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Book of abstracts

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(009) ACQUIRING DAIRY GELLING DATA VIA NON-INVASIVE LIGHT SCATTERING

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The gelling times and gelling strengths are important factors in the processing of dairy and related products. These properties have influence in production, rheology, sensory, and stability of the product and therefore influence overall customer perception of the product. Changes in formulations and the introduction of new ingredients demand that chemists characterize these new mixtures in a rapid and quantitative manner in order to improve overall quality and to optimize the new formulas.

This talk will show how Multi-Speckle Diffusing Wave Spectroscopy (MS-DWS) can be used to monitor Brownian motion of the particles and matrices inside of these dairy-based formulations during the gelling process. Factors such as salt additives, pH variables, protein additions, and temperature effect the gelling times and strengths of various type of milk (pasteurized and unpasteurized), yogurt, and other gels will be discussed. By monitoring the speed and distance traveled of the particles inside of the medium, times associated with delayed particle movement (gelling) and the extent at which the particles are moving (gel strength) are obtained.

It is observed, for example, that additions of proteins, $CaCl_2$, and lower temperatures promote gelation faster than if these additives are left out or is the temperatures are left higher (above 85 °C). Additionally, the use of $CaCl_2$ additives and lower pH values (6.4 compared to 6.8) lead to stronger gels. These trends will be discussed in detail over a series of dairy-related formulations.

(010) QUANTITATIVE CHARACTERIZATION AND PROPERTY DETERMINATION OF FOOD POWDERS

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Dried food powders that are used for beverages need to be reconstituted in a liquid, usually water or milk, before it is consumed. The performance of this mixture is critical for the customer's perception of the product and therefore needs to undergo a wide variety of rigorous testing before entering the marketplace.

We will show how Multiple Light Scattering can be used to follow the evolution of food powders as they come in contact with water. A small amount of powder is typically added to the top of a volume of water and the powder particles are analyzed as they evolve in the sample. The backscattered and transmitted light in the sample allows for tracking of particle concentration changes to provide information into powder wettability, sinkability, dissolution, and overall dispersibility quality. This typical experiment lasts only 30 minutes and provides quantitative information into powder kinetics.

Three brands of commercial chocolate milk food powders are tested using this method and the results are compared. One powder greatly outperformed the other two in all categories but it is clear that all of the powders do possess similar qualities in some areas. This quantification of the experiment will be shown and discussed.

(011) STABILITY MONITORING AND CHARACTERIZATION OF ULTRAFINE BUBBLES USING MULTIPLE LIGHT SCATTERING

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Ultrafine bubbles of less than 1 µm in size are increasingly seeing attention in a variety of fields due to their desirable physical properties. Such bubbles have applications in areas such as agriculture, cosmetics, pharmaceutical, and foods, particularly in the area of drinking water and beverage manufacturing. Since these bubbles stay in liquids longer and decrease surface tension, they are of interest to formulators.

Currently, detection and characterization is difficult and may require multiple devices to derive the desired properties of the mixtures. In this note, we will show how multiple light scattering can be used to characterize not only the size of the bubbles in their native, concentrated state, but to highlight the physical stability of these bubbles over time. By tracking the light that is scattered/transmitted through a sample data pertaining to particle size and concentration and the changes in these parameters can be gathered over time.

It is seen that the higher concentration of bubbles in ultrapure water the lower the amount of light that is transmitted through the sample. Repeating the data acquisition over time allows for real-time tracking and extrapolation of the increase in the transmission signal as the bubbles leave the solution. This extrapolation shows that the bubbles are contained in the water layer for up to 96 days for higher concentrations of bubbles and closer to 68 days for lower concentrations.

Using the same transmission data the average diameter of the bubbles can be determined. Incorporation of the refractive index of the bubbles and the solution as well as the concentration of the bubbles will allow for the particle size to be calculated. In all cases, the diameter of the bubbles were measured at 100 nm with no particle size change in the form of flocculation or coalescence observed.

(013) DROP FORMATION AND HARDENING PROCESS FOR CONCENTRATED PROTEIN SOLUTIONS

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A method of forming solid protein structures for encapsulation of water-soluble bioactives to enhance protection and delivery is presented. The overall objectives of the study were three-fold: to develop a formulation and process to produce concentrated solutions as droplets, to develop and validate methods to harden such droplets into protective beads, and to characterize solutions and final products.

Solutions were prepared by combining blends of sucrose and WPI with powdered ice at low temperatures, followed by rehydration of solutions via microwave heating on low settings. Solution droplets were formed from continuous flow through silicon tubing (2 mm I.D. & 1mm wall thickness) at room temperature, falling through air after detachment. Instant solidification of protein occurred when solution droplets falling from the tube end came into contact with oil heated to 100°C. Droplets were submerged in hot oil under continuous stirring and harvested after 1-2 minutes of heating. Solutions containing 40% WPI and 10% sucrose by weight showed the best results for final products that were hard, non-sticking solid beads.

Solutions were characterized by viscosity and flow/drip tests to gather information about solution densities, volume flow rates, surface tensions, and estimated droplet sizes. Hardened drops were characterized for porosity, hardness, bead diameter, water activity, and solids concentration.
This study provides insight into physical behaviors of high solids-concentrated dispersions. Additionally, it demonstrates an alternative encapsulation technology and method of preparing high solids solutions. Future studies will investigate the effectiveness of the matrix in encapsulating bioactive substances.

(018) POWER ULTRASOUND APPLICATION IN ORIENTED EXTRACTION AND MODIFICATION OF BIOACTIVE COMPOUNDS

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Ultrasound which is considered as an efficient, energy-saving, environmentally friendly technology has important applications in the modern food industry. Power ultrasound whose frequency between 20 kHz-100 kHz is often accompanied by various physical and chemical effects when it transmits in the medium, facilitating heat transfer and mass transfer. In this report, the history and research progress of ultrasound-assisted extraction, degradation and modification of bioactive molecules were investigated. In terms of ultrasound-assisted extraction, the systematic research on the extraction of phytochemicals including pectin, β-carotene, and flavonoids from citrus by-products was carried out. Effect of extraction conditions such as ultrasonic frequency, power density, different solvents and temperature on extraction yield were comprehensively analyzed. Moreover, the cell structure of materials and characterization of extracts were compared between ultrasonic and conventional methods. Besides, the kinetics, mechanism and the stability of ultrasound-assisted extraction were discussed as well.

From the aspects of ultrasonic modification and degradation, the physicochemical properties, structure and degradation mechanism of pectin and fucoidan were studied. For citrus pectin, the molecular weight and polydispersity index decreased with increasing time and ultrasonic power. It was notable that greater degradation effect was found under lower temperature. The monosaccharide content of pectin changed slightly while the reduced (Gal+Ara)/Rha ratio after ultrasonication indicated degradation in the neutral sugar side chains, which had been confirmed by atomic force microscopy at the nanolevel. For sea cucumber fucoidan, higher ultrasonic intensity, lower temperature, and lower fucoidan concentrations led to the more effective sonochemical effect. Kinetics and mechanism of degradation under sonication were put forward according to structure and antioxidant capacity analysis. In addition, ultrasound and pectinase showed significant synergistic effect during 20-50 °C on modification of pectin and the properties of modified pectin were also analyzed. Finally, future application prospect of ultrasound technology was also discussed.

(020) ENGINEERING FOOD DIGESTION AND OTHER NEW OPPORTUNITIES FOR FOOD ENGINEERS FOR 2050 AND BEYOND

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Food engineering plays a critical role in sustaining the world's population through ensuring a safe, quality, and nutritious food supply. The future of food engineering includes development of food processes to enhance human and animal health. This will require understanding the processing of foods in humans and animals during digestion, as well as knowledge of how food material properties influence their behavior in the complex systems found in the human body. Food engineering knowledge will need to be applied throughout the food production-consumption system to develop a holistic, systems-based approach for processing functional, personalized food products. These challenges will require a wide base of food engineers working in academia and the food industry. Going forward, it will be critical for food engineers to utilize their knowledge while working with nutritionists, scientists, and medical doctors to transform the development of personalized foods for health and wellness in the global food supply.

(021) REINVENTING FE: VISION AND STRATEGY

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Two recent global web-survey studies highlighted that the food engineering (FE) domain faces mounting challenges. The majority of the respondents indicated that FE should be integrated with another existing/evolving academic program. Furthermore, those holding a formal FE BSc and/or MSc selected other domains for their higher education. To address FE forthcoming increasing challenges, paradigm shifts in the pursuit of excellence and innovation are inevitable. FE vision should pursue to become a leader in basic science and research, and simultaneously in applied research and technology in the implementation of personalization, health and wellness, safety and sustainability. FE should also become a prominent driving force in the Food-Tech innovation ecosystem (defined as the 4-helix: academia-industry-government-private businesses). FE new paradigm should embrace "Connect, educate and innovate," strategy aspiring for up to 50% of its curricula to be founded on collaborations with other domains, utilization open- and disruptive-innovation mentality and culture. This strategy offers dual appointments of faculty members for enriching the FE domain with adjacent fields (e.g., medicine, computer science, digital communications). FE heritage (e.g., processing, sustainability, safety, feeding the world, food security, nutrition) provides the foundation that should be fully integrated with Industry 4.0, in order to create amazing new processes, technologies and food products. Striking changes are unveiled daily, and it is inevitable that their speed will accelerate in the future. These changes offer new opportunities and a vast potential for the FE domain. Striving to become a recognized leader in basic and applied science and technology mandate also that other topics (e.g., ethics, transparency, consumers' trust and needs, openness, transparency, diversity, sustainability, social responsibility) are indispensable pillars of the FE vision. Current digital era offers vast opportunities to the younger generations (e.g., Millennials, Gen Z) to pursue excellence, leadership roles and reshaping the FE future.

(022) FOOD 4.0: VIRTUAL TOOLS, CONNECTIVITY AND SMART SYSTEMS FOR THE FOOD INDUSTRY

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The so-called fourth industrial revolution (Industry 4.0) is based on and driven by virtual tools, connectivity and smart systems. Buzzwords such as big-data, computational power, business-intelligence-capabilities, human-machine interaction, robotics, internet of things, artificial intelligence and cognitive have become popular in business and technical panels but still the potential of the digital revolution in manufacturing industry (and in the food industry especially) remains unexplored.

According to a survey run by McKinsey in 2015 [Breunig, M., Kelly, R., Mathis, R. and Wee, D. 2016. Getting the most out of Industry 4.0. available on https://www.mckinsey.com/business-functions/operations/our-insights/industry-40-looking-beyond-the-initial-hype], involving 300 industry leaders, companies are not consistently aware of the emerging technologies. The present talk aims to open a discussion on the status of the fourth revolution in the food industry and the role of Food Engineers as ferrymen able to massively introduce and drive the fourth industrial revolution in the food industry (Food 4.0). The most promising virtual tools and methodologies to be applied in design and management of equipment for the food industry, innovative and/or optimized food processes, new food products, connectivity apps, smart systems are included.

Many promising technologies have hatched under the ashes for some years and probably not all of them are ready for application at an industrial scale. But nowadays some of them have reached the stage where their reliability and capability to lower costs and increase the process/product profitability are starting to make sense for innovations in the food industry. The vast potential of Food 4.0 offers unique opportunities for the future food engineer careers and mandates adequate research and development to overcome emerging challenges.

(023) FOOD INDUSTRY INSIGHTS: CURRENT AND UPCOMING ENGINEERING TALENT NEEDS

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Availability of strong and thoroughly trained engineering talent has always been a challenge for the food industry. Latest trends are further metamorphosing it into a more complicated situation. Pressures to improve productivity and minimize environmental impact, Digital Factory concepts revolutionizing the operations through advanced automation and data analytics, changing consumer preferences for healthier and fresher foods, and a large portion of skilled workforce nearing retirement are amongst the top themes widening the gap between the immediate and upcoming needs of the food industry and readiness of the engineering talent coming out of the educational institutes.

Traditionally the food industry has relied on recruiting engineers from a diverse set of academic disciplines, only a smaller fraction of which has been attributed to food engineering. Irrespective of the facts that the food engineering curriculum was specifically targeted and is arguably the most well rounded to serve the food industry, it has yet to become the preferred area of expertise for sourcing of the engineering talent. While it is up for debate whether one academic discipline provides better prepared engineers as compared to other, the industry has been taking the responsibility upon itself to further train the relevant cross-functional skills to the new hires.

This presentation will share insights regarding engineering talent needs of the food industry to encourage an introspective and forward looking analysis of the food engineering curriculum and training. It will present a high level comparison of the food engineering curriculum with the industry's technical expectations from the engineers working in various capacities, ranging from an R&D engineer driving new innovations to a plant based engineer supporting the equipment maintenance and operation, from an individual contributor subject matter expert to a person managing the engineering staff, and from a project manager responsible for new equipment and facilities installations to a process authority responsible for engineering controls ensuring food safety and compliance.

(024) AGRO-INDUSTRIAL RESIDUES IN COLOMBIA, PRODUCTION, TRANSFORMATION AND APPLICATIONS

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Colombia is a special country due to its geographical and spatial location, in addition to its great variety of climates and landscapes, which makes it a place with potential and agricultural vocation. Currently, Colombia produces around 521 million tons of food per year, represented in products such as milk, cheese, rice, cereals, fruits, vegetables, flowers, fish, chicken, meat, eggs, tubers etc. This food production is beneficial for the economy because it generates employment and promotes agroindustry; however, it produces around 6 million tons of waste per year, generating an environmental problem. The main agro-industrial wastes generated in Colombia are: glycerol, spent coffee, chaff, rice husk, waste of the sugarcane industry, and approximately 45 million liters of whey per year by the cheese industry, among others. Therefore, it is necessary to search different alternatives and engineering tools to give added value to the agro-industrial waste, such as the generation of energy, production of biopolymers, extraction of bioactive compounds, preparation of new foods, fabrication of new raw materials with applications in food, drugs or cosmetics, etc. In Colombia, some of these applications are already implemented in the industrial phase and others on a pilot scale. The applications related to biotechnology, nanotechnology and compound extraction processes are in exploratory or industrial scaling phases. It is concluded that, although in Colombia there are alternatives in terms of transformation and generation of added value for the agro-industrial waste at industrial scale, there is a need for greater investment and a legislative environment that supports and enhances biotechnological and nanotechnological applications at an industrial level. This economic and political support will allow the obtention of products with greater added value and consequently a higher economic and environmental impact for the country.

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(026) USE OF DIFFERENT DRYING TECHNICS IN THE PRODUCTION OF RAW POWDER MATERIALS FROM TWO BY-PRODUCTS OF THE FOOD INDUSTRY, WITH HIGH NUTRITIONAL AND FUNCTIONAL VALUE.

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By-products are food or part of food generated, removed or deflected of food chain and it should be recovered but are subsequently discharged, lost, degraded or contaminated. Reutilization of by-products is gaining popularity because of the increasing awareness regarding environmental protection. Between by-products are whey and spent coffee ground (SCG), there are by-products from cheese and coffee manufacture industries, respectively; which contain valuable compounds that can be used in the manufacture of functional, nutritious and beneficial foods, such as proteins and bioactive compounds. The main goals of this research were to evaluate the use of different drying technics such convective and spray dry, for the production of powder raw materials with high nutritional and functional quality. The methodology includes different engineering process like convective and spray drying. The SCG was drying through convective process and optimized with an experimental design Box-Behnken. Then, different percentages of dry SCG (4-10-16%) were mixed (2500 rpm/5min) with concentrated whey, to then taken to spray dry process at 170oC. Some properties were determinates to understand the effect of drying process in some compounds. The results show that the optimal condition to process SCG whit convective drying are: Temperature 60°C, air flow 1.3 m/s; with these conditions, the chlorogenic acid (ACGs) were retain 92% (1,944 mgACGs/gDM); which has a kinetic of first order. In the same way, some properties of the spray dry powder obtain were density 495 g/L, color 60.72 L*, moisture 3.250%, water activity 0.250, formation and stability of foam 4.46 ml and 3.43 sec, total polyphenol and ACGs was 33.044 mgAGE/gDM and 7,890 mgACGs/gDM, respectively. The relevance to food engineering profession and the food industry of this work is to find new approach of industrial by-products through different engineering process, that permit to keep bioactive compounds that could provide beneficial health effects.

(028) CURRENT AND FUTURE TECHNOLOGIES IN THE PASTEURIZATION/STERILIZATION OF LOW-MOISTURE FOODS: AN INDUSTRY PERSPECTIVE

Lombardo, S
McCormick Foods

Thermal, chemical, and irradiation technologies have been historically utilized to reduce microbial loads in low-moisture foods. Many of these (e.g. Steam, EtO) have been effective in providing safety to the consumer, but the desire for natural, higher quality, flavorful foods with less preservatives means that a number of new alternative technologies are starting to be considered in the pasteurization/sterilization of low-moisture foods. The talk will consider the advantages and disadvantages of technologies currently in use, and alternative thermal and non-thermal technologies that are being evaluated in the treatment of low-moisture foods.

(031) UNSATURATED TRANSPORT IN THE VICINITY OF GLASS TRANSITION

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During food processing applications such as baking, frying, drying and expansion, fluid transport is of unsaturated type due to the involvement of gas phase (air-vapor mixture). In addition, many food materials undergo glass-transition during the process. Unsaturated transport is significantly more complex than saturated transport as the gas phase is compressible, leaks through pores and results in capillary forces at the fluid interfaces. Near glass-transition, biopolymers relax at the same time scale as diffusion time. Thus, three predominant forcing terms affecting unsaturated fluid transport in foods undergoing glass transition are—concentration gradients (e.g. moisture gradient), pressure gradients in various phases and strain gradients in biopolymers. This presentation will discuss the generalized Darcy's law and supporting relations derived using the Hybrid Mixture Theory of porous media, which include these forcing terms. The generalized Darcy's law has an integral term that incorporates viscoelastic relaxation of biopolymers. Near glass-transition, the integral term exhibits temporally non-local effects as polymer relaxation occurs at the same rate as diffusion time. In glassy and rubbery states, the integral term merges with the concentration gradient term, which makes fluid transport of Fickian (or Darcian) type. Solution of the generalized Darcy's law for frying and starch expansion applications, and its comparison to the experimental observations will be presented. Various derived relations were used to calculate the pore pressure in the food matrix (averaged pressure exerted by fluids on the pore walls). The pore pressure affects oil uptake during frying and starch expansion in extrudate. A poroviscoelastic model in which pore pressure and viscoelastic stress oppose each other to cause expansion and contraction of starch exiting an extruder will be presented.

(032) UNSATURATED TRANSPORT AND CRYSTAL GROWTH/DECAY IN FROZEN FOODS SUBJECTED TO FREEZE-THAW CYCLES

Ying Zhao and Pawan S. Takhar
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This presentation will discuss modeling of unsaturated transport processes involved in frozen foods subjected to freeze-thaw cycles during shipping and storage. These cycles result in ice recrystallization, surface dehydration, and solute and moisture diffusion, which damage the microstructure of food matrix. The re-crystallization phenomenon involves multiscale characteristics spanning from the scale of polymers to macroscale. The transport of moisture and vapors is complicated by diffusion of solutes governed by Gibbs free energy gradients in the matrix. Hybrid Mixture Theory based unsaturated transport equations were used to model water, vapor, heat and solute transport. The unsaturated transport equations are coupled with phase change equations for predicting the crystal growth at nucleation sites. The effect of freeze-thaw cycles on crystal growth, which causes damage to the surrounding matrix will be discussed. For model validation, the predicted crystal growth/decay will be compared to the experimental pore size distribution measured using X-ray micro-computed.

(033) OHMIC-ASSISTED THERMAL RETORT

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Conventional canning treated pre-packed low-acid food products with an extreme form of heat treatment to inactivate spores of *Clostridium botulinum*, resulting in poor quality products. This study aimed to develop an ohmic-assisted thermal retort, an advanced overpressure retort, to process authentic Thai sauces (“Pad Thai” and “Thai Basil“ sauces) and soups (“Tom Yum” and sour soups) contained in 8-oz polymer pouches. The ohmic chamber was designed into a rectangular shape equipped with two electrodes connected to a high voltage transformer. Twenty packaged foods were placed on plastic racks in the ohmic chamber, submerged in conductive solution and subject to ohmic heating to heat the foods until the cold spot arrived to the target temperature. The application of compressed air to ports generated pressure of 2 bars during the treatment and cold water cooled the foods after sterilization. Since plastic film is poor electric conductor and does not allow electrical current to pass through it to heat product inside the pouch, heat is rapidly generated in the conductive solution and transfers to the product. However, the ohmic-assisted thermal retort heated the product shorter than the conventional retort, taking less than 15 min to heat the product from room temperature to 121°C. The system was further microbiologically validated through inoculated pack study using spores of *Clostridium sporogenes* as surrogate microorganisms. There was a negative growth of the microorganisms at the target process F_0 of 6 min and a positive growth at the under target process F_0 of 2 min. Consequently, the application of the ohmic-assisted thermal retort could provide considerable potential to produce sterile liquid and particulate-containing liquid foods with a short time process.

(035) ENCAPSULATION OF CHINESE PLANT EXTRACTS USING HYDROXYPROPYL-BETA-CYCLODEXTRIN AND CHITOSAN FOR ANTIBACTERIAL DELIVERY APPLICATIONS

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Food spoilage and foodborne contamination are two major problems that affect the global food industry. Natural products with antibacterial activities are highly desirable for use in food products for their low toxicity and biodegradability, and also consumers' demand for more natural products with minimal processing and synthetic preservatives. Encapsulation with hydroxypropyl-beta-cyclodextrin (HPBCD) and chitosan have the potential to improve plant extract's aqueous solubility, provide controlled release, and mask their sensory attributes; therefore, improving their applicability as antimicrobials. Hence, this study aimed to synthesize inclusion complexes using HPBCD and chitosan containing Chinese plant extracts using the freeze-drying method, and to characterize their physicochemical properties and antibacterial activities. First, 39 plant extracts including water and methanol extracts, and essential oils, mainly from Chinese herbs and aromatic plants, were evaluated for their antibacterial activity against *Staphylococcus aureus*. Subsequently, HPBCD and HPBCD-chitosan inclusion complexes were synthesized using the freeze-drying (FD) method with a mass ratio of 2:13.8 for plant extracts: HPBCD, and 2:13.8:13.8 for plant extracts: HPBCD: chitosan, respectively. Results showed that clove water extracts (CWE) (*Syzygium aromaticum*), *Amomum tsao-ko* fruit oil (ATFO), and cinnamon bark oil (CBO) (*Cinnamomum cassia*) had the best ($P<0.05$) antibacterial activities and their minimum inhibitory concentrations (MICs) were 0.25 mg/mL, 0.5 mg/mL, and 0.5 mg/mL, respectively, and their minimum bactericidal concentrations (MBCs) were 1 mg/mL, 1 mg/mL, 0.5 mg/mL, respectively. Inclusion complex formation for HPBCD and HPBCD-chitosan systems was confirmed by differential scanning calorimetry and phase solubility analysis, which also demonstrated a significant increase of plant extracts aqueous solubility with HPBCD concentration. Entrapment efficiency values ranged from 90 to 100%; for both HPBCD and HPBCD-chitosan particles. HPBCD and HPBCD-chitosan complex sizes ranged from 0.257 to 14.587 μm due to particle agglomeration, and polydispersity index from 0.277 to 0.870, indicating polydisperse systems. TEM images confirmed size distribution and oblong shape for both inclusion complexes. Plant extracts encapsulated in HPBCD and HPBCD-chitosan were able to inhibit *S. aureus* at lower ($P<0.05$) concentrations than corresponding free extracts. These natural inclusion complexes have great potential for applications in the food industry to control foodborne bacteria and consequently improve food safety.

(036) ACTIVE PACKAGING AS A MEANS TO IMPROVE FOOD QUALITY

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The metal chelator ethylene diamine tetraacetic acid (EDTA) is often used to enhance oxidative stability and the efficacy of antimicrobials. To address consumer demands for clean labels, we have synthesized non-migratory metal chelating active packaging polymers to enable removal of EDTA. Yet, while laboratory scale methods for preparing this and other active packaging materials are suitable for proof of principle studies, there is a need for more commercially scalable methods. We report a photocurable chelating polymer coating suitable for high speed production of metal chelating active packaging materials. The copolymer coating was a poly(n-butyl acrylate) based polymer (79 mol %) synthesized by emulsion polymerization, with iminodiacetic acid (2 mol %) and benzophenone moieties (19 mol %) to impart metal chelating and photocrosslinking properties, respectively. The copolymer was photocured on polypropylene to produce metal chelating active packaging films. The resulting metal chelating film was characterized using spectroscopic and surface imaging techniques, metal chelating capacity and performance in inhibiting ascorbic acid degradation. The resulting film chelated 10.9 ± 1.9 nmol/cm^2, 47.9 ± 5.3 nmol/cm^2, and 156.0 ± 13.8 nmol/cm^2 of Fe^{3+} at pH 3.0, pH 4.0, and pH 5.0, respectively. The metal chelating film controlled transition metal induced ascorbic acid degradation by extending half-life of ascorbic acid degradation from 6 days to 20 days at pH 3.0, and from 3 days to 6 days at pH 5.0, demonstrating its potential as an antioxidant active packaging material. Despite the introduction of polar iminodiacetic acid chelating moieties, the coatings retained low surface energies (24.0 mN/m) necessary to enable product release in packaging applications. We have designed a commercially scalable process for preparation of metal chelating active packaging materials. These coatings enable scalable production of active packaging materials with metal chelating functionality, thus promoting the commercial translatability of new active packaging technologies.

(042) RADIO FREQUENCY HEATING OF FOOD POWDERS AND THE INFLUENCING FACTORS

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Radio Frequency heating has many applications in the food industry. When compared to conventional heating it is more rapid thus reducing heating time. In this presentation, recent studies of RF heating on several kinds of food powders will be introduced including corn flour, spices, egg powder, and milk powder. The results indicate that RF heating can effectively pasteurize food powders. The dielectric properties of the foods are critical affecting the RF heating rates. Heating uniformity is the greatest challenge in RF heating for food applications, and many methods were found useful improving the temperature uniformity. Equipment parameters such as electrode shape and gap, and the food geometry and dimensions also have significant impact on RF heating. Future studies are needed for commercializing RF pasteurization technology to produce safe food products.

(043) PHASE TRANSITIONS OF VITAMINS C AND B1 IN FOOD PRODUCTION AND STORAGE

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The water soluble essential vitamins C and B1 are commonly distributed in their crystalline forms. These crystals may dissolve or melt during food production, and then, depending on formulation or processing conditions, have the potential to re-solidify in crystalline or amorphous forms. The objectives of this study were to compare the phase transformations, amorphization, and chemical degradation of vitamins C and B1 in formulations containing polymers with different structural and physical traits. Two forms of each vitamin (ascorbic acid, sodium ascorbate, thiamine chloride hydrochloride, thiamine mononitrate) were used in solid dispersion formulations with select polymers (polyvinylpyrrolidone, pectins, polyacrylic acid, gelatin, guar gum, etc.). Solutions containing controlled vitamin:polymer ratios (0:100 to 100:0) were lyophilized and stored in controlled temperature (25-80°C) and relative humidity (0-75%RH) environments. Samples were analyzed over time using X-ray diffraction to document physical state and high performance liquid chromatography to document vitamin degradation. Moisture sorption profiling, microscopy, infrared spectroscopy, and differential scanning calorimetry were also used to characterize the samples. Increasing storage RH often resulted in vitamin crystallization, while increasing storage temperature at a constant low RH resulted in enhanced vitamin degradation. While different polymers resulted in different T_gs, moisture sorption profiles, and vitamin degradation rates, the key findings from this study were: 1) vitamins were more labile when amorphous than when crystalline; 2) vitamin amorphization was found in the presence of a variety of polymers, with both vitamin form and polymer type influencing the minimum amount of polymer needed; 3) all vitamins degraded significantly more when present at lower amounts in the amorphous solid dispersions, thus most degradation was found in the dispersions with the highest T_gs; and 5) intermolecular interactions influenced vitamin physical and chemical stability. Vitamin degradation was found in storage environments that maintained $T<T_g$, which is representative of many low-moisture food products.

(044) ENHANCE THE SUSTAINABILITY OF FOOD PRODUCTION SYSTEMS THROUGH WASTE UTILIZATION

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Food production involves crop and animal farming, harvesting/slaughtering, storage, and processing, etc. In every step of food production, liquid and solid byproducts and residues are generated. These materials contain large amounts of energy, nutrients, and water, and should not be perceived as merely wastes. Treatment and disposal have been the primary management strategy for wastewater, while recycling, composting, and combustion of non-recyclables have been practiced for decades to capture the energy and values from municipal solid wastes. As new technologies are emerging, alternative options for utilization of both wastewater and solid wastes have become available. Considering the complexity of chemical, physical, and biological properties of these wastes, multiple technologies may be required to maximize the energy and value recovery from the wastes. For this purpose, biorefining tends to be an appropriate approach to completely utilize and therefore treat them. Research has demonstrated that the liquid waste streams have the potential to support crop and algae growth and provide other energy recovery and food production options, while the non-recyclable waste materials and bio-solids can be converted into useable heat, electricity, material, and/or fuel and chemical through a variety of processes. In this presentation, we talk about energy efficient, environment improving and water saving processes and systems for treatment and utilization of organic solid and liquid wastes from animal production facilities and food processing plants. We will focus on new breakthrough technologies, such as intermittent vacuum-assisted thermophilic anaerobic digestion, extended aquaponics, oily wastes to biodiesel via glycerolysis, and microwave assisted thermochemical conversion. These new techniques can be incorporated into biorefining schemes, enabling complete utilization and therefore treatment of organic wastes for the production of chemicals, fertilizer, energy (biogas, syngas, biodiesel, and bio-oil), foods, and feeds, resulting in clean water and a significant reduction in pollutant emissions, and thus enhancing the sustainability of food production systems..

(045) FOULING BEHAVIOR OF SWEETENED PROTEIN SOLUTIONS

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Fouling is a serious problem in food processing especially in dairy industry since almost all dairy products need to be pasteurized or treated by other types of thermal processing to ensure their safety and quality. Sugar as a sweetener is very commonly added in various dairy products, such as flavored milk, ice cream mix, functional drinks, etc. However, severe fouling is found in on-site operations when processing sweetened dairy products. While milk fouling has been studied extensively, the compositional effect of sugar content in dairy products on fouling formation is not well known.

In this study, we investigated the effects of sugars (glucose, fructose and sucrose) on the fouling behavior of whey protein isolate (WPI) solution using the Spinning Disc Apparatus at surface temperature of 80°C, and shear stress of 0.02–0.2 Pa. Results showed that adding 10 wt% sugar into 5% WPI solution reduced its fouling resistance and deposit mass by 30–50% and more than 40%, respectively. Through differential scanning calorimetry and rheological properties analyses of the test solutions, we found that the added sugars stabilized whey protein by increasing its denaturation and aggregation temperatures, which, therefore, retarded the fouling formation. Sugar/WPI solutions had smoother fouling curves with less extent of sloughing compared to WPI solution, especially under higher shear. Furthermore, adding sugars was also found to affect the composition of the formed deposits, which showed a looser and more porous structure.

(046) A MATHEMATICAL MODEL FOR THE ESTIMATION OF SPECIFIC MIGRATION OF SUBSTANCES FROM FOOD PACKAGING

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The European legislation requires verification of compliance for migration of substances from the so-called Food Contact Materials (FCMs) with existing specific and overall migration limits. To do so, a detailed series of migration tests were proposed to determine, under specified time, temperature and pH conditions, the amount of potentially hazardous compounds released from FCMs. However, the experimental determination of specific migration into food requires a considerable amount of time and, in some cases, could be inaccurate due to either technical/analytical problems, or chemical degradation/volatilization of the migrant or non-availability of reliable analytical methods.

In past decades, several scientific investigations have demonstrated that migration from FCMs into food and food simulants is a predictable physical process. Mass transfer from FCMs into foodstuffs obeys, in most cases, to Fick´s laws of diffusion. Hence, in addition to the experimental methods, a new alternative tool based on theoretical migration estimations has been introduced in both the United States and the European Union as an additional tool in support of regulatory decisions as well as a good manufacturing practice, quality assurance and compliance tool.

The present paper proposes a general and versatile transport model, which permits calculating the actual migration of different possible substances from FCMs. With reference to either 3D irregular-shaped food samples or real fittings in contact with liquid foods, the relevant transport equations were solved in a wide range of process and operating conditions in order to determine both the specific migration limit (SML) and the permitted maximum initial concentration (MIC) of certain substances present in the finished FCM. The non-linear, unsteady-state, partial differential equations modeling mass transfer were solved by a finite elements formulation, which allowed obtaining a reliable computational tool exploitable in different conditions and for different FCMs.

The major practical consequence of exploiting such a computational tool regards the possibility of achieving high-speed computer-aided access to upper bound migration values independently of any analytical limitations, thus managing any given individual food packaging system. Moreover, calculations by means of migration modelling are completely insensitive to chemical degradation and reactivity or physical volatilization of test migrants as occurring in real migration experiments. Therefore, migration modelling offers not only a very economic approach for industry to take quick decisions in relation to packaging development and design but also to surveillance laboratories who might have quick and probably unique access to otherwise difficult-to-get evaluation data referred to hazardous components.

(047) APPLICATION OF CONSTRAINED OPTIMIZATION TECHNIQUES IN OPTIMAL SHAPE DESIGN OF FOOD EQUIPMENT

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Computational science and engineering techniques have allowed a major change in the way that products can be engineered, as a computational model that simulates the physical processes can be built rather than building real world prototypes and performing experiments Among such techniques, Optimal Shape Design (OSD) (Mohammadi,et al, 2004) represent an interesting approach. In OSD, the essential element respect to classical numerical simulations in fixed geometrical configurations, is to introduce a certain amount of geometrical degrees of freedom as a part of the unknowns, which means that the geometry is not completely defined, but part of it is allowed to move dynamically in order to minimize or maximize the objective function. The applications of optimal shape design (OSD) are uncountable. For systems governed by partial differential equations, they range from structure mechanics to electromagnetism and fluid mechanics or to a combination of the three. In food industry, optimum design is not a once and for all solution tool because engineering design is made of compromises owing to the multidisciplinary aspects of the problems, and the necessity of doing multipoint constrained design. (Mohammadi,et al, 2004) .OSD is a branch of differentiable optimization and more precisely of optimal control for distributed systems (Lions 1968), where gradient and Newton based methods are natural numerical tools. The problem is that OSD is still numerically difficult, because it is computer intensive and moreover because the "optimal" is a compromise between shapes that are good with respect several criteria. In this work the applications of a multivariate constrained optimization algorithm is proposed to two specific equipment in food engineering: OSD of static mixers for Newtonian and Non Newtonian fluids and OSD of a pasta extrusion bell.

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(048) MODELING OF COALESCENCE OF SURFACTANT-LADEN MICROBUBBLES

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Bubble coalesce is central to many important technological processes, such as separations, cleaning of oil spills, microfluidics, emulsification and foaming. It is well known that surfactants, which are frequently present as additives or contaminants, delay coalescence by slowing the drainage of the liquid film separating the approaching bubbles before they make contact. However, the coalescence and surfactant transport mechanisms developed after surfactant-laden bubbles make initial contact remain poorly understood.

In this study, we characterize these mechanisms using high-fidelity numerical simulations to predict the evolution of bubble interfaces, surfactant spreading, and induced Marangoni flows. Our results show that the surfactant initially accumulates on the tiny meniscus bridge formed between the coalescing bubbles due to the rapid and highly localized contraction of meniscus area. At the same time, a Marangoni-driven convective flow is generated at the interface, which drags the accumulated surfactant away from the joining meniscus and toward the back of the bubbles. These transport mechanisms delay the rate of bubble coalescence by dynamically modifying the local pull of surface tension on the bubble interfaces.

