Processing of Oils and Fats in China and the US

Chairs: Xuebing Xu, Wilmar Global Research and Development Center, China; and Michael Boyer, AWTMS, USA

Trends of the Enzyme-assisted Aqueous Extraction of Soybean Oil and Protein in China
Xiaonan Sui*, and Lianzhou Jiang, *Northeast Agricultural University, China*

Commercial oils from oil-bearing plant materials are commonly extracted with an organic solvent. Due to the increased awareness of safety and environmental issues associated with organic solvent extraction, it is necessary to develop alternative methods. Enzyme-assisted aqueous extraction processing (EAEP) has been widely investigated to extract oil and as well as proteins from many oilseeds. Yet, during EAEP of soybeans, a large aqueous fraction (also known as soy skim) is produced. It is normally considered as wastewater, and raises a disposal issue. Therefore, developing a greener way to utilize the skim fraction could promote the industrialization of EAEP method. In this updated work, extruded soybean flakes were hydrolyzed using Alcalase to separate free oil, cream, skim and residues. The skim fraction containing soybean protein hydrolysate (SPH) was then collected. The antioxidant activity of the SPH was analyzed using chemical, simulated gastrointestinal digestion and transepithelial transport methods. SPH displayed DPPH radical scavenging (IC50=4.22 mg/mL) power, ABTS•+ radical scavenging (IC50=2.93 mg/mL) power, reducing power and metal ion chelating activities (IC50=0.67 mg/mL). Furthermore, SPH significantly (p

Processing of Rice Bran Oil in China Yuan–Rong Jiang*, *Wilmar Biotechnology R&D Center (Shanghai) Co., Ltd., China*

Background & Objectives: China has a giant edible oil consumption market while the self-sufficiency rate is only about 32.3%. To narrow the gap, the government has launched numbers of policies. One main approach is to develop the unconventional oils. Rice bran oil as a new oil category has a great potential for developing in China. As China contributes the largest rice production in the world, there are abundant raw materials which can be used for oil extraction instead of feed. Also, the oil is known for its balanced fatty acid composition and various bioactive compounds, making it suitable in trend of the consumption upgrade in China. Method(s) and Results: The quality of rice bran has a significant impact on the finished product. After milling, fat content in it deteriorates fast in the presence of lipase. Too much fatty acid in raw material will leave problems in oil refining afterwards. So the first barrier will be prevention of the rapid increased rancidity. For extracted crude oil, the moderate refining technologies are applied for higher nutrient retention rate. Until now China has developed a comprehensive and multifaceted solutions, whereby classification of material and the integration of different processes in order to produce RBO with high nutritional quality. Conclusion: RBO is a relatively new oil category in China. Development of RBO benefits not only the industry, but the country and people. It still has great potential to improve and requires for support in many ways.

Processing of Flavored Rapeseed Oil in China
Manyi Wang*[1], Xiangyu Wang[2], Fei Guo[3], Fengyan Wang[3], and Ju Hui[3],*[1]COFCO Nurition & Health Research Insititute, China; [2]COFCO Nurition & Health Research Institute, China; [3]COFCO Nutrtion & Health Research Institute , China*

China is one of the biggest rapeseed oil production and consumption country in the world. It is estimated in 2017/2018 over 18 million tons of rapeseed would be consumed. Due to the consumption upgrading, pursuing

the delicious and healthy food become a new trend in China, and more flavored rapeseed oil has been consumed to replace RBD one with the grow rate of 8.3%. The typical regional distribution of flavored rapeseed oil consumption was observed to match with the production of rapeseed consistently. For example, Sichuan, Hunan and Hubei were both consumption and production regions of rapeseed oil. Processing of flavored rapeseed oil is quite different from the RBD rapeseed oil because the generation and retaining of flavor compounds are critical. Roasting is the key step that affects the flavor compound and oil quality. The flavor compounds and intensity are tightly related with the roasting temperature because it dominates the chemical reaction which creates the flavor compounds. However, the hazard impurities such as polycyclic aromatic hydrocarbons (PAH) are also produced with high temperature processing. So it is necessary to fine tune the parameters to reduce the generation of hazard compounds as well as loss of flavor compounds in oil processing simultaneously. Degradation of sulfuric glucoside, oxidation of fatty acid as well as the maillard reaction affords the flavor compounds detected in volatile substances of flavored rapeseed oil by GC-MS. GC-O has been widely used to correlate the chemistry with sensory, and it is showed that the flavor of rapeseed oil is the combination of these characteristic components.

