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# INTERNATIONAL NONTHERMAL PROCESSING

## WORKSHOP & SHORT COURSE

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UNIVERSITY OF MINNESOTA
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Hosted by
Center For Biorefining
Department of
Bioproducts and
Biosystems Engineering
University of Minnesota

# Abstract Book

## Session 1 - Nonthermal Food and Bioprocessing for Circular Economy

**Title:** Driving sustainability of food production with high-pressure processing

**List of authors:** Jasna Ivanovic

**Organization:** Uhde High Pressure Technologies GmbH, Buschmühlenstr. 20, 58093 Hagen, Germany

**Presenter:** Jasna Ivanovic

**Abstract:** The fast-growing world population and halving the agricultural area over the last 60 years have urged all parties in the supply chain to improve the social, ecological, and social sustainability of food production. The processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for consumers, beneficial for the economic development of the communities and the health of the consumers came into focus. The examples of industrial practice and development projects in this work demonstrate traditional and emerging approaches for integrating high-pressure processing (HPP) into sustainable food systems.

Over the last 30 years, HPP at 400-600MPa has been traditionally used as an approved method for in-pack and non-thermal preservation of foods to prolong shelf life and eliminate pathogens with minimal effects on original flavor, appearance, and loss of nutrients. Longer shelf life and using HPP as post-lethal treatment contribute directly to a decrease in the over-processing and resource exploitation, transport, costs due to the disposal of adulterated products (e.g. meats). Using HPP at lower pressures (250-300MPa) has found great acceptance in the seafood sector for a clean, safe, fast, and efficient 100% separation of meat from the shell, with better sensory attributes and higher quality. Novel approaches involve using HPP as an intermediate processing step to meet the requirements of GHP while preserving thermolabile functional ingredients. To get the highest quality of a product at the lowest price, the producers reach lately for HPP to preserve ingredients made of seasonal fruits and vegetables at the best quality and price, for later use in the final products. The future trends focus on the valorization of side streams, increasing the bioavailability of functional ingredients, and utilization of HPP to treat biomass for getting high-added materials for novel food. Smart production using automation or semi-automation, optimized package design, digitalization, water recycling and cleaning programs aim to minimize costs per kg/l of the HPP products while ensuring their quality. Finally, the HPP tolling service has emerged as a successful business model to ease the logistics and reduce related costs for placing regional food producers on the market without investment in technology.

**Keywords:** High-pressure processing; Sustainable food production; Industrial solutions showcase

**Format** Oral

**Title:** Life cycle assessment and machine learning-based modelling of food waste treatment

**List of authors:** Simon, Ascher; Ian, Watson; Xiaonan, Wang; Wangliang, Li; Willian, Sloan; Zahra Hajabdollahi, Ouderji; Rohit, Gupta; Andrew, Mckeown; Zhibin, Yu; Cindy, Smith; William, Sloan; Siming, You

**Organization:** University of Glasgow, UK

**Presenter:** Siming You

**Abstract:** Sustainable bioenergy production and waste management play important roles in achieving Climate Action and Sustainable Cities and Communities as part of the United Nations Sustainable Development Goals. Environmental footprints of associated energy and environmental systems and developments are one of the key criteria that have been commonly incorporated for their optimal design.

This talk will cover some of our recent environmental impact assessment studies on bioenergy production and food waste management in the UK [1-3]. The aim of the research is to initiate mapping the range of possibilities of bioenergy production/waste management in facilitating UK's action in achieving clean and low-carbon production.

Environmental footprint assessment is often plagued by lack of reliable data input. Machine learning methods can be used to mitigate the issue/challenge e.g., by supplying reliable process production prediction [4]. This talk will also cover some of our recent effort in developing machine learning-based models for more accurate, flexible environmental impact assessment [5-6]. The application of machine learning modelling for the life cycle assessment of an integrated anaerobic digestion-heat pump development will be presented [7].

**Keywords:** Food waste; Life cycle assessment; Machine learning; Net zero

**Format** Oral

**Title:** Supercritical CO2 Technology for the Production of Cellulose Nanofiber Aerogels

**List of authors:** Zhengjie Liu and Marleny D.A. Saldaña

**Organization:** Department of Agriculture, Food and Nutritional Science, University of Alberta

**Presenter:** Zhengjie Liu

**Abstract:** Cellulose nanofiber (CNF) is a promising material in a wealth of fields, including food, cosmetics, insulation, and packaging material. CNF has been commonly prepared by mechanical nanofibrillation via grinding, high pressure homogenization and microfluidization. Then, it has been dried using freeze drying technology with some limitations. Recently, supercritical carbon dioxide (SC-CO2) has been used due to its mild critical pressure and temperature conditions of 74 bar and 31 °C, respectively. To the best of our knowledge, there is no study that reported production of barley straw CNF aerogels using SC-CO2 drying. Therefore, in this study, cellulose-rich residue obtained from barley straw was used to form CNF hydrogels where the effect of concentration and HIUS specific energy (24-72 kJ/g) on resultant hydrogel properties (water retention value (WRV), ζ-potential, fibrillation yield, rheological behavior, and diameter size) were investigated. The

optimum condition was 1 wt% CNF after HIUS treatment at 1200 W for 20 min, which achieved hydrogel with the highest WRV, and fibrillation yield >50%. All the hydrogels exhibited a typical elastic gel-like behavior. The obtained hydrogels were then dried using SC-CO2 to form aerogels, and the properties (functional groups, morphology, and thermal behavior) of aerogels were analyzed by FTIR, SEM, and TGA. The SC-CO2 drying allowed the production of aerogels with thermal stability with degradation temperature > 310oC. In addition, SC-CO2 drying was an efficient technology to produce highly porous aerogels with porosity > 80%. Furthermore, SC-CO2 reduced the surface tension of the pore solvent and dried the gel with relatively less cracking and deformation than those of current thermal, and freeze drying technologies. These aerogels can find innumerous application in the food, cosmetic and packaging fields.

**Keywords:** Aerogel; Cellulose nanofiber; Hydrogel; Supercritical CO2 drying;

**Format** Oral

**Title:** Valorization of discarded carrots into value-added and fiber-fortified smoothies by using high-pressure processing

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4 Uhde High Pressure Technologies GmbH, Buschmühlenstr. 20, 58093 Hagen, Germany

**Presenter:** Jasna Ivanovic

**Abstract:** The present study aimed to investigate the shelf life extension of a functional smoothie formulation fortified with dietary fiber that is recovered from discards in carrot production (Patent AR099281B1). The smoothies were designed to provide the daily vitamin C requirement (≈90 mg) and enhance daily dietary fiber intake in one serving (250ml). High-pressure processing (HPP) has been applied as an approved, non-thermal intervention to inactivate harmful microorganisms with minimal loss of nutrients. Growth of spoilage and pathogen microorganisms, relevant color parameters (ΔE, L*, C*, hab), and pH-value served as criteria to estimate the shelf life of the smoothies. The base and fiber-fortified smoothie formulations containing strawberry, orange juice, peeled apple, and banana were subjected to the hydrostatic pressure of 450 MPa and 600 MPa for 3 min. All the samples are kept at 4 °C for a 60-day storage test. Microbiological safety and quality were maintained for 60 days with pathogen absence (Listeria, E.coli, Salmonella spp.) and spoilage microorganism count under 100 CFU/g (molds, yeast, lactic bacteria). The total aerobic count in HPP samples on day 60 was also within the recommended limits (up to ~103 CFU/g). The initial pH value of the HPP samples (3.4±0.1) and soluble solids (10.02±0.2%) were constant over the tested storage period. The HPP treatments did not affect perceptible total color change

(ΔE<2) and caused negligible differences in L*, C*, and hab values for both formulations. The least ΔE value for the fiber-fortified formulation treated at 450 MPa (0.33) suggested a positive effect of fibers and lower pressure on color preservation. After 28-day storage, values of L*, C*, and hab in HPP smoothies decreased and the samples appeared less luminous, vivid, and slightly redder with a perceptible color change (ΔE>5). These preliminary results imply the economic potential of using HPP even at lower pressure (450MPa) to ensure microbiological and color quality of the fiber-fortified smoothie for satisfying healthier food choices demand. The effects of HPP on the nutritional quality of the tested formulations will be studied in detail in a separate study
to get an overall picture of HPP benefits.

**Keywords:** High-pressure processing; Upcycling; Dietary fiber; Smoothie; Shelf life study

**Format** Poster

**Title:** Mathematical modeling of protein extraction from Chlorella pyrenoidosa: The effect of high pressure homogenization pretreatment

**List of authors:** Alexandros, Katsimichas; Ioulia, Karveli; George, Dimopoulos; Maria, Giannakourou; Petros, Taoukis

**Organization:** Laboratory of Food Chemistry and Technology, School of Chemical Engineering, National Technical University of Athens, Greece

**Presenter:** Petros, Taoukis

**Abstract:** Microalgal proteins contain all the essential amino acids for the human diet, while exhibiting significant functional properties for industrial application in food products, such as good water and oil holding capacity. Chlorella pyrenoidosa is a photosynthetic microalga, standing out for its high protein content (40-50%). However, significant extraction barriers are posed by its cell wall and membranes. Extractability enhancement without degradation of target compounds can be achieved via nonthermal processing. High Pressure Homogenization (HPH) is a mechanical, nonthermal process in which cell suspensions are forced under high pressure through a micrometric disruption chamber. Mechanical stress causes physical disruption of cell walls and membranes, enhancing recovery of intracellular compounds.

Untreated and HPH-treated (0-800 bar, 4 passes) C. pyrenoidosa suspensions (2.5% w/w) were incubated under constant stirring at 20-40°C for up to 24 h, after adjusting their pH value to 13. At regular time intervals, aliquots of the incubation mixtures were removed, centrifuged, and the supernatants were collected. Protein concentration in extracts was determined via the Lowry method. The kinetics of protein recovery were mathematically modelled using a first order exponential model.

HPH treatment and extraction temperature significantly increased final extract protein concentration. Specifically, the increase of treatment pressure from 0 to 800 bar increased protein recovery (24 h at 20°C) from 102.8 to 248.0 mg protein/g biomass, respectively. The increase of incubation temperature from 20°C to 40°C resulted in significant increase of protein recovery from treated samples (800 bar) from 248.0 to 382.0 mg protein/g biomass, respectively. Protein characteristic extraction time was significantly dependent on pretreatment conditions and extraction temperature (5.16 h for untreated sample at 20°C vs. 1.34 h for 800 bar

treated biomass at 40°C). Finally, an accurate mathematical model that incorporates in an overall equation all process parameters was developed.
In conclusion the significant enhancement of protein recovery yields from C. pyrenoidosa suspensions via the application of HPH process was mathematically modeled. Protein recovery was accelerated by applying higher incubation temperatures and more intense HPH pretreatment.

**Keywords:** microalgae; high pressure homogenization; kinetic study, mathematical modeling

**Format** Poster

**Title:** Recovery of bioactive compounds from plant and animal origin by-products: the effect of High Pressure and Pulsed Electric Fields processing

**List of authors:** George Dimopoulos, Maria Tsevdou, Elena Karampina, Michaela Kourgitakou, Petros Taoukis

**Organization:** Laboratory of Food Chemistry & Technology, School of Chemical Engineering, National Technical University of Athens, Athens, GREECE (bac2food@chemeng.ntua.gr)

**Presenter:** Petros Taoukis

**Abstract:** The increased demand for functional foods during recent years has led the research community toward alternative routes to obtain natural bioactive compounds (BACs). Several food processing by-products contain residual amounts of BACs which remain unexploited. Their extraction has to strike a balance between yield and retention of functionality, while taking into account the use of environmentally friendly extraction methods. Novel technologies like High Pressure (HP) and Pulsed Electric Fields (PEF) can enhance mass transfer by increasing cell permeability and lead to benefits such as increased yields, selective extraction, alternative solvent use and protection of sensitive molecules. This study investigates the recovery of carotenoids from tomato pomace and ω-3 fatty acids from fish processing discards, using novel technologies combined with the use of ethanol, a commonly accepted green solvent.
Tomato pomace and fish filleting residues were dried, mixed with ethanol at different solid-to-liquid (S:L) ratios, ranging from 1:30 to 1:5, and subjected to HP (250-650 MPa, ambient temperature,0-20 min), and PEF conditions (4 kV/cm, 250-2000 pulses). The efficacy of HP and PEF-assisted extraction was evaluated in terms of carotenoid and ω-3 fatty acid yield and functionality with analytical methods such as spectrophotometry, HPLC and GC-MS.
HP treatment results indicated that the extraction process was independent from pressure time. A S:L ratio of 1:30 exhibited the highest recovery yields even at low pressures (250 MPa), which led to an increase of 28.8% and 55.6% for the extracted carotenoids and ω3-fatty acids at reduced time compared to untreated samples (24 h and 60 min, respectively). An increase in the applied pressure did not significantly promote BACs recovery from either material. PEF treatment increased the extractability of carotenoids from tomato pomace up to 58.2% (750 pulses) after 120 min of extraction (1:30 S/L), compared to untreated samples. Similarly, the extraction yield of ω-3 fatty acids from fish discards was increased by 77.1% after 10 min of extraction (1200 pulses), a value obtained for untreated samples after more than 2 h of extraction.