(049) MULTIFLASH DRYING AND MICROWAVE VACUUM DRYING FOR THE PRODUCTION OF CRISP FRUITS AND VEGETABLES

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The production of dried fruits and vegetables in relatively short times, maintaining good nutritional and sensory characteristics, is a challenge. Innovative drying processes, such as microwave vacuum drying (MWVD) and multi-flash drying (MFD) can be used to produce high-quality crispy fruits and vegetables in short times. MFD is based on the application of successive heating-vacuum pulse cycles to food to be dried. The food is heated up to the desired temperature (e.g. 60 ºC), and then a sudden decompression (vacuum pulse) is applied, leading to flash evaporation. The produced vapor causes texturization that results in dried fruits with a porous structure. The heating step can be performed by hot air (CMFD), by contact with heated plates (KMFD) or by microwaves (MWMFD). In the present study, fruit slices were dried by KMFD, MWMFD, MWVD, hot air, and freeze-drying. Fruits and vegetables were selected from their visual appearance and degree of ripeness, washed, peeled and cut into slices. Bleaching was applied in some cases. Product characteristics and drying times resulted from these different processes were compared. At the end of each drying process, moisture, water activity, micrographs and the mechanical texture of dried samples were assessed. The drying times of KMFD, MWMFD and MWVD ranged from 0.5 to 3 hours, much shorter than 12-16 hours observed from air-drying and freeze-drying. The application of successive heating-vacuum-pulse cycles during drying (KMFD, MWMFD) changed the fruit (vegetable) matrix to form a highly porous structure, with large pores. These porous structures resulted in jagged mechanical curves (puncture tests), typical of crisp products, which had greater sensory acceptance than AD and FD products. Therefore, MWVD and the multiflash drying processes (KMFD, MWMFD) are suitable for the industrial production of dried-and-crisp fruits and vegetables, resulting in products with attractive properties in very short drying times.

(051) FOOD SAFETY EDUCATION FOR ENGINEERS

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An engineering approach to food safety education is possible and can be readily implemented in existing undergraduate engineering curricula. Simulation-based learning modules can be enablers in such food safety education. These simulation modules can engage learning across multiple disciplines and effectively introduce risk-based, quantitative approaches, without getting bogged down in the computational details. As part of a nationwide effort, multi-disciplinary (predictive microbiology, process engineering, risk analysis, food science) simulation-based learning modules have been developed that are easily incorporated into existing engineering courses. Learning outcomes in food safety and risk for engineers as distinct from those for food scientists have been one of the challenges. Encouraging learning enhancement data obtained from courses in five different universities nationwide (where the modules were implemented) will be shared along with challenges in the implementation process. Benefits of simulation-based learning such as its individualized pace, being student-centered and active, are expected to make the modules attractive to students from diverse backgrounds. A paradigm shift in food safety education for engineers, enabled using these simulation modules, will better prepare the future workforce.

(053) CONTINUOUS FLOW MICROWAVE PASTEURIZATION OF APPLE JUICE: PROCESS MODELING AND VALIDATION

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Fresh cloudy apple juice was subject to continuous flow pasteurization in a pilot scale unit using microwave of conventional heating (tubular heat exchanger) at three different temperatures: 70, 80 and 90 °C. Heat transfer, fluid flow and enzymatic inactivation were modeled. Overall heat transfer coefficients were determined in experiments using water and correlated with Reynolds number. Resident time distribution experiments using water were made for various flow rates to determine level of dispersion and mean residence time of the process and its steps. Kinetics inactivation of pectin methylesterase (PME), polyphenol oxidase (PPO) and peroxidase (POD) were determined for microwave and conventional heating in batch experiments with integration of the whole temperature history of the samples and assuming two enzymatic fractions. Combination of heat transfer, flow and kinetic models provided the average time-temperature history and the final residual activity and results were compared with measurements for model validation. No significant non-thermal effects of microwaves could be confirmed for the inactivation of the enzymes. Temperature profile was in good agreement with the measurements, as well as final activity of PPO and POD; however, larger errors were obtained for the inactivation of PME, which is the most resistant enzyme in the juice. Microwave heating showed to be much faster than conventional heating, thus reducing lethality of the heating step.

(056) HIGH PRESSURE INDUCED STRUCTURAL CHANGES IN MIXED PEA PROTEIN-STARCH SYSTEMS

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Pulse proteins, such as pea protein, offer a relatively inexpensive and sustainable plant protein source that is increasingly utilized in the development of new food products. Starch is also a major component found in pulses. High pressure processing (HPP) has been shown to induce unique structural changes in protein and starch individually. However the effect of HPP on a mixed protein-starch system is not known.

This work explores pressure-induced structural changes in a mixed pea protein-starch system of varying protein and starch concentrations. Pea protein concentrate (PPC) and pea starch (PS) powders were dispersed in water to form solutions containing 9%, 12% and 15% (w/w) protein in combination with up to 8% (w/w) starch. The solutions were packed and sealed in flexible packaging and subjected to HPP treatment at 600 MPa, for 4 min, at 5 °C. Structural changes in the treated samples were investigated by dynamic rheological measurements (strain sweeps and frequency sweeps), differential scanning calorimetry (DSC) and scanning electron microscopy (SEM). Untreated samples were used as controls. All treatments and analyses were conducted in triplicate.

HPP induced significant concentration-dependent changes in all mixed systems. Gel formation did not occur below the minimum protein gel concentration of 12% (w/w), even with the addition of starch. Above 12% (w/w) protein concentration, gel strength was highly dependent on protein concentration, with starch acting as a filler. This was confirmed by SEM, which showed intact starch granules embedded in a mainly protein matrix. Compared to controls, HPP-treated samples had up to a 1000-fold increase in storage modulus (G'). DSC analyses showed that while HPP-induced protein denaturation occurred, starch remained ungelatinized. In fact, the high pressure induced further starch crystallization in the mixed system.

These findings can be used as a basis for the development of HPP-treated plant protein foods.

(058) PRINCIPLES AND APPLICATIONS OF NANOCELLULOUSE COMPOSITE COATINGS FOR IMPROVING PRODUCTIVITY, STORABILITY AND PROCESSING QUALITY OF FRUIT CROPS

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Food waste is a worldwide issue that demands the attention of researchers to improve current methods of growing, storing and processing food. This is particularly true for fruit crops, which face many obstacles on the way from farm to consumers. As a multidisciplinary team with expertise from food science and nanomaterial science, researchers at Oregon State University have been collaborating effectively to study the barrier properties of cellulose nanomaterials (CNs) composite coatings, their interactions and biocompatibility with other functional substances, and their potential applications as food coatings for improving productivity, storability and processing quality of fruit crops. Our studies have built strong fundamental knowledge on a novel approach of using CNs for creating food coatings with superior barrier to water and gases, strong mechanical properties, and stability at a wide range of temperature and humidity environment. In this presentation, we will report 1) the characteristics (size, surface chemistry, and mechanical properties) of different cellulose nanofibrils (CNFs) and nanocrystals (CNCs) and their direct contribution to coating performance; 2) interactions of CNFs and CNCs with other active substances in the coating formation for reaching desired hydrophobicity, permeability, wettability, and antimicrobial activity of coatings; 3) the effectiveness of developed coatings for protecting cherries from rainwater during production, delaying quality deterioration of fruit during postharvest storage, and retaining nutritional and physicochemical qualities of processed berry fruit. Our studies not only generated new scientific information about the nanoscale phenomena relevant to food and the coating material properties related to food engineering, but also developed practical procedures that are easily adapted by food industry.

(060) ENGINEERING CONSIDERATIONS IN DEVELOPMENT AND APPLICATION OF DYNAMIC DIGESTION MODELS

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Development of biorelevant testing approaches to understand food digestion requires knowledge of physiological processes and how these processes are modified after consumption of different meals. With this information, highly-controlled dynamic digestion models can be developed that are applicable to a wide variety of individual food systems and mixed meals. However, fundamental knowledge is lacking on the variability of physiological processes after consumption of different meals. As a result, current dynamic digestion models employ simple control schemes or utilize constant values for physiological processes, such as gastric emptying or rate of secretions. Although this may not allow for testing of individual responses to consumption of varying meals, dynamic digestion models are advantageous in increasing our understanding of how the mechanisms of food breakdown ultimately control nutrient release and absorption. Previous studies have shown that a dynamic gastric digestion model, the Human Gastric Simulator (HGS) can effectively mimic the intragastric pH, gastric emptying rate of solids, and change in hardness observed for white rice in vivo, even while using simplified physiological parameters. For example, intragastric pH in the proximal stomach region after 60 mins of digestion was 6.9 ± 0.1 from an in vivo study (in growing pigs) compared to 7.0 ± 0.1 in the HGS. After such similarities to in vivo digestion have been established, dynamic gastric models can be utilized to understand and quantify food breakdown processes, and the impact of food properties and processing on their physical breakdown during digestion. For example, changes in particle size distribution and rheological properties can be monitored. Changes in these physical properties are not easily measured in vivo for a large set of test meals. Future work is necessary to connect in vivo physiological parameters to specific food properties, allowing for development of the next-generation of dynamic digestion models.

(061) HYGIENIC DESIGN FOR FOOD EQUIPMENT

Rick Katz
Commercial Food Sanitation

This presentation covers the principles of hygienic design for food equipment and provides examples of good hygienic design and poor hygienic design. There is also discussion on how hygienic design programs are implemented in food plants including standards, hygienic review teams, scored hygienic design checklists, factory acceptance testing and qualification after installation.

(062) DESIGNING FOOD EQUIPMENT FOR AUTOMATED CLEANING

Richard Lindsay
Director of Engineering Food and Beverage Division, Ecolab

This presentation is on important design considerations if you want your food equipment to be cleaned effectively with CIP. The basic factors of cleaning are described including time, temperature, concentration and mechanical force as well as system design considerations such as drainage, dead-legs and eccentric reducers. Component selection for an effective CIP will be covered including spray devices, monitoring and recording equipment. A section on advanced CIP automation and monitoring is also presented.

(063) INACTIVATION OF DIFFERENT BACTERIA IN OYSTERS AND MUSSELS BY FREEZING AND FROZEN STORAGE

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Shellfish are considered high-risk foods. As they are filter feeders, they accumulate bacteria if seawater is contaminated with sewage organism Escherichia coli, or if naturally occurring pathogens such as Vibrio vulnificus are present. Contamination can also occur with bacteria such as Listeria monocytogenes during processing at seafood production facilities. Freezing is a well-established method for preserving food but its effects on shellfish pathogens is poorly understood.Our aim was to investigate the effects of blast freezing and frozen storage on inactivation of E. coli in Greenshell™ mussels, and inactivation of V. vulnificus in Pacific oysters. Greenshell mussels™ were inoculated with high and low doses of cocktail of non-pathogenic E. coli , blast frozen at -35ºC and stored at -10ºC and -20ºC. Blast freezing itself did not significantly reduce E. coli counts, but when the mussels were stored at either -10ºC or -20ºC average E. coli numbers reduced by 1.48 log10 MPN/g after 84 days. Pacific oysters were inoculated with cocktail of V. vulnificus, blast frozen at -55ºC and stored at -8ºC, -18ºC and -28ºC. A two-phase inactivation pattern was observed, with rapid inactivation reducing numbers by over 2 log10 during the first 3 days after blast freezing, followed by slower log-linear declines during frozen storage. The target reduction of 3.52 log reduction was achieved within 90 days at -18ºC. For second phase, response was linear; at -8°C, rate of decline in V. vulnificus numbers (log10 MPN/day) was 0.0377, while rates at -18 and -28°C were 0.0162 and 0.0051, respectively. Thus, although the preservation method of blast freezing and frozen storage was similar, there were very different effects on the two bacteria: E. coli and V. vulnificus. If designing freezing regimes for seafood industry for microbial inactivation of shellfish, careful consideration is needed where inactivation of multiple target bacteria is critical.

(065) QUINOA OIL: A GOOD SOURCE OF BIOACTIVE PHYTOCHEMICALS

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Chenopodium quinoa Willd, commonly named quinoa, an annual crop that belongs to Chenopodiaceae family, has been cultivated for five thousand years by South America populations of the Andean region. Quinoa is a pseudo-cereal whose importance has raised due to the high content in protein, starch, essential aminoacids, minerals and bioactive compounds. In the last decades several breeding programs have introduced new and traditional quinoa varieties in North America and other regions, arising questions regarding variability in their secondary metabolite profiles. In this work, we will fingerprint 28 quinoa varieties cultivated in Washington State, focusing on the poorly investigated oil fraction. Total phenolics varied from 2.7 to 5.9 mg/g DW for Kaslaea and Oro del Valle varieties, respectively. We found variability in both phenolics and carotenoids content, which is reflected in different antioxidant capacity, as measured by FRAP (range from 2769 µM to1290 µM) and DPPH (2.5 and 1.1 mg/g Trolox). Fatty acids (FA) profiles show that linoleic acid (C18:2), oleic acid (C18:1) and linolenic acid (C18:3) represent ~85% of total FA. Finally, β-sitosterol was the major phytosterol in all varieties, ranging from 21 mg/g to 46 mg/g. Through factor analysis, it was possible to classify the quinoa varieties in two classes, one comprising varieties with higher phytochemical and PUFA contents, which are suitable for targeted food applications.

(066) HARVESTING FUNCTIONAL NANOPARTICLES FROM HOUSEHOLD PREPARATION OF FRESH WATER CLAM SOUP

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Objectives: Functional nanoparticles are reported to be prepared by various methods such as synthesis, mechanical attrition, chemical precipitation, and electrodeposition, but never ever by household cooking. This work is aimed to show that opposite to what most people think, household cooking can be a most efficient way to prepare bioactive nanoparticles by investigating nanoparticles in fresh water clam soup, a traditional delicacy as well as a folk remedy popular in Southern China and Japan.
Methodologies: the process of self-assembly was monitored by light scattering determination. Fractionation of the soup was carried out by chromatographies. The hepatoprotective effect was studied by tilapia fed with high fat diet.
Results: Self-assembly was found to complete in one hour, and the soup was fractioned into two kinds of nanoparticles with high reproducibility, indicating the remarkable high structural precision and stability. Administration of the soup, nanoparticle fractions to tilapia fed with high fat diet all effectively prevented occurrence of fatty liver. The results provide scientific supports for a traditional folk food remedy, and imply that simple, easy and very familiar household cooking can be a process for the preparation of safe, stable and functional nanoparticles, which biomedical researchers are trying hard to obtain with limited success.

(067) PROTEINS NANOPARTICLES DERIVED FROM CHINESE MEDICINAL HERBS: HEAT-INDUCED SELF-ASSEMBLY, BIOACTIVITIES AND APPLICATIONS

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Functional nanoparticles (NPs) are reported to be prepared by various methods such as synthesis, mechanical attrition, chemical precipitation, and electrodeposition, but rarely by the cooking-like decocting of Chinese medicinal herbs. Many herbs, i.e. *Radix Glycyrrhizae* (Gan Cao, licorice), *Rhizoma Alismatis* (Ze Xie, Water plantain tuber), seed of *Prunus armeniaca L.* (Ku Xing Ren, bitter apricot kernel), *radix Puerariae* (Ge Gen, Kudzu), are used both as food and medicine in China for hundreds of years and are therefore generally regarded as safe (GRAS). Our studies showed that, the protein nanoparticles (NPs) self-assembled during decocting of the herbs and conducted pharmacological effects. A serial of constituent proteins of the NPs have been identified from the herbs, often in their glycated forms, showing particle forming capacity induced by heat or pH. The NPs are spherical and negatively charged, with hydrodynamic diameters from 50 to 250 nm. Approximately one such NPs is assembled with a few dozens of protein molecules, according to their calculated molecular weight. The NPs served as vehicles for bioactive alkaloids, polyphenols, flavonoids and glycosides, i.e. ephedrine, aconitine, astragaloside, alisol A, amygdalin, puerarin, berberine, baicalin etc., via adsorption or encapsulation. NPs elevate the bioavailability and bioactivities of these cargo molecules, including intracellular antioxidant, inhibition on the inflammation and cancerogenic cells, while eliminating the toxicity *in vitro* and *in vivo*. Furthermore, the direct interaction of NPs with mucosal macrophages from alimentary track suggests a previously unrecognised mode of herb/food-body interaction. It implies a promising family of nano-carriers for the safer, healthier and more sufficient utilisation of macro/micro-nutrients and nutraceuticals in foods, while minimising the food safety and health risk of endogenous toxin and environmental pollutants. These plant-derived protein NPs, prepared by self-assembly via covalent and non-covalent interaction, provide a novel approach of manufacturing food-grade nano-materials, with a potential application in advanced drug delivery.

(071) UNDERSTANDING HEAT TRANSFER FOULING FOR MORE EFFICIENT BIOPROCESSES

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Heat transfer fouling is unwanted deposition of materials on surfaces of processing equipment, which leads to additional capital investment, increased operating costs and lower processing efficiency. Multiple effect evaporators are commonly used to remove water during processing. More than 200 biorefineries in the US use these evaporators to concentrate various process streams. During fuel ethanol production, fouling occurs when thin stillage is concentrated into condensed distillers solubles. During starch production, fouling occurs as steepwater is concentrated into condensed fermented corn extractives or heavy steepwater. For these biorefineries, evaporators must be cleaned due to fouling every 7 to 14 days, resulting in increased maintenance costs, reduced potential production and increased water and chemical usage. As production of biofuels from cellulosic materials is expected to increase, the issue of evaporator fouling is expected also to increase. Thin stillage and heavy steepwater have complex composition, high compositional variability and time sensitive properties. Due to this complexity, it is difficult to study a single factor on fouling without interference from other factors. The objective was to investigate fouling properties using model fluids and compare them with properties of actual process fluids. An annular probe was used to measure the change in the overall heat transfer resistance as deposits were formed on a heated surface. Resistance increased as layers of material were deposited. Membrane filtration, probe surface temperature, suspended solids content, glycerol content, plant operation and other parameters were found to have effects on fouling tendencies.

(073) MICROBIAL VALIDATION OF EXTRUSION PROCESSING FOR LOW-MOISTURE FOODS

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Research Justification: An increase in the number of outbreaks/recalls due to *Salmonella* in low-moisture foods along with the Food Safety Modernization Act, Preventive Control rule has necessitated the development and validation of process controls.
Objective: This study aims to: (1) Develop a response surface model (RSM) for *Salmonella* inactivation during single and twin-screw extrusion of oat flour as a function of screw speed, temperature, fat, and moisture content, (2) Evaluate *Enterococcus faecium* NRRL B-2354 as a surrogate for *Salmonella* during the extrusion of oat flour, and (3) Evaluate the use of residence time instead of screw speed on the accuracy of RSM for inactivation of *Salmonella* and *E. faecium*.
Methods: Oat flour inoculated with either *Salmonella* cocktail or *E. faecium* was formulated to different moisture (14 to 26%) and fat (5 to 15%) contents. The prepared samples were extruded at different temperatures (65 to 95˚C) and screw speeds (75 to 225rpm). For objective 3, 0.5 g of red dye was added to the hopper and the color of collected samples were measured using a colorimeter. The residence time (RT) data were then used to replace screw speed in the RSM developed for *Salmonella* and *E. faecium*.
Results: For single-screw, >5.5-log reduction of *Salmonella* was achieved at temperature >85ºC at all conditions evaluated at 150 rpm. However, for twin-screw, *Salmonella* was under detection limit (<10 CFU/g) at temperature >65ºC. *E. faecium* always showed a higher heat resistance than *Salmonella* at all conditions exhibiting its use as a surrogate. The use of RT instead of SS improved the R^2 value for RSM from 0.83 to 0.85 for *Salmonella* and 0.84 to 0.88 for *E. faecium*.
Relevance: The developed model can be used by the industry to identify process conditions to achieve a desired reduction of *Salmonella*. Also, a slight increase in accuracy due to use of RT instead of screw speed may not warrant the use of RT in the model due to complexity in determination of RT.

(074) GASTRIC DISINTEGRATION AND EMPTYING AS AFFECTED BY FOOD TEXTURE AND GASTRIC VISCOSITY

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Gastric disintegration and emptying are critical steps for food digestion greatly impacting the bioaccessbility and bioavailability of the nutrients. This pretention will talk about recent studies in the influence of food texture and gastric viscosity on gastric digestion by examining the changes in gastric disintegration and emptying rates. *D*ynamic gastric model was used to test various types of foods for the textural changes and the emptying rate. The impact of viscosity on gastric disintegration kinetics and emptying patterns were determined by using indigestible and digestible solids mixed with guar gum. Results indicated that texture of foods had different level of disintegration during gastric digestion which subsequently inducing various emptying rates. Increasing the digesta viscosity reduced the disintegration levels of foods, but caused different effect on gastric emptying: increasing viscosity up to a critical value improved the particle dispersion and increased rates of solids emptying, while further increase in viscosity hindered emptying of solids. Mathematical model was used to explain the influence of viscosity, density and particle size on emptying rate.

(076) QUANTITATIVE MODELING OF BACTERIAL GROWTH IN FOOD MATRIX – CASE STUDIES

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Predictive microbiology is a resourceful tool for food safety evaluation, supporting strategies concerning the HACCP system and quantitative risk assessment. Microbial quantitative models help to estimate shelf-life and setup parameters in food processing. In the last decades, these models have evolved concomitantly with advances in computer software and food microbiology understanding. However, many issues still hinder practical applications of predictive microbiology: food matrix effects, strains variability, pre-culture conditions, presence and interaction of mixed cultures, individual cell behavior, variability and uncertainty of the physiological state of the cells, non-constant environmental conditions, among others. Matrix influence on bacterial growth was assessed in two independent studies: thermal stressed *Bacillus cereus* in dairy product and *Weissella viridescens* in non-isothermally stored meat product. *B. cereus* cultures were stressed by heat during 25 s at 72 °C, imitating pasteurization, and then grown in Reconstituted Infant Formulae (RIF) and culture medium (BHI). Results show the maximum specific growth rate in BHI higher than in RIF, as expected, with a bias factor fairly constant around 1.3 in this case. Three different strains of *B. cereus* resulted in significantly different estimated kinetic parameters. On the other hand, *Weissella viridescens* parameters based on isothermal culture medium growth data were able to describe the bacterial behavior on non-isothermal growth in vacuum-packed sliced ham. Optimal experimental design (OED) was applied to estimate the microbial growth parameters of *W. viridescens* and led to smaller confidence intervals and best statistical indexes than those determined from isothermal growth curves. Additionally, OED experimental measurements were shorter than those in the isothermal method, saving time and cost. In these two bacteria-food systems, it was demonstrated the requirement of specific studies for modeling bacterial behavior in each case, keeping predictive microbiology evolving as a research area.

(077) MENAQUINONE-7 (VITAMIN K2) PRODUCTION BY BACILLUS SUBTILIS NATTO IN BIOFILM REACTORS

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Menaquinone-7 (MK-7) is a subtype of vitamin K, which plays a key role in promoting heart and bone health. MK-7 can be excreted by many strains of bacteria. Among these strains, *Bacillus subtilis natto* seems to hold a key position. On the other hand, *Bacillus subtilis*, especially in static fermentations, tends to form pellicles and possibly biofilms under suitable conditions which promote MK-7 secretion but at the same time create operational and scaling up issues during fermentation. Therefore, biofilm reactors seem to be a viable strategy to create a controlled environment for the bacteria to form biofilm and simultaneously address operational and scaling up issues through robust agitation and aeration. This study has undertaken to optimize the growth parameters and media components in a glucose-based medium by using a biofilm reactor. Furthermore, MK-7 concentrations were enhanced using a fed-batch strategy to concentrations as high as 28.7±1.1 mg/L, which was 40.3% higher as compared to the batch process. In conclusion, this study clearly demonstrated that MK-7 can be produced in agitated systems, which can be scaled-up for commercial productions of Vitamin K.

(078) CHARACTERIZATION OF INDIVIDUAL PARTICLE MOVEMENT DURING IN VITRO DIGESTION IN THE HUMAN GASTRIC SIMULATOR

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Novel food or pharmaceutical products with targeted functionality may help to overcome public health issues such as obesity, malnutrition, or diabetes. To develop the next generation of functional food products it is important to understand the breakdown of material during digestion. During this process, nutrients are made available for absorption into the human body where they serve specific functions. Two factors influencing the breakdown process are i) particle location and ii) their residence time in the stomach. A dynamic in vitro stomach model, the human gastric simulator (HGS), was used to characterize and quantify particle movement during in vitro gastric digestion. Positron Emission Particle Tracking (PEPT) was used to track individual particles in materials of varying properties (i.e. water, glycerol, xanthan gum solutions, and soup) inside the HGS. Results showed nonturbulent particle movement in the HGS in all test meals. Residence times for flow through the gastric cavity were determined to be 1 s, 0.6 min, 1.3 min, 16.4 min, and 27.0 min in water, 0.38% xanthan gum solution, glycerol, soup, and 1% xanthan gum solution, respectively. A linear correlation was found between residence time and the consistency factor K, which was determined by rheological measurements. Residence times in the HGS were longer compared to theoretical residence times calculated with terminal velocities, e.g. 80 s (HGS) versus 8.3 s (theoretical) for glycerol showing that particles did not move in free fall through the HGS. These findings provide insight on particle location and residence time during gastric digestion and contribute to the understanding of particle breakdown, which may help to design food or pharmaceutical products with health benefits.

(079) ASSESSMENT OF OXIDATIVE STABILITY OF HOME-COOKED MEAT PRODUCTS IN US USING A PROCESSOMIC APPROACH.

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Monitoring and control of lipid oxidation in food has become a relevant topic due to its impact on product quality. It has been proved that there is correlation between dietary lipid oxidation specially, cholesterol and its oxidation products (COPs) with chronic diseases, such as cancer, atherosclerosis, and even neurological diseases such as Parkinson and Alzheimer. In addition, different studies have found a direct relationship between increased quantities of COPs and food processing conditions (i.e. temperature vs cooking time). This suggests a potential risk in long-term consumption of these lipid oxidation products and even the existence of a variability in lipid oxidation products consumption depending on the diet. Thus, the aim of this study was to evaluate the influence of the pan frying cooking method on the lipid oxidation status of the most consumed meats and meat products in the United States diet basket by a processomic approach. Primary and secondary oxidation products were measured on pork chop, ground beef (80% and 93% lean), by Peroxide Value (POV) and Thiobarbituric acid (TBARs) assays. Fatty Acids Methyl Esters (FAME) were quantified. Raw and cooked meat products were evaluated.

Results show that pan frying has a higher effect on the formation of primary oxidation products in pork chop with a decrease of 18% on the POV value, in comparison with raw samples (18.60 meq O_2/kg lipid). As expected, the pan frying method has also a higher effect on the formation of secondary oxidation products in pork chop. TBARS show an increase of 30% mg MDA/kg lipid between raw (553.05 mg MDA/kg lipid) and cooked samples. (1795.03 mg MDA/kg lipid). After FAME quantification, saturated fatty acids (SFA) percentages range between 47.32 to 87.36 (g/100g) in raw samples and 38.99 to 89.28 (g/100g) in cooked samples. Monounsaturated fatty acid (MUFA) percentages range from 6.27 to 51.02 (g/100g) in raw samples and 10.18-55.54 (g/100g) in cooked samples. Polyunsaturated fatty acids (PUFA) percentages range from1.31 to 9.35 (g/100g) in raw samples and 0.54 to 5.48 (g/100g) in cooked samples. Quantification of COPs and other derivatives was as well performed. Further studies are needed to fully characterize oxidation products and understand its influence in both meat quality related to its long-term consumption. This suggests the existence of a variability in lipid oxidation products consumption per diet. The aim of this project is to compare the lipid oxidation values of different meats present in the USA diet basket.

(081) EVALUATION OF THERMAL AND NON-THERMAL INACTIVATION TECHNOLOGIES COMBINED WITH A NOVEL ANTI-MICROBIAL PLANT EXTRACT IN A MULTI-HURDLE APPROACH

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Quality and safety are main attributes for successful industrial-scale production of foods. Thus, maintaining and extending the shelf life of products is a main goal of food preservation. On the other hand, nutrients and valuable ingredients of the food should be retained in a most efficient manner. For this purpose, novel, non-thermal inactivation processes, e.g. High Hydrostatic Pressure (HPP) or Pulsed Electric Fields (PEF), were developed, which are based on different molecular inactivation mechanisms than traditional thermal pasteurization. The addition of antimicrobials as another hurdle can further contribute to an increased inactivation. However, for new, potential antimicrobial substances this has to be evaluated in detail before an implementation is feasible.

Thus, in the present study, the anti-microbial potential of an extract from pigmented rice bran (RBE), obtained from agricultural side streams, was investigated, using heat, PEF, and HPP as additional hurdles. Mechanisms of inactivation were characterized using flow cytometry and propidium iodide / SYBR green staining. As target organisms, four bacterial strains with different Gram behaviors were chosen, two Escherichia coli strains, as well as Listeria innocua and Staphylococcus carnosus, as surrogates for the respective pathogenic species.

Inactivation kinetics were obtained, process parameter combinations for a successful inactivation were determined, and the beneficial effect of the rice bran extract was investigated. As the effect of the combination of RBE and PEF was rather limited, a more pronounced influence of up to 4 log was determined using HPP as well as thermal processing. Furthermore, mechanistic differences could be visualized.

Hence, this study contributes to an increased understanding of the interaction of thermal and non-thermal inactivation technologies and anti-microbial plant extracts. By giving indications on the mechanistic and the process level, it can help to adjust both, process and matrix properties to design effective hurdle processing schemes to obtain microbiologically safe products.

(082) TECHNOECONOMIC ANALYSIS OF LARGE-SCALE MICROENCAPSULATION OF BIOACTIVES IN CROSS-LINKED ALGINATE MICROCAPSULES

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Microencapsulation of bioactive compounds in cross-linked alginate can stabilize the cargo, offer long term shelf stability, control cargo release, and facilitate incorporation into foods. However, cumbersome production steps limit the utilization of alginate microencapsulation in the food industry. The traditional external gelation method is challenging to scale industrially, requiring several costly unit operations including spraying the cargo with an alginate solution into a calcium chloride bath, separating, and drying the microcapsules. Our group recently developed a consolidated process that accomplishes alginate cross-linking in situ during spray-drying to form cross-linked alginate microcapsules (CLAMs). This work examines the process economics of these two microencapsulation processes through technoeconomic modeling. Parallel process models were constructed in SuperPro Designer in batch mode, with each process generating 500,000 kg/year of dry microcapsules containing 25% (w/w) fish oil. At this scale, the unit cost of microcapsule production was approximately $15/kg for the CLAMs process and $38/kg for the external gelation process. The economic advantage of the CLAMs process, which was maintained at each annual production scale examined, was attributed to its shorter cycle time and considerably lower facility, equipment, and labor costs. This work demonstrates the potential commercial advantage of the CLAMs process, which may justify its eventual implementation for alginate microcapsule production in the food industry.

(084) THERMAL DEATH SANDWICH METHOD FOR DETERMINING THERMAL INACTIVATION KINETICS OF MICROORGANISMS IN LOW MOISTURE FOODS

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Introduction: The thermal resistance of microorganisms are usually determined with a sealed vessel such as thermal-death-time (TDT) disks immersed in a water/oil bath. However, it is difficult to control the come-up time (CUT) of samples in a water/oil bath. A novel method called TDT sandwiches was developed to consistently control the CUT of inoculated food samples.
Purpose: To compare the thermal resistance of *Salmonella* spp. and *Enterococcus faecium* NRRL B-2354 in ground black pepper measured using TDT disks and TDT sandwiches.
Methods: Black peppercorn samples were spray-inoculated, equilibrated to 0.45 a_w for 2 days, grinded, then equilibrated again for a day to achieve stable initial populations of 6.44±0.24 log CFU/g and 7.51±0.12 log CFU/g of *Salmonella* spp. and *E. faecium*, respectively. Samples were packed into TDT disks or TDT sandwich pouches and heated to 65, 70, and 75 °C for *Salmonella* spp. and 70, 75, and 80 °C for *E. faecium* with two replications at each time point. Samples were pulled out at selected time points, chilled in an ice bath, and plated on differential media.
Results: The D-value of *Salmonella* spp. at 65, 70, and 75 °C for the TDT disk was 17.49, 10.87, and 4.09 min, respectively, and for the TDT sandwich was 44.47, 17.68, and 7.21 min, respectively. On the other hand, the D-value of *E. faecium* at 70, 75, and 80 °C for the TDT disk was 27.54, 9.23, and 3.50 min, respectively, and for the TDT sandwich was 34.12, 12.01, and 4.18 min, respectively.
Significance: The consistently higher D-values in TDT sandwiches provide a conservative measurement of thermal resistance which is appropriate for food safety validation. Additionally, the results encourages deeper investigation into possible factors such as leakage in TDT disks that could influence the results of traditional methods utilizing water/oil baths.

(087) BACTERIOPHAGE BASED NANOSCALE DISPERSION AS BIOCONTROL AGENTS FOR AGRICULTURAL PRACTICES

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To improve sustainability of agricultural practices, significant efforts are being made to limit the use of conventional chemical pesticides/ bactericides, since conventional chemical pesticides/ bactericides have harmful ecological consequences. To reduce the use of these conventional pesticides/ bactericides, bacteriophages have been proposed as a potential promising approach for controlling pests and pathogens. Despite significant promise, inactivation by UV light is the biggest factors reducing phage persistence on plant surfaces. Thus, there is unmet need to improve stability of bacteriophage-based biocontrol products to enable sustainable agricultural practices.

This study aims to develop a bacteriophage-based nanoscale dispersion for improving UV stability of phages and use this formulation as biocontrol agents for controlling plant pathogens in agricultural practices. In this study, phage based nanoscale dispersion using combination of edible whey protein isolate (WPI) and nanoscale food grade compound were compared with phages in an aqueous suspension (control sample). The results demonstrated that nanoscale dispersion enhanced phage stability by 2 log (PFU) after exposure to UV-A for 1 hour. The ability of this nanoscale dispersion to improve UV stability of phages was also demonstrated on the leaf surface. When spraying this phage formulation on plant leaf surface and exposure to UV-A for 1 hour, the nanoscale dispersion increased the UV-A stability of phages by 2 log. The nanoscale dispersion exhibited an effective antimicrobial activity against bacteria on plant leaf surface in the presence of UV-A, more than 2.5 log reduction were achieved after 1 h treatment, while the control samples only got 1 log reduction. Overall, the results show that this nanoscale dispersion provides phage stability and antimicrobial activity to plant surface compared to the control sample, and thus may be considered an effective approach for stabilizing natural pesticide and improving agricultural sustainability.

(088) STEAM STRIPPING OF AROMA FROM ROAST AND GROUND COFFEE: A MATHEMATICAL MODELLING APPROACH

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Aroma is a major factor in consumer satisfaction when drinking coffee. Hundreds of compounds have been identified in coffee, spanning various chemical groups that contribute various aromatic 'notes' in the beverage. In instant coffee manufacture, aroma is extracted from roast and ground coffee, to be added back before the final drying stage, preventing evaporative losses upstream. One means of aroma extraction can be the steam stripping of a bed of wetted coffee grains. We present a finite difference model of mass and heat transfer describing this extraction; including bound aroma release, intra-particle diffusion, liquid-gas transfer and gaseous advection.

Different extraction mechanisms and kinetics are seen for aromas with varied physical chemical properties, namely octanol-water coefficients and Henry's volatility constants. A distinction in extraction behaviour exists between aromas with markedly different Henry's constants. Aromas that partition into the gaseous phase most strongly are stripped from the surface water quickly and become diffusion-limited. The most polar compounds partition most strongly in the water, and are limited by the water-to-gas transfer step. This partially explains the difference in extraction kinetics shown in previously published data for acetaldehyde and acetic acid. It also suggests that smaller coffee grind sizes may benefit the former group, whilst longer extraction times may benefit the latter.

Published data for other compounds show early plateaus in extraction from wetted coffee that cannot be explained by exhaustive extraction. We propose a simple binding mechanism between aroma and the soluble coffee matrix to mimic the rate of extraction observed.

This work demonstrates some of the factors governing aroma extraction from coffee via steam stripping. It suggests how different process variables will influence specific groups of aromas more than others, which forms the basis of controlling instant coffee aroma profiles via processing.