Antioxidant Activities of Natural Antioxidants in Rice Bran Oils during Oil Refining Processing
Ruijie Liu*[1], Lisha Zhang[2], Ruru Liu[2], Ming Chang[1], Qingzhe Jin[1], and Xingguo Wang[1],*[1]Jiangnan University, China; [2]Jiangnan University, China*

Introduction. Natural antioxidants often exist as minor compounds which are important for the nutritional benefits and functions of plant oils. Our aim is to investigate the relationship between the phytochemical levels and antioxidant activities of the rice bran oils (RBOs) in oil processing. Methods. The effects of each step in the commercial refining process on the chemical compositions and antioxidant activities of RBO were analyzed and the correlation between the natural antioxidants and the antioxidant activities by regression analysis. Results. The acid value and peroxide value decreased significantly after fully refining. However, chemical refining hardly affected the fatty acid composition. After all the refining steps, the loss rate of the phytosterol, squalene, γ-oryzanol and polyphenols were 30.17, 72.29, 76.51, and 83.96 %, respectively. Moreover, the refining process resulted in 64.16, 85.00, 49.57, and 65.98% losses of ABTS, ORAC, DPPH, and CAA values. These results showed that the neutralization process had the greatest influence on phytochemicals and antioxidant activity of RBO. In addition, the data also indicated that both the ABTS ($r = 0.978$, $P < 0.01$) and ORAC ($r = 0.965$, $P < 0.01$) methods had the highest correlation with polyphenols, while the γ-oryzanol content had the highest degree of correlation with the DPPH assay result ($r = 0.989$, $P < 0.01$) as well as with the CAA value ($r = 0.930$, $P < 0.01$). Furthermore, the results of the PCA and HCA analysis confirmed that except tocopherols, the chemical composition and antioxidant activities of RBO decreased significantly after refining.

Recent Progress in Converting Grain-based Feedstock into Bioethanol, Oils, and Protein Co-products
Keshun Liu*, *USDA, ARS, USA*

For the past 15 years, the fuel ethanol industry in United States has grown rapidly. In 2017, 211 U.S. plants converted 139.7 million metric tons (MMT) of grains (mostly corn) into 59.8 billion liters bioethanol, 41.4 MMT protein coproducts, and 1.6 MMT distillers oils, all at record levels. About 90% of ethanol production came from dry-grind processing, by which

whole grains are processed through sequential steps of grinding, cooking, liquefaction, scarification, fermentation, distillation, and coproduct recovery. Among many factors driving this steadily increasing bioethanol production, process innovation has been important. Over the years, several modified dry-grind methods have been developed, featured by fractionation before or after fermentation to remove one or more nonfermentable fractions (e.g., oil and/or fiber). Other innovation focused on selecting economically-feasible and locally available feedstocks, channeling co-product streams for alternative treatments/uses, improving starch-hydrolyzing enzymes and fermentation yeast, and fine-tuning processing parameters. All these efforts have improved ethanol production efficiency, reduced cost, changed composition of and added values to co-products. Some new methods have been commercialized. One successful example is production of high-value distillers oils for biodiesel feedstock and high-energy animal feed. China ranks the fourth in ethanol production, after U.S., Brazil, and European Union. In China, wheat and corn are the main feedstocks, but techniques based on energy crops and cellulosic materials are maturing. Because the Chinese government set E10 fuel as a new mandate in 2017, fuel ethanol production is poised to increase, but feedstock selection will always differ from U.S. and other countries.

BIO 3.1/IOP 3/PRO 3.1: Biofuels

Chairs: Frank Dumeignil, Lille University, France; Xiaofei P. Ye, University of Tennessee, USA; and Megan Hums, USDA, ARS, ERRC, USA

Synthesis of Thiophene and Thiolane Derivatives Found in Biodiesel Produced from Brown Grease Lipids. Shehu Isah*, *Delaware State University-USDA, USA*

Brown grease lipids (BGL), the primary component of dewatered grease trap waste (GTW) and sewage scum grease (SSG) is a potential low-value feedstock for biodiesel production. Market limitations of these feedstocks for use in biodiesel production include high sulfur (S) content. A combination of analytical techniques including GC-FID, GC-PFPD, and GC-MS have been previously used to elucidate the identity of thiophene derivatives (C4H4S-X), thiolane derivatives (C4H8S-X) and other S-bearing compounds in BGL-derived biodiesel. These compounds do not exist in the MS library; therefore, a small degree of uncertainly surrounds their identification. These molecules cannot be isolated from biodiesel because their concentrations are too low. Therefore, this project was designed to synthesize the S-bearing compounds believed to be found in BGL-derived biodiesel in quantities sufficient to characterize them by analytical methods such as NMR. We have developed strategies to synthesize thiophene and thiolane and preliminary results indicate they can be produced in yields sufficient to assist in their characterization in biodiesel. The identification of S-bearing compounds in BGL-derived biodiesel is necessary to devise effective desulfurization protocols needed to reduce the concentration of S-bearing impurities in biodiesel to < 15 ppm, as specified by ASTM.