This work shows the potential for using nonthermal processes to improve extractability of BACs from food by-products using ethanol as a solvent.

**Keywords:** by-products utilization; novel technologies; high added value compounds

**Format** Poster

**Title:** High pressure processing, a promising technology to enhance protein extraction

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**Presenter:** Silvia de Lamo Castellvi

**Abstract:** Insects are a good source of nutrients, with protein content ranging from 41 to 66%, fat between 15-50%, fiber between 2-19%. Insect protein extraction is mainly performed using chemical extraction followed by iso-electric point precipitation. So far, very little attention has been paid to assist the insect protein extraction process with technologies that have shown good results when applied to the recovery of proteins from other renewable sources. Due to the sensitivity of proteins to heat or solvents, high hydrostatic pressure (HHP)-assisted extraction can be more efficient in terms of yield and extraction time. The main objective of this work was studying the potential of using HHP to enhance insect protein extraction. Edible Tenebrio molitor and Alphitobius diaperinus powders were fully defatted with hexane. Fractions of 0.8 g were mixed with 4.2 mL of 0.15 mM NaCl solution (pH 8.3), placed in plastic bags, and treated at pressures ranging from 100 MPa to 300 MPa for 5 min at 25ºC. Treated samples were centrifuged and the supernatants were analyzed to determine protein content, molecular weight distribution (MWD) of the protein fractions, emulsifying activity, and changes in secondary structure of proteins by FT-MIR. All the pressures tested enhanced protein extraction up to 14% for both insect species tested and nonsignificant differences were detected among the treatments applied. Nonetheless, MWD results showed an increase of protein bands intensity in the range of 11-14 kDa as the pressure applied increased for both insect species. Moreover, for A. diaperinus, the protein bands intensity in the 26-27 and 37 kDa also increased with the pressure, and for T. molitor was around 18 kDa. Emulsifying activity only increased for A. diaperinus samples treated at 250 and 300MPa and that could be linked to the higher presence of 26-27 and 37 kDa proteins. Some conformational changes in the secondary structure of proteins were also detected with an increase of β-sheet and random coil and a decrease in the α-sheet content mostly for T. molitor extracts. The research shows the potential of using high pressure to increase up to 14% protein extraction and to modify functional properties.

**Keywords:** Insect proteins, HPP assisted extraction, functional properties

**Format** Poster

**Title:** Solubility of menthol in supercritical CO2 + co-solvents and its extraction from Mentha × piperita

**List of authors:** Yuan Meng; Marleny D.A. Saldaña

**Organization:** University of Alberta

**Presenter:** Yuan Meng

**Abstract:** Menthol, the primary component of Mentha × piperita, exhibits analgesic, antifungal, antibacterial and anti-inflammatory properties. This research aimed to evaluate the solubility of menthol in supercritical carbon dioxide (SC-CO2) and SC-CO2 + co-solvents, as well as to explore its extraction using SC-CO2 from peppermint leaves. The solubility of menthol in SC-CO2 and SC-CO2 + cosolvent was evaluated at various temperature (45-55 °C) and pressure (100-300 bar) conditions, with SC-CO2 density varying from 337.2 to 890.3 kg/m3. Gas chromatography was used to quantify the menthol content. The highest solubility of menthol was 1.25´10-2 mole fraction obtained at 120 bar and 45 °C using pure CO2. In addition, the menthol extraction was evaluated at different pressures (100-400 bar), temperatures (45-55 °C), CO2 flow rates (0.5 and 3 mL/min), and co-solvent types (ethanol, acetone, and isopropyl acetate). The highest menthol content (47.50%) was obtained at 110 bar and 50 °C for 120 min with a flow rate of 3 mL/min using pure CO2. Overall, this study provides significant insights into menthol extraction from peppermint using SC-CO2.

**Keywords:** Menthol; Solubility; Supercritical carbon dioxide processing; Extraction; Mentha × piperita.

**Format** Poster

**Title:** Supercritical CO2 Processing: Extraction, Enzymatic Reactions and Drying

**List of authors:** Marleny D. A. Saldaña

**Organization:** University of Alberta

**Presenter:** Marleny D. A. Saldaña

**Abstract:** Supercritical CO2 (SC-CO2) is an environmentally friendly solvent that can be used in extraction, enzymatic reactions and drying. Industrial interest to extract bioactives such as lycopene, beta-carotene and phenolics has been growing due to their nutritional and antioxidant properties. In my laboratory, lycopene and beta-carotene were extracted from tomatoes (skin+pulp) with SC-CO2 using a laboratory-scale supercritical extraction system at 40 and 70°C, 400 bar and flow rates of 0.5 and 1.2 L/min. Carotenoids were also extracted using ethanol and canola oil as a co-solvent in SC-CO2 at 5% (w/w) level, 40oC and 400 bar. Our results showed that extraction of lycopene and β-carotene from skin+pulp of tomato at 40oC, 400 bar, and 0.5 L/min of CO2 was higher with SC CO2+5% canola oil than with SC CO2+5% ethanol and SC CO2. The use of oil as a co-solvent is promising for industrial recovery of carotenoids from tomato matrix. In addition, studies were conducted on enzymatic hydrolysis of Sacha inchi oil using SC-CO2 and different enzymes to assess the optimum free fatty acids (FFA) production. The effects of pressure (10-300 bar), fat:water ratio (1:5-1:30 mol/mol) and their interaction in the FFA production were studied. Lipid classes content (FFA, monoglycerides (MG), diglycerides (DG), and triglycerides (TG)) and fatty acid composition of products obtained were determined by gas chromatography. The

increase of intermediate reaction products (MG and DG), decrease in TG and increase in FFA compared to the starting material was observed. The maximum hydrolysis of FFA was achieved in SC-CO2 media using Lipozyme TL IM. Then, a phenolic acid was reacted with TG of flax oil using lipase enzyme in SC-CO2 media at 40-80℃, 40-350 bar and times of up to 53 h. Results have shown that SC-CO2 is a promising green solvent for the enzymatic synthesis of phenolic lipids. Finally, protein gels containing beta-carotene were dried using SC-CO2. Results have shown that different applications can be targeted using SC-CO2. Also, products obtained can be used as is in a variety of nutraceutical and functional food applications.

**Keywords:** Aerogels; protein hydrogels; enzymatic hydrolysis; phenolic lipid synthesis.

**Format** Virtual

**Title:** Microbial Biotechnology Approaches for Conversion of Fruit Processing Waste in to Emerging Source of Healthy Food for Sustainable Environment

**List of authors:** Mukesh Kumar Awasthi

**Organization:** College of Natural Resources and Environment, Northwest A&F university, Taicheng road 3#, Yangling, Shaanxi 712100, PR, China

**Presenter:** Mukesh Kumar Awasthi

**Abstract:** One of the most significant and difficult jobs in food sustainability, is to make use of waste in the vegetable and fruit processing sectors. The discarded fruits along with their waste materials, is anticipated to have potential use for further industrial purposes via extraction of functional ingredients, extraction of bioactive components, fermentation. As a result of its abundant availability, simplicity and safe handling, and biodegradability, fruit waste (FW) is now the subject of extensive research. It is regarded as a resource for economic development. This vast agro-industrial waste is being investigated as a low-cost raw material to produce a variety of high-value-added goods. Researchers have concentrated on the exploitation of FW, particularly for the extraction of prebiotic oligosaccharides as well as bromelain enzyme, and as a low-cost source of fibre, biogas, organic acids, phenolic antioxidants, and ethanol. Thus, this review emphasizes on various kind of FW valorisation approaches, extraction of bioactive and functional ingredients together with the advantages of FW to be used in many areas. From the socioeconomic perspective, FW can be a new raw material source to the industries and may potentially replace the current expensive and non-renewable sources. This review summarises various approaches used for FW processing along with several important value-added products gained which could contribute towards healthy food and a sustainable environment.

**Keywords:** Fruit waste, sustainable food, prebiotics, bromelain

**Format** Virtual

## Session 2 – Innovations in Food Safety through Nonthermal Processing Technologies

**Title:** Synergistic Effect of Sequential Treatment with 222 Nm, 280 Nm, and 405 Nm Light Wavelengths on Inactivation of Foodborne Pathogens

**List of authors:** Hanyu, Chen; Carmen, Moraru

**Organization:** Department of Food Science and Technology, Cornell University

**Presenter:** Hanyu Chen

**Abstract:**

Introduction:

Light technologies with different wavelengths can mitigate the risk of contamination, but each wavelength range has limitations. A hurdle system consisting of sequential wavelengths treatments may enhance the disinfection performance by different mechanisms. This research evaluates the effectiveness, mechanisms of inactivation, and kinetics of sequential treatments with far-UVC (222 nm)+visible light (405 nm) and UV-C (280 nm)+visible light (405 nm) against several foodborne pathogens.

Purpose:

This study evaluated the effect of far-UV-C, UV-C, and blue LED sequential light treatments against several major foodborne pathogens and evaluated their inactivation mechanisms and kinetics.

Methods:

Early stationary phase (18h) colonies of Escherichia coli O157:H7, Listeria monocytogenes, Salmonella Typhimurium, Staphylococcus aureus and Pseudomonas aeruginosa were inoculated in thin liquid films (1.2 mm thickness), and exposed to two types of sequential treatments, at 21 °C: 1) 30s of 222 nm UV+48h of 405 nm blue light; 2) 30s of 280 nm+48h of 405 nm blue light. Single wavelength treatments were also conducted under the same conditions. Confocal microscopy was used to visualize bacteria distribution and quantify oxidative cellular damage. Experiments were performed in triplicate with independently grown cultures, and data was statistically analyzed.

Results:

Inactivation curves for all treatments were non-linear, and were described by the Weibull model ($0.97>R2>0.82$). Kinetics were significantly ($p<0.05$) affected by bacteria species. Synergistic effects were observed for E. coli and Listeria after exposure to both sequential treatments, with > 3 log reduction increase compared to single wavelength treatments. Additive effects were observed for S. aureus, while antagonistic effects were observed for P. aeruginosa after sequential treatments. Significant differences in reactive oxygen accumulation were found ($p<0.05$) among treatments. Mechanisms and performances of sequential light treatments were correlated with cellular oxidative damage.

Significance:

The proposed sequential treatments showed enhanced disinfection performance compared to individual treatments in most cases, which can have significant food safety benefits.

**Keywords:** KrCl excilamp; UV-C LED; Visible light; Synergistic bactericidal effect; Microbial inactivation; Escherichia coli O157:H7; Listeria monocytogenes; Salmonella Typhimurium; Staphylococcus aureus; Pseudomonas aeruginosa

**Format** Oral

**Title:** Ultraviolet light (UV) technology for microbial and viral control in food applications

**List of authors:** Tatiana Koutchma

**Organization:** Agriculture and Agri-Food Canada

**Presenter:** Tatiana Koutchma

**Abstract:** Application of ultraviolet (UV) light technology for food and beverages have been based on employing pulsed and continuous light sources, which are characterized by a polychromatic or monochromatic emission including germicidal UVC range (200 -280 nm). Conventional continuous mercury lamps and xenon pulsed lamps were mostly explored and commercialized for a variety of operations in food processing. Due to the fact that UVC at 253.7 nm can cause damage to mammalian skin and eyes, conventional UVC systems for disinfection of air, surfaces and foods must be designed and operated in a manner that minimizes exposure of humans. Recent research has demonstrated that Far UVC radiation (200-230 nm) emitted by KrCl* excimer lamps has minimal potential to damage mammalian skin and eye tissues and have similar antimicrobial efficacy. Also, over the last 3-5 years other new UVC light sources such as UVC light emitting diodes or LEDs, and novel pulsed light lamps have been developed and new applications have emerged including controlling contamination of drinks and beverages, food surfaces in processing and storage facilities and transport sanitation. The goal of this presentation is to provide a review of the current state-of-development of monochromatic and polychromatic UVC light sources (conventional and novel), knowledge of their efficiency for microbial disinfection including mechanisms of action and safety concerns. The results of comparison of microbial inactivation at 222 nm, 253,7 nm, 265 nm and 275 nm and novel electron pulsed UVC in 220 -280 nm range will be presented. Future prospects and research needs related to novel UV sources and their potential applications are also presented.