(092) TOWARDS THE CONTROL OF FOOD STRUCTURING PROCESSES: A REDUCED-ORDER MODELLING APPROACH TO ICE CRYSTAL FORMATION

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Crystallisation processes are present in a wide range of manufacturing methods and applications in food processing. For example, ice cream smooth texture and cooling sensation is enhanced by targeting a given ice crystal size. The first stage of freeze-drying processes (i.e. freezing and thus crystal formation) is key to determine a well-interconnected porous structure that allows drying and further rehydration of the products. Proper control of the crystallisation conditions will be key to define the final quality of the frozen product.

Control tools require the development and implementation of process modelling tools that are capable to operate at faster time scales than the process itself. In recent years, Phase Field models have been increasingly used to simulate and predict the formation and evolution of material microstructure and phase change interfacial kinetics. However, these methods usually lead to computationally involved numerical schemes, revealing the need for more efficient computational solutions.

In this work, model reduction has been applied to a Phase-field model for water crystallisation in food model systems. This phase-field model takes into account both heat and mass transfer phenomena, and describes the evolution of the solid/liquid interface (i.e. crystal shape). Two different model reduction techniques (i.e. Proper Orthogonal Decomposition and Laplacian Spectral Decomposition) were applied to the full model, and their performance was illustrated – and compared - using a range of undercooling and seeding conditions. Results obtained show that reduced models can accurately describe the behaviour of the full system, including the effect of the degree of supercooling on the formed crystals morphology.

Overall, this work demonstrates the potential of reduced order approaches for the modelling of food structuring processes and also for the development of virtual tools that allow a “fast” (yet accurate) monitoring, design and optimisation of food manufacturing processes.

(096) SIMULTANEOUS MULTI-PRODUCT STERILIZATION; REVISITED, EXPLORED, AND OPTOMIZED

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Since the 1980s, considerable amounts of resources and effort have been invested and directed toward the research on and search for emerging technologies in food processing, including thermal and non-thermal methods. Numerous research studies extol the benefits of these emerging technologies in retaining valuable quality attributes and bioactive components and attribute all negative aspects to the role of heat and classical processes. Since the mid-1980s, with a few exceptions, emerging technologies are far from replacing classical food processing technologies.
An interesting potential improvement and challenge in thermal processing of packaged foods is the implementation of simultaneous multi-product sterilization.
The aim of this research was to analyze, explore, and optimize simultaneous multi-product sterilization through thermal processing simulation of packaged foods considering both constant (CRT) and variable retort temperature (VRT) profiles.
The research was approached through three main tasks, which were defined to discover potential opportunities for simultaneous multi-product sterilization with the attempt to recommend the steps to follow to practically implement it.
In most cases, simultaneous multi-product sterilization for CRT processing was feasible, however, it was limited to low retort temperature and restricted to products with similar f_h. In contrast, in VRT profiles a higher flexibility for simultaneous multi-product sterilization was found.
The opportunity to carry out simultaneous multi-product sterilization provides flexibility to optimize retort utilization, reduce energy consumption, and increase processing plant productivity.

(097) GLOBAL CHALLENGES AND OPPORTUNITIES TO INSPIRE THE MILLENNIALS FOOD ENGINEERS

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The future is here today – Gen Z is the generation taking over and leading businesses and education for the next 40 to 50 years while Millennials are already in charge of developments for the next 30 years and beyond. Food Engineering (FE) has made a tremendous contribution to our modern food supply and its safety while engineering foods for digestion and health is emerging. Such contributions are needed while FE is to be seen as the discipline of *Science, Innovation and Engineering for Diet and Well-Being*. FE in its global role needs to recognize its significance beyond Food and Nutrition to operate at its major interfaces with Agriculture, Food Science, Nutrition, Microbiology, Gastroenterology and Ecology. That is FE and the role of Food Engineers will be covering the complete ecological cycle in its scientific and engineering landscape. Challenges will appear because of urbanization and changing agricultural practices for feeding expanding populations in developing countries, creation of sustainable and safe food supplies with less energy and packaging, product engineering for delivery of nutrition and health and waste utilization in food production for sustainability. FE organizations, educational institutions and food industry can prepare and plan for the challenges and opportunities by developing FE and FE programs and overseeing skills development and innovation demands for contribution into traditional FE but also to novel FE area using knowledge and learning from interfacing disciplines to serve people in 2050 and beyond.

(098) PHYSICOCHEMICAL PROPERTIES OF HIGH-PRESSURE HOMOGENIZED PULSE NANOEMULSIONS

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Protein-stabilized oil-in-water nanoemulsions are increasingly applied in the food industry for their unique physicochemical and functional properties. Oil-in-water emulsions stabilized by pulse proteins are gaining attention due to their low cost, continuous production, and nutritional value. The goal was to study different high-pressure homogenization (HPH) treatments on pulse nanoemulsion stability through their physicochemical properties. Pulse (bean/lentil/chickpea) protein nanoemulsions (2.5, 5, 10 wt%) were treated by HPH (50, 100, 200, and 300 MPa) with two homogenization passes. Nanoemulsion droplet size, polydispersity index (PdI), and ζ-potential were analyzed by dynamic light scattering, while interfacial tension (IT) was measured by the Du Noüy ring method.
Droplet size and PdI were affected by pressure and protein concentration. Droplet mean size decreased from > 1000 to 172 nm (bean), 587 to 147 nm (lentil), and 950 to 173 nm (chickpea), while PdI decreased from 0.877 to 0.209 (bean), 0.821 to 0.180 (lentil), and 0.857 to 0.259 (chickpea) as pressure and concentration increased. Pressures > 200 MPa and concentrations > 5 wt% were related to greater droplet size and PdI reduction. Nanoemulsion ζ-potential values became more positive as pressure increased; however, they were all < -30 mV, which can be considered as stable. Pulse proteins decreased oil-water IT from 16.5 mN/m to > 8 mN/m for all pulses, and smaller values were related to lentil nanoemulsions. In conclusion, pulse proteins produced stable nanoemulsions, and lentil is the protein that produces the most stable nanoemulsions. The HPH treatment is a sustainable alternative to enhance the functionality of vegetable protein, such as pulses, that could be incorporated into colloidal food systems.

(099) MECHANISTIC APPROACHES TO UNDERSTANDING FOOD SAFETY: ATTACHMENT AND INTERNALIZATION

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Along with an ever-increasing consumption of fresh produce, reported outbreaks of foodborne illnesses linked to fresh produce have been on the rise. Mechanistic modeling approaches can enhance understanding of bacterial attachment and infiltration into fresh produce and identification of the risk factors contributing to food-borne outbreaks. Here we apply this approach to address microbiological safety issues in fresh produce. We show that how and under what mechanisms human pathogenic bacteria can attach or infiltrate into fresh produce during post-harvest process operations. We will share mechanistic models for 1) passive attachment of bacteria to plant leaves, and 2) internalization of bacteria in several scenarios. These scenarios for internalization include temperature-driven infiltration into tomatoes while hydrocooling, infiltration into leaves due to pressure-driven flow during vacuum cooling, water evaporation-driven infiltration, and light-driven chemotaxis. Mechanistic understanding through modeling is a powerful enabler in identifying the primary factors contributing to attachment and internalization.

(101) TOWARDS INNOVATIVE ONLINE BIOENERGY EDUCATION

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Innovative hands-on learning activities were developed in an attempt to minimize the difficulty of teaching bioenergy topics at the graduate level to online students in Penn State's Master's of Professional Studies in Renewable Energy and Sustainability Systems (MPS-RESS). Special effort placed on the creation of innovative hands-on practical/laboratory educational experiences that utilize a variety of learning tools and counteract the difficulties associated with distance learning of technical subjects. Course material created and integrated into an online learning environment, and delivered, and the effectiveness of the courses were measured through pre- and post- testing of the students. Of particular interest was the effectiveness of the hands-on practical training component for developing student confidence and understanding. The applicability of these findings to Food Engineering will also be discussed.

(104) CONVERTING LACTOSE TO TAGATOSE USING INTEGRATED HYDROLYSIS AND ISOMERIZATION METHOD

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Lactose is a low cost and large-scale product of dairy industry, and it is a residue from the separation of high value-added proteins from whey. D-Tagatose is a low calorie sweetener, and it can also be used as an intermediate for synthesis of optically active compounds, and as an additive in detergent, cosmetic, and pharmaceutical formulation. The conversion of lactose to value-added tagatose has attracted great deal of attention. The development of effective catalyst is vital for tagatose production. In this study, lactose was converted into tagatose through a two-step hydrolysis plus isomerization process. The ratio of lactose hydrolysis to glucose and galactose reached 95.22% using Lactase at reaction time of 1h, room temperature of 25°C and lactase loading ratio of 4%. The Sn/βcatalysts with different Sn loading ratio (5%, 10%, 15% and 20%) were prepared and characterized by BET, XRD, FTIR and TEM. The prepared Sn/βcatalysts were applied in the sugar isomerization process at 100°C for 2h. It was found that 15% Sn/βcatalyst generated the highest tagatose yield at 6.58%. These results indicated that the combination of hydrolysis and isomerization using Sn/βcatalyst was an effective approach for tagatose production from lactose. This approach will benefit the dairy industry to economically utilize the low value lactose byproduct to produce high value tagatose product.

(105) HYGIENIC CLEANING; UNDERSTANDING THE IMPACT OF FILM THICKNESS ON THE EFFICIENCY OF JET CLEANING OF PROCESS PLANTS

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Cleaning in place (CIP), involves automated in line cleaning of process equipment, it is used ubiquitously in the food industry. Rotating spray devices are used to clean the inside of process vessels, with a large range of devices and operating conditions to consider. Currently the CIP programs for the spray devices focuses on coverage of the vessel, whilst being over engineered wasting water, and energy.
This research aims to further understand the impinging jet cleaning mechanisms, of a rheologically complex material, adhered to stainless steel as a thick film. High-speed photography has been used to capture a layer of deposit, as it is cleaned by an impinging water jet. Experiments focus on how the behaviour in the first second of cleaning, relates to the later cleaning stages, as a function of the jet parameters. The deposit used exhibits both a yield stress, and shear thinning behaviour, common in food products. Experiments used 2 – 8 mm thick layers, to highlight the transition of mechanisms between thin and thick films, seen in industrial processes.
Results showed for the thicker films the impinging jet did not produce a visually cleaned area in the first second, rather a 'disturbed' area was formed. In this disturbed area the jet had impinged through the deposit and broken the adhesive bonds between material and the surface. In this work we measured the disturbed area over the first second of cleaning, comparing it to a defined final cleaned area for varying jet parameters. We have studied cleaning as a function of layer thickness, water flowrate and nozzle diameter. Modelling a defined final cleaned area as a function of flow parameters has been successful. The results facilitate the development of more efficient CIP programmes to be designed and employed by food manufactures.

(109) DESIGN OF CHEMIRESISTIVE GRAPHENE NANOPLATELET - POLYMER VAPOR SENSOR ARRAYS TO DETECT VOLATILE ORGANIC COMPOUNDS

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Electronic nose devices consisting of arrays of semi-selective gas sensors have great potential to detect and discriminate numerous analyte targets. By using multiple sensors with high response diversity a unique signature is created for target discrimination. In this study vapor sensors are constructed by coating interdigitated electrode arrays with composites of graphene nanoplatelets and commercial polymers. Each polymer absorbs and desorbs analytes at a unique rate causing changes in the measured resistance. First the repeatability of sensor performance was validated by measuring the response after 80 analyte exposures over 5 days. Next 5 phosphonated CWA simulants and 8 interferent compounds were introduced as single component vapors to assess detection and discrimination capabilities of an array containing 12 unique polymer-GNP coatings. The collected data was processed with principal component analysis to achieve 95-100% classification accuracy. The results demonstrate detection and discrimination of 5 similarly structured CWA simulants amongst themselves and against 8 interferent compounds. Finally the optimal coating composition and thickness were determined to maximize sensitivity and performance of constructed sensors. The results demonstrate the potential of GNP-polymer chemiresistive sensor arrays for detection and discrimination of volatile organic compounds.

(111) SUSTAINABLE FOOD WASTE MANAGEMENT –HONG KONG EXPERIENCE

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Globally 1/3 of the food produced from our food production system are disposed without being consumed, which accounts for high amount of resources utilization including fossil based fertilizers and energy. Food waste constitutes about 30-50% of the municipal solid waste, and its disposal by landfilling poses environmental problems as well as the breakdown of the nutrient cycle. In fact, food waste itself is a resource containing intact energy, carbon, nutrients, vitamins, minerals and metals that need to be recycled back into our fossil-based economy. Therefore, it is important to develop integrated and innovative technologies to convert food waste biologically into bio-energy and value-added products. Therefore, its high-time to develop an integrated bio-technologies to re-route the waste resources for the production of fuels, energy and value-added products. Efficient recycling of food waste will benefit and support the bio- circular economy by providing: (a) *Bio-energy and Bio-fuels*, that will greatly reduce the fossil fuel demand and associated fuel/energy production costs; (b) *Bio-fertilizers*, that will improve soil quality and stability by better carbon restoration, and reduce fossil fuel based commercial fertilizer productions; (c) *Bio-products*, including new bio-products and industrial biochemical such as pigments, bioplastics, etc; and (d) *Bio-mass and Bio-feed* for production of food or feed for animals and fisheries, that will reduce the arable land and water use. Ultimately, this will provide a lot of job opportunities, reduce the GHG emissions, retain the quality of soil, reduce the waste disposal costs and substitute the fossil-based economy. However, the key points to select a technology or integration of technologies for food waste treatment should be based on the local need, economy and availability of resources. This paper explores the available and possible niches of development for the biological treatment technologies for sustainable food waste management.

(112) ROBOT-ASSISTED HIGH-THROUGHPUT PHENOTYPING OF ENERGY SORGHUM

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This presentation will discuss the design and field evaluation of a low-cost, high-throughput phenotyping robot for energy sorghum. High-throughput phenotyping approaches have been used in isolated growth chambers or greenhouses, but there is a growing need for field-based, precision agriculture techniques to measure large quantities of plants at high spatial and temporal resolutions throughout a growing season. A low-cost, tracked mobile robot was developed to collect phenotypic data for individual plants and tested on two separate energy sorghum fields in Central Illinois during summer 2016. Stereo imaging techniques determined plant height, and a depth sensor measured stem width near the base of the plant. A data capture rate of 0.405 ha, bi-weekly, was demonstrated for platform robustness consistent with various environmental conditions and crop yield modeling needs, and formative human-robot interaction observations were made during the field trials to address usability. This work will be of interest to researchers and practitioners advancing the field of plant breeding because it demonstrates a new phenotyping platform that can measure individual plant architecture traits accurately (absolute measurement error at 15% for plant height and 13% for stem width) over large areas at a sub-daily frequency; furthermore, the design of this platform can be extended for phenotyping applications in maize or other agricultural row crops.

(114) PARAMETERS INFLUENCING THE REMOVAL OF DEPOSITS DURING CIP

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The effectiveness of CIP for removal of deposits from food-contact surfaces is dependent on several key parameters. These parameters include concentration and temperature of the cleaning agent, the flow characteristics at the surface with the deposit and the time of exposure of the surface to the cleaning agent. The goal of this presentation will be to present and discuss these parameters with specific attention to scale-up of cleaning processes from bench-scale to pilot-scale and commercial-scale operations.

The removal of a food deposit from a surface using water or a liquid cleaning agent is dependent on several factors occurring at the interface between the deposit and the liquid. In general, these factors include the flow characteristics at the interface, but with specific attention to the forces required to remove layers of the deposit. These forces are related to the Reynolds Number, but can be expressed more directly as the wall shear stress at the surface. A second factor is related to the properties of the deposit. Many deposits are dry or partially dry, and require an elevation in water content before the wall shear stress is sufficient for removal of some portion of the deposit. A third factor is the chemical reaction occurring between the deposit and the cleaning agent.

The three factors influencing removal of a deposit will be discussed using a model to describe the mass transfer at the interface between the liquid cleaning agent and food deposit. The influence of each factor on effectiveness of the CIP operation will be expressed in terms of model parameters.

(116) IN SILICO MODELLING OF BOLUS HYDRATION AND PH CHANGE

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Developing our understanding of the mechanisms that control bolus breakdown could help develop treatments for food related diseases such as obesity, diabetes and heart disease. Previous work has developed kinetic models describing moisture absorption of bread boluses. However, there is has been little work done linking moisture change with corresponding pH changes within the bolus.
The presented model combines bolus hydration kinetics with the acid buffer capacity of proteins to predict the moisture content and pH distributions inside the bolus over time. Boluses are assumed to be spherical, composed of bread particles stuck together with saliva and submerged in gastric fluid. The initial pH distribution in the bolus is based on saliva (~ pH 7), while the driving force for pH change is the acidic gastric fluid (~ pH 2). The pH reduction in the bolus is slowed down by the buffering capacity of the gluten proteins contained in the bread structure.
Data obtained from *in vitro* bread bolus disintegration were used for parameter estimation and validation of the proposed models. The initial model results predict the increase in bolus size from swelling due to moisture absorption as well as the erosion of the bolus. Currently the bulk pH distribution in the bolus slows down when smaller particles make up the size of the bolus. This trend is going to be investigated by experimentally in order to validate model predictions.
These results link the bolus physical and chemical properties to their biochemical interaction with a simulated gastric fluid. While these are initial model results, this is an important step towards understanding and quantifying the mechanical-biochemical interaction because it can help the development of functional foods.

(117) EFFICACY OF OCTANOIC ACID FOR DECONTAMINATING FRESH PRODUCE SURFACE DURING WASHING AT DIFFERENT TEMPERATURES AND ITS MODE OF ACTION AGAINST ESCHERICHIA COLI O157:H7

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Washing produce with chlorine-based sanitizers is not reliable because of their reaction with organic matter present in the water and the formation of carcinogenic by-products. Natural food grade antimicrobials are alternatives to sanitize produce surface without compromising the quality and safety. We investigated the antimicrobial efficacy of a medium chain fatty acid - octanoic acid (OA) against *Escherichia coli* O157:H7 inoculated on baby spinach and grape tomato during the simulated wash processes and explored its inactivation mechanism.
Stationary phase *E. coli* treated with 3 mM OA at 25 °C and 6 mM OA at 5 °C resulted in more than 6 log CFU/mL reduction in 2 minute. Washing grape tomatoes with 3 mM OA in 45 °C water completely inactivated bacteria from the surface within 2 minute. However, washing baby spinach with 6 mM OA in 5 °C water did not result in significant bacterial reduction, highlighting the role of surface properties on inactivation efficacy. Compared to washing with water alone, washing tomatoes in 3 mM OA at 45 °C (120 rpm, 5 minutes) and baby spinach in 6 mM OA at 5 °C (300 rpm, 5 minutes) significantly reduced ($p<0.05$) the risk of cross-contamination when the source of contamination was presented in wash water (~8 log CFU/mL of *E. coli*). There were no significant ($p>0.05$) differences in the color of OA treated produce and the control after 2 weeks of storage. Less than 500 µg/g and 10 µg/g residual OA was detected for baby spinach and grape tomato, respectively, following washing. Compared to sub-lethal treatment conditions, OA at concentrations above 2 mM induced higher levels of membrane permeability and release of extracellular ATP indicating that membrane damage is the primary mechanism for bacteria death. This work demonstrated that OA is an attractive antimicrobial for washing and decontaminating fresh produce.

(123) HIGH PRESSURE STRUCTURE ENGINEERING OF HIGH CONCENTRATION MILK PROTEIN SYSTEMS

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High pressure processing (HPP) is being increasingly used for other roles besides bacterial inactivation, particularly its ability to induce structural and functional changes in proteins. HPP treatment can facilitate the creation of unique structures in high concentration protein systems. This presentation will discuss pressure-induced structural changes of milk proteins, and its effects on micellar casein concentrate (MCC) and milk protein concentrates (MPC). New product opportunities resulting from the HPP treatment of proteins will also be highlighted. In one study, MCC and MPC of up to 12.5% (w/w) protein concentration were subjected to HPP treated from 150 MPa to 600 MPa for 2-15 min, at 5°C or ambient temperature, in triplicate. The pressure-induced rheological and microstructural changes were investigated by dynamic oscillatory rheology, and scanning electron microscopy (SEM) imaging, respectively. Statistical differences ($p < 0.05$) were evaluated by ANOVA.
HPP induced significant concentration and pressure dependent changes in all protein systems. Gel formation occurred after pressure treatments above 250 MPa, with minimum protein concentration of 10% (w/w). HPP treated samples had 10 to 4000-fold increase in storage modulus (G') and loss modulus (G'') compared to the untreated counterparts. SEM imaging revealed protein aggregation at the lower concentrations and network formation at the higher concentrations. Pressures above 350 MPa led to a great extent of aggregation and network formation. The addition of calcium increased the strength of the network. These findings demonstrate how HPP can be used to engineer desired structures in high concentration protein systems. This work provides a basis for the development of novel protein rich foods with interesting structures, high nutritional and sensory properties, built-in safety and extended shelf life.

(126) EFFECT OF PRODUCT LAYER DEPTH ON SIMULATED LOG REDUCTIONS FOR PISTACHIOS ROASTED IN A FLAT-BED ROASTER

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Temporal variability exists in commercial-scale flat-bed roasting between vertical layers within a product bed, which can lead to differences in microbial inactivation between layers. No published data currently exist that quantify the impact of thermal variability between pistachio layers. Pistachios were dry roasted in a pilot-scale roaster to mimic commercial roasting. A pistachio layer ~12 cm thick (0.078 m^2 area) was roasted at 118.3°C (~25°C dew point) for 20 minutes, with air flow passing from the bottom of the bed to the top, and then airflow was inverted every 5 minutes for the duration of the process. Pistachios with thermocouples attached at the kernel surface, underneath the shell, were located at the bottom, middle, and top layers of the product bed. Measured temperature curves and simulated moisture curves from a previously published model for *Salmonella* inactivation in pistachios were used to predict log reductions achieved in each layer. The experiment was replicated four times. Simulated log reductions and 95% confidence intervals for bottom, middle and top layers were 0.78±0.045, 0.68±0.048, and 0.63±0.056 log reductions, respectively. Log reductions estimated for the bottom layer were significantly different from those of both middle (P=0.0018) and top layers (P=0.00045), but log reductions simulated for middle and top layers were not different (P=0.088). Product layer depth influenced microbial inactivation for the product and process studied. This difference may be due to the bottom layer heating up more quickly than other layers. Our findings are important for informing validation studies dependent on determining the worst-case conditions for microbial inactivation. Our results show that inactivation measured at the center layer of a product bed may not represent worst-case conditions. Our results can also aid dry-roaster manufacturers in designing systems to achieve more uniform microbial inactivation within product layers.

(131) NOVEL APPROACHES TO ENHANCE THE NUTRITIONAL VALUE OF THE FERMENTED DAIRY PRODUCTS

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Because of the increase in the contents of folate, proteins, water-soluble vitamins and minerals on a dry basis, production of bioactive peptides and vitamin K, and the presence of probiotic agents during dairy fermentation, fermented dairy products have many beneficial effects on cardiovascular, immune, and gastrointestinal systems. The chemical, microbiological, and physical properties of the fermented dairy products are affected by many factors including temperature, pH, and aeration during fermentation. Therefore, a close control of fermentation process needs to be performed during production of fermented dairy products to obtain the expected health effects. In addition to the control of fermentation process, novel approaches including microencapsulation, freeze-drying, ultrasonication, and fortification have been studied to increase production yield, viable cell counts, and the concentration of nutrients in fermented dairy products. These novel approaches will be reviewed and the future research needs for these approaches will be discussed.

(133) BIG DATA POWERHOUSE FOR FOOD ENGINEERS – OPPORTUNITIES AND CHALLENGES

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Big data is becoming one of the hottest trends within all branches of technology today. This term refers to data sets that are so big and complex that they demand cost-effective, innovative data-processing capabilities for enhanced insight and decision making. The key aspects of big data include volume (size of data), velocity (speed of data transfers), variety (different types of data), and validity (4 Vs). With the rise of the Internet of Things, people have unlimited access to huge amounts of data. According to an IBM study in 2017, around 90 percent of the data in the world today was generated within the past two years, and 2.5 quintillion bytes of data are created every day. The data comes from various types of sources, including sensors used to gather production information, traditional media outlets, social media sites and blogs, digital pictures and videos, purchase transactions, and mobile devices, just to name a few. Nowadays, every industry from healthcare to banking, from retail to manufacturing is beginning to see big data's usefulness. The application of big data technologies in the food technology and food processing domains is a new endeavor, but it is gaining momentum. This presentation summarizes the recent research activities utilizing big data to improve production efficiency, reduce operating costs, improve food safety, and optimize food quality. The limitations of big data technologies and the future trends for its use in the food processing industry will also be discussed.

(137) CHARACTERIZATION OF A NOVEL PULSED LIGHT SYSTEM FOR INACTIVATION OF LISTERIA MONOCYTOGENES ATCC 35152 IN LIQUIDS

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Pulsed light processing can effectively inactivate microorganisms from the surface of foods or in transparent liquid foods. Pulsed light systems currently available in the market operate at a fixed pulse width and frequency and these conditions might not be optimized for microbial inactivation. A novel pulsed light system (Model#X-1100; Xenon Corporation, USA) enables the researchers to adjust various parameters including pulse width (100-7000 µsec), voltage (1000-3000 V), frequency (0.1-20 Hz), % of energy (0-100%), and energy (up to 9 J/cm^2/pulse of optical energy or 2433 J/pulse of electrical energy). This study evaluated the effect of various pulsed light parameters (treatment time, voltage, frequency, energy/pulse) for inactivation of *Listeria monocytogenes* in buffered peptone water (BPW), apple juice, and apple cider. A 4-mL of sample (~2.5-mm depth) in a quartz Petri dish (5-cm diameter), artificially inoculated with *Listeria monocytogenes*, was exposed to various pulsed light treatment conditions.
The results indicated that the impact of these factors vary as many of these factors are inter-related. In general, increasing the frequency, input voltage, pulse width, and % of energy, increased the microbial reduction at the tested conditions. For instance, reductions of 1.21 and 5.47 $\log_{10}$ CFU/mL were obtained in BPW and reductions of 1.35 and 4.70 $\log_{10}$ CFU/mL was acquired in apple juice, at 0.1 and 0.82 Hz, respectively, for a 20-sec treatment at 2500 V (50% energy, 700 µsec pulse width). Increased energy per pulse resulted in increased microbial reduction. For instance, reductions of 2.30, 5.59, 6.69, and 6.69 $\log_{10}$ CFU/mL were obtained at 645, 1241, 1837, and 2433 J/pulse of electrical energy, respectively, in apple juice. Similarly, reductions of 5.34, 6.45, 6.02, and 6.56 $\log_{10}$ CFU/mL were obtained at 645, 1241, 1837, and 2433 J/pulse, respectively in BPW. Absorption of pulsed light energy resulted in temperature increase in the products. For instance, temperature increase of up to 11°C was observed at the treated conditions.
This novel pulsed light system can potentially assist the researchers in optimizing the pulsed light treatment for effective inactivation of pathogens.

(138) ADVANCES AND CHALLENGES IN THE DESIGN AND DEVELOPMENT OF PACKAGING SYSTEMS FOR HIGH PRESSURE PROCESSING OF FOOD

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High pressure processing (HPP) is a nonthermal food processing technology in which, typically, a pre-packaged product is subjected to an intense hydrostatic pressure treatment to inactivate pathogens, spoilage microorganisms, and/or quality-degrading enzymes without adversely affecting the organoleptic and nutritional properties of the product. HPP may be combined with heat treatment to inactivate bacterial spores and produce high-quality shelf-stable foods. Flexibility of the packaging materials, package integrity, seal strength, and barrier properties are some of the important considerations in designing suitable packaging systems for HPP. This presentation will highlight advances and challenges in the design and development of flexible polymer packaging for HPP treatments of food at low, moderate and elevated process temperatures. The latest findings on the evaluation of barrier, mechanical, structural, thermophysical, and migration characteristics of polymeric films in response to HPP will be discussed. Most of the findings indicate that HPP, at least at low or moderate temperatures, has no noticeable effects on the barrier properties and migration characteristics of the commonly used polymeric packaging materials. Finally, opportunities for further extending the shelf-life, enhancing food safety, and preserving the fresh-like characteristics of the product by combining HPP with active or modified atmosphere packaging will be presented.

(140) NSF REU SITE: AN INTERDISCIPLINARY RESEARCH EXPERIENCE FOR UNDERGRADUATES IN FOOD SAFETY, FOOD ENGINEERING, AND NUTRITION

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This presentation will describe about a National Science Foundation funded REU (Research Experience for Undergraduates) program at the Illinois Institute of Technology recently. This REU Site focuses on training undergraduate students in food safety, food engineering, and nutrition. The students undergo rigorous mentoring and professional development training which will help them in fine-tuning the skill sets required to become successful scientists, engineers, and entrepreneurs. Eight mentors from Illinois Institute of Technology and the U.S. Food and Drug Administration are mentoring ten undergraduate students for a ten week period during the summer.

The primary goals of the proposed NSF REU site are: 1) to provide hands on research experiences to undergraduate students in food safety, food engineering, and nutrition, 2) to provide exposure to these fields, 3) to systematically train the students in transforming basic research ideas into practical applications aimed at solving real world problems for improving the safety and nutrition of our food supply through interactive seminars and discussions, 4) to systematically mentor the undergraduate students to hone their research and professional skills through mentoring workshops, student presentations/discussions, interaction with graduate students, and K-12 outreach, 5) to expose the students to broader fields of food science to enhance their knowledge in this field (with special emphasis on food safety, food engineering, and nutrition) through seminars and tours, and 6) to train the students on research and professional ethics. Projects are offered in a broad range of topics including applications of novel food process engineering technologies (high pressure processing, pulsed light processing, and cold plasma) for ensuring food safety and nutritional quality, addressing special issues in food safety such as with low moisture foods, understanding physiological chemistry of plant bioactives in humans, modeling & simulation of food processing technologies, developing affordable nutrition through kinetic hydroponics, and repurposing of food ingredients for controlling pathogenic biofilms.

(141) BIOACCESSIBILITY OF FOOD BIOACTIVES DURING DIGESTION –FROM SIMPLE EMULSIONS TO PLANT TISSUES

Stephen Young, Rewa Rai, Yuanjie Pan, Maha Alshehab, Nitin Nitin
University of California, Davis

Bioaccessibility of micronutrients and phytochemicals is dependent upon partitioning of these compounds from food matrixes during digestion processes. Despite significant focus on micronutrient research, there is a lack of understanding of the role of physical structures and chemical properties of the food matrix in influencing partitioning of these compounds. The research presentation will discuss the continuum of encapsulation systems from simple emulsions to plant tissues and the influence of physico-chemical properties of these structures on release and bioaccessibility of micronutrients. The research results will highlight the role of interfacial and core properties of lipid based carriers in influencing release of bioactives during digestion processes. Similarly at cellular and tissues levels, the research presentation will discuss the role of cell walls and intracellular components in influencing release during gastric and intestinal digestion. In addition to detailed physico-chemical analysis of encapsulation systems, the presentation will also illustrate innovations in biophysical and bioanalytical approaches to characterize structural changes in encapsulation systems and their relationship with release of bioactives. Overall, the research presentation will provide an integrated analysis of the release of bioactives during in-vitro digestion processes from diversity of engineered and biological structures.

(142) BREAD DIGESTION: EXPLORING THE DIETARY FIBRE HYPOTHESIS

Ourania Gouseti[1]; Syahziral Muttakin[2,3]; Thomas Moxon[2]; Alexander Lamond[1]; Clifford Latty[2]; Serafim Bakalis[1]; Peter J. Fryer[2]
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The health benefits of eating whole grain breads have long been suggested (e.g. by Plato, 400BC). In the late 60s - early 70s, consumption of dietary fibre was for the first time linked with a range of health benefits for major non-communicable diseases, including diabetes, obesity, bowel cancer, atherosclerosis, appendicitis, etc. However, to date the mechanisms of dietary fibre digestion and how this impact health is not fully understood.

In this work we study digestion of dietary fibre and the associated effects on the rate and extent of bread digestion. We use a dynamic intestinal model that realistically simulates gut wall contractions by squeezing the dialysis tube that acts as the luminal wall.

Initial work has indicated that addition of thickeners (e.g. guar gum, CMC) resulted in changing the flow regime during digestion, and mass transfer reduced by an order of magnitude (Sh from 1000 to 100) as the flow became more laminar (Re<500). Extending this work, it was further demonstrated that the effect of viscosity was marginal at guar gum>1%. Digstion of breads showed an initial lag phase, where signs of digestions were not evident, followed by linear sugar absorption rate. Digestion of white breads with double the amount of arabinoxylan content showed reduced digestibility rate (by 30%) compared to the low fibre breads, and similar to that of whole grain breads. It was suggested that these digestions were mass transfer limited (Da=100). Adding thickener to the intestinal fluids resulted in bread digestions with extended (by 250%) initial lag phase but similar sugar absorption rate thereafter. Compared to breads, porridge showed similar digestion kinetics to high fibre bread for the first hour, which doubled thereafter.

Overall, this work demonstrated the potential to design healthy breads by understanding the role of dietary fibre during digestion.

(144) MICROWAVE ASSISTED PASTEURIZATION SYSTEMS (MAPS) FOR READY-TO-EAT MEALS

Juming Tang
Department of Biological System Engineering, Washington State University, Pullman, WA

Consumer desire for convenience, food safety risks associated with e-commerce and home delivery of prepared meals, and regulatory requirements imposed by Food Safety Modernization Act (FSMA) in the USA have generated great commercial interest in in-package pasteurization technologies.

In this presentation, we will present engineering design of microwave assisted pasteurization systems (MAPS) for production of ready-to-eat meals that can be stored for up to 14 weeks in refrigeration. The systems combine 915 MHz single-mode microwave cavity design with a shallow bed of circulating water to provide predictable heating patterns in food packages without edge heating. The unique system design also allows the use of metal carriers with partial metal shielding to alter electric field distribution in food packages when moving through the microwave cavities.

A pasteurization process using MAPS consists of preheating, microwave heating, holding and cooling. Microwave heating typically takes 2-4 mins (depending upon package size) to raise the cold spot temperature in a food package from preheating temperature of 40°C to 90°C. The pilot scale system at WSU has been used to pasteurize a wide range of products in 10-20 oz packages, either for our internal product evaluation or for private companies. As part of technology transfer, we offer 3-5 day bootcamps that provide theoretical training and hands-on experiences to participants from food companies. In the presentation, we will also share recent results on system improvement, process development, product quality, and our vision for future applications.

(145) ENGINEERING SOLUTIONS TO CONTROL FOOD PATHOGENS IN LOW MOISTURE FOODS

Juming Tang
Department of Biological System Engineering, Washington State University, Pullman, WA

Microbial safety associated with low moisture foods and food ingredients is an emerging issue facing the food industry that is required to comply with the Food Safety Modernization Act (FSMA) in the USA. Food companies have experienced difficulties in finding solutions to control bacterial pathogens, such as *Salmonella* and *Listeria monocytogenes,* that can survive in low moisture conditions, because those bacteria have high resistance to thermal and other treatments in a dehydrated state. There is a need to fill the knowledge gaps related to important factors contributing to the enhanced thermal resistance and identify related control parameters in industrial operations to ensure microbial safety of low moisture products. This presentation provides a summary of recent results from our research on thermal inactivation of *Salmonella* and a surrogate, *E. faecium*, in low moisture foods.

Our research consisted of three major components: 1) determining water activity of different food matrices over a range of temperatures to establish relationships between product moisture content, water activity (relative humidity), and temperature in sealed containers; 2) determining thermal resistance (D values) of *Salmonella* and *E. faecium* in low moisture foods over a wide range of temperature and relative humidity (water activity); 3) using the above knowledge to develop and validate thermal processing based on radio frequency (RF) heating. We developed novel test cells for components 1 and 2, and used pilot scale RF systems for component 3.