Modulating the Solubility of Saturated Monoglycerides (SMG) and Glycerol (GLY) in Blended Biodiesel Fuels Richard W. Heiden*[1], and Martin Mittelbach[2],[1]*R.W. Heiden Associates, LLC, USA;* [2]*Institute of Chemistry, University of Graz, Austria*

The unexpected in-situ formation of heterophases from residual impurities in biodiesel fuels has deleterious consequences stemming from limited solubility. To get beyond simple expressions of “like dissolves like” requires an understanding of compositional factors which promote or discourage entry of an impurity into the molecular network of the liquid fuel. As such, the liquid composition acts to modulate dissolution and precipitation processes. Diesel fuels are comprised of hundreds to thousands of distinct chemical compounds when mixed together in commercial blends of diesel #2(ULSD)diesel #1(ULS kerosene), renewable diesel (RD) and biodiesel FAME. Together with FAME these compounds create an environment with a defined polarity- a predisposition to modulate solubility that is determined by concentrations of main and minor hydrocarbon components at levels greater than about 0.1%. Despite the complexity in the molecular composition of biodiesel fuels, various international definitions and restrictions greatly narrow the range of possible compositions. However, low concentrations of impurities have intrinsic solubilities complicated by specific interactions*. We present here a study of possible relationships between the saturation points (SP) of GLY and SMG, fuel composition, and classical markers of solvent polarity, using existing theories to assist in explaining experimentally determined SPs and interactions. The results help establish an

improved understanding of the compositional factors defining solubility, the barriers imposed by current fuel definitions, and the magnitude of compositional changes needed to reduce the unwanted effects of impurities.
*Heiden,Schober, Mittelbach,(2017)JAOCS 94:285-299.

Co-production of acrylic acid in a typical biodiesel plant: a techno-economic assessment Xiaofei P. Ye*, *University of Tennessee, USA*

Producing value-added chemicals from glycerol is imperative for a sustainable future of biodiesel. Despite efforts worldwide, the commercial production of acrylic acid from glycerol faces challenges, both technologically and economically. Based on our patented technology using carbon dioxide as reaction medium in a two-step process to catalytically convert glycerol to acrylic acid, we established computer simulation models to analyze the energy efficiency and economics of the process. The analysis was conducted in conjunction with published data of a typical intermediate-sized biodiesel facility, aiming at the possibility of producing acrylic acid on site. Sensitivity analysis in response to the market value of glycerol, the source and cost of carbon dioxide recycling, and the changes in process kinetics will also be presented.

The Use of Controlled Flow Cavitation to Improve the Performance of Degumming, Refining and Biodiesel Operations Darren J. Litle*, *Arisdyne Systems, Inc., USA*

An overview of the application of controlled flow cavitation and compression-decompression jet atomization phenomenon for the intensification of chemical processing applications is presented. For vegetable oil acid degumming and/or neutralization reactions, the reasons for enhanced performance of the refining operation, reduced environmental impact, observed reduction in necessary acid and/or caustic addition as well as decrease in oil loss, potential savings in steam consumption and decrease in maintenance opex is discussed and industrial scale examples given. The efficient removal of residual soaps, phosphorus, ffa and metals while minimizing and in some cases even eliminating the need for water washing or silica addition is also described. Finally, the power of controlled flow cavitation to reduce catalyst consumption, increase throughput, and reduce monoglyceride content in finished biodiesel is also described.

PRO 4a: New Technologies for Oil Processing

Chairs: Mohamed Abid, Solex Thermal Science Inc., Canada; and Mehmet Tulbek, AGT Food and Ingredients, Inc., Canada

Bleaching Optimization through Use of Cellulose Adsorbents Donald F. Hearl*, *J. Rettenmaier USA LP, USA*

Gum, gel, and soap contaminants in edible oil are detrimental to product longevity, consumer taste, and industrial end use. Industry standard practices for removal of these impurities typically require the use of large quantities of traditional filter aids (diatomaceous earth, perlite, cellulose), adsorbent silica gels, and bleaching earth. This presentation will introduce an optimization of the bleaching unit operation through replacement of traditional silica gels with cellulose adsorbent fibers. The use of the adsorbent cellulose fibers have eliminated the silica gel requirement, and have lowered the consumption of adsorbents by two thirds on a weight basis; while increasing the cycle time of the filters, and reducing bleaching earth consumption. Case study results will show improved adsorbent functionality by direct replacement of the silica gel used in the bleaching filters. Also, techniques for improving overall bleaching filter operation will be shared.