**Keywords:** ultraviolet light, UVC light sources, far UVC lamps, mercury lamps, pulsed lamps, UV LEDs, safety of UV light

**Format** Oral

**Title:** Enhancing Produce Safety with Novel In-Package Surface Dielectric Barrier Discharge Cold Plasma Technology

**List of authors:** Deepti Salvi *1, Katharina Stapelmann 2, Aaron Mazzeo 3, Duncan Trosan 2, Stephen McLaughlin 3, Qingyang Wang 1, Dushyanth Kumar Tammineni 1

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**Presenter:** Deepti Salvi

**Abstract:** Cold plasma, a non-thermal technique for preserving food, utilizes high-energy to generate ions and electrons. There is growing interest in generating in-package plasma. Two types of configurations have been used for in-package applications: surface dielectric barrier discharge (SDBD) and volume dielectric barrier discharge (VDBD). However, optimization of plasma to food surface and scaling up are some of the challenges due to the rigid nature of these electrodes. Our team is working on comfortable lightweight electrodes that can be used as packages. We developed three-layer paper-based conformable electrodes for in-package plasma generation. Circular and origami cone electrode designs were tested electrically and against E. coli and Listeria on TSA plates, spinach, and tomatoes. On TSA plates, over 2-to-10-minute treatment, both pathogens showed 3 to 5 log reduction with no significant difference between 5 and 10 mins ($p>0.05$). On spinach, E. coli reduction was ~4 logs with no significant difference ($p>0.05$) between treatment times. On tomatoes, E. coli reduction ranged 2.5-4.5 logs with no significant difference between 5 and 10 minutes ($p>0.05$). Although paper SDBD electrodes showed good inactivation of different bacteria on produce surfaces and phytonutrients concentration was not affected significantly ($p>0.05$), their failure time ranged to a few minutes. Hence a new 5-layer electrodes were developed to replace dielectric material from paper to Kapton and PET. Electrical characterization and ozone generation studies suggested improved electrode stability and ozone production, proportional to input power. Kapton-based electrodes showed longevity even after seven hours of continuous operation. Kapton-based electrodes showed 5.4 logs E. coli O157:H7 reduction on spinach leaves versus ~4.7 logs for PET-based electrodes over 10 minutes of treatment. The reductions of biofilms were 3.2 and 1.72 logs with initial concentrations of 6.5 and 7.6 log CFU/leaf for Kapton and PET electrodes, respectively. Kapton- and PET-based SDBD plasma did not have a significant ($p>0.05$) impact on spinach polyphenols, antioxidants, and Vitamin C. This shows in-package plasma potential for microbial inactivation without affecting phytonutrients. Further research includes transparent packaging development and applying this technology to food contact surfaces.

**Keywords:** Cold Plasma, In-package plasma, Kapton, E. coli, Listeria, Biofilms

**Format** Oral

**Title:** Ozone use for decontamination of food, water, and processing environment

**List of authors:** Ahmed E. Yousef
**Organization:** Professor, Ohio State University
**Presenter:** Ahmed E. Yousef

**Abstract:** Ozone is one of several gases that constitute an emerging non-thermal decontamination technology. Ozone, a triatomic oxygen molecule, has a high oxidizing power and potent antimicrobial properties. The gas is produced electrochemically using air or water, and excess ozone is readily decomposed using heat, UV, or inorganic catalysts. Most bacteria, fungi, viruses, and protozoa are sensitive to ozone treatment. Ozone has numerous applications in its gaseous or

aqueous state. These include food, water, medical, and environmental applications. For example, ozone is widely used in the treatment of municipal and bottled water, as a safer alternative to chlorine. Emerging food applications include decontamination of fresh produce, whole shell eggs, nuts, and spices. Ozone not only inactivates microorganisms on raw agricultural commodities, but the gas is also capable of reducing pesticide residues and mycotoxins on these products.

Methods to use ozone to sterilize medical instruments are being developed. Ozone-based washers are available for cleaning and sanitizing walls and floors in food processing facilities. Research is underway to integrate ozone into the cleaning-in-place (CIP) technology. Recently, researchers found ozone to be promising in removing tenacious microbial biofilms from processing equipment during a custom-designed CIP process. Despite its many advantages, there are challenges that limit the spread of ozone use in food applications. Some of these challenges are due to the nature of ozone itself. Others are related to equipment that generates the gas. Well-thought designs are needed for treatment chambers where gaseous or aqueous ozone comes in contact with the treated product. Control of ozone in work environment is essential for the safety of equipment operators and other workers in the facility.

**Keywords:** Ozone. Decontamination. Food. Water. Processing environment. Cleaning-in-place

**Format** Oral

**Title:** Nonthermal processing technologies to enhance microbial safety and quality of fresh produce

**List of authors:** Xuetong Fan

**Organization:** USDA, ARS

**Presenter:** Xuetong Fan

**Abstract:** Microbial fresh produce safety continues to be a concern in the U.S. A number of Nonthermal intervention technologies have been developed and evaluated in recent years in an effort to minimize the risk of human pathogen contamination during postharvest handling and processing. In this presentation, chemical and physical technologies will be discussed in terms of their efficacy against common foodborne pathogens and their impact on sensory and nutritional quality of fresh and fresh-cut fresh produce. Technologies and testaments covered include washing with chemical sanitizers, gaseous and aerosolized antimicrobials (such as ozone and chlorine dioxide), UV/pulsed light, antimicrobial coating and packaging, advanced oxidation process, and integrated approaches. Challenges and considerations for commercial application of the technologies will also be discussed.

**Keywords:** Foodborne pathogens, sensory, nutrition, fresh-cut produce, wash, UV, Pulsed light

**Format** Oral

**Title:** Effects of pressure, shear, temperature, and their interaction on the inactivation of Clostridium sporogenes PA3679 spores during ultra-shear processing

**List of authors:** Hetian Hu (a); Jerish Joyner Janahar (b); V.M. Balasubramaniam* (a,b) ; Ahmed Yousef (b); Edmund Ting (c)

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**Presenter:** Hetian Hu

**Abstract:** Ultra-Shear Technology (UST) is a novel semi-continuous high-pressure food processing. By pressurizing liquid foods up to 400 MPa and decompressing them through a small gap (shear valve), the process was designed to pasteurize or sterilize liquid foods, and to modify liquid food structure and rheological characteristics. This study aims to evaluate the effects of pressure, temperature, shear, and the combination of these lethal factors on the inactivation of the endospores of Clostridium sporogenes PA3679, a non-pathogenic surrogate for proteolytic Clostridium botulinum strains.

C. sporogenes PA3679 spores (6.3 ± 0.02 log CFU/ml) were suspended in pressure-stable HEPES buffer (pH 7.0) and used for all the experiments. UST experiments were conducted at 200 or 400 MPa with exit temperatures of 30, 105, and 125oC to evaluate the lethal effects of pressure + shear and pressure + temperature + shear. Additional experiments were conducted to investigate the spore lethality of pressure-holding prior to shear discharge. A batch high-pressure processor was used to evaluate the lethal effects of pressure-only and pressure + temperature by processing the samples at 400 MPa, 30 and 105oC with 0s and 5 min holding. The thermal-only lethal effect was determined using an oil bath set at 105oC with 0s and 5 min holding. After the treatments, the survivor spores were enumerated by pour-plating the treated samples into TPGY agar plates and incubating anaerobically at 32oC for 3 days.

Results indicated pressure (400 MPa), temperature (≥ 105oC), shear, and pressure holding time (5 min) had synergistic effects on spore lethality. 400 MPa-105oC treatment resulted in a 3.3-log reduction when the spores were subjected to 5 min pressure-holding, compared to 0.4-log reduction without holding. 400 MPa-125oC UST treatment (pressure-holding at 85oC for 5 min, followed by shear discharge at 125oC) also resulted in 3.3-log spore inactivation. Less inactivation (2.2-log) was observed for the same UST treatment without pressure-holding. This illustrates the greater contribution of pressure-thermal history on spore inactivation.

Overall, this study highlighted the relative importance of pressure, temperature, and shear intensity, and treatment history on spore lethality. This study will help identify safe harbor processing conditions for high-pressure-based sterilization technologies.

**Keywords:** Ultra-Shear Technology; Clostridium sporogenes; Food Safety; Food Engineering; Commercial Sterilization
**Format** Oral

**Title:** Innovations in pulsed light technology for pasteurization of beverages
**List of authors:** Anubhav, Pratap-Singh

**Organization:** B.C. Food and Beverage Innovation Centre, Faculty of Land and Food Systems, The University of British Columbia, Vancouver, Canada

**Presenter:** Anubhav Pratap-Singh

**Abstract:** Pulsed light technology is well established in terms of food safety for food surfaces and contact equipment, and also for pasteurization of water. Challenges related to pasteurization of beverages with limited light transmittance is an important research direction to allow the extension of this technology for beverages. We will report a thin-profile continuous reactor design that achieved required 5-log reduction for pulsed light pasteurization of beverages on its' own for semi-transparent beverages like apple juice, grape juice, watermelon juice, beer, wine (absorption coefficient < 50cm-1). For almost opaque beverages like full-fat milk and carrot juices, with absorption coefficient > 50 cm-1, downstream ultrasonication processing in a continuous reactor was able to achieve 5-log reduction. Further, effects of using filters to cut-off certain wavelengths that may cause off-flavour in beer will be discussed.

**Keywords:** Pulsed light, ultrasound, beverages, milk

**Format** Oral

**Title:** Inactivation of Clostridium sporogenes PA 3679 by a synergistic pressure, temperature, and antimicrobial compound combinations

**List of authors:** Liz Astorga-Oquendo; Hetian Hu; Ahmed E. Yousef; V.M Balasubramaniam

**Organization:**

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**Presenter:** Liz Astorga-Oquendo

**Abstract:** Pressure-assisted thermal processing (PATP) technology is an emerging sterilization method for food processing with minimal heat damage while ensuring microbiological safety. This screening study aimed to investigate the antimicrobial efficacy of 23 antimicrobial compounds (enzymes, polysaccharides, cyclodextrins, and plant & fruit extracts) to enhance the inactivation of Clostridium sporogenes PA 3679 spores during pressure-assisted thermal processing (PATP).
Experiments were conducted using a bench scale high pressure processor. Spores suspended in pressure-stable buffer were pressurized at 600 MPa, 90°C and 105°C for 3- and 6-min holding time, analyzed by spread-plating on TPGY (Trypticase-Peptone-Glucose-Yeast Extract) agar, and incubated at 32°C for 5 days in anaerobic conditions. 600MPa PATP treatment with processing temperatures of 90°C (3 min holding time) and 105°C (3- and 6-min holding time) inactivated the spore survivors by 1.5-, 3.8-, and 5.8-logs, respectively. Among all the antimicrobial compounds analyzed, spore survivors were reduced by 7.9- and 6.9-logs when treated by PATP (600 MPa, 105°C, 6-min holding time) with the addition of low-molecular-weight and high-molecular-weight chitosan (0.2% w/v). We hypothesize that combined pressure-thermal treatment caused structural damage to spore coats and cortex, which facilitated the exposure of the spore core membrane to chitosan activity. Under acidic conditions, negatively charged bacteria cell membrane would interact with the positively charged protonated amino groups of chitosan, resulting in the

disruption of spore core contents, with the subsequent sporicidal effect. Unlike chitosan, other antimicrobial agents did not enhance PATP lethality. Overall, this study demonstrated that combining chitosan with PATP treatment can be an effective synergistic strategy to inactivate the spores of C. sporogenes PA 3679.

**Keywords:** Pressure-assisted thermal processing, Clostridium sporogenes spores, antimicrobial compounds, chitosan, cyclodextrins, microbiological safety.

**Format** Poster

**Title:** Pecan halves subjected to pulsed UV light: Microbial safety and quality

**List of authors:** Rabin Gyawali; Hema Degala; Ajit K. Mahapatra

**Organization:** Food Engineering Laboratory, College of Agriculture, Family Sciences, and Technology,
Fort Valley State University, Fort Valley, GA 31030

**Presenter:** Ajit K. Mahapatra

**Abstract:** Tree nuts, including pecans, can be vulnerable to bacterial contamination such as E. coli, Salmonella, and Listeria monocytogenes through harvesting methods with orchard conditions, storage, handling, and packaging during processing. Several recalls of tree nuts have been issued in the U.S. While thermal decontamination method used currently (hot water conditioning with the addition of chlorine) can inactivate pathogens, it comes with challenges of varying severity on the product, consumers, and the environment. Pulsed ultraviolet light (PUVL) has shown promise in the surface decontamination of liquid, powdered, and solid foods. To our knowledge, no previous studies have evaluated PUVL treatment's efficacy on pecan halves safety and quality. This study evaluated the application of PUVL treatment for inactivating Salmonella Typhimurium on pecan halves (Carya illinoinensis of "Stuart" variety) and its effect on kernel quality. Pecan halves inoculated with Salmonella (~6.0 log CFU/g) were treated with PUVL (3 pulses per second and 1.27 Joules/cm2) at different distances from the light source (8.28, 10.82, or 13.36 cm) and the duration of treatment were 10, 20, or 40 s. Log reductions of 1.10 to 4.52 CFU/g were achieved. Decreasing the distance between the pecan halves and the light source demonstrated an increase in bacterial reduction. Inactivation efficacy increased significantly with the increase in treatment time. Peroxide values, moisture content, water activity, color, and hardness values were tested. Results showed that these values were not significantly ($P > 0.05$) different from those of nontreated samples. Consequently, our study provides the basis for the application of PUVL treatment as an alternative treatment method to hot water and chlorine conditioning treatment for maintaining safety and quality of the nut for pecan industry.