Our studies show that water activity of food samples rich in protein and starch increased sharply with increasing temperature, whereas samples with high oil contents did not increase much or even decreased with temperature. The bacterial inactivation data shows that at a fixed temperature D value for *Salmonella* and *E. faecium* in difference matrices increased exponentially, by up to 100 fold, with reduction of water activity (measured at treatment temperature) from 0.7 to 0.2. The findings supported our early hypothesis that water activity of food matrices at treatment temperatures (not measured at room temperature) is a determinant factor on thermal resistance (D values) of bacterial pathogens. The above results explain the difficulty in thermal activation of bacteria pathogens in foods having low water activities at elevated temperatures and, in particular, the challenges in inactivating pathogens in oil-rich products. Our studies suggest that relative humidity at treatment temperature should be considered as a control parameter in designing effective thermal treatment operations for pathogen control in low moisture foods.

(146) EFFECT OF ELECTRIC AND MAGNETIC FIELD ON SUPERCOOLING OF BEEF STEAKS WITH DIFFERENT FAT LEVEL

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Freezing has been recognized as an appropriate method to preserve food materials for a long period of time; however, the ice crystal formation involves several physical and chemical quality deteriorations such as disruption of cell structures. Supercooling has the potential to improve the shelf-life and quality of food products due to its subzero storage temperatures and no ice crystals growth. The supercooling behavior of a food material is highly depends on different intrinsic food properties such as composition. In this study, the effect of electric (EF) and magnetic field (MF) which are employed to prevent ice nucleation during freezing process on the supercooling preservation of beef steaks with different fat level was investigated. Top round and sirloin steaks were used to represent lean and fatty beef samples, respectively and the chemical composition and electrical properties of beef samples were analyzed. Beef steaks were preserved in a supercooled state supported with EF and MF for 7 days and quality changes were investigated and compared to samples subject to the conventional refrigeration and freezing conditions. Lean beef steaks were successfully preserved in the supercooled state at -4˚C with EF treatments, whereas the supercooling in fatty beef samples was maintained at -4˚C when the samples were exposed to the EF and MF combination treatments. Fat consistently showed lower electrical conductivity, resulting in different supercooling behaviors of beef. The beef samples preserved in the supercooled state showed significantly lower values in drip loss compared to the refrigerated and frozen samples. In addition, the color changes, microbial counts, and microstructure observations showed that there were no significant differences between the supercooled beef and fresh samples. In conclusion, fat content was important factor affecting the supercooling behavior of beef steaks and the EF and MF combination treatment allowed to preserve beef steaks in the supercooled state.

(147) OPTIMIZATION OF THE MUNICIPAL SOLID WASTE MANAGEMENT WITH AN ANAEROBIC DIGESTION REACTORS SYSTEM OF 2ND GENERATION IN HETEROPHASE AND MULTISTAGE.

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Waste management strategies in many urban regions of Latin America attend the organic fraction of municipal solid waste (OFMSW) as a public health problem but not since its possible use. This work shows the main results of three projects that improve OFMSW Management through an 2nd generation Anaerobic Digestion Reactors System in Heterophase and Multistage, to produce sustainable energy and allows exploring new strategies in accordance with green growth and circular economy concepts. The system preserves the microorganisms inside them, maximizing the performance and minimizing residence times. Heterophase and Multistage system implies that OFMSW is hydrolyzed in a first reactor, the process continuous in two Up-flow Anaerobic Sludge Bed reactors in series. Coproducts are biogas with high methane content (>65%) and Organic-mineral fertilizers. Additionally, environmental benefits such as reducing emissions of greenhouse gases, expand useful life of landfills and improving environmental conditions in local agro-ecosystems can be obtained. The three systems are located in the municipalities of Carmen de Viboral, Támesis and Moravia a neighborhood whit a closed landfill in Medellín, where 15 tons/month, 2 tons/week and 100 kg / day are treated respectively. The average production of biogas is in the range of 5 to 7 liters / kg. The average effluent production is 0.7 liters/kg. The biogas is used for cogeneration of electric and thermic energy, while the fertilizers are used in local crops. These projects show that it is possible to improve Waste Management in a community through strategies of sustainable energy production from OFMSW separated by source using 2nd generation Reactors Systems, which generate impacts in the community needs thought using biogas and fertilizers for their own benefits. From the perspective of the circular economy and sustainable cities, is viable alternative in environmental, social and economic terms for many municipalities in Colombia.

(149) INTELLIGENT PACKAGING: MATERIALS, SENSORS AND SUPPLY CHAIN INTEGRATION

Dr. Paul Takhistov
Rutgers the State University of New Jersey

Globalization of the food supply chain results in formation of supply network of great complexity with long transportation distances and multiple delivery routes. With the advent of the Internet-of-Things, ubiquitous sensing technology and cloud computing, there is a strong need for new methods for dynamic real-time decentralized decision making that allows faster and safer delivery of food products. In this presentation current development of the sensing devices that can be integrated with the food packaging and how they can change current food supply chain will be discussed.

(150) LOW-COST, FLEXIBLE ELECTROCHEMICAL BIOSENSORS WITH PRINTED AND LASER INDUCED GRAPHENE

Jonathan Claussen
Department of Mechanical Engineering – Iowa State University

The use of monolayer graphene grown through high temperature chemical vapor deposition (CVD) processes is generally not conducive to most electrochemical biosensing applications due to its non-conductive basal plane, costly high-temperature growth process, and tedious transfer process to flexible or disposable substrates. Alternatives to CVD graphene including printed graphene (PG) and laser induced graphene (LIG) have recently shown promise in the fabrication of low-cost, flexible electrical circuits. However, biosensing applications involving PG and LIG have been constrained due in part to low resolution printing, destructive post-print annealing steps, low electrochemical reactivity, and relatively smooth, planar surfaces. In this presentation, we demonstrate how the utility of PG can be expanded through high-resolution patterning, post-print laser annealing, and biorecognition agent functionalization techniques. First, a new patterning technique [i.e., inkjet maskless lithography (IML)] is used to form high resolution, flexible graphene films (line widths down to 20 µm) that significantly exceeds current graphene inkjet printing resolution (line widths ~ 60 µm). IML uses an inkjet-printed polymer lacquer as a sacrificial pattern layer, viscous spin coated graphene, and a subsequent graphene lift-off to make the patterned films without the need for pre-fabricated stencils, templates or cleanroom technology (e.g., photolithography). Next, a rapid pulse laser annealing technique is used to change the properties of the printed graphene from highly resistive (> 100 MΩ/sq. sheet resistance) to highly conductive (~ 50 Ω/sq.); hydrophilic (water contact angle ~ 45°C) to superhydrophobic (water contact angle ~ 155°C); the electrochemical reactivity from slow, irreversible charge transport to fast, reversible charge transport; and finally a from a 2D planar surface roughness to one that is 3D nano/microstructured with stitched/welded graphene flakes. We also demonstrate how a similar rapid pulse laser technique can be used to improve the electroactive surface area and electrical conductivity of LIG. All of these processes can be formed on chemically and thermally sensitive substrates (paper, polymer) that are both flexible and disposable. We demonstrate how these graphene electrodes can be biofunctionalized with enzymes, ionphore membranes, aptamers, and antibodies for pesticide and nitrogen sensing in soil as well as bacteria detection within broth solutions. The detection limits of the biosensors so far have achieved approximately 3 nM for organophosphate pesticides, 20 µM for ammonium and nitrate ions, and ~30 CFU/ml for *Salmonella.* Such sensing results demonstrate that PG and LIG technology is well-suited for in-field, low-cost biosensing.

(151) NANOTECHNOLOGY AND FOOD MANUFACTURING PROGRAMS AT THE NATIONAL INSTITUTE OF FOOD AND AGRICULTURE (NIFA), USDA

Dr. Hondga Chen
National Program Leader, NIFA-USDA

Dr. Hongda Chen is the National Program Leader for Food Manufacturing Technologies and Nanotechnology for Agricultural and Food Systems programs at National Institute of Food and Agriculture (NIFA), USDA. Food manufacturing technologies are primarily focused on developing and implementing comprehensive strategies that increase productivity, improve quality, and reduce the costs of producing, processing, and packaging food and food products. Food manufacturing encompasses engineering, processing technologies, packaging, sanitation, robotics, nanotechnology, sensors, high-speed automation, mathematical modeling, computer simulation, and quality/safety inspections of food and food products. While, nanoscale science, engineering, and technology embrace opportunities in a wide range of critical challenges facing agriculture and food systems. This program area priority encourages applications in the following broad areas: innovative ideas and fundamental sciences to develop nanotechnology enabled solutions for food and nutrition security through improved productivity, quality, and biodiversity; improved nutritional value of feeds, feed additives, and more effective therapies that significantly impact animal health and wellness; enhanced food safety and biosecurity; and increased protection for natural resources, the environment, and agricultural ecosystems. These two programs and their respective funding mechanisms and opportunities will be discussed.

(152) SMARTPATH: GROWER-DIRECTED CONVERGENCE OF NANOTECHNOLOGY AND SMART DECISION ANALYTICS FOR IRRIGATION WATER QUALITY MANAGEMENT RELATED TO PATHOGENS

Eric McLamore
Agricultural and Biological Engineering Department, University of Florida

Agricultural water shortage problems arise from deteriorating quality, groundwater depletion, uncertainties in precipitation associated with climate change, and unsustainable freshwater usage. This project focuses on reducing overall freshwater use by developing new smart irrigation systems emphasizing the quality of alternative water sources with potential pathogen contamination (SmartPath). We will develop innovative software and hardware solutions for on-farm water management, enabling small farmers that do not have access to a nearby analytical lab service to meet the Food Safety Modernization Act (FSMA) requirements for testing water quality within eight hours of sampling. Treatment systems will be coupled with sensing systems for measuring physical, chemical and biological constituents including: temperature, pH, salinity (ions), dissolved oxygen, nitrate and phosphate, and fecal bacteria, and integrated into an internet of things wireless decision support system. Economic feasibility will be evaluated across various spatial scales (from individual farms to regions) for growers in 4 key regions of the US with varying drought conditions (Florida, Texas, Iowa and Maryland) and three types of alternative water sources (treated domestic wastewater, brackish groundwater, and surface water that does not meet regulatory requirements). Through laboratory testing and field case studies, SmartPath will develop and validate water treatment systems and increase the use of alternative water for irrigation of fresh produce, decreasing freshwater withdrawals and closing basin water gaps. SmartPath will train a transdisciplinary cohort of 12 graduate students and 20 undergraduate students. We anticipate reaching at least 1,000 stakeholders through integrated extension, research, and education efforts.

(153) IMPACT OF E-COMMERCE, CLICK AND PICK, AND OTHER NEW MODELS OF SHOPPING ON THE FOOD INDUSTRY

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The retail marketplace is expanding at exponential rates into non-traditional sales venues. The impact of on-line shopping on the food industry is forcing food companies to overhaul many of their traditional means of producing and distributing products. Many facets of the food industry are being deeply impacted by shopping decisions, and this presentation will explore the scope of changes in the marketplace including a review of e-commerce, click and pick shopping, and other technology-driven shopping and examples of the impact that the changing marketplace is having on the engineering function for the food industry. Product design issues and packaging concerns will be discussed.

(155) HYGIENIC DESIGN OF FOOD FREEZING EQUIPMENT

JOHN LARSON
SENIOR APPLICATION SPECIALIST, JBT CORPORATION

Much of the food consumed in homes, restaurants and institutions has been frozen or chilled in various types of mechanical freezers. The ability for users of this equipment to quickly, thoroughly and effectively clean these machines is important to help provide a safe and nutritious food supply.

EQUIPMENT DESIGN

The first step in assuring that equipment meets this goal is in following the practice of "Hygiene by Design." Examples include:
Elimination of all hollow or closed structures
Elimination of sandwiched surfaces or joints
Elimination of crevices
Minimizing parts found in and above the product zone

CLEANING SYSTEMS

Automated cleaning systems are often provided to assure that all areas of the machine are cleaned, rinsed and sanitized on a consistent basis without operator variability. Because of the size and complexity of freezers the cleaning systems are equipped with multiple cleaning zones. Depending on the type of soil found cleaning systems may be a single pass recirculating.

VALIDATION OF CLEANING SYSTEM EFFECTIVENESS

Food producers need to be able to prove the efficacy of the cleaning equipment and processes. Methods used include:

- Visual inspection of equipment post cleaning to assure that nozzle placement is correct and that nozzles are operative.
- ATP/Black light. Provides a simple test to assure that cleaning is effective in removing food debris from all areas of the machine
- Temperature Monitoring. Equipment that can be safely steam sanitized can be equipped with temperature sensors and a logging system to assure that all areas of the machine attain the required temperature/ hold time to achieve the required kill.

Equipment Suppliers have recognized the need for safe cost effective food freezing. Designs and features have evolved to reflect this fact. Systems are custom designed to meet this challenge.

(158) CHARACTERIZING AND MODELING WEAR–RECOVERY BEHAVIORS OF ACID-INDUCED CASEIN GELS

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Hydrogels are soft materials that have wide applications in the food and medical industries, such as food gels and artificial cartilage. The mechanical properties of hydrogels are important due to their influences on sensory texture and industrial processing abilities. While wear behaviors of hydrogels are important to their processing ability and lifetime as a bearing surface, little is known about hydrogel wear behaviors in comparison to their rheological behaviors. Additionally, hydrogel wear behaviors can be difficult to characterize because it is challenging to accurately measure the amount of hydrogel removed from a contact area during sliding operations. Therefore, the objective of this study was to develop a novel method to accurately measure hydrogel wear. Casein hydrogels were prepared at different concentrations (8-15 %) and pH (2.3-4.8). Creep–recovery behaviors were evaluated in the linear viscoelastic region; wear–recovery behaviors were evaluated at constant sliding speed (33 mm s^{-1}) and several normal forces (0.3-0.5 N). Casein hydrogel wear was determined by comparing creep–recovery and wear–recovery data to separate the penetration depth caused by hydrogel deformation from that caused by wear. Wear–recovery behaviors were also fitted to an exponential model. Recovery from both creep and wear increased with lower casein concentration and higher normal force and pH. Lower pH and normal force and higher casein concentration resulted in less wear. During both creep and wear, higher casein concentration decreased irreversible deformation, while higher normal force and lower pH increased irreversible deformation. The R^2 values of the models for casein gel wear–recovery behaviors were greater than 0.98, indicating good fit. The wear measurement method developed in this study can be used to measure wear in hydrogels and other soft materials, providing a rapid, accurate method for evaluating wear lifetimes of soft materials.

(171) LISTERIA MONOCYTOGENES IN THE FROZEN FOOD INDUSTRY: CHALLENGES AND OPPORTUNITIES

Sanjay Gummalla
American Frozen Food Institute

Frozen foods are at an important intersection in the industry's evolution, especially from the perspective of enhancing food manufacturing practices and meeting consumers' changing needs. From a food safety perspective however, frozen foods have in recent years been subject to frequent food recalls and even attributed with illnesses and outbreaks worldwide. These events highlight the public health risks posed by the presence of Listeria monocytogenes (Lm) and other pathogens in frozen foods and have raised significant concern among food manufacturers, regulatory agencies, and consumers alike.
At the heart of this challenge is the trend towards more convenient foods and the perception that all frozen foods are innately ready-to-eat (RTE) food products. This presentation will outline the American Frozen Food Institute's (AFFI) Lm strategy and current efforts to combat food safety risks associated with frozen foods: through scientific research, enhancing best manufacturing practices, consumer labelling and education initiatives; and practical regulatory approaches.

(172) THE ROLE OF INTELLIGENT PACKAGING AND THE INTERNET OF THINGS

Claire Koelsch Sand
Packaging Technology and Research, LLC

Intelligent packaging is packaging that communicates. Intelligent packaging and the internet of things (IoT) are maturing into a powerful tool for the entire value chain. By 2020, 70% of the world population is predicted to have smartphone access. With this higher connectivity and the realization of the pragmatic capability of IoT, packaging is moving from supply chain specific communication in which different labels are used by manufacturers, distributors, consumers, retailers, and post-consumer handlers to multifunctional packaging. Emerging multifunctional intelligent packaging that spans the entire value chain has the most promise. This is because the cost of the technology can be spread through the whole value chain. Packaging adds more value when it, for example, conveys expiration dates and product information and enhances the product experience using AR elements specific to a consumer or retailer, and provides information tailored to distributors, retailers, and brand owners. Multifunctional intelligent packaging provides added value expected in the IoT. Research that quantifies the intelligent packaging benefits at each link of the chain is needed.

(173) ADVANCES IN TRANSMISSION RATE TESTING

Wade Sand
Mocon, Ametek

Oxygen, water vapor and carbon dioxide transmission testing has evolved from static off-line measurements to inline rapid measurements. Further, measuring transmission rates through low barrier films as well as oxygen transmission at variable relative humidity has advanced the field of predictive package modeling. These advances will be discussed in terms of mechanics of permeability, diffusion, and sorption.

(174) JUMPING TO CONCLUSIONS: WHAT ASSUMPTIONS ARE YOU USING WHEN TEACHING ENGINEERING?

Helen S. Joyner[1]
[1]*University of Idaho*

Engineers are often required to make assumptions when solving problems. These assumptions can be based on fundamental properties of the system as well as previous experience with similar systems. Accurate assumptions can simplify problem-solving and provide accurate results, but poor assumptions can result in inaccurate results and frustration. These statements about engineers and assumptions carry over to teaching engineering. We often make assumptions about our teaching practices and students. Correct assumptions lead to an enjoyable experience for the instructor and students, but incorrect assumptions lead to frustration, boredom, and disengagement. There are several key assumptions that need to be checked for validity when teaching engineering, particularly when teaching engineering to non-engineers. These assumptions include student preparation, student ability to rapidly connect concepts and applications, and student understanding of the relevance and importance of engineering concepts in real-world scenarios. Reviewing the assumptions made, often unconsciously, when teaching engineering can help uncover key reasons behind student difficulties in mastering engineering. It is best to make worst-case scenario assumptions: students are not prepared mathematically, cannot connect concepts and applications without step-by-step guidance, and see no connection between what they learn in class and the real world, so assign it little importance. These worst-case assumptions can be used to design learning activities that account for student underpreparation, guide students through the application process, and boost knowledge of the relevance of the concepts at hand. These learning activities typically involve explicit explanations, model correct problem-solving procedures, or ask questions that are designed to promote thought about what is happening in a scenario and why. As students complete these activities, they gain confidence in their ability to solve engineering problems and gain a better understanding of how engineering concepts apply to their everyday lives.

(176) EFFECT OF CONTROLLED GERMINATION WITH PHYSICAL STIMULATION BY ULTRASONICATION ON SPROUTED GRAINS

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Controlled germination is an effective method for enhancing the nutritional value of whole grains. During germination, dormant enzymes are activated, the digestibility of the grains is enhanced, and the functional property of the flour is improved on account of the enzymatic hydrolysis. The treatment of grains with physical stimulation, e.g. high pressure, power ultrasound, pulsed light, and cold plasma, before and during germination is a new realm of endeavor for enhancing the quality of the sprouted grains and their end products.

Power ultrasound (known as high-intensity ultrasound in frequencies of 20-100 kHz and intensities of 10-1,000 W/cm^2) as an emerging acoustic processing technology has been investigated for improving bioactive compounds in plants, including edible seeds, sprouts, fruits and vegetables. Our aim was to evaluate the effects of controlled-germination and power ultrasound treatment (25 kHz) on the nutritional properties (i.e. amino acids, reducing sugars, and vitamins) and flour functionality (i.e. starch pasting properties and dough-mixing performance) of selected grains including red rice, oat groats, and whole wheat. Our study attempted to provide insights into the observed enhancement of health-promoting compounds in sonication-treated grains. The results from metabolite analyses showed that some plant metabolites, such as γ-aminobutyric acid (GABA), alanine, glucose-6-phosphate, succinic acid and other organic acids, were significantly increased after sonication during germination. The total phenolic compounds content and antioxidant capacities (DPPH• scavenging capacity) were also enhanced. The images of Environmental Scanning Electron Microscopy (ESEM) and 3D X-ray Micro-Computed Tomography (Micro-CT) showed the changes in the external and internal microstructures of the ultrasonicated grains, which indicated that the power ultrasound had cleaned the surface and created holes.

The current challenges, limitations and future applications of ultrasound treatment during sprouted-grain production are summarized.

(178) EVAPORATION PROMOTES RETENTION AND INFILTRATION OF BACTERIA INTO PLANT LEAVES: A MECHANISTIC MODELING APPROACH

Mohsen Ranjbaran, Ashim K. Datta
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Evaporation of a water film at a leaf surface is a process that frequently happens during pre-harvest and post-harvest treatment of leafy greens. Evaporation can generate internal flows within the water film that can transport bacteria and facilitate their retention at the leaf surface and infiltration into the leaf tissue. Despite the mentioned risk, there is no study concerning the sole effect of evaporation on the bacteria infiltration into fresh produce. In this work, a mechanistic model for transport of bacteria within an evaporating sessile droplet at a leaf surface is introduced. The model includes fluid flow within the droplet and gas phase, gas-water interface tracking during evaporation, transport of vapor in the gas, passive and active transport of bacteria within water, and heat transfer. The model results for bacteria distribution and infiltration are validated by available literature data. Our results indicate that evaporation can cause internal flows within the droplet that can move and accumulate bacteria close to the leaf surface and within the stomatal opening. Wettability of the leaf surface plays an important role in the bacteria infiltration. The microstructures at the leaf surface such as trichomes, stomata and grooves can trap bacteria and facilitate their infiltration into the leaf tissue. The model is further used to study the effects of the most important factors (e.g., leaf topology and roughness, stomatal opening size, evaporation rate, and liquid surface tension) contributing to the infiltration of bacteria into the leaf openings and providing practical food safety recommendations.

(179) ONE-STEP DYNAMIC KINETIC ANALYSIS AND MODELING IN PREDICTIVE MICROBIOLOGY

Lihan Huang
Eastern Regional Research Center, USDA Agricultural Research Service, Wyndmoor, PA

Predictive modeling in microbiology is a useful tool for microbial shelf-life prediction, process and quality control, and risk assessment. The success of predictive modeling relies on kinetic models. The accuracy of kinetic parameters determines the reliability and performance of predictive models. Inverse analysis is a mathematical method for estimating kinetic parameters from experimental observations. Traditionally, kinetic parameters are estimated from isothermal growth and survival studies by curve-fitting through linear or nonlinear regression. It usually involves a two-step process that is time-consuming and labor-intensive for data collection and analysis.

One-step dynamic kinetic analysis and modeling is a new approach that directly constructs a tertiary model from dynamic growth and survival curves. During dynamic inverse analysis, the microbial growth and survival is described by ordinary differential equations (ODEs), and the kinetic parameters in the primary and secondary models are determined by simultaneous numerical analysis and optimization to minimize the residual errors globally. The approach can result in accurate determination of kinetic parameters and directly interpretable error estimates.

This method has been used to estimate the kinetic parameters of different models for foodborne pathogens, including *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* O157:H7, and *Clostridium perfringens* in various substrates. The models constructed from one-step dynamic analysis can be directly used to predict the growth of microorganisms exposed to both dynamic and isothermal conditions. Validation results have shown that the residual errors of prediction are generally within ± 0.5 log CFU/g of observations. One-step dynamic kinetic analysis is a more efficient method, and can be used to develop and validate mathematical models for predicting the microbiological shelf life of products and conducting risk assessments of foodborne pathogens in the supply chain.

(181) PROCESSING AND PACKAGING REQUIREMENTS FOR COLD EXTRACTED LIQUID COFFEE

Ted Labuza
Dept. of Food Science and Nutrition Univ. of Minnesota

With new beverages, there are food safety concerns that have not been researched sufficiently. This talk will address one new beverage-cold extracted coffee. It is unknown if cold extraction coffee ingredients are antimicrobial and/or of sufficient pH to inhibit growth of pathogens or kill pathogens. This topic area is complex and there are unanswered questions significant to food safety of this “new” beverage. Questions and the research process to explore these questions will be shared. These include: does cold extracted coffee inhibit pathogen growth or kill pathogens, what cold (non-thermal) methods can be used to achieve a viable pathogen kill-step, what packaging kill-step and processes are required for an aseptic fill.

(182) FUTURE FOOD PACKAGING TO MEET CHANGING SUPPLY CHAINS

Scott Morris
University of Illinois

Global changes in supply chains, transportation, and retail structures are demanding adaptation of new paradigms in food packaging in order to retain customers and create a positive market presence. Globally-sourced mass-customization and micro-niche trends will necessarily change the design and structure of food packaging and challenge quality and safety metrics. The role of the package as a simple, uniform protective container in a standard regional sales platform is giving way to attracting and identifying the individual customer and correlating with their digital identities, while delivering products that rely on fewer additives and better packaging structures.

(183) NANO-ENGINEERED STAINLESS STEEL SURFACE TO PREVENT BIOFILM FORMATION OF FOODBORNE PATHOGENS

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Due to ever increasing trends in food safety, food manufacturers should take sanitary/ hygienic processes into key consideration. Minimizing the attachment of spoilage and pathogenic organisms to the surface of food processing equipment is one of the major challenges in the fields of food science and biosafety. Biofilms, the surface-associated complex communities of bacteria adhered to both biotic and abiotic surfaces have been explored in omnipresent environments. In particular, surface structure and related nanoscale fabrication technologies have been intensively studied for prevention of microbial adhesion and the consequent biofilm formation. This study demonstrated nanofabrication and anti-biofilm characterization of the self-cleanable surface on stainless steel substrates. The 304 grade stainless steels were electrochemically etched in dilute Aqua Regia solution consisting of 3.6% HCl and 1.2% HNO3 at various voltages (5, 10, and 15V) and treatment times (5, 10, and 15 min) to fabricate hierarchical nanoporous structures. Difference in applied voltage and treatment durations led to variations in the etch rate and surface morphologic characteristics; the plates treated at 10 V showed nanoscale pores which are needed to improve the self-cleanability while maintaining the intrinsic food grade quality of stainless steel. The etched samples coated with an additional hydrophobic Teflon layer showed a maximum static water contact angle above 150°. Under static and dynamic flow environments, *Escherichia coli*, *Salmonella* Typhimurium, and *Listeria monocytogenes* were used for testing antibacterial adhesion and antibiofilm performances of the developed surfaces. The surfaces etched at 10 V with Teflon coating, compared to the control stainless steel, showed significant antibacterial adhesion effects (2.1-3.0 log reductions) in both static and dynamic flow conditions. The successful fabrication of superhydrophobic, electrochemically etched surfaces can be used in food industries to prevent biofilm development, resulting in the improvement of food safety.

(184) ENHANCING BIOAVAILABILITY OF LIPOPHILIC BIOACTIVES USING NANOPOROUS BIOAEROGELS AND SUPERCRITICAL FLUID TECHNOLOGY: A NEW APPROACH

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Bioactive food compounds have received much attention as health-promoting food ingredients; however, incorporation of lipophilic (water-insoluble) bioactives into foods is a major challenge from a technological and food quality standpoint because they are crystalline powders that are insoluble in water, as well as in the aqueous phase of the intestinal juice. Consequently, lipophilic bioactives added to foods are not bioavailable.

We found that bioaccessibility of lipophilic bioactives in the intestinal juice was enhanced if we decreased their size and crystallinity using our new approach that combines nanoporous starch bioaerogels (NSB) and supercritical CO_2 technology. In this presentation, our work on curcumin will be presented as a case study. In short, we created a first-of-its-kind curcumin formulation that may revolutionize the inclusion of water-insoluble bioactives into foods. Based on these promising results, our goal was to develop a novel approach to enhance curcumin's bioavailability and validate its biological efficacy in vitro and in vivo. The specific objectives were (1) to design, fabricate, and characterize NSB; (2) to decrease the size and crystallinity of curcumin using our novel particle formation method that utilizes NSB and supercritical CO_2; and (3) to determine the bioavailability and bioactivity of this new form of curcumin in vitro and in vivo.

This project will bolster the agro-industry by transferring this new technology to food manufacturers and by maximizing the use of bioactive compounds derived from agricultural products. This project will also improve food quality and health by addressing the chief limitation that poor bioavailability of food bioactives represent and by generating key biomarker profiles for comparison with human data.

(185) RECENT ADVANCES OF NANOSCALE SCIENCE AND NANOTECHNOLOGY FOR FOOD SECURITY, SAFETY AND NUTRITION CHALLENGES IN USA

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USDA/NIFA

Nanotechnology R&D in agriculture and food system has quickly emerged as an important endeavor in many research and educational institutes in the US. Nanotechnology has shown broad applications in agriculture and food systems to address the pressing grand challenges of sustainability, vulnerability, human health, and the quality of life. This presentation will provide an update on the recent advancements in nanotechnology R&D relevant to food science, technology, nutrition and human health. An overview of nanotechnology for food and nutrition applications including effective delivery of bioactives and micronutrients in food matrices, enhanced food safety and biosecurity through better detection and intervention technologies will be given. A brief summary of some research activities on the assessment of the exposure and perceived risks of engineered nanoparticle used in food, either intentional or as contaminants, will be presented. In addition, research to assess the perceptions and acceptance of nanotechnology applications in foods and nanotechnology-based products by the general public and other stakeholders using appropriate social science tools will be presented.

(186) MODELING OF STERILIZATION OF FOOD PARTICULATES IN CONTINUOUS RETORT

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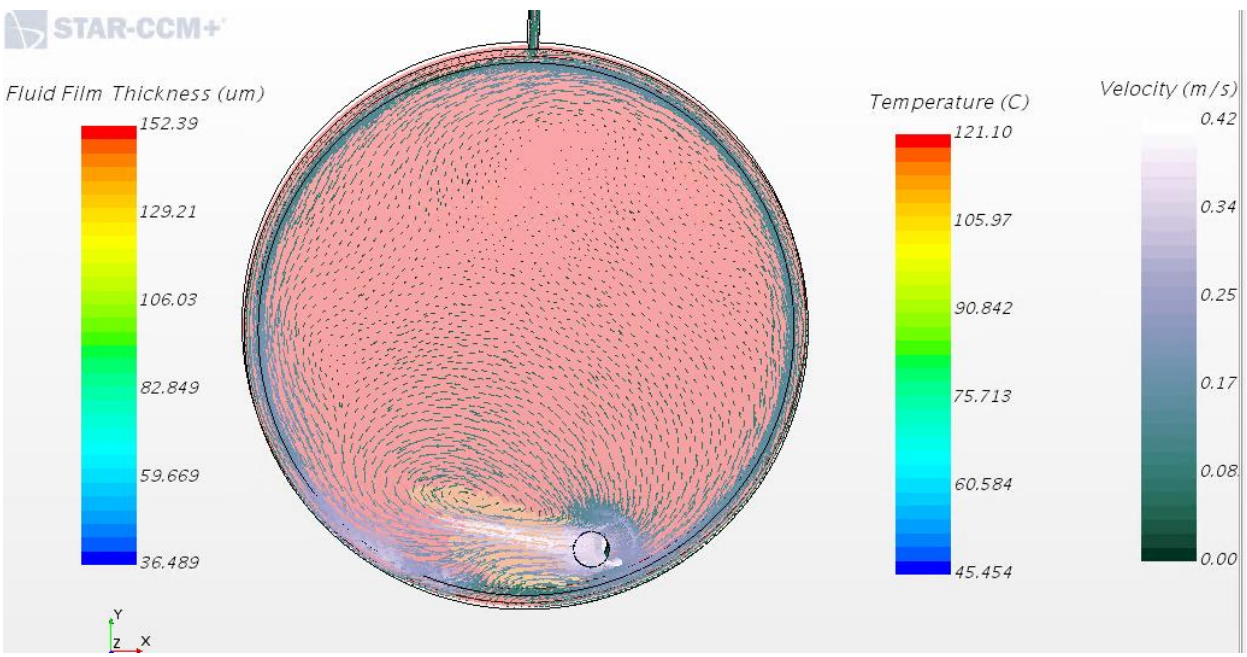
A classical method of thermal preservation, caning, is still the basis of a very large food industry, despite the bargain quality of many canned products. The most challenging aspect of the designing a thermal process is monitoring the temperature of the slowest heating particulates in a package which contains particulates, sauce, and headspace air. Since the precise location of the coldest spot within the container is not known, products are often over processed; this leads to deteriorated product quality and operational inefficiencies. Sterilization in a continuous rotary commercial retort process involves heat, mass and momentum transport; as well as discrete particle interactions. To better comprehend these dynamics during sterilization, a 3-D model was built in STARCMM+ software. This 3-D multiphysics model is comprised of Eulerian VOF phases for steam side, headspace and liquid phase in can, and DEM particles for solid particulates. The developed model was validated with experimental temperature profiles of the can obtained in a pilot plant retort. Once the average heat transfer coefficient at the can surface is determined, the model computation domain can be reduced to the can level for computing efficiency. In the future, the model will be used for understating effect of particles shape, size and loading characteristics on the heating profile of the slowest heating zone in the can.



(192) ESTIMATING SALMONELLA INACTIVATION PARAMETERS FROM DYNAMIC TEMPERATURE DATA IN LOW-MOISTURE FOODS

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Research Justification: Over the past two decades, processors, researchers, and government regulators have become increasingly concerned about the danger of pathogen survival in low-moisture foods. Because of the risk, the USDA gave a marketing order in 2015 that handlers must prove that their applied process or treatment achieves a 4-log reduction of *Salmonella* on almonds. Other processors of low-moisture foods are responding to regulatory guidance or voluntarily applying a treatment to ensure a minimum log reduction of pathogens. Processors must rely on multiple labor-intensive trial-and-error experiments of surrogates in the product during the process. Two technical challenges are: 1) Commercial processes are typically nonisothermal, and 2) When conducting inactivation experiments at temperatures above 100°C, the majority of the inactivation occurs before reaching isothermal conditions.

Objective: To develop a method to estimate *Salmonella* inactivation parameters in low-moisture foods with dynamically increasing temperature.

Methods: Previously published data on *Salmonella* reductions in low-moisture foods were used. The 1-g samples of inoculated food were sealed in steel containers with a 1-mm gap. Oil bath temperatures of 80, 90, 100, and 120°C were used, giving nonisothermal temperature profiles. The primary model was the differential Weibull. The secondary model was the Bigelow. Scaled sensitivity coefficients (SSCs) were plotted to determine parameter identifiability. The parameters deltar, z, and n were estimated for each oil bath temperature.

Results: Parameters z and n were correlated, and were separately estimated. Delta at 80°C = 1 min.,10% error. The range of z values were from 5 to 30°C, 20% error. n ranged from 0.4 to 1.0, 10% error. RMSE < 1 log.

Relevance: This study provides a method to obtain parameters when isothermal data are not available, and when food temperatures are > 100°C. Processors will find these methods and models useful to minimize effort and expense to meet regulations.

(196) DESIGN AND EVALUATION OF COMMERCIAL SCALE SEQUENTIAL INFRARED DRY-BLANCHING AND HOT AIR DRYING (SIRDBHAD) TECHNOLOGY FOR HEALTHY SNACK PRODUCTION

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With an alarming rise in diabetics and obesity cases, the demand for healthy snacks is increasing. Snacks production by hot air drying (HAD) and freeze drying (FD) methods have high energy consumption, longer drying times and low capacities, besides needed separate blanching for HAD and high cost of FD equipment. Sequential infrared dry-blanching and hot air drying (SIRDBHAD) is a sustainable technology with high processing and energy efficiency. The objectives of this study were to build and evaluate a commercial scale SIRDBHAD system to produce healthy fruit and vegetable snacks and compare the quality and energy usage with FD and oil frying. The SIRDBHAD system with an IR dry-blanching/drying, a multi-pass hot air drying and an ambient air cooling sections with a capacity of 75-125 kg/h fresh vegetable and fruit slices was built and evaluated with apple, carrot, kale, pear, sweet potato, pepper and zucchini slices. The results showed that fruit/vegetable slices were dried to a moisture content of about 5% with 2-2.5 min IR dry-blanching followed by 50-60 min of HAD. The system had the capacity to dry 78.5 kg/h to 132.3 kg/h of fresh slices and produced high quality crispy and healthy chips with attractive color and taste, and high nutrient retention. The IR dry-blanching inactivated 50-99% of the peroxidase enzyme and significantly reduced the enzymatic browning. Crispness test with the textural analyzer confirmed that the chips were crispy and crunchy with same or better level of overall acceptance compared to freeze dried products. The required energy to dry 100 kg of produce with SIRDBHAD system ranged from 228.17 kwh to 614.09 kwh. The energy saving by SIRDBHAD technology varied from 26.3-72.6% compared to the traditional oil frying and from 62.5-82.5% compared to FD. The study demonstrated that SIRDBHAD technology can be used to produce high quality healthy snacks with high processing and energy efficiency.