New Concept in Shallow Bed Extractors Anibal Demarco*, *Desmet Ballestra, Argentina*

Today in the Solvent Extraction, there are several extractor type . While the basic technologies used is similar, the different mechanical designs make important difference in between. Is well known that some Oilseed Companies has preference for certain type of the extractors and the called “shallow bed” is one of those type. Desmet Ballestra had designed, constructed and started up successfully in 2015 the first extractor with low layer material with unique features in the market. Modular , easy to transport , expandable , very simple among others are the features of the this new extractor design called LLL (Low Layer Loop) . As well is very important to mention than easy maintenance, high performance and safety are in the basis of the design.

Advanced Process Filtration in Oil Hydrogenation Using Porous Metal Technology Patrick Hill*, *Mott Corporation, USA*

Liquid filtration using porous sintered metal media can operate at conditions up to 1700F, 1500psi and with pH values of 12-13 all while achieving throughput efficiencies up to 99.9% and particle capture of 99% or more. This presentation will focus on the three major types of liquid filtration using porous metal (dead-end, low velocity recirculation, and high velocity cross flow), the operational scheme of each, and the selection process for each. Participants will learn how inside-out, dead-end filtration results in an efficient package size and uniform hydraulic resistance in each filtration cycle. Through testing and proper material selection, systems can be designed for conditions with temperatures ranging from cryogenic to 1700F, pressures in excess of 1500psi, and corrosive process chemistries with solids loading from several ppm to over 10 wt. %. Participants will learn how closed-loop porous metal filter systems can achieve throughput efficiencies in up to 99.9% while recovering greater than 99% of catalysts/solids with no additional rotating equipment. No system is without limitations, and in this presentation, participants will learn how compressible solids, limited particle size distribution and high solids loading can all present challenges to a liquid filter design.

Dry Tribo-electrostatic Protein Enrichment of Oilseed Meal Kyle P. Flynn*[1], Abhishek Gupta[2], Frank Hrach[2], and Philip Ronsivalli[2],[1]*ST Equipment & Technology, USA;* [2]*ST Equipment &*

Technology, United States

Electrostatic separation is a completely dry process requiring no water or chemicals. Dry electrostatic separation methods offer an opportunity to generate oilseed meal with increased protein content for use as a high value animal feed. A sample of hexane extracted sunflower seed meal was obtained by the researchers. Two meal samples were finely milled (dry), the first with a hammer mill, and the second with an air classified mill. The ground oilseed meal samples were then separated using a high throughput tribo-electrostatic belt separator. Finely milled dry sunflower seed meal samples demonstrated significant separation of protein. For the coarser (d50 = 70 micron) sample, the feed sample containing approximately 40% protein (dry basis) was separated into a product containing 52% protein and a by-product with a 29% protein, in a single pass through the high rate electrostatic separator. For the finer (d50 = 25 micron) sample, a product with a 53% protein content was generated, with a by-product with 25% protein, in a single pass through the separator. The tribo-electrostatic belt separator demonstrated the capability to process finely ground sunflower seed meal to significantly upgrade the protein content, making it more valuable as an animal feed. This separation was achieved without the addition of water or chemicals. The tribo-electric belt separator is a high rate, low energy usage, industrially proven processing device suitable to commercialize the recent developments in electrostatic food and feed processing.

Enzymes in Oil Processing: Milder, Sustainable and Economical Solution for Oil Quality Requirements Véronique Gibon*, Wim De Greyt, and Marc J. Kellens,*Desmet Ballestra Group, Belgium*

Enzymes are increasingly used in the industry; in edible oil processing, refineries need to reply to more stringent environmental rules and want to improve their efficiency on both operational costs and delivery of highest quality products. Current trends come with the use of less chemicals and solvent, less energy consumption, reduced environmental impact, safer process, milder operating conditions and optimized nutritional quality; the enzymatic processes meet these criteria. However, being biological molecules, enzymes are heat sensitive and easily inactivated; their price is generally higher compared to chemical catalysts. They have been employed for a long time in the dairy, brewing and baking industry; use in oil processing is more recent. New and improved production methods made it more economical. After extraction, crude edible oils are further refined by entering several purification steps which also generate co-products whose valuation is attractive; downstream modifications allow to extend their application. Some enzymatic processes are industrially proven or are waiting to be proven; some are still under development. Today, main areas in which enzymes are regularly applied are degumming and interesterification. Enzymatic lecithin de-oiling and enzymatic fat splitting are about to emerge. Recent findings have shown effectiveness of an enzyme in increasing palm oil extraction rate. Other relate to rectification of high acidity palm oils by enzymatic condensation on diacylglycerols. Chlorophyll removal through enzymatic degradation is described. Enzymatic production of biodiesel from low-quality feedstocks can be profitable. This presentation will review all the enzymatic processes, their advantages and limitations in edible oil processing.