**Keywords:** Pecans; pulsed ultraviolet light; Salmonella; microbial inactivation

**Format** Poster

**Title:** Investigation the Interaction of electric fields with the key components of spores of Bacillus subtills during Ohmic heating

**List of authors:** Shyam, Singh; Mohamed, Ali; Peter, Setlow; Sudhir, Sastry

**Organization:** The Ohio State University
University of Connecticut Health

**Presenter:** Shyam Singh

**Abstract:** Prior work shows that the electrical components of ohmic heating (OH) cause accelerated inactivation of bacterial spores. In this work we explored the effects of electric field on the inactivation of different strains of Bacillus subtilis lacking some crucial component of the spore and compared it with the conventional heating. Matching the temperature history is crucial for comparing the thermal and ohmic treatment: we used a specialized apparatus that allowed us to achieve that goal. In this study we allowed the temperature to rise linearly by applying a constant electric field, and once the samples reached the set temperature, they were immediately cooled i.e., with zero holding time. We conducted experiments at different field strength and temperatures. Our results showed that field strength had a strong effect on the inactivation of both spores, for instance the reduction in B. subtilis counts increased from 1.72±0.04 CFU/ml for 30 V/cm to 4.94±0.28 CFU/ml at 115oC for 50V/cm. We compared the inactivation data of ohmic with that of conventional heating by matching the temperature histories and we found a significant difference between ohmic and conventional (OH giving almost double inactivation at the same treatment condition). Furthermore, results of tests with spores of B. subtilis that lacked small acid soluble proteins (SASPs) suggest that SASPs are one of the targets of the electric field. Additionally, results with mutant lacking one of the inner membrane proteins (IM) suggest that EF also interact with the IM of the spore. Also, our results with recA mutant follows similar inactivation trend compared to wild type spore, suggesting that recA is not a target of OH. These findings add to our understanding of the nonthermal effects of OH and highlight the potential of OH to be used as an efficient way to kill spores without significantly affecting product quality.

**Keywords:** Ohmic heating, Spores, Small acid soluble proteins, Inner membrane, Electric field

**Format** Poster

**Title:** A novel edible coating based on UV-C treated gallic acid and chitosan: antimicrobial efficacy against Salmonella cocktail

**List of authors:** Sudarshan Reddy Medagam; Qingyang Wang; Deepti Salvi

**Organization:** Department of Food, Bioprocessing and Nutrition Sciences, North Carolina State University, Raleigh, NC

**Presenter:** Sudarshan Reddy Medagam

**Abstract:** Edible coatings, thin layers of material that can be applied to any food surface, are known to extend the shelf life of food products, preventing spoilage and quality deterioration. Edible coatings have shown promising results in inactivating several pathogens, including Salmonella. Salmonella, a foodborne pathogen, is responsible for over 1.3 million foodborne illnesses in the USA annually. In our study, we developed a novel edible coating using chitosan (CH) and gallic acid (GA) to inactivate the Salmonella cocktail. Gallic acid is a natural plant compound that has shown enhanced antimicrobial properties after being treated with UV-C light. Coating solutions were prepared with 1.5% chitosan and 1% gallic acid (at pH 3.4). Two different UV-C treated edible coating solutions were developed: EC1, where gallic acid was treated with UV-C before mixing with chitosan, and EC2, where UV-C treatment was conducted after gallic acid was mixed with chitosan. The UV-C treatment times were 10, 20, or 30 minutes. A 30-minute UV-C treated EC1 was

most effective, reducing Salmonella Typhimurium by over 6.8 log CFU/ml. With increased UV-C treatment time, EC1 improved Salmonella inactivation while EC2 decreased efficacy. Later, a 30-minute UV-C treated coating (EC1) solution was tested on the Salmonella cocktail made from S. Newport, S. Infantis, S. Typhimurium, S. Enteritidis, S. Heidelberg, and it inactivated Salmonella cocktail by > 6.9 log CFU/ml in planktonic studies. Edible coating solution (EC1), using UV-C treated gallic acid, and chitosan effectively inactivated multiple Salmonella strains and showed promise as a novel antimicrobial coating for food safety applications.

**Keywords:** Edible coating, UV-C, Salmonella, light treatment

**Format** Poster

**Title:** In Vitro resistance of free and microencapsulated Lactiplantibacillus plantarum by complex coacervation

**List of authors:** Srujana, Mekala(a); Nataly, de Almeida Costab(b); Érica, Nascif Rufino Vieiraa (a&b); Marleny, D.A. Saldaña (a)

**Organization:** a: Department of Agriculture, Food and Nutritional Science, University of Alberta, Edmonton, T6G 2R3, AB, Canada

b: Department of Food Technology, Federal University of Viçosa, Viçosa, MG, Brazil

**Presenter:** Srujana Mekala

**Abstract:** The viability of probiotics can be affected by the type of process used, wall material, application as probiotic foods, storage, and passage through the human gastrointestinal system. To date, microencapsulation has been widely used to stabilize sensitive compounds. Therefore, it can be a suitable alternative to promote the stability of probiotics subjected to extreme conditions, such as low pH, high temperatures, and in the presence of enzymes. Among the processes, complex coacervation stands out as a phenomenon of liquid-liquid phase separation that occurs under mild pH and temperature conditions. This study aimed to microencapsulate probiotic cells of Lactiplantibacillus plantarum using the complex coacervation method with gelatin and gum arabic to evaluate their resistance during in vitro simulation at gastrointestinal conditions. Microcapsules were formed using 2.5% gelatin and 2.5% gum arabic. Then, the pH of the solution was adjusted to 4.0 with 0.1 mmol/L hydrochloric acid solution. The solution was cooled to 30 °C and then immersed in an ice bath until it reached 10-12 °C. Subsequently, the solution was filtered with filter paper to remove the precipitate, which was stored in a sterile flask at 8 °C. The produced microcapsules were evaluated for viability, encapsulation efficiency, microscopy with 40x magnification, and survival of free and microencapsulated L. plantarum subjected to in vitro gastrointestinal conditions. The viability of the encapsulated L. plantarum cells was 7.7 Log CFU·g−1, and the encapsulation efficiency was 94%. After the in vitro simulation of gastrointestinal conditions, the viability of free cells showed a reduction of approximately 5 Log CFU·g−1, while the microencapsulated cell showed a reduction of approximately 1 Log CFU·g−1, confirming the resistance of the microcapsules produced to maintain the stability of the probiotics. It is concluded that the complex coacervation method produced microcapsules with characteristics suitable for application in food, as they showed high efficiency for encapsulating L. plantarum and high cell viability after in vitro simulation of gastrointestinal conditions.

**Keywords:** complex coacervation, microencapsulation, Lactiplantibacillus plantarum, probiotics
**Format** Poster

**Title:** Cold microfiltration: an alternative nonthermal pasteurization method for fluid foods and beverages
**List of authors:** Carmen, Moraru
**Organization:** Cornell University
**Presenter:** Carmen Moraru
**Abstract:** Cold microfiltration (MF) is an effective nonthermal process for the physical removal of microorganisms from fluid foods and beverages, such as skim milk, beer, wine, or juices. This presentation will review the main factors that control the effectiveness of microfiltration, the effect of processing parameters and feed properties in specific applications, as well challenges related to membrane fouling will be discussed and illustrated with data. Additionally, data on the use of MF in hurdle treatments by combining it with other nonthermal processes (i.e., ultraviolet treatment) or mild heat treatment to ensure product safety and/or extend the shelf life of juices and milk, while maintaining product quality, will be presented.
**Keywords:** Microfiltration; microbial removal; food safety; shelf life extension; hurdle treatments
**Format** Oral

**Title:** Waterless Plasma Treatment for the Safety of Shell Eggs
**List of authors:** Urvi, Shah; Deepti, Salvi
**Organization:** North Carolina State University
**Presenter:** Deepti Salvi
**Abstract:** The U.S. Food and Drug Administration (FDA) estimates that 79,000 cases of foodborne illness and 30 deaths each year are caused by eating eggs contaminated with Salmonella. Our current study investigates the efficacy of a novel technology plasma in sanitizing shell egg surfaces. Plasma, the fourth state of matter, is an ionized gas produced by applying high electrical energy. The reactive species generated by plasma have been shown to inactivate pathogens and spoilage organisms in various environments. A plasma jet with compressed air as a feed gas was used to produce plasma at high velocity through a rotating nozzle (> 2000 rpm). Eggs spot inoculated with avirulent strain Salmonella Typhimurium MHM112 or nalidixic acid resistant Klebsiella aerogenes B199A were treated with plasma at various times and at various distances from the plasma nozzle. Our results indicate that treatment conditions of 3 cm for 3 min provide a reduction of 2.5 ± 1.1 log and 2.2 ± 0.5 log for K. aerogenes and S. Typhimurium respectively. Since plasma treatment causes an increase in surface temperature of shell eggs, a hot air treatment was performed to evaluate the role of heat in microbial inactivation. However, hot air caused a very low reduction of 0.7 ± 0.05 log and 0.4 ± 0.1 log for K. aerogenes and S. Typhimurium respectively and was statistically significant from plasma treatment. There was no difference between plasma treatment side and

control side of the same egg in L*, a*, and b* values that were measured at 3 locations on equatorial region of each side of shell egg. Similarly, a cuticle dye study performed to investigate the degree of cuticle coverage (the outermost protective layer) showed insignificant difference between plasma treated and control side of the same egg. All experiments had a minimum of 3 independent replications and statistical analysis was performed using student t-test at $p<0.05$. Plasma can be a new sustainable technology to replace the existing washing system, reduce water and chemical usage, and improve the safety of shell eggs without damaging cuticle.

**Keywords:** Plasma; Shell Eggs; Cuticle; Salmonella

**Format** Poster

**Title:** Continuous high-capacity particulate foods pasteurization system and process

**List of authors:** Dongjie Chen, Peng Peng, Erik Anderson, Juer Liu, Yiwei Ma, Yanling Cheng, Kirk Cobb, Laurence Lee, Paul Chen, and Roger Ruan

**Organization:** University of Minnesota

**Presenter:** Dongjie Chen

**Abstract:** Low-moisture particulate foods comprise a wide range of food products such as milk powder, protein powder, egg powder, whey powder, spice, flour, grain, and seeds. Various pathogens or toxins such as C. sakazakii, Salmonella spp., Bacillus cereus spores, and deoxynivalenol (DON) can be present and potentially infectious in particulate food matrices. These contaminants are physiologically dormant and metabolically quiescent in low moisture particulate foods and are therefore resistant to conventional thermal processes. Thermal processing may also cause some degree of undesirable flavor and quality changes in particulate food products that may render them unacceptable for use by consumers and food industries. This invention describes an apparatus that enables the pasteurization of particulate foods. Contributing to 3-5 log10 CFU/g pathogen reduction within 30-120 seconds. The system is explicitly designed to be compatible with harsh external environments. The intense pulsed light (IPL) source is incorporated with a seal on the treatment chamber, covered with a flexible insulation jacket, that ensures a stable internal environmental condition, to maintain the quality of the samples. Humidity and temperature sensors mounted on the apparatus are used to monitor and control the internal environmental conditions. Finally, a combination of volumetric and vibratory feeders is utilized to offer the feasibility of continuous treatment. This prototype system is ready to scale up, and further test for market applications, and looking for prospective investors and collaborators.

**Keywords:** Low-moisture particulate foods, Intense pulsed light

**Format** Poster

## Session 3 - Enhancing Nutrition, Quality, and Health through Nonthermal Processing

**Title:** Extraction of Anthocyanins from Amazon Matrices Using Ultrasound and Natural Deep Eutectic Solvents (NADES)

**List of authors:** Ianê, Valente Pires; Miguel, Franco Londoño; Luiza Helena, Meller da Silva; Antonio Manoel, da Cruz Rodrigues; Marleny D., A Saldaña

**Organization:** University of Alberta (Canada): Ianê, Valente Pires; Miguel, Franco Londoño; Marleny D., A Saldaña
Universidade Federal do Pará (Brazil): Ianê, Valente Pires; Luiza Helena, Meller da Silva; Antonio Manoel, da Cruz Rodrigues

**Presenter:** Miguel Franco Londoño

**Abstract:** Anthocyanins are natural pigments widely available in various plant sources and known for their antioxidant properties and potential health benefits. Extraction of these anthocyanins is of paramount interest for the food and pharmaceutical industries. This study focuses on the utilization of Natural Deep Eutectic Solvents (NADES) as environmentally friendly and sustainable extraction process for anthocyanins from açaí (Euterpe oleracea), mangosteen peel (Garcinia mangostana L.), and purple yam (Dioscorea trifida). NADES are composed of naturally occurring compounds, making them an attractive alternative to conventional organic solvents. The high intensity ultrasound extraction process involved a systematic investigation of the mixture of choline chloride and lactic acid (ChCl:LA) in different molar compositions to optimize the yield of anthocyanins while considering factors such as molarity, solid-to-liquid ratio (S/L), water content, extraction time and power (W). The extraction efficiency of anthocyanins was significantly influenced by the molarity of the NADES. A higher amount of lactic acid increased anthocyanin yields. Additionally, the incorporation of water to the NADES significantly improved the extraction yield, suggesting a water-enhanced mechanism for anthocyanin extraction. Overall, higher power levels resulted in increased anthocyanin recovery. The results showed that the NADES, ChCl:LA (1:2 molar ratio) + 30% of water exhibited high extraction efficiency for anthocyanins from açaí and mangosteen peel while the composition ChCl:LA (1:3 molar ratio) + 20% of water had the best performance for purple yam. The results were compared to those obtained using traditional solvents, specifically methanol, ethanol, and water, and demonstrated comparable, or in some cases, superior effectiveness in anthocyanin extraction. Overall, this research underscores the promising potential of NADES as green solvents for the efficient extraction of anthocyanins from açaí, mangosteen peel, and purple yam. The comprehensive anthocyanin extraction enhances our understanding of these natural compounds and opens doors for their utilization in various industries, particularly in the development of functional foods and pharmaceuticals.