(197) DYNAMIC TEMPERATURE EXPERIMENTS USING A PRESSURIZED DEVICE FOR MICROBIAL INACTIVATION

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Research Justification: Low acid aseptic food manufacturing requires inactivation of spores that is usually achieved with process temperatures above 130°C. Microbiological challenge study is critical to the commercial production of shelf table aseptic products. Spores of surrogate organisms such as Geobacillus Stearothermophilus or Clostridium Sporogenes are used for product, filter and packaging material sterilization. However, processors often rely on inactivation parameters that are either done at lower temperatures or in a different media that is not representative of the product being processed.
Objective: To develop a user friendly tool for determining microbial inactivation parameters
Methods: A device, TPCell, was developed to estimate the temperature dependent thermal properties of food products. The samples in a pressurized test cell is heated from room temperature to 140°C in one minute at the center of the test cell. TPCell has the capability of heating food products in three different modes, 1) from the surface, 2) from the center, and 3) a combination of surface and center heating. From a single experiment, temperature dependent thermal properties were estimated for sample food. The thermal properties were then used to design the experimental conditions for microbial inactivation experiments using mode 3 of the TPCell. Since there were gradients of temperature inside the test cell, an average value of the log reduction was used. The sample temperature variation was accommodated for in the mathematical model. Several simulated experiments were performed to estimate the D and z values of surrogate microorganisms.
Results: Parameters from simulated experiments were estimated with less than 10% error. The correlation of parameter was minimized by the choice of optimal reference temperature. Root mean square error was less than 0.8 log.
Relevance: Food processors and researchers will benefit from a user-friendly tool, which is a combination of physical device and software. The inactivation parameters obtained from this tool will be valuable for existing process validations or a new line installation validation.

(198) EAT LOCAL OR EAT FRESH? A SUSTAINABLE CHOICE OF BLUEBERRY IN THE MIDWEST

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Blueberries have significant nutritional quality and economic value. Although consumption of locally-produced blueberries is generally considered more environmentally sustainable, they cannot be grown in all regions of the U.S. in all seasons. During the winter time, consumers in the Midwest have the choice of purchasing domestic frozen blueberries or imported fresh blueberries from South America. While freezing is known to be more energy-consuming than refrigerating blueberries, the transportation for a long distance from South America to the Midwest makes the consideration of which option is more sustainable a non-trivial question.

In this study, a comparative Life Cycle Assessment (LCA) was performed to analyze the environmental profiles of frozen organic blueberries grown in Michigan, and fresh organic blueberries shipped from Chile. This LCA covered all the stages from cradle to consumer, including farming and harvesting, processing, transportation, and storage. The farming and harvesting, postharvest processing, and transportation stages were identified as the environmental impact hotspots. The Chilean fresh blueberries were more sustainable than the Michigan frozen blueberries in terms of acidification, global warming, ozone layer depletion, human toxicity, fresh water and marine aquatic ecotoxicity, and photochemical oxidation, as well as human health endpoint impact (presented as disability-adjusted life year). Whether consumers should choose the frozen or fresh blueberries was found to be highly sensitive to the type of refrigerant used and the length of frozen storage.

(199) STEAM AND SOUND - COMBINATION HEATING: MICROBIAL DECONTAMINATION AND HEAT TRANSFER

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Steam is by far the most effective medium for heating with perhaps the highest level of heat transfer coefficient associated, and is widely and successfully used in thermal processing applications. However, for rapid direct heating of food products it poses some serious difficulties because of the presence of air along the surface and internal tissues of the food products. The presence of air interferes with the heat transfer mechanism and slows down the effective heating of the surface. Even if one were to subject the food prior vacuuming, the air present in the atmosphere still poses the same problem. Adding an ultra sound combination to steam helps to remove this surface barrier and promote better heat transfer. A limited success has been achieved by a commercial process for killing microorganisms such as *Campylobacter, Salmonella, Listeria and E.coli* on the skin and surface cavities of poultry and other food products. The technology has gained FDA recognition although the reduction in microbial count has been relatively small (2 log kill). While vast amount of information is available on ultrasound enhancement of heat transfer in liquids, the information available is very limited for steam and sound. This paper brings some preliminary results on the use of steam and sound for microbial decontamination.

(200) 3D FOOD PRINTING

Anjan Contractor
BeeHex

The last few years, increased emphasis has been placed on foods made for every individual's needs in order to achieve optimal health potentials and to the creative culinary touches of distinctive meal experience. Customers have demonstrated a willingness to pay more for unique occurrences. One particular driver is the perception that tailored food is of higher quality and healthier option. Food companies are consistently evaluating how to capitalize on consumer demands and integration of any niche factor that will appeal to the competitive marketplace. The integration of 3D printing of food products touches on unique attributes, personalization potential, nutritional flexibility, and signature product offerings for the elderly and those with dietary restrictions and conditions. BeeHex is developing technology that is rapidly impacting the personalized food production industry through automation and increased efficiency. Integrating with food presents its own set of changes, yet upon successful implementation has the potential to enhance consumer experience and revolutionize the way food is prepared.

(202) NONTHERMAL OSMOTIC CONCENTRATION OF LIQUID FOODS

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Due to consumer and industry interest in foods that are minimally processed, significant efforts are made to develop processing methods able to achieve desired function and functionality in foods, but also maintain a high nutritional value, taste and flavor of the processed foods. Nonthermally processed juices and beverages have become an extremely popular. Since juices are better preserved and stored in concentrated form, it became necessary to develop new methods for their nonthermal concentration. Membrane concentration methods are increasingly used in juice processing as an alternative to thermal processing. Reverse Osmosis (RO) has become a popular alternative to thermal concentration of juices or fluid foods. Unfortunately, RO cannot achieve high concentration factors because of pronounced concentration polarization and membrane fouling. Forward Osmosis (FO) is gaining increasing attention as an alternative to both RO and thermal evaporation, since it allows concentration of feeds with high solid levels, without significant membrane fouling. This talk will review the basics of RO and FO, highlighting similarities and differences, using data obtained for both fruit juices and dairy fluids (milk, whey). Additionally, a nonthermal RO+FO combination process that combines the ability of RO to efficiently concentrate liquids with low solids content with the great potential of FO to achieve high concentration levels, will be introduced. The impact of these osmotic concentration processes on product quality and energy consumption will also be discussed.

(203) MONITORING AND CONTROLLING OF A COLD CHAIN FOR FOOD

Subramaniam Sathivel
Louisiana State University

Cold chain management with respect to food is managing a temperature-controlled supply chain from harvest or slaughter to end use. Harvesting or slaughtering, processing, packaging, storage, transportation, marketplace and consumers are major steps involved with the food supply chain. The food professional should have a degree of control over all steps mentioned, with the possible exception of "consumers". Even at that step, the food professional exerts some influence through instructions on the packaging. There is increased demand for frozen food. This may be a result of several factors including: convenience, increased aversion to canned products, improved ability to store refrigerated and frozen products at home and, particularly for frozen foods, the ability to harvest food at peak quality and to preserve the quality for long periods.

Air blast freezing and cryogenic freezing are commonly used in the food industry. Freezing can minimize the shelf life quality changes of food. These changes depend on many factors, including the rate of freezing and thawing, storage temperature, temperature fluctuations, freezing-thawing abuse during storage, transportation, retail display and consumption

Low temperature reduces the microbial growth and biochemical reactions in refrigerated foods. It is important to maintain a particular temperature for particular food throughout a cold chain. Temperature abuse may lead to food borne illnesses and /or a loss of quality. In recent years, cold chain management has been a talking point for the food industry, especially, the refrigerated/frozen food sectors, regulators and academia. In this session, we will highlight cold chain management and focus on monitoring and controlling the cold chain.

(204) GOLD NANOPARTICLE OPTICAL SENSING FOR SIMULTANEOUS DETECTION OF FOODBORNE PATHOGENS

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Optical sensing methods have received substantial interest for pathogen detection. Gold Nanoparticles (AuNPs) are emerging novel colorimetric reporters for the detection of various substances such as nucleic acids, proteins and antibodies. This talk will present optical biosensing methods using oligonucleotide-functionalized AuNPs and discuss the potential for direct and simultaneous detection of foodborne pathogens.

(205) ENCAPSULATION OF BLUEBERRY AND PURPLE CORN EXTRACTS IN ALGINATE-PECTIN HYDROGEL

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Encapsulation is utilized to protect bioactive compounds from degradation and for controlled and targeted delivery of them. Anthocyanins are chemical compounds which provide desired colors to many fruits and vegetables and also have many beneficial properties such as antioxidant, anticancer, antiobesity.
Purple corn (PC) and blueberry (BB) extracts containing anthocyanins were encapsulated in alginate-pectin hydrogel particles. Alginate to pectin ratios at 82 to 18% and 43 to 57% and total gum concentrations (TGC) at 2.2% and 2.8% TGC were prepared to encapsulate both PC and BB ACN. The alginate-pectin hydrogel particles were produced by dripping solution into pH 1.2 buffer. Effect of initial ACN concentration in droplets, particle shape, alginate to pectin ratio, TGC, ACN source, and curing bath conditions on encapsulation efficiency (EE) was investigated.
Blueberry extract encapsulation efficiency was found to be significantly higher than that of purple corn extract. The initial ACN concentration and particle shape didn't influence the EE,\ while the alginate to pectin ratio, TGC, ACN source and the pH of the curing bath showed significant effect on the EE. The EE increased from 26% to 65% for PC ACN and from 48% to 116% for BB ACN by adding ACN to curing bath. The ACN retention during storage (ARs) in hydrogel particles stored in pH 3.0 buffer was improved at low temperature and high particle weight to solution volume ratio. ACN retention in the spherical hydrogel particles was higher than in disc shaped particles. Encapsulation in hydrogel particles significantly reduced the anthocyanin photodegradation upon exposure to fluorescence light. The half-life values of encapsulated ACN degradation were 630 h for PC ACN while it was 58 h for PC ACN aqueous solution.
Hydrogel production and subsequent storage conditions can be optimized to increase the anthocyanin delivered to human body using the low pH beverages such as fruit juices as a delivery vehicle.

(207) INNOVATIVE EXTRACTION TECHNOLOGIES FOR THE FOOD WASTE UTILIZATION

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Food industry is generating annually huge quantities of by-products and waste, which are generally considered as problem, as their disposal is associated with environmental and health related issues. Food waste and by-products could be a good source of valuable nutraceutical compounds. During the last decade, numerous research groups and industries have been interested in valorizing these by-products by extracting valuable compounds and incorporating them generally in food and/or cosmetic products, which enhances the profitability of the process. Conventional extraction methods are extensively used for such purposes and showed high yields in many cases. In many cases, the extraction method used is not economically feasible and sometimes involves the use of toxic solvents, thus hindering their subsequent management. Thus, the need to replace toxic organic solvents, shortening the extraction time, and reducing the energy consumption has incited the researchers to develop and evaluate alternative methods which are more environmentally friendly and cost effective. In this symposium, the potential of using innovative processing technologies (i.e., super critical fluid extraction, electrotechnologies, ultrasound- and microwave-assisted extractions, etc.) for improving the recovery of high added value compounds (e.g. bioactives, enzymes, oils, pigments, etc.) from food waste materials will be discussed and the advantageous and challenges of using these techniques will be highlighted. Solid–liquid extraction procedures are commonly used. These processes involve concentration gradient during the passage of the targeted compounds from solid to liquid phase in order to reach a chemical equilibrium. Maximizing the recovery yields and the process velocity requires the optimization of the extraction method (e.g., solvent nature, solvent concentration, pH, temperature, solid–liquid ratio) dependent on the targeted compounds and their physicochemical characteristics (e.g., solubility, thermal stability).

The application of these novel techniques has been suggested to overcome most of the aforementioned challenges and to optimize the extraction efficiency.

(208) RESEARCH NEEDS FOR FOOD FREEZING AND FROZEN FOOD STORAGE

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The freezing and storage of food represents an outstanding approach to preserving quality attributes and extending shelf-life of the food. The quality attributes of frozen foods are recognized as among the highest when considering currently available preservation methods. However, the freezing process and frozen food storage are energy intensive, and both will require improved efficiencies as demands for natural resources increase.

In order to improve efficiencies of the frozen food chain, careful attention must be given to the processes for removing thermal energy from the product. In addition, a more thorough understanding will be required on the influence of storage temperature on shelf-life of frozen foods. For both approaches, a fundamental understanding of the influence of heat transfer during freezing and temperature during storage on product quality attributes should be given priority.

(209) PROCESS VALIDATION TECHNIQUES FOR CONTINUOUS FLOW THERMAL PROCESSING OF PARTICULATE FOODS

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Continuous flow thermal processing of low-acid particulate foods is complicated by the fact that its process validation in the U.S. requires documentation of the thermal process delivered to the slowest heating point within the food. Traditionally, continuous flow thermal process validation of liquid foods has been done by monitoring the temperature at the slowest heating point within the food product using a thermocouple. This point is usually located at the radial center at the exit of the holding tube. For particulate foods heated using traditional heating techniques (heat transfer taking place from outside to inside), the slowest heating point within a food product is at the center of the slowest heating particle, also called the critical particle. The critical particle in a food product depends on the size, density, and thermal diffusivity of particles within the food.

The next step was to create a conservative carrier particle, which is a hollow plastic particle created based on the largest, fastest moving (neutrally buoyant), and slowest heating (lowest thermal diffusivity) particle in the food product. Since the thermal diffusivity of plastics are generally much lower than that of food particles, a lower thickness of plastic particle is sufficient to ensure that heat penetration to the center of the conservative carrier particle takes place slower than that to the center of the slowest heating food particle in the system. The required thickness of the plastic particle was determined using mathematical modeling of heat transfer. A hollow plastic particle was created based on the mathematical modeling. The next step was to validate the conservative nature of the plastic particle by comparing the rate of heating of the plastic particle and food particles. The final step was to incorporate enzymes, surrogate organisms, and/or thermomagnetic implants and ensure that they were subjected to sufficient thermal treatment.

(211) ADVANCED THERMAL TREATMENT FOR MILITARY RATION DEVELOPMENT

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Introduction: Ohmic heating is an advanced thermal processing method wherein the food material, which serves as an electrical resistor, is heated by passing electricity through it. Electrical energy is dissipated into heat, which results in rapid and uniform heating. The food material shall maintain its sterility while aseptically filled into pre-sterilized contains. Ohmic heating can be used for rapidly heating liquid foods containing large particulates, such as soups, stews, and fruit slices in syrups and sauces, as well as heat sensitive liquids. It is possible to process large particulate foods (up to 1 inch) that would be difficult to process using conventional heat exchangers. The US Army Natick Soldier RD&E Center has been exploring advanced thermal processes to improve the quality of Meal-Ready-to-Eat (MRE) and Unitized Group Ration (UGR) entrees that are currently processed via traditional retort thermal sterilization, which has a known detrimental effect on the quality of entrees due to a long thermal exposure. The challenge of increasing consumption and acceptability of MRE and UGR entrees may be met by leveraging on-going breakthroughs in the area ohmic heating sterilization process.
Methods: Four ration entrée recipes, Buffalo Chicken, Plain Pasta, Chicken Potpie Filling, and Macaroni & Cheese, were processed to the same sterility using an ohmic system and retort. Microbial validation was conducted before storage test; i.e., 2 & 4 weeks at 120F, and 2, 4, 6 months at 100F. Sensory evaluations on appearance, flavor, aroma, texture, and overall acceptance were conducted.
Results: The modern ohmic heater is more compact in design, easier to operate, and provides faster and more uniform heating. Regardless of the homogeneity of the recipe, ohmic treated products showed significantly better quality than the retorted counterparts. The magnitude of sensory quality difference varied with different recipes, but stayed very consistent during prolonged storage.
Significance of the research to the food science field: Ohmic heating technology is suitable to produce particulate-containing ration entrees that need fresh quality and long shelf life. Future plan is to validate nutrient stability of the ohmically treated products (vs. retort treated).

(212) PHASE TRANSITIONS, THERMODYNAMICS AND KINETICS OF POLYELECTROLYTE COMPLEXATION LEADING TO A WINDOW OF SUCCESS IN THE FABRICATION OF LAYER BY LAYER NANOTUBES

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The fabrication of Layer-by-layer (LbL) nanotubes as a delivery system is an intriguing process from the point of view of adsorption, nucleation, deposition, and phase transitions during the process of formation of nanotubes. We have studied the LbL assembly of bovine serum albumin (BSA) and sodium alginate to design and fabricate an edible polyelectrolyte complex nanotube. The formation of nanotubes involves several phase transitions that are complex and need to be understood for the a priori design of these delivery systems. First, the zeta potential/pH behavior is critical in identifying the most effective window for oppositely charged polyelectrolytes to successfully interact through electrical forces to form a condensed phase. We studied the thermodynamics of interaction of the interaction and complexation of these polyelectrolytes using isothermal titration calorimetry (ITC) to establish the stoichiometry and the enthalpy of complexation to form a polyelectrolyte complex assembly. The next step in the fabrication is the successful adsorption and nucleation on the template wall leading to the deposition of a layer until the excess charge fades away and opens the door for the next oppositely charged polyelectrolyte to be exposed to the first layer and similarly adsorb, nucleate and form the second layer. The conversion of two liquid phases to a solid phase is a kinetically controlled process, which depends on the concentration of each solute, the residence time, and the competition between adsorption forces and shear forces to allow for the formation of a successful layer leading to a LbL deposited nanotube. The current progress we have made in understanding the dynamics of this process as well as the conditions, which form a window for successful fabrication, will be discussed in this presentation. We may not be right but we hope we will expose the audience to interesting and useful thoughts.

(213) CHALLENGES AND OPPORTUNITIES IN THE FOOD INDUSTRY – REFLECTION ON TECHNOLOGY BASED BUSINESS VENTURES.

Laurence Lee
LZL Engineering, LLC

Food industry is one of most dynamic and technology driven industries in the nation, being the largest job creation sector economy and leading and impacting the industry globally. However, it has significantly evolved in the last two decades, which brought with new challenges and opportunities for companies larger or small, and especially entrepreneurs who engaged/engaging newer technology based business and ventures. This presentation will share some insider stories and reflection, but focus on discussion on key area such as new product demands, technologies and engineering solutions in industry upgrades and innovations. Food safety/ quality, process integration, healthy and nutritional foods, convenience and greener operation, are key areas present greater opportunities for new startup businesses. As a case study, LZL's innovations and venture experience on fluid bed processing technologies will be reviewed, for entertaining and discussions, as well as newer initiatives on particle coating and microencapsulation for active ingredients and actives protections and controlled release/deliveries for new product development.

(214) BUILDING SUCCESSFUL EXTENSION PROGRAMS TO MEET THE FOOD INDUSTRY NEEDS

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Food industry is a fast-paced system. The needs of the industry vary significantly, depending on the types of products being produced as well as the size of the companies. There are many needs are in the areas of food processing, food product development, food safety and quality among others. Extension and outreach play a significant role in meeting the needs of the industry and ultimately contributing to our economy.

At the Washington State University, we have developed a well-established extension program that serves the food industry, through a collaborative approach. The extension services include, processing solutions to product development and food safety issues. The program is broadly divided into three major categories: i) Assistance to the broad industry issues, ii) Assistance to individual companies, and iii) Training programs tailored to the industry needs. These services are provided to companies of all types and sizes, including small and medium sized firms.

This presentation will provide some examples to illustrate how the extension programs help meet the needs of the industry. Examples will be provided to showcase the varying needs of the industry based on their type and size. It further will highlight some of the proven best practices that help to build successful extension programs to meet the industry needs.

(218) NONTHERMAL OSMOTIC CONCENTRATION OF LIQUID FOODS

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Due to consumer and industry interest in foods that are minimally processed, significant efforts are made to develop processing methods able to achieve desired function and functionality in foods, but also maintain a high nutritional value, taste and flavor of the processed foods. Nonthermally processed juices and beverages have become an extremely popular. Since juices are better preserved and stored in concentrated form, it became necessary to develop new methods for their nonthermal concentration. Membrane concentration methods are increasingly used in juice processing as an alternative to thermal processing. Reverse Osmosis (RO) has become a popular alternative to thermal concentration of juices or fluid foods. Unfortunately, RO cannot achieve high concentration factors because of pronounced concentration polarization and membrane fouling. Forward Osmosis (FO) is gaining increasing attention as an alternative to both RO and thermal evaporation, since it allows concentration of feeds with high solid levels, without significant membrane fouling. This talk will review the basics of RO and FO, highlighting similarities and differences, using data obtained for both fruit juices and dairy fluids (milk, whey). Additionally, a nonthermal RO+FO combination process that combines the ability of RO to efficiently concentrate liquids with low solids content with the great potential of FO to achieve high concentration levels, will be introduced. The impact of these osmotic concentration processes on product quality and energy consumption will also be discussed.

(219) BUILDING BRIDGES ON PILLARS: GLOBAL RESEARCH PLATFORMS TO ADVANCE THE SCIENTIFIC AGENDA

Catherine Woteki
Iowa State University

The second of the Sustainable Development Goals, adopted by the member countries of the United Nations, aims to achieve zero hunger by the year 2030. The latter depends on increasing agricultural productivity while reducing inputs and pre- and post-harvest food losses. Reaching these objectives, in turn, depends on application of science and engineering to foster innovation. Yet, rather than increasing investment in R&D, the United States is decreasing its public funding for food, natural resources and agricultural research. The chasm between poor and rich countries, in per capita spending on publicly-funded agricultural research, is widening. Adoption of global collaboration platforms to further agricultural science can help to advance the scientific agenda, accelerate knowledge diffusion and aid the global scientific community. Key platforms include open data and open access to scholarly publications (result of public funding), open access to germplasm, enhanced technology transfer, improved agricultural statistics, and a science policy forum where countries can share ideas and monitor progress on much needed research to achieve global food security.

(220) UNCONVENTIONAL NANOMATERIALS AND PARADIGMS FOR WATER PURIFICATION AND QUALITY CONTROL IN THE 21ST CENTURY

Rohit Karnik
Massachusetts Institute of Technology

Innovations across the entire spectrum of technology, policy, and society are needed to address the challenge of providing an adequate amount of clean water in the 21st century. In this talk, I will present my perspective of this issue through the lens of a nanotechnology engineer and scientist involved in developing a spectrum of technologies for water purification and quality control. At the smallest scale, we present the development of the thinnest possible membranes from one atom-thick graphene. In these membranes, water can rapidly flow through angstrom-sized holes that reject contaminant molecules and salt ions, which has inherent advantages in
energy-efficient and versatile water purification. At a larger scale, we show that the sapwood of conifers can be used as natural, chemical-free, low-cost, manufactured filters to removemicrobes and turbidity from drinking water. These filters exploit the naturally-occurring membranes in the xylem tissue to remove microbes and present opportunities to create unique pay-as-you-go business models in household water filters with replacement costs of only a few cents. At the systems scale, we present our findings in India, and the technology development to address the gap in monitoring trace contaminants in water by 'dry sampling' – a paradigm that repurposes materials developed for water purification to easily preserve and convey water samples from the water source to a central laboratory, thereby enabling the measurement of contaminants that is not possible with local infrastructure. These studies illustrate the opportunities and challenges involved in fundamental research and development and its translation to ground reality to provide clean water.

List of
Poster presentation abstracts

(001) INFLUENCE OF ULTRASOUND ASSISTED VACUUM DRYING ON THE TOTAL CAROTENOIDS CONTENT OF PAPAYA

Edvaldo Vieira da Silva Júnior[1], Lívia Lins de Melo[2], Rafael Augusto Batista de Medeiros[1], Zilmar Meireles Pimenta Barros[3], Edilene Souza da Silva[2], João Henrique Fernandes da Silva[2], Shirley Clyde Rupert Brandão[2], Patricia Moreira Azoubel[2]
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Papaya has a very pronounced reddish orange color, indicating the presence of carotenoids. However, these compounds are very sensitive to degradation when fruit is subjected to some processing conditions. Since drying is commonly performed at high temperatures and in the presence of oxygen, some undesirable quality changes can occur. The objective of this work was to investigate the effect of a novel drying technique using a combination of ultrasound and vacuum on the total carotenoids content of dried papayas. Drying was performed at 60°C using two techniques: ultrasound assisted vacuum drying (USVD) and control (without ultrasound and vacuum) drying (CD). The experimental set consisted of an ultrasonic bath and a vacuum pump. For all drying methods, the same experimental set was used and the samples were placed in a flask that was connected to a vacuum pump. For USVD both devices were used, while for CD, the devices (vacuum and ultrasound) were switched off. Drying tests were conducted until the sample final moisture reached 16% (wet basis). All samples showed a reduction of their carotenoid content. The CD samples showed the higher total carotenoid content reduction (loss of 41%). This result can be attributed to the longer processing time of these samples. The USVD samples showed a percentage loss of 11 %. The association of ultrasound with vacuum allowed a greater conservation of carotenoids possibly by increasing their extraction by the use of these techniques, which act by reducing the available oxygen for the formation of free radicals, since the mechanism of action of carotenoids is to chelate the singlet oxygen and its degradation kinetics is favored by the presence of oxygen and elevated temperature.

(002) CENTRIFUGATION-ASSISTED BLOCK FREEZE CONCENTRATION APPLIED TO BLUEBERRY JUICE

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Block freeze concentration is a method for recovering a food solute from a solution based on the separation of pure ice crystals from a freeze-concentrated aqueous phase. Centrifugation is an assisted technique to improve the efficiency of freeze concentration process. The aim of this work was to study the influence of the time-temperature parameters in the centrifugation process, as an assisted technique, applied in cryoconcentration of blueberry juice. A completely randomized 4x3 factorial design was used, which considers 2 factors: temperature (5, 10, 15, 20 °C) and time (10, 15, 20 min). To force the separation of solutes from the frozen samples we used a centrifuge operated at 1878 rpm. The solid content in the concentrated fraction increased significantly after the process, compared to the initial value (18 °Brix), reaching a value approximately 40 °Brix, and approaching 60% of the percentage of concentrate in the first cycle of blueberry juice cryoconcentration. The combination of factors Temperature - Time affected the response variables percentage of concentrate and solutes recovered obtaining the best results for a temperature of 15 ºC and a centrifugation time of 20 min. The centrifugation can be used as an assisted technique to enhance the efficiency of block freeze concentration in blueberry juice, obtaining promising results.

(004) ULTRASOUND ASSISTED DRYING OF NECTARINE

Edilene Souza da Silva[1], Shirley Clyde Rupert Brandão[1], Amanda Lopes da Silva[1], Edvaldo Vieira da Silva Júnior[2], João Henrique Fernandes da Silva[1], Antonio Carlos Duarte Coêlho[1], Patricia Moreira Azoubel[1]
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Fruits tend to deteriorate during storage due to their high water activity, which negatively influences the nutritional value and sensory properties of the product. Drying has been widely used as a food preservation method since ancient times. In recent years, attempts have been made to shorten the drying period to improve the energy efficiency of the drying process and the quality of the dried products. Ultrasonically assisted drying (USD) has been a topic of interest. Thus, the effect of ultrasound on nectarine drying kinetics was investigated. Experiments were carried out at 60°C. The ultrasound frequency used for ultrasound assisted drying was 25 kHz. Experimental data were fitted successfully using the Page model, with coefficient of determination greater than 0.9935 and average relative error lower that 11%. The diffusional model was used to describe the moisture transfer and the effective water diffusivity was determined in the order of 10-8 m2/s. It was found that the highest effective moisture diffusivity was determined in the fruit dried with the ultrasound assisted technique. The ultrasound application represents an interesting alternative to traditional drying by shortening drying time, which may involve an energy saving concerning industrial applications.

(005) INFLUENCE OF ULTRASOUND PRETREATMENT ON MOISTURE DIFFUSIVITY DURING CONVECTIVE DRYING OF MELON

João Henrique Fernandes da Silva[1], Danilo Emídio de Souza Cavalcanti[1], Edilene Souza da Silva[1], Shirley Clyde Rupert Brandão[1], Edvaldo Vieira da Silva Júnior[2], Mohand Benachour[1], Patricia Moreira Azoubel[1]
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The drying process can remove much of the free water from the fruit, allowing transportation and storage at a relatively low cost, but can cause damage to the quality of many products. With the attention focused on this fact and in order to reduce the initial water content or modify the cellular structure of the material so that drying becomes faster, the use of pre-treatments has received great attention. The objective of this work was to study the drying kinetics of melon, evaluating the use of ultrasound as a pretreatment. The fruits were washed, peeled manually and the pulp cut into rectangles (5.0 x 3.0 cm) of 0.5 cm thickness. For the pretreatment, a set of two samples were immersed in distilled water (sample:water ratio of 1:4) and submitted to ultrasonic waves for 10, 20 and 30 min. Pretreatment was conducted in an ultrasonic bath at 20 ° C and 25 kHz frequency. Drying was performed in a fixed bed dryer at temperatures of 50 and 70 °C and air velocity of 2 m/s. Moisture effective diffusivity obtained were in the order of 10^{-7} m^2/s and it increased with increasing temperature and with the application of ultrasound prestep, while drying time was reduced, which may represent lower energy costs.

(006) PACKAGING FILM GAS BARRIER PROPERTIES AND STORAGE TEMPERATURE INFLUENCE ON QUALITY OF THERMALLY PASTEURIZED CARROT PUREE

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This study aims to investigate the effect of oxygen transmission rate (OTR) of multilayer polymeric films and storage temperature on the quality of thermally pasteurized carrot puree. The OTR of three selected films F-1, F-30 and F-81 was 0.99±0.05, 29.8±1.38, and 80.9±2.15 $cm^3.m^{-2}.day^{-1}$, respectively. Carrot puree was vacuum packed in pouches and hot water pasteurized at 90ºC, 14min process. Weight loss, pH, instrumental color, β-carotene, and ascorbic acid were evaluated for 45, 80 and 100 days at 13, 8 and 4ºC, respectively. A significant (P<0.05) effect of film OTR and storage temperature was observed on the quality and nutritional attributes. High barrier film (F-1) retained whereas low barrier film (F-81) contributed to higher processing and storage losses of all parameters tested. Weight loss was highest in the F-81 pouches, but less than 0.5% at the end of storage period. pH of the puree was stable in high and medium barrier films throughout the storage period but decreased in packages with low oxygen barrier film. Redness (a^*) and yellowness (b^*) of puree in high barrier pouches (F-1) were stable whereas they started decreasing towards the end of storage period in the F-30 and F-81 pouches. The overall color difference during the storage period was between 0.37–2.93 irrespective of OTR and storage temperature. Puree in F-1 pouches showed significantly (P<0.05) higher retention of β-carotene; there was no significant differences in retention of β-carotene for puree packed in the F-30 and F-81 pouches. The ascorbic acid retention varied from 0–89% depending upon the type of packaging. Based on the ascorbic acid degradation kinetics, activation energy and Q_{10} values ranged from 20.3–72.3 kJ/mol and 1.36–2.96, respectively. Our study demonstrated the sensitivity of nutrient stability to the OTR and applicability of medium barrier films for in-pack pasteurized products.

(007) THERMAL AND MECHANICAL GLASS TRANSITION PROPERTIES OF MACA (*LEPIDIUM MEYENII WALPERS*)

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This study aimed to understand the effect of water sorption on the glass transition temperature (T_g) and caking of maca (a South-American functional root). Maca powder was vacuum-dried, and held at various relative humidity (RH) at 25°C. Sorption isotherm was evaluated gravimetrically. Thermal and mechanical T_g were investigated by differential scanning calorimetry (DSC) and thermal rheological analysis (TRA), respectively. Thermal T_g was taken on the onset of the second DSC scan. Mechanical T_g was taken from the departure point of the force-drop upon heating. Enthalpy relaxation (H_{relax}) behavior was studied in DSC after isothermal aging from T_g-30°C to T_g+40°C. Mechanical relaxation was investigated in the TRA by isothermally heating samples at 25°C, the force difference (ΔF) was plotted respect to RH. For caking, wet samples (prepared at sorption conditions) were vacuum-dried, then sieve-shaken in a 1.4mm mesh; a caking index was calculated gravimetrically. The thermal T_g showed an extremely broad endothermic shift due to a wide distribution of molecular mobility. The mechanical T_g showed a clear force-drop that supported the thermal T_g. The T_g and sorption isotherm were analyzed by the Gordon-Taylor and GAB models respectively, from these, the critical RH (RH_c) wherein T_g=25°C was obtained. The H_{relax} evidenced lower values when aging T <T_g, a maximum at T_g+10°C, then declining values at higher aging T. This H_{relax} pattern explained the distribution of molecular mobility due to the multicomponent nature of maca. Mechanical relaxation showed that ΔF was constant in glassy maca, yet higher ΔF values were depicted after RH_c. A drastic increase in the caking index was independent of RH_c because of the distribution of molecular mobility; stronger caking occurred only above RH=75%. These fundamental data will provide insights of maca T_g and further comprehension of the caking phenomena.

(008) EFFECTS OF WATER, OIL, AND ADDITIVES ON THE GLASS TRANSITION TEMPERATURE AND TEXTURE OF DEEP-FRIED FOOD MODEL

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Deep-fried food has become very popular throughout the world due to it's appealing flavor, and texture. Crispness is a unique textural parameter for deep-fried food. But, crunchy texture is lost during storage, since glass transition is triggered by water sorption. Therefore, it is practically important to recognize the glass transition temperature (T_g) of deep-fried food. Although differential scanning calorimetry (DSC) is extensively used technique to recognize T_g, but it is difficult to determine T_g of food because of their multi-components systems. In that case, mechanical approaches for instance thermal mechanical analysis (TMA), thermomechanical compression test (TMCT) and thermal rheological analysis (TRA) are effective. The purpose of this study was to evaluate T_g of deep-fried models (mixtures of wheat flour, oil, water, and additives) using the TRA and to investigate the effect of glass transition on the texture properties of it. T_g of deep-fried models was detected clearly by TRA, and T_g was evaluated as a function of water content. The T_g decreased with increase in water content because of water plasticizing. The oil free sample and corn-added sample had a higher T_g than the normal sample at each water content. Texture properties were investigated using a rheometer, and it was confirmed that fracture properties changed from brittle to ductile at the critical water content (i.e., those at T_g = 25 °C). These results would provide insights to predict and control the physical stability of deep-fried foods.

(012) NON-INVASIVE EVALUATION OF PROTEIN EFFICIENCY FOR WINE CLARIFICATION

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Mineral- or polymer-based fining agents are added to beverages in order to increase flocculation and sedimentation of fine particles in order to ultimately clarify the beverage. This has an economic impact in relation to the amount of fining agents that are used as well as time of conditioning, filtration, and packaging. Aesthetically, this will enhance the clarity and overall perception of the product and increase customer appreciation of the beverage.

In this study, we will show how multiple light scattering can be used to determine the performance of fining agents but also to show the effectiveness of the dosing of each. This technique allows for the user to see both transmitted and backscattered light at all points in a non-diluted sample allowing sedimentation, clarification, flocculation, and turbidity kinetics to be quantified in a one-hour test. Such information can be used by the formulator or manufacturer to enhance the quality of their wines and to reduce costs in the process.

Specifically, it will be shown how two different fining agents have an impact into the clarification of the wine as well as the concentration effect of the best agent. Low concentrations of these particular agents do not provide satisfactory results. And while a high concentration may provide the best results in terms of fastest sedimentation and clarification, medium concentrations can provide the same results with a bit more processing time. These findings will allow operators to choose the best economic and efficiency options for their production.