Feedstock Oil Pretreatment using Active Adsorbent - Filter Aid: A Mechanistic Analysis. Li-Chih Hu, Andy Riley, Andrew Oh, and David Gittins, Imerys Performance Minerals, USA

Vegetable oil, animal fat and mixed feedstock including used cooking oil often contain contaminants which cause issues in production of biodiesel or oleochemicals. Pretreatment with chemical-treated filterable adsorbents, or "Active Adsorbent - Filter Aid" is often shown to be the most powerful strategy. The contaminant removal power by these formulations may be categorized into three mechanisms: chemical reaction, adsorption and filtration. In this study, we report a analysis of the relative role of each mechanism on the removal of each type of contaminant, at different treatment conditions and for different types of oils. This will assist the design and selection of optimized formulation in the purification of biodiesel or oleochemical feedstocks.

IOP 4 / PRO 4.1: Biorefinery Technology and Catalysis

Chairs: Helen Ngo Lew, USDA, ARS, ERRC, USA; and Kris Knudson, Crown Iron Works Co., USA

An Efficient Catalytic Approach to the Synthesis of Wax Esters from Fatty Acid Methyl Esters Duc Hanh Nguyen[1], Guillaume Raffa[1], Yohan Morin[1], Simon Desset[1], Frédéric Capet[1], Véronique Nardello-Rataj[1], Franck Dumeignil*[2], and Régis Gauvin[1],[1]*UCCS, France;* [2]*Université de Lille, France*

Objective: Wax esters are commodity materials used as cosmetics, lubricating agents, plasticizers or surface coatings. They are obtained either from specific bioresources, with limited availability, or from non-trivial synthetic processes. In order to circumvent these issues, we propose to develop an efficient access to these compounds using catalytic upgrading of fatty acid methyl esters (FAME). Methods used: To achieve this, we reasoned that catalytic dehydrogenative conversion of alcohol into esters and its reverse reaction, ester hydrogenation, can be performed using the same cataytic system, by adjusting operational conditions. Thus, we targeted the one-pot, two-step conversion of fatty acid methyl esters into wax esters using a molecular ruthenium-based catalyst. The first step was performed under hydrogen pressure, affording fatty alcohols, which were then converted into wax esters by H2 extrusion. Results: In the absence of solvent and of base additive, and after optimization, excellent conversion and selectivity were reached, from both methyl oleate and from a commercial FAME mixture. Specific studies were devoted to feed purification, which proved to be the key to achieve full conversion of FAME substrates. Physicochemical investigations revealed that resulting compounds display properties similar to benchmark commercial products such as jojoba oil, of lesser availability compared to the herein considered bioresources. Conclusions: This study validates the interest of this simple and efficient access to specific cosmetic oils. It paves the way for further larger implementation of this catalytic approach, which affords wax esters from readily available bioresources, with applicative properties comparable to those of benchmark products.

Towards the Biolubricants Endgame: Building Superior Lubricants, One Structural Feature at a Time Latchmi Raghunanan*[1], Laziz Bouzidi[2], and Suresh Narine[2],[1]*Trent Centre for Biomaterials Research, Departments of Physics & Astronomy and Chemistry, Trent University, Canada;* [2]*Trent University, Canada*

Structure-property relationships are increasingly valued for the identification of specifically engineered materials with properties optimized for targeted application(s). To date, a significant amount of research effort has been exerted globally towards the preparation of bio-derived lubricants with continually improved performance properties, including a large body of work from our own group, the Trent Center for Biomaterials Research. However, while numerous reviews can be found in the recent literature on the synthesis and performance of bio-derived lubricants, those content which review specifically the recent advances in their predictive cold flow properties (i.e., crystallization/melting, viscosity and flow behaviours) are still noticeably absent from the literature. Such studies are important not only for applications including lubricants and biodiesel production which are obviously influenced by fluidity at low temperatures, but also for applications whose properties are in whole or in part dependent upon thermal processing and/or flow. The latter includes materials such as phase change materials for energy storage, and waxes for cosmetic formulations and as food modifiers. In this contribution, the structure-property

relationships of linear and branched esters prepared from lipid-based oleochemicals are reviewed from a fundamental perspective. We will show that ester materials with tunable-on-demand cold flow properties can be custom engineered based on the judicious design of the molecular architecture from a toolbox of sorts comprising of all possible structural elements.