**Keywords:** Anthocyanins; extraction; green chemistry; Natural Deep Eutectic Solvents (NADES)

**Format** Poster

**Title:** Lentil protein and pectin gels loaded with β-carotene: Understanding the effect of ultrasonic ethanolic gelation and supercritical CO2 drying

**List of authors:** Srujana, Mekala; Marleny, D.A. Saldaña

**Organization:** University of Alberta

**Presenter:** Srujana Mekala

**Abstract:** There has been a growing interest to encapsulate bioactive compounds like β-carotene to enhance its bioavailability and stability. High-intensity ultrasound (HIUS) and supercritical CO2 (SC-CO2) technology offer a non-thermal approach to encapsulate thermolabile β-carotene. In addition, the increasing interest towards plant-based diets by consumers has led to a change in food consumption patterns. In this context, pectin and lentil protein can provide a sustainable, biocompatible, and nutritionally rich food source characterized by its high protein content and micronutrients. Also, lentil protein has favorable functional characteristics in terms of solubility, emulsification, and foaming. However, there is limited research on exploring the gelling properties of lentil protein for encapsulation. Therefore, this study investigates the use of ultrasound-assisted ethanolic gelation of lentil protein and pectin as a potentially effective technique for encapsulating β-carotene. The impact of HIUS nominal power, pH, and ethanol on the physico-chemical and functional properties of the lentil protein-pectin emulsion gels were evaluated in this study. The gelling ability was significantly dependent on the HIUS nominal power, and ethanol content. The addition of ethanol promoted instantaneous gelation phenomenon. The stability of the emulsion gels was determined by performing syneresis test. The emulsion gels processed at high nominal powers of 600 W and 900 W exhibited low syneresis, indicating improved stability. In addition, the emulsion gels formed at acidic and alkaline pH (2-3 and 8-10, respectively) were stable due to the protein-protein and protein-polysaccharide interactions. However, extreme pH conditions contributed to the disintegration of the gel network due to pH-induced denaturation. Additionally, the HIUS nominal power caused breaking down of larger protein-polysaccharide aggregates thereby promoting the interactions between lentil protein and pectin. Furthermore, the emulsion gels obtained were dried using SC-CO2 to form aerogels with improved storage stability. The aerogel structures formed using SC-CO2 drying had a porous structure with low density. In conclusion, ultrasound and SC-CO2 drying showed promising results for encapsulating β-carotene. The emulsion gels and aerogels obtained in this study had desirable physico-chemical properties such as stability and microstructure, making them suitable for applications in functional foods and nutraceuticals.

**Keywords:** High-intensity ultrasound, supercritical CO2, gels, β-carotene

**Format** Poster

**Title:** Effect of non-thermal processing on physicochemical and immunochemical properties of seafood proteins

**List of authors:** Qinchun Rao; Chunya Tang; Yaqi Zhao; Xingyi Jiang

**Organization:** Florida State University

**Presenter:** Qinchun Rao

**Abstract:** Introduction: The seafood allergy prevalence in the US was 2.3%. Specifically, finfish parvalbumin and finfish/crustacean shellfish tropomyosin are well-recognized allergens, contributing further to the prevalence of seafood allergies. Non-thermal processing techniques such as ultrasonication and cold plasma treatment offer an alternative to conventional thermal processing in the seafood industry as they better preserve heat-sensitive nutrients.
Purpose: This study investigates the effect of two novel non-thermal processing methods - cold plasma treatment and ultrasonication - on seafood protein analysis.
Methods: Water was activated using cold plasma with two gas sources (i.e., air and nitrogen) for various durations (5, 10 and 20 min). Lyophilized white shrimp (Litopenaeus setiferus) and Atlantic cod (Gadus morhua) were extracted using untreated (control) and plasma-activated water. In addition, the control water-soluble protein extracts were treated with probe sonication at 20% and 50% amplitude for 10 min each. Non-thermal processing-induced protein physicochemical changes, such as solubility, size distribution and zeta potential, profile, and immunoreactivity, were studied using bicinchoninic acid (BCA) assay, dynamic light scattering, gel electrophoresis, and enzyme-linked immunosorbent assay (ELISA), respectively.
Results: The results indicated that air-cold plasma-activated water exhibited significantly higher nitrate and peroxide levels and lower pH than untreated water. Regarding the shrimp extracts, ultrasonication decreased the particle size but increased the zeta potential, a trend not observed in cod extracts. The protein profile from plasma-activated water-soluble shrimp and cod protein extracts was similar to the control sample. However, large molecular weight seafood proteins were dissociated as a function of ultrasonication amplitude. As for antigenicity, the immunoreactivity of shrimp tropomyosin decreased with ultrasonication, while cod tropomyosin remained unaffected. Plasma-activated water extraction increased the immunoreactivity of shrimp tropomyosin but decreased that of cod parvalbumin.
Significance: The significance of this study lies in the potential applications of cold plasma-activated water extraction and ultrasonication to alter protein physicochemical properties, particularly in relation to food allergens. These techniques offer a promising approach for tailoring the antigenicity of seafood allergens, which could ultimately contribute to improved safety and quality in the seafood industry.

**Keywords:** Ultrasonication; Cold plasma treatment; Physicochemical and immunochemical properties; Seafood proteins

**Format** Poster

**Title:** Addition of lutein in minimally processed fruit salads by vacuum impregnation

**List of authors:** Zhengjie Liu (a); Nataly de Almeida Costa (b), Mônica Santana Moreira (a), Thábata Ludmila Isidoro (a), Érica Nascif Rufino Vieira (ab) and Marleny D.A. Saldaña (a)*

**Organization:** (a) Department of Agriculture, Food and Nutritional Science, University of Alberta, Edmonton, T6G 2R3, AB, Canada
(b) Department of Food Technology, Federal University of Viçosa, Viçosa, MG, Brazil

**Presenter:** Zhengjie Liu

**Abstract:** An exponential growth in the consumption of fresh fruits and vegetables has been observed due to changes in the population's lifestyle and the preference for healthier eating habits. Lutein is a carotenoid that acts as an antioxidant, protecting cells from oxidative damage and reducing the risk of developing some chronic degenerative diseases. In addition to its benefits, lutein has been used in the food industry as a natural dye to enrich fruit products. Therefore, the objective of this study was to evaluate the addition of lutein in banana, peach, papaya, and mango minimally processed by vacuum impregnation to elaborate a functional food of vegetable matrix, adding value to the product and contributing to the increase in consumption of fruits. Lutein was added to minimally processed fruit salad by vacuum impregnation, and preliminary tests were carried out to select the ideal treatment conditions (Pressure of 500 mmHg and a vacuum time of 7 min). Samples were evaluated for total carotenoid content by spectrophotometer, HPLC, color, vitamin C, and texture. Using vacuum impregnation, maximum carotenoid retention was observed despite changes in the color and firmness of the fruit used. The treatment that used vacuum impregnation of lutein presented the minimum recommended daily amount of 6 mg of carotenoids in 25 g of salad. Regarding texture, the vacuum impregnation technique promoted a reduction in firmness in minimally processed fruits compared to fresh fruit. For vitamin C content, it was observed that there was no significant difference between the control treatments and those added with lutein by vacuum impregnation. Therefore, it was verified that the intake of 25 g of fruit salad evaluated in this study immediately after processing can supply the recommended daily amount of carotenoids. It is concluded that vacuum impregnation is a viable technique for incorporating components with high nutritional value, capable of adding value and greater functionality to the product.

**Keywords:** Lutein; Minimally processed fruit; Vacuum impregnation

**Format** Poster

**Title:** High Intensity Ultrasound Extraction of Anthocyanins and Total Phenolics from Cranberry Pomace using Natural Deep Eutectic Solvents

**List of authors:** Miguel, Franco Londoño; Marleny D., A. Saldaña

**Organization:** Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada

**Presenter:** Miguel Franco Londoño

**Abstract:** The utilization of high-intensity ultrasound (HIUS) in conjunction with natural deep eutectic solvents (NADES) represents a novel approach for obtaining desired compounds from natural matrices. Cranberry pomace, a by-product of the juice industry, is known for its high concentrations of anthocyanins and phenolics, which have potential health benefits. The objective of this study was to optimize the extraction of these valuable compounds from cranberry pomace by employing HIUS at power levels ranging from 300 to 1200 W, with extraction times of up to 5 min. The HIUS-assisted extractions using NADES were compared with those using a conventional solvent, 70% ethanol (v/v). The total anthocyanin content and total phenolic content were determined.

The results from the HIUS treatments revealed that specific NADES did not exhibit statistically significant differences in the extraction performance compared to

traditional solvents. Notably, a mixture of Glucose:Lactic acid (1:5 molar ratio + 20% water w/w, 1/50 solid-to-liquid ratio) yielded a total phenolic content of 21.9 mg gallic acid equivalent (GAE)/g, while 70% ethanol yielded 22.3 mg GAE/g. Furthermore, Chloride:Glycerol (1:5 molar ratio, + 50% water w/w) and Choline Chloride:Acetic Acid (1:2 molar ratio, + 30% water w/w) resulted in total anthocyanin contents of 0.77 and 0.75 mg cyanidin-3-glucoside equivalent (Cy3GE)/g, respectively, offering a promising alternative to ethanol, which yielded 0.86 mg Cy3GE/g, all samples were treated at 600 W for 5 min.
It is noteworthy that the viscosity and pH of NADES are critical factors influencing the extraction of bioactives in the sample. The enhanced efficiency of NADES-assisted HIUS extraction can be attributed to their ability to improve solubility and interact favorably with anthocyanins and phenolics. These findings contribute to the expansion of environmentally friendly extraction methods and offer potential applications for the resulting extracts in the food, pharmaceutical, and nutraceutical industries.

**Keywords:** Anthocyanins, Cranberry Pomace, High Intensity Ultrasound (HIUS), Natural Deep Eutectic Solvents (NADES)

**Format** Poster

**Title:** High Pressure Processing (HPP) of pulse proteins: effects of acidification and calcium addition on protein structure and functionality

**List of authors:** April, Huang; Carmen, Moraru
**Organization:** Cornell University
**Presenter:** Carmen Moraru

**Abstract:** There is growing interest in using pulses as a plant protein source, driven by environmental, ethical, and health concerns. Pulse proteins exhibit useful functionalities, including gelation, which is crucial for the texture of many food applications. Their utilization can be expanded by utilizing processing methods and formulations able to optimize their functional properties. In this work, the effect of high pressure processing (HPP) (600MPa, 5°C, 4 min), as well as acidification and calcium addition on the structure and functionality of pea, lentil, and faba bean proteins was investigated, and compared to the effect of thermal processing (95°C, 15 min). Protein concentrates were used to prepare solutions with 15g protein/100, which were then subjected to the specified treatments and evaluated using rheological, texture profile, and water holding capacity analyses. Both HPP and thermal processing resulted in strong gel formation (tanδ1 rad/s <0.25), with HPP-induced gels generally having lower strength (G') and lower water holding capacity, but higher cohesiveness than the thermally-induced gels ($p<0.05$). HPP-induced gels were visually smoother and more homogenous compared to thermally-induced gels. Acidification increased gel strength ($p<0.05$) for both HPP and thermally processed samples as a result of protein aggregation caused by reduced electrostatic repulsion near the pI of pulse proteins. The effect of calcium differed based on acidification level and process. At lower acidification levels (starting pH ~6.5, 5.5), calcium increased gel strength (G') and hardness for HPP-induced gels, but decreased hardness for thermally-induced gels. This work can help guide new product formulation of high-protein food applications using pulse protein ingredients by mapping out the diversity of distinct gel characteristics that

can be achieved through both nonthermal and thermal processing, as well as formulation.