(014) EFFECT OF FRYING OIL DEGRADATION ON OIL PHYSICAL PROPERTIES

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Frying oil degrades via exposure to heat, oxygen and water resulting in the formation of volatile and non-volatile products, which act as surface active substances and change heat and mass transfer rates. Effects of oil degradation during frying were quantified by measuring viscosity, surface tension, and static and dynamic contact angles of fresh oil (Total polar materials, TPM=4) and used oil (TPM=12). Higher TPM of used oil indicates the presence of amphiphilic compounds, which may affect surface and interfacial properties. Oil viscosity decreased exponentially with increasing temperature (24-140°C). Used oil viscosity was higher than fresh oil at room temperature; no significant difference was recorded above 60°C. Pendant drop technique was used to measure air-oil (24-200°C) and steam-oil (100-200°C) surface tension of both oils. Surface tension decreased linearly as temperature increased. There was no effect of surrounding medium (air/steam) or oil quality on surface tension. Surface tension was time independent for both oils, as observed with a 5hr. measurement using rising-bubble technique. Advancing, receding angle and hysteresis were measured on a Teflon surface using the volume of liquid method. Static contact angle of used oil (55.5°) was lower than fresh oil (60.5°), indicating improved wettability of used oil, which can affect amount of oil absorbed during frying and post-frying cooling. Lower hysteresis in used oil (12.7°) compared to fresh oil (14.9°) was attributed to the high molecular weight of used oil which reduces degree of surface adsorption of oil. Lower hysteresis in oil as quality degrades can impact rate of oil drainage during post-frying cooling.

(015) MODELING AND OPTIMIZATION OF THERMAL PROCESSING USING ARTIFICIAL INTELLIGENCE TECHNOLOGY

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Thermal sterilization is a method which uses high-temperature to inactive microorganisms. Although in recent years, high pressure processing (HPP), pulsed rlectric fields (PEF), plasma sterilization technology and other new non-thermal food sterilization technologies continue to emerge, thermal processing remains the principal and traditional method of microbial inactivation and reduction for consumers and food industry because of its effectiveness and convenience.

For canned tuna, the Nelder-Mead simplex method (NM), Back Propagation Neural Network(BPNN), Genetic Algorithm (GA) and Artificial Intelligence (AI) technology were used to study the Constant Retort Temperature (CRT) and Variable Retort Temperature (VRT) of single objective and multi-objective optimization of the sterilization process. The CRT process was optimized by Nelder-Mead algorithm at 116 °C, 113 °C and 110°C, and the optimum process time was 29.41 min, 46.17 min and 78.76 min, respectively. Taking 116 °C CRT as the benchmark, through the establishment of thermal sterilization process of the BP neural network model and based on Genetic Algorithm (GA) optimization of sterilization process parameters, Variable Retort Temperature (VRT) process parameters for single step sterilization temperature were determined at A=1.38712 °C and t= 3.80562 min. Under optimal conditions, compared with CRT, VRT could increase quality and vitamin B (VB) retention by 44.81% and 271.80%, respectively.

Studies have shown that the method combining neural network modeling and genetic algorithm optimization was used for the complex nonlinear system such as optimization of thermal sterilization parameters of VRT. This method could achieve high simulation accuracy and avoid error introduced by oversimplified mathematics model.

(016) ULTRASOUND ASSISTED ENZYMATIC HYDROLYSIS OF STARCH: THE MECHANISM INVOLVED, AND ITS EFFECT ON STARCH MOLECULAR COMPOSITION

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Starch is widely utilized in the food industry. Various methods have been used to modify starch in attempting to improve its quality. Enzymatic modification is a popular and common method due to its high selectivity, substrate specificity and mild reaction conditions. Ultrasound was reported to promote enzymatic reactions. We have found that ultrasound could enhance starch hydrolysis catalyzed by glucoamylase. However the main reason for this phenomenon is still unclear. There are three possible mechanisms in ultrasonic promotion of enzymatic reaction: i Ultrasound degrades starch directly; ii Ultrasound activates glucoamylase; iii Ultrasound promotes mass transfer and reduces mass transfer limitation. The mechanism involved was deeply explored in the present work.
Ultrasound was introduced in glucoamylase pretreatment, starch pretreatment or the mixed reaction system treatment to enhance the hydrolysis efficiency. The hydrolysis degree of starch was evaluated through reducing sugar yield using the 3, 5-dinitrosalicylic acid method. The result showed that pretreating glucoamylase by ultrasound hadn't increased the hydrolysis degree. Ultrasound didn't activate glucoamylase at the experimental conditions but cause enzyme inactivation at high temperature, high ultrasonic power and long processing time. Pretreatment of starch led to the increase of starch hydrolysis degree, which indicates that starch degradation caused by ultrasound is responsible for the acceleration of the enzymatic reaction. Meanwhile, the starch hydrolysis was significantly more improved by sonicating the enzymatic reaction system than pretreating substrates with ultrasound. It can be concluded that the promotion of mass transfer induced by ultrasound is the main cause of the acceleration of enzymatic hydrolysis. The amylose contents and chain length distribution of samples were analyzed by iodine binding method and size exclusion chromatography separately. The results of the two experiments illustrated that ultrasound could promote the enzymatic hydrolysis of amylopectin which is harder for glucoamylase to hydrolyze compared to amylose.

(017) EFFECT OF INDIVIDUAL AND COMBINED ULTRASONICATION, THERMAL AND PRESSURE TREATMENTS ON INACTIVATION OF *BACILLUS CEREUS* SPORES

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Bacillus cereus spores are of concern to the food industry due to their high resistance to processing and the ability to germinate to vegetative cells under suitable condition. This research aimed to elucidate the mechanisms of *Bacillus cereus* spore inactivation under ultrasonication (US) combined with thermal (thermosonication, TS), pressure (manosonication, MS), thermal and pressure (manothermosonication, MTS). Electronic microscopy, dipicolinic acid (DPA) release and flow cytometric assessment were used to investigate the inactivation effect and understand the inactivation mechanism. The sporicidal effects of US and thermal were meager, MS and TS also did little inactivation effect. However, MTS has remarkable inactivation effect reaching 3.12 log CFU/mL reduction after 30 min. MS caused over 90% DPA release accompanied by core hydration and cortex degradation, which were responsible for the reduction of heat resistance. The morphology changes were significant after treatment with MS and MTS, although MTS was the most effective and exhibited a large fraction of damage. Ultrasonication promoted the detachment of exosporium, while the thermal treatment induced decrease of electron density in similar nucleus region with a relatively intact exosporium and coat. MS and MTS had a significant impact on the intracellular structure of spores, with coat destroyed and cortex damaged. These results indicated that ultrasonication combined with thermal and pressure has a significant sporicidal effect on *Bacillus cereus* spores, and is a promising sterilization technology in the food industry.

(019) MANOTHERMOSONICATION (MTS) TREATMENT: EFFECTS ON THE DEGRADATION KINETICS AND STRUCTURAL CHARACTERISTICS OF CITRUS PECTIN BY A CONTINUOUS-FLOW SYSTEM

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Pectin is a colloidal acidic heteropolysaccharide with high structural diversity which is widely used as a gelling agent, thickening agent or stabilizer in jams, baked goods, and dairy products. It can also be regarded as dietary fiber, a prebiotic or fat replacement, and it shows certain bioactive and functional properties. Although mano-thermo-sonication (MTS) that incorporates ultrasound, mild heat and low hydrostatic pressure enhances acoustic cavitation activity, it has not been reported for use in polysaccharide modification. In this study, the continuous-flow MTS was used to modify the physicochemical properties and chemical structure of citrus pectin as well as enhance its antioxidant activity.

The effects of pressure, temperature, time and power density on the molecular weight (*Mw*) and polydispersity index of citrus pectin by MTS were investigated and compared with those of an ultrasonication-alone (US) treatment. A kinetic study, degree of methoxylation (DM), a monosaccharide analysis, FTIR, and ^{1}H NMR were also performed. In addition, the 1,1-diphenyl-2picryl hydrazyl radical (DPPH) was used to determine the antioxidant activity of the treated pectin.

The results showed that the MTS-treated pectin (400 KPa) degraded much more (48.8%) than the US-treated pectin (23.8%) within 5 min at 100% amplitude and 45°C, and had a narrower *Mw* distribution. Furthermore, the MTS-treated pectin had a greater effect on the reduction of the methoxyl group on the main chain, which accorded with FTIR results. The ^{1}H NMR showed that pectin from both treatments had similar chemical structures, but some differences were found in the detailed monosaccharide ratio. Moreover, the MTS pectin exhibited higher antioxidant activity than the control group.

The novel MTS technology derived from ultrasonication shows potential for saving process time and achieving greater results in the modification of the structural and functional properties of bio-polymers.

(025) EVALUATION OF THE APPLICATION OF AN EDIBLE COATING AND FRYING TEMPERATURE ON THE CONTENT OF ACRYLAMIDE AND FAT IN FRENCH FRIES

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Worldwide, fried potatoes are considered one of the most consumed food products, due to their sensory properties; however, it contains high levels of fat and neo-contaminants such as acrylamide, which can cause cardiovascular diseases, diabetes and cancer when consumed excessively. It is then necessary, search new alternatives process to reduce the content of undesirable compounds in the fries. Given the above, the objective of this work was to evaluate the effect of the application of an edible coating, developed from whey proteins and rosemary extract, on the reduction of fat content and acrylamide in French fries, with different temperatures of process. The methodology included a multi-level experimental factorial design taking as independent variables: percentage of whey protein (5-11%), percentage of rosemary (0-2%) and frying temperature (171-190 ° C). The fat and moisture content were determined according to AOAC and the acrylamide by HPLC; In addition, the firmness of the potato chips was determined. The optimal process conditions that allow obtaining the lowest content of acrylamide, fat and a firmness of 3N are 180 ° C, 11% and 2% for the temperature of frying the content of protein and rosemary, respectively. This research is a contribution from engineering, to the improvement of the health of fried food consumers and its application to frying processes at the industry level, being an alternative solution to the public health problems of developing countries.

(029) EVALUATION OF THE ANTIOXIDANT AND PHYSICAL PROPERTIES OF AN EXFOLIATING BODY CREAM DEVELOPED FROM COFFEE GROUNDS

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Currently, in the world approximately 584,000 million cups of coffee are consumed per year, generating around 6 million tons of waste know as spent coffee grounds (SCGs). The SCGs are considered a source of environmental pollution due to the organic load they generate; however, they are susceptible to process due to the bioactive compounds they contain. The main goal of this research was to develop an exfoliating body cream from the SCGs; besides determining some of their physical properties and antioxidants. The methodology included the drying of the SCGs at 60 °C, and an air flow of 1.5 m/s; subsequently the exfoliating cream was formulated with three percentages of SCGs (4, 6 and 8%); the antioxidants and L (parameter of color) were determined by ABTS+ and according to CIELAB, respectively. The adhesiveness and cohesiveness were analyzed with a TPA; the reduction of melanin in the skin was evaluated with a Mexameter® MX18. The results were analyzed by means of an ANOVA analysis, with α = 95%. As a main result, a final moisture of SCG was 5%. The polyphenol content of the cream was 38.96, 61.03 and 42.71 mg/g DM for the samples of 4, 6 and 8%, respectively. The adhesiveness parameters and L* showed significant differences for the treatments analyzed ($p < 0.05$). The average cohesiveness of the cream obtained here was 0.62, similar to that of a commercial cream that was 0.63. The reduction of melanin in the skin was 464.3 to 458.3 with the cream with 4% of SGC. This research is of great importance because it applies deferent integrates engineering processes to the food and cosmetic industry, through the use of an agroindustrial waste in the development of a product with potential beneficial effect for health.

(030) MODELLING OF EXTRUSION OF SPROUTED QUINOA USING RESPONSE SURFACE MODELLING AND ARTIFICIAL NEURAL NETWORKS

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Introduction: Finger foods are mostly tools for practice in self-feeding. They must be healthy and nutritious like main meals. However, there is a thirst for more nutritious snacks among parents. Quinoa is a naturally gluten-free grain. It is high in protein and one of the few plant foods that contain all nine essential amino acids. Flavonoids, quercetin and kaempferol are found in large amounts. Germination of quinoa breaks down the phytic acid and increases Gamma-amino butyric acid content and mineral absorption. Hence, a snack derived from quinoa would increase options for healthy feeding. The objective is to develop a healthy finger food from sprouted quinoa that can be used as a nutritious snack for infants by optimizing the extrusion process.

Methods: White quinoa seeds were soaked in cold water for 8 hours and then allowed to germinate for various time periods. Single and twin screw extrusion were carried out. Effects of germination time (0-48 hrs), feed moisture content (15–20 %), screw speed (100–200 rpm) and temperature (90–140°C) on the physical characteristics of the extrudates was investigated using response surface methodology and artificial neural networks. The physical properties measured were color, bulk density, unit density, water absorption index (WAI), water solubility index (WSI), texture and expansion ratio

Results: The total color change in the extrudates ranged between 15.0-23.0. The hardness of the expanded products was below 7 N while the expansion ratio varied from 0.9-4.0. The WSI increased with increasing temperature and screw speed and decreasing feed moisture content due to the fact that high thermal and mechanical energy inputs favor starch dextrinization. The structured nature of the RSM is useful to exhibit the factors contributions from the coefficients in the regression models. This ability is powerful in identifying the insignificant main factors and interaction factors or insignificant quadratic terms in the model and thereby can reduce the complexity of the problem. However, ANN has consistently performed better than the RSM in all aspects.

Significance: With quinoa attaining a superfood status, it needs to be utilized well. It can be used to make novel, healthy, extruded, snack-type food product as a first step.

(034) FATE, TRANSPORT, AND RISK ASSESSMENT STUDY OF NOROVIRUS AND ROTAVIRUS DURING LEAFY GREENS (ROMAINE LETTUCE) PRODUCTION USING TREATED MUNICIPAL WASTEWATER

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High demand for food and water mean water reuse programs are being explored including treated municipal wastewater usage in agriculture. However, these sources could contain high contaminant levels, and pose risks to public health. The objective of this study was to grow and irrigate leafy greens (romaine lettuce) with inoculated wastewater effluent to track AP205 bacteriophage prevalence through cultivation and post-harvest storage to assess fate and transport. AP205 is a bacteriophage that infects *Acinetobacter baumannii,* and was used as a surrogate for enteric viruses, norovirus and rotavirus. Subsequently, quantitative microbial risk assessment (QMRA) was performed to estimate risk of illness to the public. Low and high dosages of AP205 at 4.8 ± 0.4 Log PFU/mL and 6.6 ± 0.2 Log PFU/mL, respectively, were prepared to examine viral load influence on contamination levels and risk of illness. Foliage, leachate, and soil contamination levels were directly ($P < 0.05$) related to AP205 concentrations in the effluent. AP205 concentrations increased throughout cultivation for foliage and leachate, suggesting bacteriophage accumulation. During post-harvest storage (14 day at 4 ^{o}C), there was a significant decrease in AP205 concentration present on the foliage. QMRA results revealed significant chance of illness for norovirus and rotavirus with a 0.3-0.4 probability of illness developing from infection. Risk of illness varied between dosages by only 5% and 1% for norovirus and rotavirus, respectively. Results show that non-traditional water usage for leafy greens cultivation can pose health risks to humans.

(039) EFFECT OF HIGH PRESSURE PROCESSING ON THE PHYSIOCHEMICAL AND FUNCTIONAL PROPERTIES OF YELLOW LENTIL PROTEIN

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This research was aimed at studying the effect of High Pressure Processing (HPP) on the physiochemical and functional properties of yellow lentil (*Lens culinaris*) protein in an effort to replace artificial additives such as polysorbates in processed food.
Yellow lentil protein concentrate (10% w/w) solutions were subjected to HPP using a Box-Behnken (BBD) design of experiments. The three independent factors were pressure (150-550 MPa), time (5-15 min) and pH of the protein solution in citrate phosphate buffers (3-7).
The pressure treated, freeze dried samples were analyzed for emulsification capacity, foaming ability, solubility, fat binding capacity, surface hydrophobicity, and surface zeta potential in two different pH systems- pH 3 and pH 7. Unprocessed yellow lentil protein was used as the control.
It was observed that lower pressures (150 MPa) and intermediate treatment times (10 min) on neutral pH protein solutions were more effective in improving the functional properties of the protein. Emulsification stability was enhanced from 93% in unprocessed control to 231% in a pH 3 system and from 127% to 205% in a pH 7 system. Solubility increased slightly from 43.93% to 53.2% in the pH 7 system. The fat binding capacity increased from 346% for the control to about 796%. Foaming ability was not significantly affected by the HPP treatment in both systems. The surface hydrophobicity increased with an increase in the pressure and time of holding at pH 7. The processing variables of pressure, time, and pH of the protein solutions and their interactions were found have significantly affected the change in the physiochemical and functional properties of the protein.
In conclusion, milder pressure treatments on neutral pH protein solutions were found to be better at improving the functional properties compared to more intense treatments on lower or higher pH protein solutions.

(040) SERS DETECTION OF SMALL MOLECULE TOXINS VIA SUBSTRATES WITH POLYMER AFFINITY AGENTS

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There are a variety of small molecule toxins found in crops that can be extremely carcinogenic to humans, posing dangerous hazards in food production and consumption. Current detection methods for these small molecules are expensive and lack a universal sensing technique to detect a multitude of toxins in complex food matrices. This work exploits commercially available polymers as capture agents for various toxin targets. The capture agents are immobilized on plasmonic substrates known as FONs, or film over nanospheres, based on their end group reactivity whilst maintaining an affinity for a target. These FONs with short, anchored polymer chains serve as a novel sensing system when paired with surface-enhanced Raman spectroscopy (SERS). SERS is an attractive analytical technique due to its high enhancement factors and its ability to assign specific vibrational modes to certain molecules at very low concentrations. By providing fingerprint spectra for various targets, one can easily detect for these them in relevant complex matrices. While investigating varying polymer chain length, anchoring chemistry, attachment schemes, this work demonstrates optimization of SERS sensing to achieve limits of detection comparable to current detection methods with a simpler and more flexible signal transduction mechanism.

(041) HIGH PRESSURE STRUCTURE ENGINEERING OF HIGH CONCENTRATION MILK PROTEIN SYSTEMS: EFFECTS OF PH AND CALCIUM

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Structural modification of proteins allows the creation of foods with various textural characteristics. This is achieved by using either heat treatment or certain additives. Recent work has shown that high pressure processing (HPP) can also induce structural changes in proteins, with minimal impact on the nutritional and sensory properties of the food. The objective of this work was to explore pressure-induced structural changes in milk protein concentrates (MPC), and the effect of pH and calcium on the developed structures.

MPC powder was reconstituted to form a 12.5% (w/w) protein solutions. Adjustment of pH (5.0 – 6.8) and calcium content (24 – 36 mg/ g protein) were achieved by addition of glucono-delta-lactone (GDL) and calcium chloride, respectively. Samples were then HPP treated at 600 MPa for 2-4 min, at 5°C, in triplicate. The pressure-induced rheological and microstructural changes were investigated by dynamic oscillatory strain sweeps, conducted in duplicate, and scanning electron microscopy (SEM) imaging, respectively. Statistical differences ($p < 0.05$) were evaluated with an ANOVA test, using the JMP-Pro 14 software.

After HPP treatment, significant pH and calcium dependent changes were recorded. Pressurization of MPC led to extensive protein aggregation and network formation. HPP combined with calcium synergistically increased the gel strength, expressed by the storage modulus (G'). G' values in the range 3500 - 4100 Pa were obtained, characteristic of strong gels. By comparison, pH reduction produced weaker gels, with G' substantially lower (around 100 Pa), and higher loss tangent (tan δ) values. SEM micrographs confirmed the formation of a porous, heterogeneous microstructure with a reduction in pH. These findings demonstrate how HPP can be used as a means to engineer desired structures in high concentration protein systems. This work provides a basis for the development of novel protein rich foods with high nutritional and sensory properties, built-in safety and extended shelf life.

(050) SWEET POTATO CHIPS PRODUCED BY MICROWAVE VACUUM DRYING WITH CONTROLLED TEMPERATURE BY POWER MODULATION

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Healthy convenient products are continuously drawing the attention of consumers and are an opportunity for the food industry. Oil-free chips are an example of them, which can be produced by specific drying methods. This study investigated the drying of blanched slices of sweet potatoes by microwave vacuum drying (*MWVD*) with a rotating container and modulated power, comparing its product to those obtained by freeze-drying (*FD*), air drying (*AD*), and conductive multi-flash drying (*KMFD*). Raw sweet potatoes were peeled, sliced, blanched and dehydrated. In *MWVD*, the surface temperature of the samples was measured with an infrared sensor and controlled at 60 °C by modulating the microwave power using a PID controller system. The produced chips were evaluated by sensory analysis, microstructure images, porosity, and instrumental texture. Sensory tests were preference, purchase intention, and acceptance based on appearance, color, taste, texture, and overall evaluation. *MWVD* with rotating container and controlled surface temperature guaranteed the homogeneity of heating, resulting in dehydrated products without burned regions, which indicates the absence of hot spots. *MWVD* and *KMFD* produced sweet potato chips in less than 3 h, while *AD* and *FD* required around 16 h. Sweet potato chips porosity was very different for each method: *FD* resulted in 58,4%, *MWVD* and *KMFD* produced similar values, respectively 44,2% and 38,7%, while *AD* led to only 18,4%. *AD* samples were compacted, whereas *FD* samples had a spongy structure with small pores, and samples dried by *MWVD,* and *KMFD* presented expanded (puffed) structure with large pores. These expanded structures resulted in jagged mechanical curves with peaks, which is a typical result for crisp products. Both *MWVD* and *KMFD* had greater sensory acceptance than *AD* and *FD*. Therefore, *MWVD* with temperature control has great potential for industrial production oil-free crisp sweet potato chips.

(052) EFFECT OF CONTINUOUS INTENSE PULSED LIGHT ON *CRONOBACTER SAKAZAKII* INOCULATED IN DIFFERENT POWDERED FOODS

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C. sakazakii can cause disease in humans of all ages, and can be more serious in elderly and immunocompromised people, and clinical symptoms of *C. sakazakii* infection include necrotizing enterocolitis, bacteremia, and meningitis. *Salmonella* spp. is another foodborne pathogen associated with dry foods, which would cause diarrhea, fever, and abdominal cramp. Various non-thermal techniques have been developed to inactivate *C. sakazakii* in PIF. However, these techniques are not effective, fast, or feasible in application. Intense pulsed light (IPL) is warranted to kill *C. sakazakii* in powdered food prior to packaging. Our previous results indicated that a synergistic effect of IPL and an appropriate temperature of ~57.5± 0.7°C exhibited a maximum inactivation of 3.18 log10 CFU/g for *C. sakazakii* in NFDM with minimal quality degradation at the initial temperature of 25 °C, at the water activity level of 0.25, and a residence time of 28 s. In the current study, effect of IPL on NFDM with thickness of 1.2, 1.6, and 2.0 mm; height at 6, 8, and 10 cm were investigated and compared. The results showed the highest inactivation could be achieved at the height of 8 cm, the thickness of 1.2 mm. In addition, effect of 1-4 passes IPL treatments on a variety of powder vectors such as NFDM, wheat flour, whole egg powder, egg white, and ground pepper were evaluated. The results revealed that around 5 $\log_{10}$ CFU/g reductions of *C. sakazakii* or 3 $\log_{10}$ CFU/g reductions of *E. faecium* could be achieved for NFDM, wheat flour, and egg white after 4 passes IPL. Furthermore, more than 5 $\log_{10}$ CFU/g reductions of *C. sakazakii* was achieved after 44 s using modified IPL system. Overall, the study demonstrates that IPL can be potentially applied in *C. sakazakii* inactivation in some powdered foods.

(054) NUMERICAL MODELING AND EXPERIMENTAL VALIDATION OF A PASTEURIZATION UNIT WITH TWO PLATE HEAT EXCHANGERS AND A COILED HOLDING TUBE

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A computational fluid dynamics (CFD) model of a pasteurization process that comprises two plate heat exchangers (PHE) and one coiled holding tube was developed. Each PHE has 16 channels with flat plates and series flow (one channel per pass). The 3D model represents channels, plates and tubes. The control volumes of the PHE were discretized in a grid of hexahedral elements using the software *Gambit (version 2.4.6)*. Computational simulations were performed in the software *Ansys Fluent* (*version Student 18.2*) using the algorithm SIMPLE, which is referred as a pressure-velocity segregated solver. Numerical runs were carried-out considering steady-state conditions. Model was experimentally validated using a lab scale pasteurizer (Armfield, UK) with water as product, heating and cooling fluids with flow rates of 20, 36 and 72 L/h, respectively. Fluid temperatures were recorded using data acquisition hardware (National Instruments, USA) measured at nine points after steady operation state was confirmed. Model results were in good agreement with the experimental data. Next steps are to include the inactivation kinetics in the model and run experiments with real food products such as a fruit juice or pulp.

(055) MODELING THE WEAR BEHAVIOR OF DAIRY PROTEIN GELS

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There has been a marked increase in tribological analyses of food products over the past two decades. The increased interest is driven mainly by the hypothesis that friction-related food textural attributes are related to instrumentally-measured friction profiles. Therefore, food tribological work has focused on friction and lubrication behaviors of semisolid foods. However, tribology has a third component that may be key to food industrial and oral processing behaviors: wear. Wear, the removal of material from a surface due to sliding contact, is present in many industrial processes, such as slicing, shredding, extrusion, and sheeting. It may also play a role in texture experienced during sucking and palating solid foods. Yet there is little published literature on food wear behaviors. Thus, the objective of this study was to characterize and model the wear behaviors of casein hydrogels under different conditions. Casein hydrogels were prepared at 3-5% w/w concentration using a 200 mM NaCl solution. Hydrogel penetration depth (deformation plus wear) behaviors were evaluated at room temperature (22$\pm$2°C) and a constant sliding speed of 33 mm s^{-1}. Normal force was varied between 0.1-0.3 N. Penetration depth was modeled using a kernel-based statistical model. The model showed three distinct regimes: 1) deformation-dominant, where penetration depth rapidly increased during the initial portion of the test, 2) constant wear, where penetration depth increased slowly due to wear, and 3) failure, where penetration depth rapidly increased again due to high wear rates. Lower casein concentration and higher normal force increased penetration depth and rate of wear in the constant wear rate region, and decreased time to reach the failure regime, as expected. Overall, these results show that wear behaviors follow a predictable pattern. Further work is needed to determine if this pattern is universal for soft materials or particular to protein hydrogels.

(057) EFFECTS OF POWER ULTRASOUND AND CONTROLLED GERMINATION PROCESS ON THE SELECTED METABOLITES AND MICROSTRUCTURE OF OAT

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Whole grain oat is rich in proteins, dietary fibers and polyphenols, especially avenanthramides. A controlled germination process has been reported for enhancing the nutrition and sweetness of grain-based products. Power ultrasound as an emerging non-thermal processing technology has been studied for stimulating seeds as well as plants to enhance germination and the accumulation of health-promoting metabolites such as γ-aminobutyric acid (GABA) and phenolic compounds in the germinated grains.

This work was undertaken to evaluate the effects of power ultrasound and controlled germination on the nutritional properties and the microstructure of oat groats. Oat groats were treated with sonication for 5 min. after soaking for 4 hrs. and then germinated at 24°C for up to 4 days. The key metabolites in GABA-shunt, soluble sugars, avenanthramides (2c, 2p, 2f), total phenolic content (TPC), and DPPH• scavenging capacity, were determined. Changes in the external and internal microstructure of oat kernels were investigated using Environmental Scanning Electron Microscopy (ESEM) and 3D X-ray Micro Computed Tomography (Micro-CT).

After a 4-day germination, GABA, glutamic acid, alanine, maltose, glucose, and fructose increased by 30.4-, 6.5-, 2.9-, 113.0-, 20.7-, and 11.9-fold, respectively, compared with that of the raw oat flour. The avenanthramide content reached a peak on Day 2, where the 2c was 41.7 times, the 2p was 24.9 times, and the 2f was 17.6 times higher than in the raw oats. TPC and antioxidant capacity were significantly enhanced ($P<0.05$). Power ultrasound significantly enhanced the GABA (Day 2-Day 4), alanine (Day 1-Day 4), succinic acid (Day 2-Day 3), total phenolic content (Day 1), and avenanthramides' 2p and 2f (Day 1). The ESEM and Micro-CT images indicated that ultrasound treatment cleaned the oat surfaces, cut off the villus, created holes. Power ultrasound showed promise as a tool to improve the accumulation of nutrients through metabolite regulation.

(059) ACEROLA AND CERIGUELA DRIED MIXED PULP BY SPRAY DRYING, SPOUTED BED DRYING AND FREEZE DRYING: PROCESS OPTIMIZATION

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Fruits are highly perishable and, therefore, it is necessary to apply preservation methods to prolong its useful life, maintaining its qualities. The objective of this work was to optimize the drying process of acerola and ceriguela mixed pulp (ACMP) by different methods (spray drying, spouted bed drying and freezing-drying) in relation to physicochemical properties and ascorbic acid retention, aiming a powder product with low water activity (aw), moisture content (MC) and hygroscopicity (H), and higher ascorbic acid retention (RAA). The influence of process conditions on moisture content, water activity, hgroscopicity and ascorbic acid retention were analyzed by means of a complete factorial design 23 composed by 11 tests. In the experimental conditions of this work, the parameters carrier agent concentration for spouted bed drying, temperature for spray drying and temperature and chamber pressure for freeze-drying were the variables that had a significant influence on RAA. The optimum process conditions to obtain acerola and ceriguela mixed pulp powder by spray drying were: drying temperature (140 ºC), flow rate (0.60 L/h) and carrier agent concentration (20%); for spouted bed drying were: drying temperature (75 °C), suspension flow rate (5 mL/min) and carrier agent concentration (15%); and for freeze-drying: temperature (-20 °C), chamber pressure (500 mTorr) and carrier agent concentration (25%). Freeze-dried samples presented higher RAA (77%), followed by the spray dried ones (75.7%). ACMP obtained by the different drying methods presented aw, MC and H within the range established by legislation for powdered foods.

(064) A CERO-CARBON VACUUM DRYER TO PRODUCE FRUITS AND VEGETABLES AT SMALL SCALE

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Convection drying has high energy consumption and other shortcomings related to the quality of the dried food. Conductive multi-flash drying (KMFD) has been reported as a suitable process to produce dried-and-crisp fruits and vegetables. KMFD is based on the application of successive heating-vacuum pulse cycles to food to be dried. The food is heated by conduction up to the desired temperature (e.g., 70 ºC), and then a sudden decompression is applied, leading to flash evaporation. The produced vapor causes texturization that results in dried fruits with porous structures. Solar energy is an abundant and non-polluting source of energy that can supply the energy needs from KMFD process. A hybrid solar dryer that operates under vacuum conditions, using solar energy (thermic and photovoltaic) was constructed for the drying of fruits and vegetables. The drying system consists of drying chambers, with a capacity of 4-5 kg of raw material. Fruits (banana, mango) were selected from their visual appearance and degree of ripeness, washed, peeled and cut into slices. Water was heated up to 90 ºC by the solar collector and used to heat the plates (recirculation pump) on which the raw fruits were placed. The vacuum system consists of a vacuum pump and a vacuum tank. A photovoltaic panel is used to supply the electrical energy to the vacuum and recirculation pumps. Fruit slices could be dried in 2.5 hours, resulting in products with a water activity of less than 0.3. Dehydrated fruits presented a crispy and porous texture. Therefore, this ‘zero carbon’ drying system is suitable to produce crisp fruits in short times using solar energy. The system is easy to operate and can be installed on small farms to add value to raw materials. The use of solar energy can contribute to reducing both, energy costs and greenhouse gas emissions.

(068) INSTRUMENTAL AND SENSORY CORRELATION TO ASSESS THE DRYING METHOD IMPACT ON BANANA CRISPNESS

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Dehydration can increase fruits shelf-life and sensory attributes. The drying method influences on product microstructure, and so its sensory acceptance, mainly when the fruit becomes hard and non-crispy. The food industry is interested in using faster methods than sensory analysis to assess food crispness. Previous studies have shown that acoustical and mechanical measurements have the potential to correlate with sensory crispness determined by trained panels, and it may reduce analysis time and costs. The aim of this study was to evaluate the correlation among mechanical, acoustical, and sensory measurements of crisp bananas obtained by four different methods: air drying, vacuum drying, freeze-drying, and multiflash drying. Bananas were selected by ripeness (23.0±0.1 °Brix), peeled and sliced in 5 mm thick cylinders. After drying, sample crispness was evaluated by simultaneous mechanical and acoustical essays. Puncture tests were performed with a Texture Analyser at 3 mm s^{-1}, while acoustic signals were captured by a free-field half inch condenser G.R.A.S 46AE microphone using a high sampling rate at 51.2 kHz. A trained panel was set up for sensory analysis. Correlations among all instrumental and sensory data were made through the correlation matrix and principal component analysis. Strong correlations between sensory crispness, the number of acoustic peaks (r = 0,796), number of force peaks (r = 0,723), porosity (r = 0,797) and sound pressure level (r = 0,700) were found for banana slices dehydrated by all the different methods. The filter applied to acoustical data was relevant for the results, in which the Arimi's filter was more effective to detect differences. The multiflash drying process produced the crispier bananas, as well as was preferred in the consumer acceptance test. Mechanical and acoustical measurements were useful and can be used instead of sensory analysis to evaluate the crispness of dried bananas.

(069) ATMOSPHERIC PRESSURE NON-THERMAL PLASMA FOR SANITIZING ANIMAL PRODUCTION FACILITY AIR

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Airborne pathogens from poultry production, such as Newcastle disease \virus (NDV) and avian influenza, pose serious threats to human health and economic stability. The objective of this study is to employ an engineering approach to control airborne pathogens. Specifically, this study utilizes non-thermal plasma technology to treat viral aerosols containing pathogenic Newcastle disease virus. Preliminary data demonstrates complete inactivation (at least 4-log reduction) of airborne NDV. Implementation of this technology into commercial poultry facilities could potentially eliminate the health and economic risks posed by airborne pathogens.

(070) APTAMER BASED BIOSENSOR FOR REAL-TIME DETECTION OF LISTERIA MONOCYTOGENES USING PH-RESPONSIVE POLYMER NANOBRUSH AND METALLIC NANOPARTICLE PLATFORMS

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Listeria monocytogenes is one of the main concerns among the recurrent foodborne pathogen outbreaks that negatively affect consumers' health and producers' finances. There is a need for rapid, label-free, reliable detection methods for pathogens to replace current highly technical and time-consuming methods. Biosensors can meet this need. This study aimed to develop an electrochemical biosensor with a pH-responsive polymer nanobrush embedded with platinum nanoparticles (nPt) platform using aptamers for real-time detection of *Listeria monocytogenes* with enhanced limit of detection and sensitivity. This new structure is expected to improve bacteria capture, due to polymer pH-actuation, and detection, as nPt distributed on nanobrushes would enhance electron transport and facilitate thiol-terminated aptamers binding. A new approach using a one-step metal and polymer simultaneous deposition was tested using two pH-sensitive polymers and DNA-aptamer selective to *Listeria*`s surface protein internalin-A. Briefly, alginate and chitosan were modified through amine-carboxyl coupling with cysteine and thioglycolic acid (TGA), respectively, to present thiol-termination. This thiol-termination allows for covalent binding of polymers to the electrodes' surface and to nPt at the same time, i.e., simultaneous sonoeletrodeposition process (one-step procedure). Cyclic voltammetry was used to evaluate optimal deposition parameters and aptamer concentration, and response to stimulus. Bacteria detection was performed via electrochemical impedance spectroscopy for depositions at 6 V, 60 cycles (120 s) and 0.15% chitosan-TGA concentration and 5.75 V, 140 cycles and 0.05% alginate-cysteine, which presented electroactive surface area of 0.36 ± 0.01 and 0.20 ± 0.03 cm^2, respectively. Actuation tests demonstrated stimulus responsive behavior. Biosensors' detection range was 1 to 5 log CFU/mL in 17 min response time, detecting *L. monocytogenes* at levels as low as 35 CFU/mL, with ongoing work to improve this limit of detection. The designed biosensor platform showed great potential to replace current standard methods used by the food industry for rapid *Listeria monocytogenes* detection.