Renewable Diesel from Waste Lipids: Challenges and Conversion Impacts David Schwalje*[1], Larissa Perotta[2], and Michael Zhao[3],*[1]Axens NA, USA; [2]Axens, France; [3]Axens, USA*

Renewable diesel production via the hydrogenolysis, saturation, and isomerization of lipid feedstocks is a proven technology solution, with multiple worldwide projects either in operation, construction, or engineering. Recent debates related to land usage and multi-industry demand for traditional vegetable oils coupled with regulatory incentives has resulted in renewable diesel plants increasing the percentage of feedstocks derived from animal fats and wastes such as tall and used cooking oil. This presentation will focus on the catalytic and processing impacts of those feedstocks including: • Tall oil rosin acid conversion and impacts • The effects of organic nitrogen on hydroisomerization activity and the value of reliable feedstock pretreatment • Used cooking oils: contaminants and process impacts • Co-processing alternative feedstocks with petroleum diesel and catalytic challenges associated with alternative feedstocks The topics will be addressed utilizing pilot test results, case studies, and commercial feedback.

Challenges in converting various fats and oils into a high yield of renewable jet fuel Asbjørn S. Andersson*,*Haldor Topsoe A/S, Denmark*

In order to convert fats and oils into renewable jet fuel the feed stock needs to undergo various types of chemical reactions, like hydrodeoxygenation (HDO), hydrodewaxing (HDW), hydrocracking (HDC) and hydrodearomatization (HDA). Detailed knowledge and control of these reaction mechanisms is key to design a process, that will produce a high yield of renewable jet fuel meeting the ASTM D 7566 specification. The properties of different fats and oils have been analyzed, and the impact of those properties, like fatty acid distribution, contaminants ect. on the design and setup of the conversion process, will be discussed. Especially, the carbon chain length plays a huge role in determining the final jet yield, since alkanes with a carbon number of 18 of higher cannot be included in the jet fuel product, and therefore has to be converted into molecules with lower carbon number, which result in a jet yield loss. Another important step in the process is the isomerization of linear alkanes into branched alkanes, a step that is key to produce a jet fuel meeting the low freezing point requirement. Case studies covering the whole process from fats and oils to renewable jet fuel will be presented.

Effect of Thermal Treatment on Feeding Value of Expeller Soybean Meal in Hexane-free Soybean Processing Michal Kaválek*[1], and Vladimír Plachý[2],*[1]Farmet a.s., Czech Republic; [2]czech, Czech Republic*

Extrusion-expeller processing (EP1) of soybeans is used mainly in local processing and it is suitable for annual capacities up to 400,000 tonnes. The EP1 process is based on separation of oil from seed in a screw press, therefore no chemicals like hexane are used. EP1 products are expeller meal and vegetable crude oil. Expeller meal has about 6-8% of residual oil. Before oil pressing in a screw press, the oilseed is usually conditioned and extruded. Extrusion process is accompanied by flash steam release – a mixture of steam and air under atmospheric pressure. About 65 kilograms of flash steam per tonne of soybeans is released. Therefore there

is a great potential for recuperation of energy and it can be transferred to soybeans in multistep preheating conditioner before soybeans reach the extruder. During the study the amount of recuperated energy and influence of thermal exposition on feeding values has been evaluate (PDI, urease activity, protein fraction according to CNCPS and protein digestibility in chicken balance trials). Experiences have shown that it is possible to recuperate 20 kWh per tonne from this flash steam. Recuperation of heated air from the oil press can save additional 10 kWh per tonne. Energy savings of recuperation amount to about 25%. Optimization of thermal exposure during the EP1 is the key to achieve the best feeding value at lower operating costs. Different thermal exposition of soybeans causes changes in the protein solubility and digestibility, therefore an optimized feed for ruminants and monogastric animals can be produced.

Maximizing Heat Recovery in Soybean Processing Mohamed Abid*,*Solex Thermal Science Inc., Canada*

Soybean processing plants are always evaluating options to maximize operating margins. Conditioning of Soybeans is an energy intensive process and is critical in achieving target efficiency in oil extraction plants. The availability of waste heat sources vary with plant layout, steam sources and meal cooling technology used. However the choice of a heat transfer technology to efficiently recover this low grade energy is critical to finding an efficient and economical solution. Plate Heat exchangers provide high density of heat transfer area within a compact design that allows for an efficient utilization of the recovered energy. The plate channels maintain high velocities which is essential to higher rates of heat transfer. The Bean Heater Modules allow existing installations to reduce steam consumption, with low capex and minimal shutdown time for installation. These modules can be installed on top of existing bean conditioners, allowing use of waste heat to increase capacity, improve overall conditioning or replace leaking tube sections. The modular design makes installation faster and less expensive. The modules can also be used for new conditioning application using a combination of waste heat and steam sources. The long life of the plates in this abrasive environment reduces maintenance costs associated with frequent replacement of tube sections and required downtime. The external flexible hoses connected to manifolds allow for easy isolation. Any plate can be blocked off without opening the modules. Also each module has an access door that can be used to replace any plate with minimal disruption of production.