**Keywords:** HPP; Pulse Proteins; Gelation; Calcium addition; acidification

**Format** Poster

**Title:** Conversion of almond hulls to functional ingredients for clean label foods and nutraceutical products

**List of authors:** Juer Liu; Jun An; Yiwei Ma; Dongjie Chen; Nan Zhou; Renchuan Zhang; Yanling Cheng; Peng Peng; Min Addy; Paul Chen; Chi Chen; Guangwei Huang; Roger Ruan*

**Organization:** University of Minnesota

**Presenter:** Juer Liu

**Abstract:** California produces more than 80% of world's supply of almonds. Almond hulls are residues which take up to 50% by dry weight of the almond fruits yielded. We found that almond hulls are rich in sugar and contain considerably high crude fiber and antioxidants contents in our preliminary studies. The physical modification including ultra-sound sonication, homogenization and freeze-drying techniques were adopted in the research for reducing size and altering the structure of almond hulls to improve functional properties and release antioxidants. Potential products made from the functional ingredients for different versatile uses, ranging from ingredients, drink powder, bottled drink to moisturizer, were explored. Moreover, the phenolic composition in the phenolic-rich extract from almond hull (PEAH) was also characterized and its bioavailability and protective effect on human intestinal oxidative stress Caco-2 cells induced by t-BOOH was evaluated.

**Keywords:** almond hull; non thermal technology; antioxidant;

**Format** Poster

**Title:** Potential Benefits of Monitoring Perishable Non-Thermally Preserved Foods Quality through their Package's Quick Response (QR) Code

**List of authors:** I. Sam Saguy; Eli Cohen; Micha Peleg

**Organization:** The Robert H. Smith Faculty of Agriculture, Food & EnvironmentThe Hebrew University of Jerusalem, Israel; Gilford Glazer Faculty of Business Administration, Ben-Gurion University of the Negev Beer-Sheva, Israel; Department of Food Science, University of Massachusetts, Amherst, MA 01003, United States

**Presenter:** I. Sam Saguy

**Abstract:** Non-thermal preservation offers food products of superior quality. To maintain quality and ensure their safety, relatively low temperatures is kept during handling, transport, and storage, until their consumption. Inevitably, the individual product's temperature fluctuates and can reach levels that can have noticeable adverse effect on its consumer acceptance, increase waste, and in extreme situations may even become a potential health hazard.
Quick-Response (QR) with built-in colorimetric sensors with a customized smartphone application to simultaneously read the QR code and the colorimetric sensors can be exploited to minimize these risks, serving as a quality indicator, and an aid to marketing decisions. QR popularity stems from its ease of use,

augmented by smartphones proliferation. In principle, its output can be combined with that of other QRs of the same product, and/or at different times, and translated into a decision on how to proceed with the aid of artificial intelligence algorithms.
The approach ought to be based on the product's deterioration kinetics with emphasis on the temperature's role in the pertinent range, and on the kinetics of the colorimetric changes in the QR itself and their temperature dependence. If needed, the roles of humidity, light and/or other factors might be quantified too or eliminated by appropriate specific means.
The parallel kinetics of the food product and the QR sensor(s) can be quantified in term of conventional or novel mathematical models depending on the monitored reactions. These reactions can be the degradation of a chosen ingredient or the synthesis of new compounds in the food, or in the chosen marker of the QR. If needed, more than one reaction in each could be monitored, its kinetics quantified and used to establish the product quality criteria, which might be surpassed in more than one way. Because data obtained from a single QR and especially several QRs are expected to be collected at irregular intervals, statistical method(s) will have to be developed to translate them into useful information about the monitored product's quality and their reliability. This is where AI could be particularly useful to establish the methodology and expand its use by the food industry.

**Keywords:** Quality management, time-temperature data, kinetic model

**Format** Virtual

**Title:** The impact of nonthermal processing on the bioaccessibility of health-promoting compounds

**List of authors:** Eden Eran Nagar (1); Anna-Sophie Stübler (2); Kemal Aganovic (2); Zoya Okun (1); Avi Shpigelman (1)

**Organization:** (1) Faculty of Biotechnology and Food Engineering, Technion, Israel Institute of Technology, Haifa, 3200003, Israel
(2) DIL German Institute of Food Technologies e.V, Prof.-v.-Klitzing-Str. 7, 49610, Quakenbrück, Germany

**Presenter:** Avi Shpigelman

**Abstract:** Considerable epidemiologic evidence has indicated that consuming fruits and vegetables is associated with a lower incidence of chronic diseases like cancer, cardiovascular and many others. Often, the high content of polyphenolic compounds in those products was suggested to be responsible for the beneficial effect, with those compounds presenting a range of biological activities, including anti-allergic, anti-inflammatory, antiviral, anti-proliferative, and anti-carcinogenic activities, additionally to effects on mammalian metabolism. It was suggested that the most limiting issue in the application of those natural compounds for the development of both preventive and treating preparations or in their optimal utilization from foods is their low in vivo bio-efficacy, often originating from the low bioaccessibility associated with low aqueous solubility, limited intestinal absorption, chemical instability in the preparation or the gastric track, microbial metabolism in the lower intestine and other limitations. Nonthermal processing, especially high pressure (HP) based and pulsed electric fields (PEF), were studied as

tools to ensure microbial safety, yet they also result in different impacts on bioaccessibility and bioavailability compared to the standard thermal processing. Most existing studies tested the bioaccessibility only in real and complex food matrixes. While such research provides the most direct and wholesome information for the specific matrix/product, the many superimposing effects, strongly affected by the impact of processing on the macrostructural properties of the food, make it harder to reveal the underlying mechanisms and to predict the bioaccessibility in slightly different matrixes and/or processing conditions. The talk will present updated information regarding nonthermal technologies' potential advantages and shortcomings as tools for engineering the bioaccessibility of health-promoting compounds. Furthermore, it will compare the results of complex foods systems with the most simplistic model systems, showing that the impact of nonthermal processing goes beyond the modification of the macro- and cellular-structure of foods and can affect the bioaccessibility of those health-promoting compounds via the impact on stability, interactions with macromolecules such as polysaccharides and proteins and even polyphenol-polyphenol interactions. Finally, we will discuss the future of utilizing nonthermal technologies and formualtion to engineer polyphenol-rich foods for optimal maximal health benefits.

**Keywords:** Nonthermal processing; Bioaccessibility; polyphenols

**Format** Poster

**Title:** Industry Perspectives on the Future of Food: Implementing Nonthermal Processing Technologies in Industrial Practice

**List of authors:** Marcia Walker

**Organization:** Oregon State University

**Presenter:** Marcia Walker

**Abstract:** The consumer demand for innovative, healthy and convenient foods has been a theme in my food career. Food innovation can involve the development of new food processes, products and packages to bring new and exciting products to market. Food industry Innovation involves all aspects of the food supply chain. Food and beverage companies continuously find more ways to produce healthier and newer options for consumers. Food innovations are often seen in products with healthier or premium ingredients or offer a consumer a convenient option for healthier RTE or prepared foods.

Consumer requests for food that is produced in a sustainable way, minimally processed, natural, free from additives and provides a maximum level of safety, convenience, taste, and nutrients are currently challenging food manufacturers to keep up with this demand. Processing technologies play a major role in food innovation, I will highlight the technical aspects of commercializing new technologies through product, process and packaging. And share lessons learned in adoption of new technologies.

I will also highlight my experience with developing and marketing plant-based food products utilizing nonthermal technologies. With the diversity of the consumer eating plant-based foods shifting, so has an increased expectation for these products to deliver on flavor, quality and innovation. Traditional vegan or vegetarian products are no longer the acceptable norm. HPP offers an innovative path to creating better quality products as well as improving the ingredient

statements and shelf-life.
The presentation will give an overview on innovation and meeting the consumer need and explore the opportunity that HPP and new technologies can offer in developing and commercializing innovative food and beverage products.

**Keywords:** HPP;innovation; commercialization;nonthermal processing

**Format** Oral

## Session 4 - Nonthermal Process Development and Validation

**Title:** Head-to-Head: Comparing Air and Surface Disinfection Systems

**List of authors:** Rick L. Falkenberg

**Organization:** Rick Falkenberg, Ph.D., CFS

**Presenter:** Rick L. Falkenberg

**Abstract:** Background: Pathogenic contamination of air and surfaces continues to be a serious challenge to food safety; causing death, illness, and product loss. Examining innovative, no-touch, chemical-free air and surface disinfection technologies is critical. Many no-touch air and surface disinfection technologies have come to market recently, but testing protocols have not been standardized and marketers of these products often don't use scientific language, making comparisons difficult. This study identifies a Modulated Dielectric Barrier Discharge air treatment system as an innovative and effective nonthermal technology to control pathogens in air and on surfaces.

Methods: We evaluated five commercially available air treatment systems representing four distinct technologies: Modulated Dielectric Barrier Discharge (MDBD), Bipolar ionization (BPI), Photocatalytic Oxidation (PCO), and UV-C to measure antibacterial and antiviral efficacy in the air and on common surfaces. The treatment room was 22' x 12' x 10'. Enterococcus faecium bacteria and the F-9 strain of Feline Calicivirus were both aerosolized and used to inoculate stainless steel, plastic, linoleum, and fabric coupons.

Results:
Log reductions at 1 (one) minute of treatment of aerosolized virus:
MDBD 7.74, BPI 0.12, PCO 0.05, and UV-C 0.03.

Log reductions at 2 (two) minutes of treatment of aerosolized bacteria:
MDBD 7.82, BPI 0.32, PCO 0.06, and UV-C 0.06.

Log reductions at 15 (fifteen) minutes of treatment of surface virus:
MDBD 7.70, BPI 0.42, PCO 0.24, UV-C 0.15

Log reductions at 30 (thirty) minutes of treatment of surface bacteria:
MDBD 7.89, BPI 0.54, PCO 0.11, UV-C 0.04

Conclusion: The results of this study objectively reveal the efficacy achieved with

the Modulated Dielectric Barrier Discharge air treatment system was significant, and far greater than the efficacy of the Bipolar Ionization, Photocatalytic Oxidation, and UV-C Germicidal Air Chamber systems tested. This comparison of technologies reveals a modulated dielectric barrier discharge air treatment system may be a novel and effective enhancement to traditional disinfection protocols.

**Keywords:** no-touch disinfection;disinfection technology comparison;food biosafety;novel technology

**Format** Oral

**Title:** Modeling of Pulsed Electric Field Processing

**List of authors:** Sudhir K. Sastry

**Organization:** The Ohio State University

**Presenter:** Sudhir K. Sastry

**Abstract:** Modeling the physics of the pulsed electric field (PEF) process for pasteurization is challenging, due to the rapid and fleeting nature of the electric field, and the multiscale characteristics of the problem. Verification of such models is equally challenging since electric field and temperature distributions within commercial systems cannot be easily measured. This has resulted in most researchers focusing on microbial inactivation kinetics rather than transport phenomena or the basic physics.

Herein, we discuss the modeling of the pulsed electric field (PEF) process, with attention focused on the originally intended application of pasteurization of liquid foods. First are the models for electroporation (of molecular scale), derived from physics and physical chemistry considerations, and their extension to probabilistic approaches which treat pore formation as a random process. We discuss the more recent approaches involving molecular dynamics.

Then, we consider treatment-chamber and system scale models, which are based on continuum physics approaches, and rely on computational Multiphysics codes for their solution. In this section, we discuss the base assumptions for several modeling studies, particularly the fully transient treatments and the quasi-steady-state treatments, and discuss the challenges inherent in simplifying assumptions. Various attempts at experimental verification are also discussed. Here again, challenges exist due to difficulties in temporal and spatial resolution.

We also consider models for inactivation kinetics for bacteria exposed to PEF, including the first order, Hulsheger, Peleg and Weibull models. In these situations, the use of continuous flow systems for characterization of kinetics results in errors due to residence time distributions. We close with discussions of other models and experimental approaches for model verification and obtaining kinetic parameters from continuous flow PEF systems.

**Keywords:** mathematical modeling; pulsed electric field; pasteurization

**Format** Oral

**Title:** AI-assisted process design and optimization in ultrasound applications

**List of authors:** Amir Malvandi; Mengyi Dong; and Hao Feng

**Organization:** University of Illinois at Urbana-Champaign; Duke University; North Carolina A&T State University
**Presenter:** Hao Feng
**Abstract:** In recent years, AI has gained increasing significance in food processing design and innovation. AI-assisted process design and optimization enables food engineers to make data-driven decisions to maximize process efficiency, improve product quality and safety, and enhance sustainability. In this presentation, we will highlight two studies exemplifying the integration of AI tools into ultrasound-assisted food processing.

The first study focuses on the non-thermal drying of food polymeric materials. In this research, a strategy was devised using dynamic programming and reinforcement learning to design and optimize an innovative ultrasonic drying process. This process aimed to reduce energy consumption and enhance product quality. Additionally, within the ultrasonic drying procedure, the role of NIR (Near-Infrared Spectroscopy) was explored for monitoring, adaptive controlling, preventing over-processing, facilitating data-driven decision-making, and further improving product quality and safety.