(072) MINING HIDDEN FACTORS INFLUENCING CONSUMER PREFERENCES FOR TARGETED-PRODUCT OPTIMIZATION: APPLICATION OF A BIG DATA TECHNIQUE

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Food companies have to make their product development process more customer-driven to succeed in the current competitive environment. It is thus essential for them to respond to consumers' preferences to improve their market share. Firms usually utilize customers' opinions in the form of structured data collected from market surveys, customer interviews or market research. Recently, the huge amount of unstructured data available on social media (e.g. Twitter) provides an unprecedented opportunity for acquiring timely and sharp business insights. However, the biggest challenge is how to utilize the massive unstructured data in the decision-making process. In this work, we applied a big data technique – text mining – to a case study: "Cakes of the world" to discover hidden factors influencing consumer preferences. Descriptive analysis and preference analysis were used as the tools. The goal was to provide recommendations for targeted-product optimization. 1,185,004 Twitter posts were collected by application-programming-interface (API) streaming. For the descriptive analysis, features including sensory descriptors and the basic ingredients were collected to make a "bag of words." For the preference analysis, a rule-based sentiment analysis was conducted to calculate the tweet polarity. Finally, words frequently associated with very positive tweets and very negative tweets were regarded as driving factors influencing consumer preferences towards each product. While most people expressed positive perceptions of cakes on social media, the distributions of the consumer preferences were skewed. By looking into terms frequently associated with the extreme tweets, features such as 'crust', 'creamy', and 'light' were driving factors for strong preferences in cheesecakes, for example. Terms commonly used by consumers to express extreme dislike were 'hard', 'dry', 'frosting', 'sticky', and 'sour'. These varied in weight among the cakes. By combining text mining techniques and domain knowledge, useful insights for targeted-product optimization could be attained with potential to guide new-product development and marketing.

(075) PASTEURIZATION OF SHELL EGGS USING RADIO FREQUENCY IN COMBINATION WITH HOT WATER SPRAYING

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Radio frequency (RF) processing of shell eggs followed by hot water immersion (HWI) has been demonstrated to achieve more than 5 log reduction of Salmonella Typhimurium in 20 min and result in a higher quality egg. Because the RF process includes spraying eggs with warm water, it might be advantageous to use hot water spraying (HWS) as the second step rather than HWI. Therefore, the objective of this study was to compare the efficiency of RF in combination with HWS versus HWI in the inactivation of S. Typhimurium in shell eggs, as well as, the quality of RF/HWS- and RF/HWI-treated eggs. Shell eggs inoculated with S. Typhimurium ATCC 53647 were processed for 4.5 min by RF at a power of 35 W and a cooling water temperature of 38 °C, followed by either HWS or HWI at 56.7 °C. Eggs were taken out at appropriate time intervals and cooled down in ice water for 5 min. Cell counts were enumerated by plating onto 3M™ Petrifilm™ Aerobic Count Plates and incubated at 37 °C for 24-48 h. Haugh unit, yolk index, and albumen turbidity of untreated, RF/HWS- and RF/HWI-treated eggs were determined. The results showed that only five more minutes were required for HWS to reduce S. Typhimurium by 5 log compared to HWI. Quality analysis indicated that there was no significant ($P \geq 0.05$) difference in Haugh unit and yolk index between untreated, RF/HWS-, and RF/HWI-treated eggs, and no significant difference in albumen turbidity between RF/HWS- and RF/HWI-treated eggs. However, albumen turbidity of both types of treated eggs was significantly higher than that of untreated eggs. This study demonstrated the applicability of HWS in combination with radio frequency to shell egg pasteurization. Based on these results, a commercial-prototype RF/HWS unit is being designed in conjunction with an industrial CRADA partner.

(080) INFLUENCE OF SOLUTE CONCENTRATION AND VEGETABLE PRETREATMENT ON HEAT OF COMPRESSION

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Heat of compression (δ) refers to the transient temperature change of the materials undergoing isostatic compression or decompression during high pressure processing. A study was conducted to evaluate the influence of solute concentration and pretreatments on heat of compression values of selected vegetable pickles. Heat of compression experiments were carried out in a laboratory scale high pressure processor at 600 MPa at initial temperatures (Ti) of 25°C and 60°C using salt and sugar pickling solutions of different concentrations as well as four different vegetables suspended in pickling liquid (green beans, cucumbers, beets and banana pepper). The influence of two different pretreatments (overnight soaking and thermal blanching) on the heat of compression values of vegetables was also investigated.

Amongst the salt and sugar solutions tested, 5% salt and 5% sugar reported highest δ values of 3.15°C/100 MPa and 3.27°C/100 MPa, respectively ($p<0.05$) than that of water (3.00°C/100 MPa). δ values decreased with increasing solute concentrations possibly due to limited packing of molecules under pressure. Among the vegetable samples, both pretreatments influenced the δ with 3.24°C/100 MPa (at Ti=25°C) and 4.22°C/100 MPa (Ti=60°C) compared to raw vegetables ($p<0.05$). At Ti=60°C, thermal effects appears to be dominant in comparison to pretreatment or concentration effects. This study will aid food processors to consider thermal non-uniformities of various food products during high pressure processing.

(083) LC-MS BASED CHEMOMETRIC PLATFORM MONITORS INTENSE PULSED LIGHT ELICITED EFFECT ON THE CHEMICAL COMPOSITION OF NON-FAT DRY MILK

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Introduction: Intense pulsed light (IPL) is being developed as a novel method to pasteurize powdered food. However, the effects of IPL treatment on the physical, chemical, and nutritional properties of powdered food remain unknown.
Purpose: The purpose of this study is to identify and establish chemical markers that can be used to monitor potential changes elicited by IPL on non-fat dry milk (NFDM).
Methods: Non-fat milk powder was treated with IPL, UV, and plasma. The samples of control and treated milk powder were prepared by solvent extraction and then examined by liquid chromatography-mass spectrometry (LC-MS) analysis. Untargeted chemometric analysis were performed to determine the chemical changes in treated samples.
Results: Untargeted chemometric and structural analysis identified the formation of oligopeptides and the degradation of B vitamins as prominent changes in response to light treatments (IPL and UV). Under the comparable microbial reduction level, UV treatment induced chemical changes in a greater magnitude than both IPL and plasma. IPL showed comparable changes with UV.
Significance: Untargeted chemometrics is an efficient analytical approach for monitoring the chemical changes of non-fat dry milk. Identification of sensitive markers of light treatment could facilitate the development and optimization of IPL technology.

(085) MODELLING THE INACTIVATION OF *B. CEREUS* BACTERIA IN TIGER NUT MILK TREATED WITH DIELECTRIC BARRIER DISCHARGE PLASMA

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The impact of dielectric barrier discharge plasma was investigated in the inactivation kinetics of *Bacillus cereus* 14579 bacteria in tiger nut milk and the resulting quality changes. The influence of different input power (39, 43, 46 w) and treatment time (0, 30, 60, 120, 150, 180, 200, and 270 s) were analyzed and fitted with Weibull and biphasic mathematical models to represent the microbial kinetic inactivation in the plasma-treated tiger nut milk. The result showed the microbial inactivation increases with an increase in input power and treatment duration. The log reduction achieved under 39 to 46 W input power was 5.38 log CFU/mL without a significant change in titratable acidity and ^{o}Brix. The kinetics of microbial inactivation was best described by the Weibull model than the biphasic model. The higher input power of 43 and 46 W after 120 s of treatment resulted in a significant decrease in pH, total flavonoid contents, and antioxidant activity. Whereas an increase in colour and total phenolic contents was equally observed. The results indicate that the plasma-generated reactive species such as H_2O_2 and O_3 are responsible for the microbial inactivation and some chemical changes in the plasma-treated tiger nut milk.

(089) MODELLING AND OPTIMISATION OF DRUM-DRYER OPERATION

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Current environmental policies promoting a more sustainable food sector have boosted efforts to reduce energy demand during processing, and particularly during drying operations. One of the routes towards more sustainable/efficient drying processes is the design and implementation of optimal operational routines for existing drying equipment. In the food industry, drum-dryers are typically employed for the production of food powders from viscous slurries in a wide range of applications (milk or cocoa beverage powders, instant soups, flours or flavours).

In this framework, we propose a model-based optimisation routine for the operation of a double drum-dryer (under atmospheric conditions) used in the manufacture of breakfast cereal porridge. This problem defines optimal steam temperatures and rotation speeds that minimise the energy demand of the dryer operation for a range of operation conditions i.e. different product formulation, final moisture contents, thickness and initial temperature of the wet slurry.

Results showed that for a given formulation (i.e. 80% water, 20% oats), thicker slurries (0.1, 0.3, 0.5 mm) required (i) higher temperatures (145°C, 164°C, 184°C) of the saturated steam (ii) faster rotation speeds (7.9 m/s, 9 m/s, 9.4 m/s) of the drum to reach a final moisture content of 8% (w/w). A decrease of the final moisture content of the dried powder (10%, 6%, 4% w/w) also resulted in higher energy consumptions (601 kJ/s, 635 kJ/s, 652 kJ/s). The optimal values for the steam temperature laid within a range of approx. 7°C (162 ^{o}C, 167°C, 169 ^{o}C). No significant differences on the on total energy demand of the process were observed when different inlet temperatures (66°C, 75°C, 85°C) - effect of sensible heat - was evaluated.

Overall, this work demonstrates the potential of model-based approaches to achieve further energy reductions during food manufacturing, and also support the virtualisation of the sector.

(090) HOW DO SURFACE PROPERTIES AFFECT TO CLEANING PERFORMANCE?

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To optimise the widely implemented clean-in-place (CIP) systems, it is critical to understand the influence of the interactions between surfaces, foulant, and chemical agents, on the efficiency of the cleaning process. The present work investigates the effect of temperature and surface roughness on the surface free energy (SFE) of stainless steel (SS) and that of a representative foulant, whey protein. For both studies, equilibrium contact angles (ECA) of three different liquids were measured on the surfaces of interest. Three different liquids, namely ethylene glycol, bromonaphathalene, and diiodomethane, were used to quantify SFE, whilst roughness of SS coupons was examined by White Light Interferometry (WLI).

It was found that the total surface energy of SS 316L does not change notably as a function of temperature from 20 to 80°C - there is no noticeable variation between dispersive components on the coupons of different roughness. However, the polar component increases on mirror polished surfaces in comparison to satin and brush polishing. The behaviour of polar part coincides with the delay of the ECA increase for drops of water over mirror surfaces.

Regarding the effect of surface roughness, it is was found a strong influence on surface wettability. The greater surface roughness, the lower contact angle and the higher SFE on the range studied (Ra < 0.83 µm). As suggested in a previous work[1], ECA decrease into small roughness limits before increasing ECA with respect to roughness values. The results so far confirm the importance of surface characteristics in determining interfacial energy, and consequently the efficiency of CIP for food engineering.

[1]*Kubiak, K.J., Wilson, M.C.T., Mathia, T.G., Carval, Ph. (2011). Wettability versus roughness of engineering surfaces. Wear 271, 523–528.*

(091) MODEL DISCRIMINATION OF REHYDRATION KINETICS IN FREEZE-DRIED TOMATOES

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Drying is a common food processing operation, but dried foods often have poor textural quality once rehydrated. Ensuring fast rehydration and the preservation of food organoleptic properties, especially in vegetables and fruits, is key in the design and optimisation of convenience and ready-to-eat foods. Well-connected porous networks, such those resulting from freeze-drying, can enhance water absorption and transport, leading to higher quality products. Characterising rehydration kinetics is the first step to understand the effect of microstructure on the quality of rehydrated dried products.

In this work, fresh tomatoes were initially freeze-dried during 48h and then rehydrated at different temperatures (20 ^{o}C, 40°C and 50 ^{o}C). The rehydration capacities obtained from the experiments were fitted to four rehydration models: Peleg, first order kinetics, exponential and Weibull using regression analysis (Least Square method). The goodness-of-fit was evaluated using: error (RMSE), adjusted R-square (R_{adj}), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

According to the selected model discrimination criteria - i.e. minimal RMSE, higher R_{adj} and lower AICC and BIC values - results show that both Exponential and Weibull models can predict accurately the fast initial water absorption rates and subsequent relaxation that characterises the rehydration of the freeze-dried tomatoes.

Increasing the temperature of the rehydration medium (20 ^{o}C, 40 ^{o}C and 50 ^{o}C) resulted in higher rehydration capacities (35%, 41% and 52%, respectively) and equilibrium moisture contents. The energy activation of the rehydration process has been also calculated via the estimated Peleg's and Weibull's rate constants, with values in accordance with the existing literature (E_{a_peleg} = 25.5 kJ/mol, $E_{a\_weibull}$ = 18.3 kJ/mol). In addition, the estimated values of Weibull's shape parameter (approx. 0.4) suggest the existence of a capillary flow contribution to water absorption in the initial times of the rehydration process, explaining the fast initial absorption rates observed.

(093) CHANGES IN MICROSTRUCTURE AND EMULSIFYING STABILITY OF CITRUS FIBERS SUBJECTED TO HIGH PRESSURE HOMOGENIZATION

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Orange pulp and peels are residues from orange juice manufacturing. The fibrous components and pectin in the orange residues can be turned to bulking and emulsifying agents. In this study, the emulsifying properties and microstructures of dried orange pulp and peel fibers processed under different processing conditions were evaluated. The high pressure homogenization (HPH) was found to significantly decrease the particle size and bulk density ($P<0.05$), and markedly increased the water and oil holding capacity ($P<0.05$) irrespectively of citrus pulp or peel. After high speed dispersing, all samples showed significant increases in ζ- potential with or without HPH, this actually indicates that HPP has a significant augment effect on the stability of citrus orange fiber emulsions. Furthermore, the microstructure showed that the orange pulp and peel fiber treated with HPP appeared to be smaller flakes, other than a larger chunk seen in the samples without HPP treatment. Confocal laser scanning microscopy also showed an increased stability of samples treated with HPP by forming a more viscous systems. In conclusion, HPP treatment can effectively improve the stability of processed citrus pulp and peels when used for emulsification and physisorption.

(094) EXTRACTION OF ANTIOXIDANTS FROM ALMOND HULL USING EXTRACTANTS OF DIFFERENT POLARITIES

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Almond hull represents a large portion of the biomass residues generated from the almond industry. The industry has yet to find alternatives to current use of hull as animal feed. Attempts have been made to extract sugars and antioxidants from almond hull but failed to arouse any significant commercial interests. The present study is intended to develop an efficient technique to maximize the recovery of bioactive antioxidants from almond hulls. The influence of different polarity extraction solutions (water, ethyl alcohol and combination of water and ethyl alcohol) on the free and bound polyphenol content, total flavonoids and antioxidant activity in almond hulls from three almond cultivars, namely Nonpareil, Carmel, and Hardshell, were examined. The extraction from Nonpareil, Carmel, and Hardshell hulls using ethyl alcohol and water (1:1, v/v) resulted in a high yield of total phenolic compound of 58.34, 77.16 and 83.91 mg GA/g DW, respectively, and the flavonoids content is 71.32, 110.40, 128.10 mg QE/g DW, respectively. Furthermore, the extractions from Hardshell by ethyl alcohol and water (1:1, v/v) also showed higher antioxidant activity, then followed by Carmel and Nonpareil. The ABTS scavenging ability of Nonpareil, Carmel, and Hardshell is 33.58, 44.49 and 58.48 mgTE/g DW respectively, FRAP is 33.39, 49.65, 57.45 mgTE/g DW respectively, indicating the antioxidant activity related closely with the total polyphenol and flavonoid content. The oil and water partition coefficient Log *P* between -1.5 and 0, showed that the extracts can be very easily absorbed by human regardless of hydrophilicity or hydrophobicity of the solvents.

(095) INTER- AND INTRA-LAB FACTORS IN CHARACTERIZATION OF SALAD DRESSING RHEOLOGICAL PROPERTIES

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Rheometry, including viscosity profiles and viscoelastic behaviors, are widely used for characterizing the mechanical properties of liquid and semisolid materials. Although fundamental tests are typically used for characterization, the precision and accuracy of these measurements among different labs are not generally considered. While the fundamental nature of these tests should result in statistically similar measurements, differences in rheometer brand and model, measurement geometry, sample preparation, and test settings can all introduce data artifacts that can result in significantly different results in separate laboratories. Therefore, the objective of this study was to determine whether rheometers in different laboratories can produce statistically similar rheological measurements for a given food product. Five rheometers from four labs were used to measure the viscosity profile and viscoelastic properties of two Catalina salad dressing samples with same brand but different lots. Shear rate, strain, and frequency sweep tests were conducted at 8, 25, and 60°C using parallel plates with diameter, 20, 40, 50, or 60 mm. Salad dressings from different lots did not have significantly different viscosity profiles and viscoelastic properties. Although all labs reported that salad dressing viscosity profiles and storage modulus decreased with higher temperature, viscosity profiles and storage modulus values varied significantly among the different rheometers and geometries. Both viscosity profiles and storage modulus measured at same shear rate, strain, or frequency increased with smaller diameter plates. This study indicated that rheological measurements produced by different rheometers and geometries were not consistent; however, all labs reported similar observations on how temperature influenced the measurements.

(098) PHYSICOCHEMICAL PROPERTIES OF HIGH-PRESSURE HOMOGENIZED PULSE NANOEMULSIONS

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Protein-stabilized oil-in-water nanoemulsions are increasingly applied in the food industry for their unique physicochemical and functional properties. Oil-in-water emulsions stabilized by pulse proteins are gaining attention due to their low cost, continuous production, and nutritional value. The goal was to study different high-pressure homogenization (HPH) treatments on pulse nanoemulsion stability through their physicochemical properties. Pulse (bean/lentil/chickpea) protein nanoemulsions (2.5, 5, 10 wt%) were treated by HPH (50, 100, 200, and 300 MPa) with two homogenization passes. Nanoemulsion droplet size, polydispersity index (PdI), and ζ-potential were analyzed by dynamic light scattering, while interfacial tension (IT) was measured by the Du Noüy ring method.
Droplet size and PdI were affected by pressure and protein concentration. Droplet mean size decreased from > 1000 to 172 nm (bean), 587 to 147 nm (lentil), and 950 to 173 nm (chickpea), while PdI decreased from 0.877 to 0.209 (bean), 0.821 to 0.180 (lentil), and 0.857 to 0.259 (chickpea) as pressure and concentration increased. Pressures > 200 MPa and concentrations > 5 wt% were related to greater droplet size and PdI reduction. Nanoemulsion ζ-potential values became more positive as pressure increased; however, they were all < -30 mV, which can be considered as stable. Pulse proteins decreased oil-water IT from 16.5 mN/m to > 8 mN/m for all pulses, and smaller values were related to lentil nanoemulsions. In conclusion, pulse proteins produced stable nanoemulsions, and lentil is the protein that produces the most stable nanoemulsions. The HPH treatment is a sustainable alternative to enhance the functionality of vegetable protein, such as pulses, that could be incorporated into colloidal food systems.

(100) A MECHANISTIC MODEL FOR LIGHT-DRIVEN ACTIVE INTERNALIZATION OF BACTERIA INTO LEAFY GREENS

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Along with an ever- increasing consumption of fresh produce, reported outbreaks of foodborne illnesses linked to fresh produce have been on the rise. Light is one of the factors that can play a role in bacteria infiltration into leafy greens by keeping stomata open and providing photosynthetic nutrients for microorganisms. Despite the known infiltration risks, limited mechanistic knowledge regarding this important infiltration pathway is available. In this work, by looking at one stomatal opening, we model chemotactic transport of bacteria within a leaf tissue in response to the photosynthesis occurred within plant mesophyll and guard cells. The model includes transport of carbon dioxide, oxygen, sugar, and bacteria within the leaf tissue. In addition, biological processes of carbon fixation in chloroplasts, and respiration in mitochondria of the plant cells, as well as motility, chemotaxis, nutrient consumption and quorum sensing in the bacteria community are considered. Our results show that the photosynthetic products, such as sugar (glucose) and oxygen, diffuse within the liquid at the leaf surface. Concentration gradients of nutrients induce bacteria chemotaxis within the liquid, leading to their association around the guard cells and infiltration into the leaf tissue. The model is further used to study the effects of the most important factors contributing in the infiltration of bacteria into the leaf openings. The infiltration increased for higher light intensities and when application of a blue light (compared with a green light). The ability of bacteria to do chemotaxis was a major factor for infiltration.

(102) EVALUATING FUNGAL CO-PRODUCTION OF CELLULASE AND XYLANASE ENZYMES AT SHAKE-FLASK SCALE USING DISTILLERS DRIED GRAIN WITH SOLUBLES (DDGS) AND ITS VALIDATION IN BENCHTOP FERMENTERS

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Most of the corn ethanol plants use dry-mill process and generates large amounts of distillers dried grains with solubles (DDGS) as the co-product in addition to ethanol and carbon dioxide. The DDGS is a promising feedstock for fermentation industry due to rich content of cellulose and xylan. Thus, the goal of this study was to optimize production of cellulase and xylanase enzymes by *T. reesei* (NRRL 6156) using DDGS as the carbon source at shake-flask scale and validate the shake-flask results at benchtop fermenters. The dilute-acid pretreated DDGS media containing varied levels of DDGS, yeast extract, and peptone were examined for maximal enzyme production at shake-flask at 30°C, initial pH of 5.0 and 180 rpm with 3% (v/v) inoculum size using the Box-Behnken response surface method. According to the analyses of results, co-production of xylanase and cellulase enzymes was not achieved in the same medium; higher solid load of DDGS favored cellulase enzyme only while lower solid load induced the xylanase enzyme. Maximal xylanase of 18.5 IU/mL was predicted with 5% DDGS load, 0.1 g/L yeast extract, and 2 g/L peptone, while maximal cellulase of 1.1 IU/mL was predicted with 20% DDGS load, 1 g/L yeast extract, and 0.5 g/L peptone. Of the two developed models obtained from shake-flasks , xylanase model predicted successfully the fermenter results with 1.5 L working volume compared to cellulase model, which needs further refinement.

(103) INACTIVATION OF *SALMONELLA ENTERITIDIS* ON WALNUTS BY PULSED UV TREATMENT

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Pulsed UV light is a novel technology that is employed to eliminate the microorganisms on food sources. In this study, the effectiveness of pulsed UV light on *Salmonella* Enteritidis on shelled walnuts was evaluated. Inoculated walnut halves and pieces were treated in a pulsed UV light system chamber at different distances from the quartz window (5, 8, and 13 cm) for different times. A maximum log reduction of 3.18 was obtained after pulsed UV treatment at 8 cm for 45 seconds. The energy and temperature changes of the nuts were also evaluated. Results show that pulsed UV light processing has a potential in the nut industry.

(106) DEVELOPMENT OF A CONTINUOUS NON-THERMAL PLASMA (NTP) DISINFECTION SYSTEM FOR MILK POWDERS

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Due to their heat-sensitive nutritional contents and low water activity, the disinfection of milk powders remains to be a challenge for food processers. The low water activity hostile environment makes certain microbes, such as Clostridium spp. and Bacillus spp, become physiologically dormant and metabolically quiescent, which further makes them less susceptible to bactericidal interventions. If they are contaminated with pathogens, they can cause widespread foodborne diseases. In this study, bacteria inactivation in milk powders using non-thermal plasma (NTP) was investigated. The preliminary bench-scale study showed a promising 2 to 3 log reduction of E. coli in milk powders using NTP. After the preliminary studies, four designs for the scaled-up system were proposed and tested. The performances of the different designs were tested and evaluated based on initial multiphysics simulations, transportation of powdered foods, log reduction, and system throughputs.

(107) PREDICTING THE MAXIMUM SHEAR STRESS DIFFERENCE IN EXTRUSION FROM OFFLINE CAPILLARY VISCOSITY MEASUREMENTS.

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Extrusion is an efficient technology that is used in the food industry that applies thermo-mechanical transformations to food products such as starch. Understanding the effect extrusion has on product material properties is vital in accurately predicting product quality, heat generation, expansion, and flow behaviors. However, measuring the rheology in-line with the extruder is expensive and time consuming. The objective of this work is to determine how extrusion conditions affect the product rheology. Degermed, dehulled cornmeal grits were extruded through a self-heating autogeneous single screw extruder with inner restrictions. Various feed rates were tested at 32.5%, 35%, and 37.5% w.b. moisture content. The screw speeds tested were 100, 200, and 300 rpms. The temperature rise and viscosity was measured using a novel two hole die. The viscosity was modeled using superpositioning and a Harper type model which considers shear rate, moisture content, and temperature. The inline data was shifted with feed rate, screw speed, and moisture content for various shear rates. The inline data was compared to offline capillary rheometer measurements to estimate the effect extrusion condition have on product properties. The difference between predicted and actual viscosity was modeled using the Harper type equation giving rise to a maximum shear stress difference. The difference was used to predict product viscosity within a 14% error. The temperature rise increased with screw speed and decreased with increasing moisture content. The offline flow behavior index was 0.2 while the inline became more Newtonian with increasing screw speed. Being able to predict inline rheology from offline techniques will save time and money when developing extrusion operating conditions and provide insight to material transformations.

(108) FINITE ELEMENT MODELING OF AN AUTOGENOUS EXTRUDER WITH INNER RESTRICTIONS

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Scaling up or scaling down extrusion processes is complicated due to complex flow patterns and geometries. A mathematical model is needed to aid in extruder design that can solve for heat generation, flow profiles and pressure gradients and material property changes during extrusion. The objective of this work is to develop an analytical model using Finite Element Methods with fewer assumptions paired with the Newton Raphson Method to simulate an autogenous single screw extruder with inner restrictions.. The model was then redesigned to consider 2-dimmensional flow and a nonlinear temperature rise containing two different regions: screw flight and inner restriction. The assumptions made to help simplify flow theory included the screw flight as an unwrapped long continuous channel with a step change in gap height as the inner restriction. The screw was set to be stationary while barrel is set to be rotating. The material was assumed to be entering at a velocity profile proportional with gap height. The temperature of the material entering was set to be constant along with thermal and physical properties were assumed constant. It was assumed that the barrel and the screw root was perfectly insulated. The dimensionless Naiver-Stokes equation and Heat equation was solved in Cartesian coordinates resulting in the model predicting a max dimensionless temperature rise, velocity profile, and pressure gradient. The model was run under creep flow conditions and shown to generate the same flow characteristics as previous analytical models. Ultimately the model can be used for single screw extruder design, scaling, and product output characteristics.

(110) NOVEL MODERATE ELECTRIC FIELD, MECHANICAL TREATMENT AND NISIN COMBINATION TECHNOLOGIES FOR NON-THERMAL FRUIT AND VEGETABLE JUICE PASTEURIZATION

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With increase in consumer's expectations for fresh food products with least amount of chemical preservatives and/or processing conditions, food industry is seeking improved non-thermal methods of bacterial pathogen inactivation. We applied a new concept of combination processing, involving rotational shear stress (SS), moderate electric field (MEF) and nisin (NS) alone or in combination to study their effect on inactivation of Gram-negative and Gram-positive bacteria in apple juice and apple:kale blend juice with minimum thermal effect. Tests were conducted using a lab-scale device, consisting of a graphite-electrode concentric cylinder system, the inner cylinder being rotated by a variable-speed motor. Gram-negative (Escherichia coli K12) and Gram-positive (Listeria innocua) were treated under various combination conditions- shear rate (464.6-2879 s^{-1}); electric field (Duty cycle: 0.50-0.99 (=120-168 V/cm)); nisin treatment (0-100 IU/ml)) at 27 ± 0.5°C. Antibacterial susceptibility was evaluated using plate-counting method concomitantly with flow cytometric analysis with double-staining (propidium iodide (PI) and SYTO9 or carboxyfluorescein diacetate (cFDA)). Selected quality attributes (pH, color, antioxidant activity and chlorophyll contents) were also evaluated pre- and post-processing. The optimum non-thermal combination process parameter values for 5-log cycle reductions of both E. coli K12 and L. innocua were estimated at 2879 s-1 under 168 V/cm with nisin treatment of 100 IU/ml (within 5 min). The flow cytometry results showed the mechanism of cellular damage differed according to the bacterial species. Working mechanisms were proposed for synergism: for the Gram-negative bacterium *E. coli* K12, the outer membrane was damaged first by applied SS and MEF, followed by electropermeabilization and nisin jointly acted on and destroyed the cytoplasmic membrane, leading to further intracellular damage; for the Gram-positive bacterium L. innocua, combined SS, MEF and nisin acted on the cytoplasmic membrane together leading to cell death. Considering that heat treatment may destroy some heat-sensitive qualities of products, this study shows the synergistic effects of SS combined with MEF and nisin in a short treatment time without intense heat generation. This provides evidence for such combined treatment in the fruit-vegetable juice and related beverage industries.

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(113) MICROWAVE PASTEURIZATION OF APPLE JUICE: MODELING THE INACTIVATION OF *ESCHERICHIA COLI* O157:H7 AND *SALMONELLA* TYPHIMURIUM AT 80-90°C

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The demand for fresh juices has substantially risen over the last years. Due to their inherent acidity, fruit juices are thought to be safe. However, several outbreaks have been reported. Apple juice was implicated in 10 of the 21 outbreaks reported to CDC. Microwave heating advantages - shorter start-up time, lower processing time, and energy efficiency - have attracted the attention of microwave treatment as an alternative to conventional pasteurization. To design suitable processing conditions, mathematical models are essential. The objective of this study was to model the inactivation kinetics of *Escherichia coli* O157:H7 and *Salmonella* Typhimurium under microwave pasteurization at temperatures achieving 80 to 90°C, i.e. conditions similar to conventional pasteurization. Experimental runs were performed in both commercial and fresh apple juices. Inoculated juices were treated over combinations of power level (720W, 600W) and treatment times (10s, 15s, 20s, 25s, 30s). Obtained survival curves were fitted with the Weibull model because of their non-linearity and shouldering effects. Time-temperature profiles were obtained by three fiber-optics sensors placed in contact with juices allowing continuous data collection, and parameters control. A nonlinear heating regime captured these dynamic conditions. A log-logistic equation related the rate of killing with the temperature history. For calculating the survival ratio under nonisothermal conditions, a non-linear ordinary differential equation was solved numerically by Runge-Kutta method (ode45 in MATLAB). The lsqcurvefit function optimized the kinetics parameters. Results indicated that inactivation increased with power level, temperature, and treatment time, reaching up to 7 Log_{10} cycles. Thus, meeting the FDA 5 Log_{10} reduction guidelines. This study is relevant to food engineering and food industry because provides mathematical tools to predict survival characteristics of pathogens which are important to improve food safety. Furthermore, the modeling approach allowed the estimation of practical kinetic parameters such as the critical temperature necessary to enhance inactivation.

(115) PRIOR EXPOSURE TO ENVIRONMENTAL STRESSES INFLUENCE SUBSEQUENT RESISTANCE OF *E. COLI* O157:H7 TO NON-THERMAL TREATMENTS BASED ON THE SYNERGISTIC INTERACTION BETWEEN GALLIC ACID AND UV LIGHT

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Justification

Foodborne pathogens can develop adaptive responses toward the sublethal stresses encountered in the environment, affecting the inactivation efficacy of following food process interventions. Bacterial adaptive responses are thus of vital importance in food safety.

Objective

The objective is to study the adaptive response of *E. coli* O157:H7 towards two newly developed non-thermal inactivation treatments based on the synergistic interaction of UV light and gallic acid, with or without prior exposure to different sublethal environmental stresses.

Methods

E. coli O157:H7 stationary phase growth-phase cells (37 ^{o}C, 22h) were exposed to sublethal stresses including heat (42 ^{o}C, overnight), acid (TSB with supplemented 1% glucose to achieve a final pH of 5, overnight), NaCl (4.5%, 3h), and H_2O_2 (0.2 mM, 3h). Then, the bacterial cultures were treated either simultaneously by GA and UV-A light (GA+UVA), or by GA with an enhanced antimicrobial activity by previous UVC light irradiation (UVC-GA). Results were obtained by plate count method.

Results

E. coli O157:H7 with previous exposure to heat stress showed significantly ($P < 0.05$) lower sensitivity to subsequent antimicrobial treatment of either GA+UVA (1.27±0.20 fold) or UVC-GA (3.51±0.41 fold) treatments compared with controls. On the contrary, bacteria pre-exposed to NaCl and H_2O_2 showed increased sensitivity towards both GA+UVA and UVC-GA treatments. Interestingly, pre-exposure to acid due to overnight fermentation of glucose induced resistance of bacteria towards GA+UVA treatment ($P < 0.05$, 2.04±0.26 fold), but sensitivity towards UVC-GA treatment ($P > 0.05$, 1.38±0.53 fold). Further investigations are underway to identify the reasons behind this trend.

Relevance to food engineering and industry

Results of this study showed the variety in the effect of environmental stresses on microbial adaptive responses toward novel inactivation technologies that both resistance and sensitization can be induced depending on the stress applied and the technology studied. Thus, sublethal conditions encountered in the food processing environment should be taken into account for the development and optimization of novel non-thermal technologies.

(118) MODELING THE SUBCRITICAL HYDROLYSIS OF ICE-CREAM WASTEWATER

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The hydrolysis kinetics of ice-cream wastewater was studied under subcritical conditions (130-230°C and 20-60 bar) in a continuous stirred-tank reactor. The kinetic was monitored by measuring the degree of hydrolysis (*DH*, %) at different time intervals (up to 240 min). Samples of ice-cream wastewater were collected from the university dairy plant after a typical clean-in-place protocol. Overall, the reaction time and temperature significantly increased the DH, reaching a maximum value of 40.99±0.81, 34.44±0.47, 20.61±0.42, and 5.74±0.36% after 200-240 min at 130, 170, 200 and 230°C, respectively. The experimental data were modeled using the Weibull distribution model showing a satisfactory correlation between experimental data and predicted values (R^2=0.981). The apparent activation energy for subcritical hydrolysis was 37.53±5.21 kJ mol^{-1}. After 240 min of reaction, the hydrolyzates were recovered, and their antiradical ability was measured through free radical scavenging (2,2-diphenyl-1-picrylhydrazyl) method. Additionally, the angiotensin converting enzyme (ACE)-inhibitory ability was determined. The inhibition of a free radical was found to increase linearly with the DH (R^2=0.991). The hydrolysate recovered at 230°C showed the highest ACE-inhibitory ability (98.0 ± 1.6%). The study outcomes present an opportunity for utilizing subcritical hydrolysis to convert wastewater into valuable materials.

(119) PRODUCTION OF LACTOBIONIC ACID THROUGH CATALYTIC OXIDATION OF LACTOSE AND WHEY PERMEATE

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Lacobionic acid is obtained from the catalytic oxidation of lactose and its production has gained remarkable attentions due to its antioxidant, chelating and humectant properties. Lactose-derived nutraceuticals are often produced via enzymes, fermentation, and catalytic using concentrated and purified lactose as feedstock. This is because the performance of enzymes, microorganisms, and catalysts is adversely affected by the presence of minerals, salts, and pH. In this study, we investigated the effect of pressure on the catalytic oxidation of lactose directly from whey permeate. The catalytic oxidation was conducted using a model solution of lactose and whey permeate using 0.5% of ruthenium supported on activated carbon (Ru/C). The oxidation kinetic of lactose was studied at different temperatures (50, 60, 70, and 80°C), oxygen pressures (15, 40, 60, and 80 bar), and agitation levels (600, 900, and 1200 rpm) in a continuous stirred-tank reactor. Overall, the concentration of lactobionic acid increased gradually over time. The highest concentration of lactobionic acid (3.13 ± 0.13 mM) was obtained after 210 min at the temperature of 70ºC under oxygen pressure of 60 bar with 600 rpm agitation. Higher temperatures (≥80°C) initially increased the production of lactobionic acid (after of 90 min of oxidative reaction and 4.33 ± 0.02 mM) but subsequently the concentration of lactobionic acid decreased due to broke down of its chemical structure. This study shows the viability of producing lactobionic acid directly from whey streams.