A New Material for Reducing Glycidyl Esters in Edible Oil Chelsea L. Grimes*, and Cristian Libanati,*W.R. Grace, USA*

Glycidyl esters (GE) in edible oil are known carcinogenic and mutagenic process contaminants that have recently been subjected to European legislation. In order to reduce glycidol concentrations in one pass RBD oil to proposed regulatory limits, we have studied a material at different temperatures, contact time, dosages, and initial GE concentrations without adversely affecting oil quality. Our presentation will outline properties of this novel material as well as catalytic performance in multiple oil matrices. We will also present a kinetic analysis of this reaction to incorporate this material into existing oil refining technologies and ultimately remove the necessity for secondary refinement.

A Comparison of Conventional Short Path Distillation to a Proprietary Short Path Stripper in Reducing Glycidyl Fatty Acid Esters (GEs) and 3-MCPD Esters in Refined Edible Oils Marc

Koukoulas*,*Artisan Industries Inc. , USA*

Short Path Distillation has been identified as a potential technology for significantly reducing the concentration of GEs and MCPDs, identified as potential carcinogens, in refined edible oils. The technology, also commonly referred to as “Short Path Evaporation” has been predominantly used in the distillation of high boiling, heat sensitive materials, such as FAMEs, monoglycerides, tocopherols, and similar products, owing to its ability to operate at extremely low pressures. This presentation compares the viability of applying “Short Path Distillation” in eliminating these heat-induced contaminants to a “Proprietary Short Path Stripper”. An overview of the features of the Short Path Stripper and Short Path Distillation is presented for this “Stripping-only” application.

PRO-P: Processing Poster Session

Chair: Alan R. Paine, Desmet Ballestra, Belgium

1. **Effects of Moisture and Heat Pretreatments on the Quality of Crude Corn Germ Oil.** Liyou Zheng*[1], Jianhua Huang[2], Xingguo Wang[3], and Qingzhe Jin[3], *[1]State Key Laboratory of Food Science and Technology Synergetic Innovation Center of Food Safety and Nutrition School of Food Science and Technology, China; [2]School of Food Science and Technology, Jiangnan University, China; [3]Jiangnan University, China*

Objective Wet-milled corn germ is a value-added co-product generated during the starch production as it contains over 30% oil. Traditionally, such oil is removed from the milled germ with pretreatments prior to oil extraction. The changes in the quality of crude corn oil caused by moisture and different thermal pretreatments (oven heating and microwave irradiation) of wet-milled corn germ were evaluated. Methods Used Five moistures (8%, 11%, 15%, 20%, and 25%), three oven roasting (OR) temperatures (125, 150, and 175 °C) and microwave (MW) radiation with two powers (440 and 800 W) were used. Indexes like oil color, oxidative stability index, fat compositions, triacylglycerol species, and tocopherol and phytosterol levels were determined. Results The different moisture contents of corn germ caused no significant differences in the fatty acid composition. Significant increases were observed in the levels of 1,3-diacylglycerol, total diacylglycerol, free fatty acid, and oleic acid increased substantially (P0.05) of phytosterols content were observed among most samples tested during these three pretreatments. Conclusions Certain roasting temperatures, MW radiation or moisture pretreatments could significantly affect the content of individual tocopherol and phytosterol. Proper pretreatments did good to the quality of crude corn oil.

2. **Flavor Generation, Characteristics and Stability of Roasted Sunflower Oil.** Xiaojun Liu*, Shengmin Zhou, and Yuan Rong Jiang, *Wilmar Biotechnology R&D Center (Shanghai) Co., Ltd., China*

Objective: In China, planting of sunflower seeds had a long history. Roasted sunflower oil is quite favored by local consumers because of its unique rich flavor with roasted sunflower seed flavor and/or burnt flavor. Its flavor composition, characteristics and flavor stability were studied in our research. Methods used: Roasted sunflower oil is mainly processed by traditional processing. After roasting at high temperatures, the sunflower seeds were immediately pressed by screw expeller to obtain roasted sunflower oil. Flavor compounds were detected and analyzed by HS-SPME/GC-MS. Results: Its characteristic flavor was mainly formed during processing, especially high temperature roasting. The proteins, sugars and lipids contained in sunflower seeds underwent a series of complicated reactions to generate a large amount of volatile and non-volatile components during roasting process, which had a significant impact on the flavor and quality of roasted sunflower oil products. And also, the flavors would be quite different by dealing with various roasting conditions. The flavor substances of roasted sunflower oil were mainly composed of three major categories: terpenes, Maillard reaction products (MRPs) and lipid oxidation products, which respectively provided roasted sunflower oil with sunflower seed flavor, roasty/nutty or burnt flavor, and oxidation flavor. Conclusions: These compounds were combined together to give unique flavor of roasted sunflower oil. Among them, the proportion of terpenes and MRPs had a significant effect on the flavor characteristics of roasted sunflower oil. And these also would affect the flavor stability during shelf life of the

product, which is quite worthy of being further investigated.