The second study explores the use of Taguchi DOE and machine learning to understand how multiple sanitation factors work together to shape a dynamic ultrasound-assisted fresh-cut leafy green sanitation process and its outcomes. The models were further used to optimize the sanitation factor settings of agitation speed, batch load, ultrasound power, and sanitizer concentration.
**Keywords:** Ultrasound, AI, machine learning, reinforcement learning, fresh produce
**Format** Oral

## Session 5 – Sustainable Nonthermal Food Processing

**Title:** Nonthermal Processing and Sustainability
**List of authors:** Dennis R Heldman
**Organization:** The Ohio State University
**Presenter:** Dennis R Heldman
**Abstract:** As interests in sustainability of the entire food supply chain increase, more investigations are evaluating the impacts of different food preservation processes. The overall objective of this review is to highlight differences and similarities of traditional and non-traditional approaches to preservation of food.
Traditional approaches to food preservation have involved significant adjustments of product temperature. Thermal processes have achieved preservation by significant elevations in product temperature, as needed for inactivation of microbial populations or other shelf-life limiting reactions. Reductions in product temperature to near 0 C or to temperatures causing phase change in water have been equally popular. As attention to energy resources increases, these traditional approaches to food preservation will require more careful analysis.
This presentation will review current literature on outcomes from Life Cycle

Assessment (LCA) for different food preservation processes, with a focus on comparison of traditional processes, as compared to nonthermal processes. The analysis will compare the impacts of thermal and nonthermal preservation processes on natural resources, as well as the overall impacts of the entire supply chain for each on energy demand and environmental quality.

**Keywords:** Sustainability, LCA, Preservation, Resources

**Format** Oral

**Title:** Achieving high concentrations without heat or pressure with Porifera's forward osmosis technology

**List of authors:** Jennifer Klare; Olgica Bakajin

**Organization:** Porifera Inc.

**Presenter:** Jennifer Klare

**Abstract:** While food and beverage concentrates are used in the industry to save on storage and transportation or to flavor other products like ice cream, conventionally made concentrates do not preserve the authenticity of the initial product. Conventional thermal processes can reach high concentrations but severely degrade flavor and aroma. An alternative concentration technology, freeze concentration, encounters difficulties at high concentrations due to viscosity.

Porifera's PFO products are ideal for concentrating streams with high osmotic pressures and suspended solids in both waste and food and beverage applications, such as fruit juice, coffee, and beer. Porifera's innovations include a new high flux, high selectivity forward osmosis (FO) membrane combined with a new element design for FO processing. The advantages of Porifera's PFO technology include low head-loss, reduced footprint, and both co-current and counter-current processing. Porifera has also developed FO membrane systems with draw recovery for high osmotic pressure processing, competing with thermal evaporators.

Implementation of Porifera's technology results in reduced greenhouse gas emissions and water use paired with improved concentrate quality. This talk will provide the latest information on Porifera's PFO technology including our success on beer concentration that produces a 6x beer concentrate!

**Keywords:** membrane concentration; forward osmosis; sustainable processing

**Format** Oral

**Title:** Conversion of Almond Hulls to Value-added and Upcycled Food Ingredients

**List of authors:** Guangwei Huang

**Organization:** Almond Board of California

**Presenter:** Guangwei Huang

**Abstract:** Central Valley of California produces 80% of global almond supply. Almond hulls are a byproduct from hulling and shelling process of almond nuts, accounting for about 50% of almond nut weight, and currently used as a feed supplement by local dairy and beef cattle farms. Hulls are outer layer fruit flesh of almond nuts, just like dried peach or apricot flesh, but they are enriched with a high level of phytochemicals during natural drying process as nuts on the trees are exposed to sunlight for a long duration. Almond hulls are rich in fiber and phytochemicals, and

these make hulls unique for value-added utilization. Almond hulls contain 36% dietary fiber, including 6.5% soluble fiber, also contain up to 42% extractable sugars with about 9% non-fermentable sugars. Extracted phenolic compounds make up about 4 to 5.5% of almond hulls. Several food ingredients, such as functional dietary fibers, emulsifier, functional syrup, antioxidants, and a functional beverage drink powder, have been prepared from hulls by our collaborators at ABC. The prototype products made from hull-derived ingredients have shown good palatability and improved nutrient profile in dietary fiber level, and a greater antioxidant capacity than popular commercial products. Based on preliminary economic analysis, the derived ingredients can increase hull value by 10 to 50 times after processing costs. Therefore, processing almond hulls into functional food ingredients add value to a byproduct and the hull derived ingredients are qualified for Upcycled Food Ingredient claim. The presentation will review nonthermal processes used for production and functional properties of hull derived ingredients, and characteristics of a few prototype food products.

**Keywords:** Almond, hull, dietary fiber, phytochemicals, phenolics, antioxidant, nonthermal processing

**Format** Oral

**Title:** Transforming the Food and Agriculture System to be Sustainable and Circular

**List of authors:** Norman R. Scott

**Organization:** Cornell University

**Presenter:** Norman R. Scott

**Abstract:** No area of human activity is more essential to society than a sustainable Food and Agriculture System (FAS). Agricultural productivity has been a consistent and important focus during the 20 th and 21 st centuries, with good reason, to feed a growing world population. However, while providing safe and affordable food remains a driving force for the FAS, there are emerging and numerous factors that challenge our present and future FAS. Some of these are: impacts of the FAS on the environment; trust in science and technology; increasing urbanization; climate change; changing food preferences; globalization; integrated value chains; international regulations; economic viability of rural communities; and more recently a recognition of the disruption that major events such as a pandemic and a war can create for the FAS. Since the 1990's to present, the sustainability of the FAS has become an accepted concept to capture the intersection of environment, economics and equity (or social responsibility). More recently the ASABE (American Society of Agricultural and Biological Engineers), in collaboration with other group, has developed a Society-wide initiative to include circularity as a key concept to develop sustainable and circular food and agriculture systems. A major focus is decarbonization of the FAS through a comprehensive assessment of scientific and technological developments to transform the FAS.

The seminar focuses on: the characterization of the FAS, from domestication to today's highly complex and adaptive system; both the impact of the FAS on the environment and the effect of the environment on the FAS (climate change); the role of the FAS as an energy supplier as well as an energy consumer; the effects of changing food preferences and dietary changes on emissions and energy; the role of the FAS in meeting Sustainable Development Goals (SDGs); the challenges of

socio-technical innovations across global and local levels; and the impact of such specific technologies: food processing, reducing food loss & waste, renewable energy sources (solar power, wind, geothermal and bioenergy, including biofuels and biochar), digital agriculture, nanotechnology, biotechnology (CRISPR), regenerative agriculture/agroecology, agroforestry, electrification, the circular economy, and synthetic biological food developments.

**Keywords:** Food and Agriculture System, sustainability, climate change, waste, renewable energy

**Format** Oral

**Title:** High Pressure Processing (HPP) of pulse proteins: Effects of acidification and calcium addition on protein structure and functionality

**List of authors:** April Huang; Carmen I. Moraru

**Organization:** Department of Food Science, Cornell University, Ithaca, NY 14853

**Presenter:** April Huang

**Abstract:** There is growing interest in using pulses as a plant protein source, driven by environmental, ethical, and health concerns. Pulse proteins exhibit useful functionalities, including gelation, which is crucial for the texture of many food applications. Their utilization can be expanded by utilizing processing methods and formulations able to optimize their functional properties. In this work, the effect of high pressure processing (HPP) (600MPa, 5°C, 4 min), as well as acidification and calcium addition on the structure and functionality of pea, lentil, and faba bean proteins was investigated, and compared to the effect of thermal processing (95°C, 15 min). Protein concentrates were used to prepare solutions with 15g protein/100, which were then subjected to the specified treatments and evaluated using rheological, texture profile, and water holding capacity analyses. Both HPP and thermal processing resulted in strong gel formation (tanδ1 rad/s <0.25), with HPP-induced gels generally having lower strength (G') and lower water holding capacity, but higher cohesiveness than the thermally-induced gels ($p<0.05$). HPP-induced gels were visually smoother and more homogenous compared to thermally-induced gels. Acidification increased gel strength ($p<0.05$) for both HPP and thermally processed samples as a result of protein aggregation caused by reduced electrostatic repulsion near the pI of pulse proteins. The effect of calcium differed based on acidification level and process. At lower acidification levels (starting pH ~6.5, 5.5), calcium increased gel strength (G') and hardness for HPP-induced gels, but decreased hardness for thermally-induced gels. This work can help guide new product formulation of high-protein food applications using pulse protein ingredients by mapping out the diversity of distinct gel characteristics that can be achieved through both nonthermal and thermal processing, as well as formulation.

**Keywords:** high pressure processing; pulse protein; gelation; rheology

**Format** Poster

**Title:** Cold Plasma Modification of Nanocellulose Crystals: Advancing Sustainable Biodegradable Films

**List of authors:** Jiannan Feng; Azin Farmanfarmaee; Fanbin Kong

**Organization:** Department of Food Science and Technology, The University of Georgia, Athens, GA, USA

**Presenter:** Azin Farmanfarmaee

**Abstract:** Nanocellulose crystals (CNC), a renewable and biodegradable nanomaterial derived from cellulose, have garnered significant attention in recent years due to their exceptional mechanical, thermal, and barrier properties. This study explores a novel approach to enhance the functionality of nanocellulose through cold plasma treatment, aiming to expand its applications in developing eco-friendly biodegradable films.

Cold plasma, a non-thermal ionized gas, offers a versatile platform for surface modification of nanocellulose without chemical additives or harsh conditions. This process facilitates introducing functional groups onto the nanocellulose surface. The resultant modified nanocellulose can be incorporated into biodegradable film matrices, offering numerous advantages in sustainability, performance, and functionality.

This research aims to utilize cold plasms-treated nanocellulose crystals (CNC) blended with alginate to make a biodegradable film. In this study, the atmospheric cold plasma jet was composed of a 1 kV–16 A power generator (FG5001), plasma jet (CD50), and high voltage transformer (HTR11). Oxygen/nitrogen was adjusted to the ratio of 1:4 with processing time at 10 min. Treated and nontreated CNC was blended with 2% alginate plasticized with 6.4% (w/w) glycerol, then the casting method was used to make films. Characterization techniques, including Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM), are employed to analyze the structural and morphological changes in the nanocellulose after plasma treatment. Subsequently, light transmission and transparency of films, mechanical properties, water contact angle, water vapor permeability, and oxygen transmission rate (ORT) were evaluated.

The results showed that cold-plasma-treated CNC could reinforce the tensile strength (TS) and elongation at break (EB) of the film compared with nontreated CNC. The water vapor permeability was 5.3 $mm/m^2 \cdot day \cdot kPa$, with a significant difference from nontreated CNC. The water contact angle was increased, which indicated the film surface was more hydrophobic. There is no significant difference in the effect of light transmission and oxygen transmission rate.

In conclusion, cold plasma modification of nanocellulose represents a promising avenue for expanding the utility of this renewable nanomaterial. The resulting modified nanocellulose materials make them ideal candidates for biodegradable film applications. Further research must optimize the treatment condition to improve its application as a biodegradable material and contribute to a more sustainable future.

**Keywords:** old plasma; nanocellulose; biodegradable film;

**Format** Poster

**Title:** Ex-ante life-cycle assessment (LCA) and cost comparison among non-thermal food technologies

**List of authors:** Minliang Yang; Qingyang Wang; Tyler Hill; Muhammad Shah Meer

**Organization:** MY & TH - North Carolina State University; QW & MM - Oregon State University

**Presenter:** Minliang Yang

**Abstract:** Significant improvements are needed in food and beverage industry to accelerate the decarbonization process. As one of the largest energy consumption sector, food industry is accountable for approximately one-third of total greenhouse gas (GHG) emissions globally. Alternative energy-saving technologies such as non-thermal processes are explored to overcome the challenge. However, a straightforward cost and environmental impact comparison among different non-thermal food processes are limited due to the early-stage of these emerging technologies. This study aims to fill this research gap by performing an ex-ante LCA and technoeconomic analysis of four non-thermal food technologies (high pressure processing, pulsed electric field, cold plasma, and ultraviolet) in orange juice production. Our results shows that relative to conventional thermal pasteurization, production costs of these non-thermal food technologies are slightly higher with HPP being the most expensive, and the cradle-to-gate GHG emissions from these non-thermal process are comparable or lower than conventional thermal process. Additionally, LCA results also reveal the large GHG contributors in orange juice production are orange plantation and juice packaging. The outcome of this study provides insights on both economic and environmental sustainability of different non-thermal food technologies and identified the hotspots and barriers for future commercialization.