3. **Study on Rice Bran Nutrition Extractions by Combined Enzymatic Approaches.** Guang Zhang*, Mingshou Lyu, Yan-Guo Shi, and Zhihui Sun, *Harbin University of Commerce, China*

Rice bran is a main byproduct during the rice milling process and it has large annual production and nutritious in China. However, it hasn't been widely applied in food industry due to its rancidity, rough taste and poor functional properties. It has been reported that rice bran contains large amount of unsaturated fatty acid which is conformed to WHO recommended dieting standard. Meanwhile, it also contains much amount of dietary fibers and proteins such albumin, globulin and glutelin. In order to extract the rice bran oil, dietary fibers and proteins, enzymatic method has always been a first choice due to its mild process conditions. More rice bran oils can be extracted while nutrition activity of rice bran proteins won't be destroyed by enzymatic methods. As a result, combined enzymatic approaches was adopted to extract oil and proteins in rice bran. Cellulase, amylase and protease were opted for consideration of extracting rice bran oil and protein simultaneously. The dosage, solid-to-liquid ratio, pH, temperature and reaction time were observed for the combined method to improve the extraction rate of rice bran oil to over 90%.

4. **Concentration of Carotenoids from Tomato using Supercritical Carbon Dioxide.** Shinhae Hwang*[1], Heejin Kim[2], Aree Lee[1], and In-Hwan Kim[1], *[1]Korea University, South Korea; [2]Dept. of Public Health Sciences, Graduate School, Korea University, Republic of Korea*

Carotenoids in tomato were successfully extracted using coconut oil ethyl ester and concentrated by supercritical carbon dioxide. Firstly, carotenoids were extracted from grinded tomato using coconut oil ethyl ester as a solvent. The carotenoids extracted in coconut oil ethyl ester were concentrated in the residue after removal of coconut oil ethyl ester by supercritical carbon dioxide. Operation of supercritical carbon dioxide was performed at the pressure range of 6.89-12.41 MPa and the temperature range of 40-60℃. The optimum condition was a pressure of 9.65 MPa and a temperature of 50℃ temperature for concentration of carotenoid. The level of carotenoids in the residue obtained under optimum condition was significantly higher than that of carotenoids in the starting material.

5. **The Reduction of 3-MCPDs and GEs in Palm Oil Using Acidified and Non-Acidified Bleaching Earths.** Victor Vega* and Frank Filippini, *Oil-Dri Corporation of America, USA*

The reduction of 3-monochloropropane-1,2-diols (3-MCPDs) and glycidyl esters (GEs) has been a central focus in the palm oil refining industry. Limited by space, refineries are interested in bleaching products that achieve traditional specifications with minimal formation of 3-MCPDs / GEs and serve multiple purposes. The effect of bleaching earth on managing 3-MCPDs and GEs before and after deodorization is the main focus in this study. Crude oil was physically refined to typical product specifications using palygorskite based bleaching earths ranging in acidity (by pH). Determination of 3-MCPDs and GEs was based on the AOCS Official Method Cd 29b-13. A direct relationship was observed between the acidity of the bleaching earths and the reduction of GEs in both deodorized oils and post treated deodorized oils. However, the use of high acidity bleaching earths was found to be potentially detrimental to the reduction of 3-MCPDs.

6. **Factors Affecting Cottonseed Hull Strength.**

Michael K. Dowd*, Roji Manandhar, and Christopher D. Delhom, *SRRC-ARS-USDA, USA*

Cottonseed damage is a recent growing concern for ginners and oil processors. Reduced hull durability may be related to the long sustained efforts to breed varieties for maximal fiber yield. Increased damage during harvesting and ginning results in considerable seed free fatty acid rise and oil loss for the seed crusher, and results in more seed coat fragments in the fiber, which causes problems for fiber and yarn processers. A test to evaluate the durability of seed varieties would be beneficial to breeders developing new varieties. Toward this goal, cottonseed hull strength was studied with a tensile strength tester fitted with an adapter to apply compression. More force was needed to crack seed when the seed was oriented vertically in the tester than when oriented horizontally. Differences in environment relative humidity (35 to 65%) affected the compression results, indicating that seed need to be conditioned to obtain consistent results. Significant differences were discernible among different seed samples, but acid delinting of the seed did not affect hull strength. Additionally, the initial results suggest that the hull strength was greater for long-stable cottons (*G. barbadense* varieties) than it was for short staple cottons (*G. hirsutum* varieties). Finally, tests on individual varieties produced in different locations suggests that growing conditions have a significant influence on cottonseed hull strength.