**Keywords:** life-cycle assessment (LCA); technoeconomic analysis (TEA); non-thermal food technologies

**Format** Poster

**Title:** From processing to product: utilizing high-pressure homogenization for producing fermented plant-based yogurt alternative

**List of authors:** Rachel Levy; Zoya Okun; Avi Shpigelman

**Organization:** Technion-Israel Institute of Technology

**Presenter:** Rachel Levy

**Abstract:** The demand for dairy-free yogurt alternatives based on alternative proteins has increased; a shift towards a plant-based diet could contribute to food production sustainability and reduced environmental impact. Yet, many plant-based proteins have limited techno-functional properties limiting their use and diversification of yogurt alternatives. Many commercialized yogurt alternatives suffer from nutritional limitations such as allergenicity and/or poor nutritional profile (e.g., low protein content). High-pressure homogenization (HPH) has been suggested as a potential tool for improving techno-functional limitations. This work studied the combination of a high concentration (5%) of an alternative model plant protein, potato protein isolate (PPI), with HPH to produce a fermented yogurt alternative in a bottom-up approach without additional external stabilizers. The proposed concept of using a bottom-up approach to produce yogurt alternatives allows for full control of various nutritional aspects, including the enrichment with different

prebiotic and probiotic compounds. Aiming that HPH will decrease the technological gap to produce fermented plant-based yogurt alternatives and provide fundamental knowledge regarding the effects of HPH on lactic acid fermentation of plant-based protein emulsions. HPH as a pre-processing step (200MPa, inlet temperature=15°C) increased isolate solubility (from 92.7±1.1% to 97.5±0.8%) and reduced downstream PPI sedimentation, likely due to a partial breakup of protein aggregates by HPH. Before inoculation with lactic acid bacteria, PPI emulsion (3% oil) was subjected to a second homogenization step (30-200MPa). Such a process stabilized the emulsion against separation, allowing the formation of finer and whiter emulsion with improved physical stability against separation, thus allowing sufficient time to form a homogenous gel-like system during fermentation. Utilizing HPH also presented the potential to develop yogurt alternatives with a wide range of oil content (1.5%-10%). The oil droplet size distribution and microscopic imaging of the HPH gels revealed a more even distribution of components compared to the non-homogenized samples. HPH increased the overall whiteness index, while the highest value was obtained for 200 MPa 10% oil gel (76.01±0.50), similar to milk yogurt value. This work may expand the opportunities to develop a wide range of yogurt alternatives from different protein sources, with higher protein content and improved physicochemical attributes.

**Keywords:** High-pressure homogenization; Alternative proteins; Yogurt substitute; Oil concentration

**Format** Virtual

**Title:** POTENTIAL OF MICROALGAE/FUNGI PELLETS AS BIOFERTILIZER FOR FOOD CROPS

**List of authors:** Ana Beatriz, Lobo-Moreira; Solange, Xavier-Santos; Samantha Salomão, Caramori; Roger, Ruan.

**Organization:** University of Minnesota; Universidade Estadual de Goiás, Brazil; Universidade Estadual de Goiás, Brazil; University of Minnesota.

**Presenter:** Ana Beatriz Lobo-Moreira

**Abstract:** Food distribution and food insecurity are problems that society has faced for centuries. In addition, chemical additives added to food to stimulate growth and pest control are also issues we face daily, especially as they involve human health, land use, and sustainability, such as climate change and soil/water contamination. The use of alternative, renewable, and natural sources of nutrients for growing food has shown promise in economic and environmental terms. Therefore, the aim of this work was to test the potential of microalgae harvested by fungi pellets as a source of nutrients for the growth of food crops. Microalgae were cultivated for 14 days in BG11 medium, 25°C, 18:6 light:dark (18W) and 100 rpm. Fungi were grown in Potato Dextrose Broth for 72 hours, 30°C, and 50 rpm. Fungi pellets were added to the algal culture for harvesting at the proportion of 1:10 (wet weight: milliliter). Different concentrations of the microalgae:fungi consortium were analyzed for nitrogen, phosphorus, and potassium content (NPK), the three main elements used in food crop fertilizers. The NPK levels found in the consortium's dilutions reached levels suitable for use in food crops compared to purchased chemical fertilizers. The dilution that presented NPK values closest to commercial fertilizers was 4%, in which nitrogen, phosphorus, and potassium concentrations were 2.47, 1.27, and 2.63 g.L-1. In this study, the bioavailability of these elements for crops was not tested, therefore, new studies can contribute to the advancement of this new

source of nutrients for use on larger scales. Also important to understand the mechanisms of interaction within native soil microorganisms and their absorption by the most consumed food varieties.

**Keywords:** biofertilizer; microalgae; fungi; agriculture; sustainability

**Format** Poster

## Session 6 - Industry Perspectives on the Future of Food: Implementing Nonthermal Processing Technologies in Industrial Practice

**Title:** Challenges and Innovations in High Pressure Processing Commercial Implementation

**List of authors:** Mario González; Rui Queirós; Carole Tonello

**Organization:** Hiperbaric, S.A.

**Presenter:** Mario González

**Abstract:** Consumer demand for high quality, health conscious and minimally processed food products has driven a shift towards non-thermal technologies in the food industry. Among these, High Pressure Processing (HPP) emerged as a leading contender, effectively meeting the requirements to fulfill consumer expectations. The process uses elevated hydrostatic pressure to inactivate microorganisms and ensure food safety without significant thermal effects. However, implementation at an industrial scale faced several challenges and requires of continuous innovation.

For example, switching from a vertical to a horizontal configuration was key to adapting the equipment to the production flow of the food industry. In the same way, increasing the volume of processing chambers (vessels) favored the development of new applications for which the existing equipment in the early years of industrial implementation had low productivity. Moreover, the introduction of equipment for in-bulk beverage production has brought the technology closer to large manufacturers and opened the doors to new product categories. In addition, as a means of increasing efficiency, reduce environmental impact and reduce labor, current efforts focus on water and energy saving solutions and automation.

Nevertheless, pushing the limits of HPP requires the support of research from an engineering and food science viewpoint. In this regard, the development of insulated carriers for the application of High Pressure Thermal Processing (HPTP) using conventional HPP equipment has sparked interest in novel food applications. This solution overcomes the engineering and cost-related challenges that have prevented the commercial implementation of HPTP technology for more than 20 years after its approval by the Food and Drug Administration. The process allows the inactivation of bacterial spores, which expands the range of shelf- and chilled-stable low-acid foods with improved sensory and nutritional profiles compared with products that have only been heat-treated. The use of insulated carriers on already optimized HPP equipment minimizes conduction heat loss of the packaged food products and the water surrounding them, while preventing convection

gradients inside the HPP vessel during pressure holding time.

Overall, the continuous evolution of HPP keeps transforming the food industry landscape and paving the way for safer and more nutritious products.

**Keywords:** HPP; HPTP; In-Bulk; HPP Equipment

**Format** Oral

**Title:** Equivalent Processing for Pasteurization of Fruit Juices by Selected Nonthermal Technologies

**List of authors:** Gustavo V. Barbosa-Canovas

**Organization:** Washington State University

**Presenter:** Gustavo V. Barbosa-Canovas

**Abstract:** Identifying equivalent processing conditions, while using various technologies to treat a given food product is critical for a relevant comparison of food quality attributes. Three technologies are considered, High Pressure Processing (HPP), Pulsed Electric Fields (PEF) and Ultrasound (US) to pasteurize selected fruit juices and their blends at different proportions. We are analyzing the equivalent processes for at least 5-log reduction of Escherichia coli and Listeria innocua (a surrogate for Listeria monocytogenes), these are microorganisms of concern for the juices under consideration. Since each technology could operate at different processing conditions, the identification of “best-technology/best processing condition” becomes challenging. If other factors are considered like carbon footprints, costs, expected shelf-life, type of packaging, multiple recommendations could be very possible depending very much on how much weight is given to each factor under consideration.

**Keywords:** nonthermal processing; equivalent processing; pulsed electric fields; HPP; ultrasound

**Format** Oral

**Title:** UltraShear Nanoemulsions as Functional Ingredients for the Food Industry

**List of authors:** Alexander Lazarev

**Organization:** Pressure BioSciences Inc.

**Presenter:** Alexander Lazarev

**Abstract:** Nanoemulsions have received broad attention in recent years due to a significant potential they offer in many markets from drug delivery, nurtaceuticals and personal care, to functional foods. Oil-in-water nanoemulsions are colloidal suspensions of nanometer-size droplets of oil in aqueous continuous phase that are kinetically stable, could be filter-sterilized, and offer an opportunity to blend water-insoluble hydrophobic materials with water-based matrices such as beverages. This presentation will describe the new, highly scalable high-energy nanoemulsion manufacturing approach termed UltraShear(TM) technology, featuring a clog-free throttling homogenizer valve operating at pressure up to 60,000 psi (400 MPa) and capable of manufacturing 40-60 nm oil-in-water nanoemulsions in 5 passes or less. The formulation strategies to achieve unprecedented nanoemulsion stability will also be discussed. Several examples of

nanoemulsified hydrophobic functional food ingredients such as vitamins, antioxidants, and Omega 3-6-9 fats will be shown.

**Keywords:** UltraShear, Nanoemulsions, colloidal, Functional Ingredients,

**Format** Oral

**Title:** Application of Pulsed Electric Fields for energy efficient processing in the peach industry

**List of authors:** George Dimopoulos, George Stoukogiorgos, Petros Taoukis

**Organization:** Laboratory of Food Chemistry and Technology, School of Chemical Engineering, National Technical University of Athens, Greece

**Presenter:** Petros Taoukis

**Abstract:** Greece is among the global leaders in peach processing. The limited peach harvesting season necessitates the use of late-harvest cultivars which are harvested in mid-September. These exhibit significantly increased fruit firmness leading to processing difficulties such as low juicing yields and frequent cutting equipment blade replacements. Pulsed Electric Field (PEF) pretreatment offers an energy-efficient solution to these challenges, since it is a well-established nonthermal process which targets plant cells and leads to tissue softening. In this work mild PEF treatments (2.0 kV/cm, 0-2.73 kJ/kg) were applied to whole peaches (Everts variety) before cutting and juicing. The treatments were able to reduce fruit firmness by 28%, which corresponded to cutting blade replacement only once every 7 days instead of every 8 hours commonly seen in the industry. Juicing yield significantly increased from 65% to 79%, with an energy saving of 170 kJ/kg compared to thermal blanching. Quality parameters in the resulting purees were comparable to those of untreated samples, except for a slight reduction in Bostwick consistency (8 cm/30 s). Ongoing industrial-scale experiments validate these promising lab results in an industrial setting, using a continuous belt-drive PEF system. The experiments involve treating substantial quantities of peaches with PEF to assess scalability, energy efficiency, and product quality. Current results show successful peach softening, supporting the viability of PEF for industrial peach processing. This research establishes PEF pretreatment as a cost-effective and energy-efficient solution for peach processing. This unprecedented application of PEF holds the potential to significantly benefit Greece's peach industry, one of the nation's most thriving agri-food sectors.

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**Keywords:** Pulsed Electric Fields; Fruit and Vegetable Processing; Energy efficiency; Industrial application

**Format** Poster

**Title:** Characterization of astaxanthin nanoemulsions produced by intense fluid shear through a self-throttling valve-based UltraShear high pressure homogenizer

**List of authors:** Gary Smejkal; Edmund Ting; Richard Schumacher; Alexander Lazarev

**Organization:** Pressure BioSciences, Inc., South Easton MA 02375 USA

**Presenter:** Alexander Lazarev

**Abstract:** Stable, oil-in-water nanoemulsions containing astaxanthin (AsX) were produced by the UltaShear™ high pressure homogenizer employing intense fluid shear forces resulting from pumping reagents through a self-throttling annular gap valve at 300 MPa. Compared to emulsions prepared by conventional homogenization, a size reduction over two orders of magnitude was observed for AsX-containing oil droplets following just a single pass through the UltraShear device. In krill oil formulations, mean hydrodynamic diameter of lipid particles was reduced to 60 nm after only two passes through the valve, and reached a minimal size of 24 nm after eight passes. Repeated processing of samples through the valve progressively decreased lipid particle size, with an inflection in the rate of particle size reduction generally observed after 2-4 passes. Krill and argan oil-based nanoemulsions were produced using an Ultra Shear Technology (UST) approach and characterized in terms of their small particle size, low polydispersity, and stability.

**Keywords:** Nanoemulsions; high pressure homogenization; UltraShear Technology; antioxidants

**Format** Poster

**Title:** Inactivation of Airborne Poultry Viruses by Non-thermal plasma and Microwave – assisted Treatment Processes

**List of authors:** Nan Zhou; Charles Schiappacasse;; Juer Liu; Jianfei Guo; Yuancai Lyu; Zheng Xing; Peng Peng; Yanling Cheng; Carol Cardona; Yuying Liang; Kevin Janni; Sally Noll; Paul Chen; Roger Ruan*

**Organization:** University of Minnesota

**Presenter:** Juer Liu

**Abstract:** Non-thermal plasma (NTP) is a partially ionized gas, commonly generated by subjecting gases to a strong electric field. When air is exposed to a strong electric field it rapidly decomposes into a variety of reactive species including UV photons, high-energy electrons, reactive oxygen species, etc., which have powerful wide-spectrum antimicrobial properties.

Microwave (MW) systems represent another emerging antimicrobial technology. Microwaves are a form of electromagnetic radiation, in the frequency range of 300MHz to 300GHz. The thermal inactivation effects of MWs are well documented for a variety of microbial species.

In this study, these two technologies were used to inactivate poultry viruses in laboratory-scale systems. The energy cost and potential application scenarios were discussed.

**Keywords:** AVI; Microwave; NTP

**Format** Poster