(120) INKJET MASKLESS LITHOGRAPHY GRAPHENE INTERDIGITATED ELECTRODES FOR BACTERIAL PATHOGEN BIOSENSING

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The prevalence of bacterial foodborne contamination is a serious threat to food safety and security. As a result, pathogen testing currently makes up **$4B** of the global market for food safety testing. Despite increasing regulations in food processing plants, the technologies for commercialized testing procedures remains stagnant, relying on slow enrichment/amplification processes that are necessitated by low sensitivity of current testing methods. Recent developments in pathogen biosensors have demonstrated low detection limits (1-10 CFU/mL), however, wide-scale implementation into food processing plants is still impeded by required bacterial amplification, high cost-per-test, performance in physiological media, and integration into facile detection systems. To create a sensitive, enrichment-free, low-cost test, we investigated several options for making graphene interdigitated electrodes (IDEs) using our rapid, inexpensive, inkjet maskless lithography (IML) method. IML-IDEs were printed on silicon, polyimide, or polyethylene terephthalate and the graphene pattern was annealed with increasing laser powers. Post-annealing, the IML-IDEs were characterized for topography, graphene structure, and electroactivity using electron microscopy, cyclic voltammetry, and spectroscopy techniques (Raman, FT-IR, and electrochemical impedance). Devices treated with higher laser powers demonstrated lower resistance and increased surface area. IML-IDEs functionalized with anti-*Salmonella* Typhimurium antibody (or aptamer) were incubated in various medias (buffered saline, peptone water, and chicken broth) spiked with bacteria (5-3000 CFU/mL). Electrochemical impedance spectroscopy was used to evaluate the signal after 15 minutes and sensitivity was determined by evaluating the change in charge transfer resistance (LoD = 30 CFU/mL). Results indicate that both substrate composition and laser power play a significant role in device sensitivity. Additionally, IML-IDEs have lower baseline impedance than microfabricated IDEs, making them ideal candidates for detection of low numbers of bacteria (1-10 CFU/mL) when placed inside microfluidics devices. Most importantly, IML-IDEs can be functionalized with biorecognition agents against *Salmonella*, *Listeria*, or *E. coli* to facilitate broader applications for pathogen testing.

(121) ENGINEERING ASPECTS OF HYDRODYNAMIC CAVITATION FOR APPLICATIONS IN DAIRY MANUFACTURING

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In recent years, strategies leading to reduce the impact of thermal processing and effectively inactivate microorganisms have become a topic of industrial interest. Hydrodynamic cavitation (HC) is an emerging technology for continuous processing of liquid foods. HC mainly consists of a stationary cylinder and a high-speed rotating inner cylinder with indentations. Due to the high-speed of the inner cylinder, cavities are formed and subsequently collapsed, releasing waves of energy that instantaneously elevates the fluid temperature. This temperature change is achieved without additional heat input and is due solely to the work done on the fluid during the cavitation. Such mechanical effects can be put to work for mixing, dispersion, emulsification, and pasteurization. This presentation will summarize our efforts in understanding process engineering aspects of hydrodynamic cavitation, including flow diagram and process characterization, velocity profiles, temperature history, cavitation number and residence time distribution. Experimentation utilized pilot scale hydrodynamic cavitation with custom fabricated fluid handling arrangement. The increased in the temperature (ΔT) due to cavitation as evaluated as function of the total solids and yielding values of 31.35±2.7, 35.15±1.6, and 42.85±1.4°C at 11, 25, and 36%, respectively. The experimental ΔT data were modelled using a polynomial equation showing a satisfactory correlation (R^2=0.98). Knowledge of the reviewed engineering aspects can be used to improve process performance and for scale-up purpose.

(122) STRUCTURAL BREAKDOWN AND FATTY ACID BIOACCESSIBILITY FROM IN VITRO DIGESTION OF ALMOND PARTICLES

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Almonds are potential component of functional foods engineered to deliver fatty acids in the gastrointestinal system. However, development of such foods requires an improved understanding of the factors which influence structural breakdown and fatty acid bioaccessibility from particles of digested almonds. The objective of this study was to compare structural breakdown and fatty acid bioaccessibility from almond particles subjected to in vitro digestion. Almond particles of a size consistent with particles in the masticated bolus were subjected to either gastric digestion in a shaking water bath, or gastric digestion in the Human Gastric Simulator (HGS). The size distribution of the particles was determined at different time points using image analysis. Bioaccessible fatty acids were extracted from liquid digesta using the Folch method and quantified using gas chromatography with flame ionization detection. Total percent fatty acid bioaccessibility increased from 0% to 11.1 ± 0.3% over the entire gastric and intestinal digestion. Fatty acid bioaccessibility was significantly higher at the end of the gastric phase in the HGS (8.8 ± 0.3%) than in the shaking water bath (6.3 ± 0.1%) ($p<0.01$). The size of almond particles at the end of the gastric phase was significantly smaller in the HGS (14.7 ± 0.1 mm^2) than in the shaking water bath (18.1 ± 0.1 mm^2) ($p<0.01$). Results from this study suggest that the peristaltic motion of the HGS can cause size reduction of almond particles during gastric digestion. It is hypothesized that this was responsible for the increased fatty acid bioaccessibility in the HGS. These findings suggest that engineered functional food systems should consider validation in dynamic in vitro models to ensure accurate representation of food structural breakdown in the human digestive system, which may affect bioaccessibility of key nutrients such as fatty acids.

(124) CONTROLLING SODIUM RELEASE USING MALTODEXTRIN AND OCTENYL SUCCINIC ANHYDRIDE (OSA) MODIFIED STARCH WITH TWO TYPES OF SPRAY DRYER NOZZLES

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Controlling release of sodium during oral processing of food is a promising way to achieve sodium reduction in food products. Microencapsulation is a potential technique to control the sodium release. The objective of this study was to develop sodium chloride-loaded microcapsules and to characterize the sodium release of those microcapsules. Maltodextrin (DE10) and octenyl succinic anhydride (OSA) modified starch were evaluated as carriers to create microcapsules using spray drying with a 2-fluid and 3-fluid nozzle. For the 2-fluid nozzle, the carrier solution (5 or 10% w/w) and NaCl solution (25% w/w) were mixed before spray drying. For the 3-fluid nozzle, the carrier solution and NaCl solution flowed separately through two different channels without mixing for spray drying. The morphology of microcapsules was observed by Scanning Electron Microscope (SEM). The SEM images showed most sodium was encapsulated into the carriers successfully. Microcapsules made with OSA modified starch had more smooth, round, and uniform spherical shape than with the maltodextrin samples. The sodium release was measured in the form of total dissolved solids using a conductivity probe. Increasing the concentration of OSA modified starch significantly decreased R_{max} (maximum sodium release rate), C_{50} (sodium concentration at 50s) and C_{150} (sodium concentration at 150s) and the same trend was observed for the maltodextrin. Generally, the samples spray dried with a 2-fluid nozzle released sodium faster than the samples with a 3-fluid nozzle. This study indicated the delivery of sodium could be altered by using various kinds and concentration of carriers as well as the types of spray dry nozzles, which may provide strategies to reduce sodium content in foods, especially salty snack foods.

(125) RHEOLOGICAL ASSESSMENT OF ETHANOL-INDUCED WHEY PROTEIN ISOLATE GELS.

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The gelling ability of whey protein can be used to develop functional foods by incorporating nutraceuticals into gels. Whey proteins may be used as hydrogels for controlled delivery of bioactive substances .One of the most common methods to prepare protein gels is heat treatment. Heat gelation involves unfolding of protein which causes exposure of buried hydrophobic sides and interaction of hydrophobic sides of protein forming a gel network which entraps water and water soluble substances. However, this method is applicable to water soluble bioactive compounds and may damage heat sensitive compounds. The investigation of novel delivery systems for water insoluble materials, such as vitamins, is required to improve their solubility and bioavailability in aqueous media. The aim of this research is to gain an understanding of gelation mechanism of ethanol induced whey proteins isolate gels. In this study, oscillation tests were employed to investigate the viscoelastic properties of whey protein gels formed upon addition of varying ethanol contents and reveal the effect of protein composition on gelling ability of whey protein in ethanol-water binary solvent system.
The effect of addition of ethanol on gelation properties of whey proteins isolate (WPI) was investigated with rheological measurements. Dynamic rheological properties of WPI at 10-20% protein concentration were studied in 40-60% ethanol solutions. The rheological behavior of WPI in ethanol-water mixture was dependent on protein concentration and ethanol content. WPI immediately gelled at 10% protein concentration in 60% ethanol. Below those ethanol and protein concentrations, it exhibited a weak gel behavior. Viscosity of WPI dispersions rose with increasing ethanol content of solution. The current results suggest that different protein compositions influenced gelation of protein and final gel properties of WPI in ethanol-water mixture.

(127) MICROFLUIDIC CO-ASSEMBLY OF NISIN AND ZEIN FOR ENHANCED ANTIMICROBIAL ACTIVITY

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Each year,Foodborne illnesses affect 48 million people in the United States and impose over $15.5 billion of economic burden to the industry and government. Recently, nisin is gaining more attention as a food grade natural antimicrobial peptide against *Listeria monocytogenes*. The application of nisin in food has been limited due to its instability and insolubility in food matrices where nisin can be readily degraded by other components in food such as sodium metabisulfite, Ca^{2+} and Mg^{2+}, as well as neutral pH. The objective of this study was to encapsulate nisin using a microfluidic device through an internal phase separation approach, and to control the release rate of nisin to extend its antimicrobial efficacy. In this work, nisin-loaded zein microcapusles were prepared using a T-junction microfluidic chip. The release profiles of nisin from the microcapusules were tuned by changing the nisin loading and flow rates during the microfluidic process. Rapid release of nisin was achieved with low dispersing phase flow rate (0.2 ml/hr) and high nisin loading (~15 µg/mg), while slow release was achieved with high dispersing phase flow rate (0.3 ml/hr) and low nisin loading (~7 µg/mg). Microbial test results indicated that the zein microcapsules with slow nisin release effectively inhibited the growth of *L. monocytogenes* in a fresh cheese stored at 4°C. Compared to free nisin as a control, the microcapsule with slow release of nisin reduced the *L. monocytogenes* concentration from 4.11 log CFU/g to non-detectable level, while the *L. monocytogenes* in the free nisin control sample climbed to 4.22 log CFU/g. AFM-IR spectrum suggested that the distribution of nisin in zein was homogeneous, which indicates that co-assembly between zein and nisin occurred during the microfluidic internal phase separation process. The co-assembled zein and nisin could be an effective way to control *L. monocytogenes* contamination in foods.

(128) NONDESTRUCTIVE CHARACTERIZATION OF STRUCTURAL CHANGES DURING IN VITRO GASTRIC DIGESTION OF APPLES USING 4D MICRO-COMPUTED TOMOGRAPHY

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During digestion, food structure is altered by chemical and physical processes in the gastrointestinal tract. These structural changes can be monitored using indirect measurements of moisture and texture. However, direct visualization of food structure during digestion provides additional information compared to indirect methods. The objective of this study was to utilize nondestructive imaging to detect and quantify food structural changes during gastric digestion. An apple cube (var. *Granny Smith*) was placed in a tube with either water or gastric juice. 3D micro-computed tomography images were collected continuously over 12 hours. Additional apple cubes were incubated under the same conditions outside the scanner for measurement of moisture and texture changes. Intensity-based image analyses were compared with hardness and moisture changes to relate images to physical property changes occurring during gastric digestion. Apples in gastric juice showed greater intensity increase after 12 hours relative to water ($p < 0.001$). A similar trend was observed in hardness, with apples in gastric juice showing greater hardness decrease after 12 hours ($p < 0.001$). Apples with an initial hardness of 71.2 ± 9.7 N showed 47 ± 5.8 % and 89.0 ± 1.78 % hardness decrease in water or gastric juice, respectively. Moisture uptake was the same in both gastric juice and water ($p > 0.05$), with apples in both water and gastric juice increasing from a moisture content of 5.65 ± 0.58 to 15.7 ± 0.8 g water/g dry matter after 12 hours. The correlation of image intensity with hardness and not moisture suggests that changes observed in intensity were the result of structural changes in apple tissue. Nondestructive characterization of food structural changes during digestion will provide insight required for simulation and modeling of food breakdown. These models could be utilized for design of new foods for health, streamlining product innovation.

(129) DEVELOPMENT OF A MULTI-MODULE PERISTALTIC SIMULATOR FOR GASTROINTESTINAL RESEARCH

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Peristalsis involves involuntary wavelike muscular contractions, and is the main mechanism for transporting food through the gastrointestinal tract. To date, most in vitro models do not effectively simulate physiologically-relevant peristaltic contractions. There is insufficient knowledge on the relationship between gut motility and nutrient release or microbiome biodiversity in the gastrointestinal tract. A physiologically-relevant simulator could be utilized to better understand the relationship between food and gastrointestinal motility in conditions such as irritable bowel syndrome and gastroesophageal reflux disease. The objective of this project was to design a mechanical mechanism that simultaneously imposes physiologically-relevant peristaltic motion across 12 modules. Using Chebyshev's Hoeken mechanism, rollers (12.7 mm diameter) were configured to move downward across 12 suspended flexible modules (25.4 mm diameter, 229 mm height). The mechanism was fabricated from aluminum materials, linear bearings and plastics. The flexible modules were made from thin-walled polypropylene (0.1 mm thickness) that could represent transit in the esophagus, small intestine, or large intestine. To characterize mixing performance, five tubes were filled with 50 mL water and 0.2 mL brilliant blue dye, and the time to become fully mixed was recorded. Temperature in the enclosure of the peristaltic simulator was controlled using an Arduino controller. The Hoeken mechanism was able to apply peristaltic contractions to the 12 flexible modules. Blue dye was fully mixed in the peristaltic modules in a shorter time (11±1.25 min) compared to diffusion in static fluid (20±1.20 min). Temperature could be consistently controlled to 37±1°C over a 2 hr period. Development of a multi-module peristaltic simulator can provide deeper insight into the fundamentals of digestive processes and mixing patterns with physiologically-relevant conditions. Quantitative and qualitative data can be used in agricultural, industrial, and commercial applications involving nutrient transport and absorption, and improving gut health for humans and animals.

(130) EFFECT OF VACUUM COOLING ON E. COLI K 12 INFILTRATION IN FRESH BABY SPINACH

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Infiltration of pathogenic microorganisms in fresh leafy greens is a significant food safety risk factor. Vacuum cooling is used as an effective evaporative cooling method for pre-cooling leafy greens to prolong their storage life. To prevent vacuum cooling associated weight loss fresh produce is often sprayed with water which may facilitate cross-contamination of the cooled produce.

In this study two main ways of contamination were examined: contamination from outside during the vacuum release step and cross-contamination from inside the vacuum chamber during the vacuum step. All experiments were performed in a model cylindrical glass vacuum chamber, equipped with baffles to simulate multiple leafy surfaces. A vacuum releasing valve at the chamber inlet was connected to a tube, filled with 5-20 mg of powdered freeze-dried *E. coli* K12. Within the chamber MacConkey agar served to detect the presence of *E. coli*. After reaching the vacuum below 0.667 kPa the valve was opened and the airflow carried the particles inside the vacuum chamber. All the replicates showed the presence of *E. coli* on the baffles and the bottom of the vacuum chamber.

For the cross-contamination experiment, baby spinach leaves were contaminated with simulated fecal matter and placed on the baffles next to MacConkey agar. After reaching the desired vacuum and 5 min of exposure the Petri dishes were collected and incubated at 37 ° C for 24 h. All the replicates revealed growth of *E. coli* on MacConkey medium.

For the vacuum internalization experiment baby spinach leaves were spot inoculated with 5 droplets of 1 µL of *E. coli* K12 cell suspension and placed on the baffles. After reaching the desired vacuum the samples were held at vacuum for 30 min then chamber was repressurized and half of the leaves were subjected to surface sanitization. Then homogenized leaves were surface plated onto MacConkey agar. It has been shown that deeper vacuum and slower vacuum release causes higher levels of microbial infiltration.

Our results revealed that externally located bacteria in the dry state may penetrate and spread inside the vacuum chamber during the repressurization. Within the chamber, vacuum-induced boiling of simulated fecal matter may spread contamination to other locations. It also may cause the internalization of foodborne pathogens deeper into the tissue of the leafy greens.

(132) UTILIZATION OF COMMERCIAL FRUIT DEHYDRATION BIOWASTES FOR SUPERCAPACITOR APPLICATION

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This research documents variability in electrode performance of activated carbons produced from two different commercial fruit dehydration wastes through hydrothermal carbonization and chemical activation pathway. Commercial Spent Osmotic Solutions (SOS) from blueberry dehydration (BSOS) and glycerated cherry dehydration (CSOS) waste materials were subjected to hydrothermal carbonization at 250°C under nitrogen conditions for 30 min to extract hydrochars. BSOS- and CSOS-derived hydrochar powders were further activated using phosphoric acid at 900°C to produce Activated Carbons (ACs). The produced ACs were utilized in a symmetrical Electrical Double Layer Supercapacitor (EDLCs) to measure their performance as an electrode. Overall, the AC electrodes derived from the SOSs were comparable to many bio-derived electrodes used for EDLCs, but subsequent enhancement to surface chemistry and surface area is required to outperform some of the best ACs and engineered carbon materials this application.

(134) INACTIVATION OF *ESCHERICHIA COLI* INDUCED BY INTENSE PULSED LIGHT: A PROTON NUCLEAR MAGNETIC RESONANCE STUDY

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High-resolution proton nuclear magnetic resonance (^{1}H NMR) is adapted for studying the death kinetics of foodborne pathogens during different methods of bacterial inactivation. It has been reported that the CH_2/CH_3 ^{1}H NMR signal ratio was proportional to the percentage of apoptotic cells in vitro and extensively used in the clinical field. The ratio of signal intensity at 1.4 ppm and 0.9 ppm of ^{1}H NMR spectrum was found to reflect the bacterial death percentage and the signal intensity at 3.2 ppm provides the supportive evidence. The actual functional groups of the dead cells responsible for the changes on NMR peaks are yet to be identified. Metabolomics analysis suggests that the changes in lipid may be a response of bacteria to inactivation treatments. In this study, *E. Coli* was subjected to several different inactivation methods and the NMR peak changes and the log reduction of bacteria count were measured. The intense triple peaks observed at 1.1 ppm was considered from valine. There might be DNA damages involved in the inactivation mechanisms of intense pulsed light (IPL) besides membrane damage. The Pearson's correlation coefficient of 0.98, showed that the ratio of signal intensity of 1.4/0.9 ppm was relevant to the bacteria log counts. In general, combined with other analytical techniques, the ^{1}H NMR spectrums can predict *E. coli* death kinetics during inactivation processes with minimal sample preparation and without chemical agents involved.

(135) INVESTIGATION OF THE PHYSIOCHEMICAL PROPERTIES AND FUNCTION OF POLYSACCHARIDE FUNCTIONING FIBERS DERIVED FROM CITRUS PEEL

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The processing of the functional fiber derived from citrus wastes enables the further utilization of the industrial fruit and vegetable by-products, thus a sustainable and environment-friendly cycle. The impact of changes in key processing variables on functionality of fibers derived from citrus peel and the estimation of the production costs were examined. The fiber samples were characterized in terms of their particle size distribution, the rheological properties of aqueous fiber solutions, the measured oil carrying capacity of the fiber in fiber-stabilized oil in water emulsions, and the stability of oil- fiber-water suspensions. The effects of peel concentration during homogenization on any of the measured physical properties was found to be negligible, the mean particle size showed a decreasing behavior ranging from 52 ± 4 to 240 ± 10 µm, depending on the pressure for low-pass homogenized samples, yet displayed independence of pressure under high number of passes. The measured oil carrying capacity (g oil/g fiber) tended to increase appreciably with the number of homogenizing passes and showed a moderate dependence on homogenization pressure at a low number of passes, ranging from 1.5 to 8.4. Moreover, the oil carrying capacity only decreased with increasing temperature for low pass samples but not the ones with high number of passes. The rheological properties of 2% concentration aqueous fiber samples were found to be dependent on both the pressure and duration of homogenization.

(136) INVESTIGATION ON PHYSIOCHEMICAL PROPERTIES OF ALMOND HULLS TO DEVELOP VALUE-ADDED FOOD PRODUCTS

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Almond hull, takes up to 53% of the almond biomass and has been used as livestock feed for its low cost and nutritional values. The purpose of this research is to improve the desired physiochemical properties of this by-product with common food processing and elevate the functional performance. Three main types of almond hull originated from California: Carmel, Nonpareil and Hardshell were investigated and the compositions were analyzed. Noticeably, the raw materials contained high sugar content ranging from 20.97% to 36.25% (dry basis) and the total fiber content up to 34.72% (dry basis). The water-holding capacity (WHC) of almond hull samples did not change significantly after homogenization, nonetheless the oil-holding capacity (OHC) of almond samples increased from 2.14 g oil/g sample up to 4.47 g oil/g sample after homogenization . The emulsifying capacity (EC) of untreated almond hull samples with the aid of homogenization for evaluation varies from 50% to 82%, and the emulsion stayed relevantly stable. Yet, the treated almond hull samples with homogenization processing as the pretreatment, showed satisfying EC from 58.3% to 71.4%, which can be potentially utilized in the food and beverage industry as the emulsifying agent without any other follow-up processing to stabilize the system. The Carmel samples were found to have the most desirable properties amongst all three types of almond hull.

(139) A NOVEL KINETIC HYDROPONICS SYSTEM FOR SPROUT PRODUCTION

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A novel kinetic hydroponics system (KHS) was successfully designed for **growing the sprouts under water** within a small footprint. Principles of mass transfer, momentum transfer, and fluid flow were used for designing different KHS. Each of the KHS units were evaluated and further improvements were made. The objectives of this study were to: i) develop a novel kinetic hydroponics system (KHS) to grow the sprouts under water, ii) evaluate natural microflora proliferation during alfalfa sprouts production at various conditions, iii) understanding the efficacy of sanitizers on microbial growth during sprouting, and iv) evaluate the shelf life of the sprouts grown using KHS.

The microbial load on sprouts and water were determined every day (initial load on seeds was also determined). Effect of calcium hypochlorite (150-200 ppm) and commercial Milton sterilizing tablets (a sodium dichloroisocyanurate and troclosene sodium based sanitizer; concentration suggested by the manufacturer was used) on aerobic bacteria, *Escherichia coli* O157:H7, *Listeria spp., Salmonella spp.,* yeast, and molds in sprouts and water were determined.

The KHS system provided a higher yield (up to 225 gram of sprouts for every 20 gram of seeds) compared to traditional methods. As expected, increased sanitizer concentration increased the microbial reduction. At all the tested conditions, there were no *Escherichia coli* O157:H7, *Listeria spp*., *Salmonella spp*. found on the seeds or the final product. Shelf life studies indicated that KHS grown sprouts retained it freshness for more than 21 days.

The KHS can potentially provide an effective sprouting system for use in households. These systems can be scalable to large scale commercial production.

(143) EFFECT OF ULTRA-SONICATION ON THE TOTAL PHENOLIC AND ANTIOXIDANT ACTIVITY IN COLD BREWED CHAMOMILE TEA

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Chamomile tea a rich source of antioxidants, phenolic compounds, essential oils and other natural bioactive which have been shown to exhibit health-promoting effects. Brewing is the most important step which is carried out for the extraction of bioactive components from tea leaves. Hot brewing techniques leads to the degradation of thermo-sensitive compounds and hence, cold brewing as an alternative method can be used to preserve the flavors and other components in the tea. However, the application of this method is limited due to the lower extraction efficiency and enhanced extraction time. Nowadays, there is a great interest in using new innovative processing methods such as ultra-sonication to improve the extraction of valuable nutrients from the plant sources with lower extraction time and temperature.

In this study, a classic univariate approach of OVAT (One-variable-at-a-time) procedure was used to evaluate the effect of ultra-sonication at different solute to solvent ratios (1:10 to 1:100) with a constant temperature maintained at 14˚C and sonication for a period of 15 minutes with an amplitude of 70% on the extraction of total phenolic content (TPC) and antioxidant activity (ABTS) from chamomile tea. The initial moisture content of the tea leaves was measured (8.72% w.b.). All the treated samples along with the controls for each of the samples were analyzed for TPC using Folin-Ciocalteu assay and antioxidant activity using ABTS assay.

Increasing the concentration of the solute in the solvent at the constant amplitude (70%), sonication time (15 minutes) and temperature (14˚C) resulted in enhanced the extraction of TPC and the antioxidant values. Samples treated at a higher concentration had better TPC values and antioxidant activity when compared with the controls (without ultra-sonication). From the results compared with the controls, there has been an average increase of 36% for TPC and 30% for antioxidant activity for Chamomile tea.

The results in this study showed the potential for producing the cold brew Chamomile tea with higher nutritional values at lower extraction time using the method of Ultra-sonication.

(154) USING HIGHLY VISUAL OR INTERACTIVE MEDIA TOOLS TO INCREASE UNDERSTANDING OF FOOD ENGINEERING RESEARCH

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The use of highly visual and interactive communications techniques and teaching tools can make complex food engineering technologies and concepts more understandable and accessible to your stakeholders. In some cases, a visualization or interactive animation can elucidate a new food engineering process or concept at a more technical level than even an in-person tour of your research facility.

In addition, today funders, stakeholders, and industry decision makers often expect reports and communications about your emerging food engineering research and processes to include scientific visualizations, interactive online demonstrations, and animations.

This presentation will help you identify the parts of your research or class presentation that would most benefit from scientific visualization, animation, or other multimedia communications techniques. It will also explain the message design process our studio uses to help scientists distill their research into targeted and highly-effective communications tools.

(156) INFLUENCE OF MULTI-PULSED HIGH HYDROSTATIC PRESSURE ON THE INACTIVATION AND GERMINATION OF BACILLUS SUBTILIS SPORES DURING PRESSURE-TEMPERATURE PROCESSING

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To investigate the effects of multi-pulsed and continuous pressure treatments on the inactivation and germination of *Bacillus subtilis* spores, spore suspensions with an initial concentration of 10^8 CFU/ml were treated at 35 ~ 60 °C under 200 and 500 MPa. The equivalence of processing intensity was attempted by controlling the overall processing time to 10 or 30 min, with the pulse number varying from 1 to 10. For 30 min processing, 4.23 ~ 4.43 log of *B. subtilis* spores germinated at 200 MPa, 60 °C with 1, 3, 5, 10 pressure pulses. The highest germination was obtained as 5-pulses of hydrostatic pressure was applied, with each pulse duration of 6 min. However, pressure treatment for 30 min was sufficient to cause lethal damage to almost all germinated spores since there was no significant difference in the reduction of germinated and inactivated spores ($p < 0.05$). In contrast, a shorter processing time for 10 min reduced the lethality. For 200 MPa treatment at 40 °C, 50 °C, 60 °C, the number of spores germinated was about 1.5, 2.5, and 3.2 log, while the inactivated spores was about 0.7, 1.0, 2.5 log, respectively. Higher pressure processing at 500 MPa enhanced the spores germination to about 1.5, 2.5 and 4.0 log at 35 °C, 40 °C and 50 °C, respectively. However, the inactivation efficacy of increased pressure was opposite at different temperatures. Reduced inactivation to 0.5 log was noticed at 40 °C, while a notable inactivation of more than 2.5 log was observed at 50 °C. Moreover, spore inactivation was improved with increased pressure pulse number. This suggested that multi-pulsed high hydrostatic pressure processing shows potential in spore inactivation as compared to continuous pressure processing.

(157) DEVELOPMENT AND OPTIMIZATION OF A BIODEGRADABLE NANOCOMPOSITE BASED ON CORN STARCH AND POLY(VINYL ALCOHOL) BLEND INCORPORATED WITH NANOCELLULOSE FOR FOOD PACKAGING APPLICATIONS

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The use of biopolymers as film-forming materials has increased attention towards packaging application field recently. Even though these materials are biodegradable, highly available, low-cost, and from renewable sources, their large-scale application is limited by their poor performance properties. Incorporation of nanoparticles, like nanocelluloses, it is one of the most used strategies to overcome this hurdle. This study aimed to develop and characterize nanocomposite films based on corn starch and poly(vinyl alcohol) blend, incorporated with cellulose nanocrystals (CNC) and nanofibers (CNF) according to a central composite design to optimize the concentrations of nanocelluloses using the desirability function. Films were evaluated according to their morphology, mechanical, and barrier properties. The film-production process resulted in a good and homogeneous dispersion of the nanocelluloses within the polymer matrix. Regression models for tensile strength (TS) and Young's modulus (YM) were significant ($p < 0.05$). TS and YM increased by the incorporation of the nanocelluloses mainly with the increase of CNC concentration, which is highly crystalline, being able to receive the transferred stress from the polymeric matrix due to the high-level of interaction between them. The model for the film's elongation at break was not significant for the studied levels of nanocelluloses; however, compared to the control film, their presence increased the EB by 56%. Regression models for water vapor permeability (WVP) and oxygen permeability were also significant ($p < 0.05$). The incorporation of CNC and CNF at intermediate levels resulted in a film with minimum WVP. Conversely, CNC levels higher than the studied are needed to reduce the films' oxygen permeability. The optimum formulation was obtained with 5.83% (wt.) of CNC and 0.6% (wt.) of CNF. The biodegradable nanocomposite film presented suitable characteristics for sustainable packaging materials, with potential for further improvements upon the addition of active compounds to broaden its applicability the food industry.

(159) DEVELOPMENT OF AN INDICATOR TO IDENTIFY AND CHARACTERIZE DEFECTS IN METAL-OXIDE COATED MULTILAYER POLYMERIC POUCHES FOR STERILIZED FOOD PRODUCTS

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Metal-oxide coated multilayered polymeric pouches have provided a suitable alternative to foil-based packaging for sterilized products with higher shelf-life. The barrier performance of these structures depends on the performance of deposited metal oxides which tend to deteriorate due to deformations caused by exposure to heat during sterilization as well as mechanical flex during handling. In this work, a methodology was developed to identify and characterize these defects. Four pouches MOA (AlO_x coated PET/Nylon/PP), MOB (SiO_x coated PET/ON/CPP), MOC (Organic coating/AlO_x coated PET/Nylon/ PP), MOD (AlO_x coated PET/Nylon/ PP) with different coatings were retorted for 30 and 40 minutes at 121 °C. A methylene blue based oxygen sensitive gel was prepared to show the defective sites. The packages were filled and sealed with gel after sterilization and stored at 23 °C and 40 °C for 6 and 3 months respectively. The gel showed localized color changes indicating the defective sites in the packaging. The oxygen transmission rate of all the packages increased by 4 to 40 times after processing while water vapor transmission rate of MOA, MOC and MOD increased 1-3 times and that of MOB decreased by 32%. This increase was attributed to increase in deformations after sterilization which was confirmed by the color change in the gel. Samples were drawn from the defective sites and cracks, pinholes and delamination in the multilayered structures were identified using microscopic methods. The melting enthalpy was also measured which increased after sterilization. This could be attributed to deformations in deposited coating due to an increase in crystallinity and resulting brittleness of the substrate. Overall the method could be used to assess the performance of metal-oxide coated structures for high barrier applications and thereby could be used to design better packaging for sterilized products.

(160) POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN SMOKED FOODS

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Smoked foods are widely available in the commercial market. However, smoke flavor introduces Polycyclic aromatic hydrocarbons (PAHs) to food. Amount of PAHs vary depending on the smoking process used. PAHs are reported carcinogens and therefore, they are a potential source of toxicity in the smoked foods. PAHs of various chemical make-up are formed from the incomplete combustion of wood. Several countries have come up with strict regulations related to the concentration of PAHs in smoked food. Concentrations of PAHs in smoked foods are influenced by temperature, type of wood, oxygen concentration, and type of smoker. **This presentation focuses on status of regulations for foods treated with refined liquid smoke (RLS). Presence of PAHs in smoked foods will be discussed in detail along with the safe limits allowed by various regulatory agencies.**

(161) ADVANCING YOUTH EDUCATION OF THE FOOD, ENERGY, WATER NEXUS THROUGH IMMERSIVE SIMULATION ENVIRONMENTS

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More and more people are becoming concerned with where their food comes from. Yet, with farmers and ranchers making up only 2 percent of the U.S. population, few civilians have the opportunity to witness agricultural production first-hand. Immersive simulation environments resolve this disconnect by providing a scientifically authentic representation of real world scenarios. However, developing these environments can be quite challenging due to the fine balance of game entertainment, scientific authenticity, and educational outcomes. In this presentation we will share our experience with producing a large scale videogame to educate youth about the interactions within the Food-Energy-Water (FEW) Nexus in the Midwest. In particular, how researchers can connect real scientific models to game environments to bring about targeted educational objectives in an authentic way. Currently, the beta version of the game has been deployed in both K-12 and undergraduate environments. Promising strides have been seen in knowledge of the FEW nexus, sustainability, and agricultural management.

(162) SC-CO_2 EXTRACTION AND TRIPLE TOF–LC–MS–MS CHARACTERIZATION OF POLYPHENOLS FROM OILS EXTRACTED OF TIGER NUTS BY-PRODUCTS

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Tiger nuts are the raw material used to produce “Horchata de Chufa” a traditional beverage, mainly commercialized in Spain. Tiger nuts oil contain phenolic compounds, which are associated with beneficial effects on health such as blood circulation activation, prevention of heart diseases and thrombosis, and the reduction in the risk of appearing colon cancer. During “Horchata de Chufa” production process a large amount of tiger nuts by-products is generated, thus being a useful material to obtain oil rich in phenolic compounds. Therefore, the aim of this study was to compare the impact of supercritical carbon dioxide (SC-CO_2) (10-40 MPa) and Folch (conventional extraction, CE) on polyphenol profile of by-products obtained during “horchata” production process. The phenolic profile and contents were largely influenced by extracting conditions. The main phenolic compound obtained by SC-CO_2 was the isohydroxymatairesinol, particularly at 30 and 40 MPa, while 3-vinylphenol was the predominant compound in oils extracted by CE method. Increasing SC-CO_2 extraction pressures enhanced the extraction of individual phenolic compounds.

(163) EXTRACTION OF OIL AND FATTY ACIDS FROM TIGER NUTS BY-PRODUCTS OBTAINED DURING "HORCHATA DE CHUFA" PRODUCTION PROCESS ASSISTED BY SC-CO_2

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An increased interest has been recently shown by food industry regarding the wastes and by-products obtained during food processing, due to their high-added value compounds and the different uses that they offer. Currently, there are different methods for extracting high-added value-added compounds from by-products. Some methods are conventional, while others are innovative. The innovative methods are, in some cases, more efficient, ecological and sustainable than conventional techniques. This is the case of supercritical carbon dioxide, which has been used for decades in different food applications. One possible application of supercritical carbon dioxide is the extraction fatty acids from food processing by products. The present study explores the extraction of fatty acids and vitamin E from tiger nuts by-products obtained during "Horchata de Chufa" production by supercritical carbon dioxide. The by-products from *"horchata"* presented a profile where monounsaturated fatty acids (MUFA) were the predominant fatty acid, representing ≈ 70% of total fatty acids (except for oil samples obtained after applying SC-CO_2 at 10 MPa; ≈64%). Regarding, polyunsaturated fatty acids (PUFA), the content of C18:2*n-6* was the most representative, although the C18:3*n-3* were also detected at 0.47-0.79% of total fatty acids. The amount of SFA and PUFA was higher and MUFA lower in 10 MPa samples compared to the oils extracted using SC-CO_2 at 20, 30 or 40 MPa, where no significant differences were detected. On the other hand, a linear decrease in the amount of α-tocopherol was observed when SC-CO_2 pressure was increased, although the amount was higher in any case compared to conventional extraction.

(164) ESTABLISHING THE RELATIONSHIP BETWEEN ANTIOXIDANT COMPOUNDS AND LIPID OXIDATION PARAMETERS AFTER SC-CO_2 EXTRACTION OF OILS FROM TIGER NUTS BY-PRODUCTS OBTAINED DURING "HORCHATA DE CHUFA" PRODUCTION PROCESS

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Some previous studies have evaluated the potential of conventional and innovative methods to extract oil from raw tiger nuts. However, despite the great potential of *"horchata"* by-products as source of oil with high content in antioxidant bioactive compounds, at this stage of development, there is no available information about the impact of SC-CO_2 on antioxidant and lipid oxidation reactions of the extracted oils from *"horchata"* by-products. Therefore, this work was devoted to evaluating the effects of SC-CO_2 at different pressures on the antioxidant and lipid oxidation of the oils extracted. Moreover, the relationship between these parameters was also observed. The determination of the total antioxidant capacity (expressed as millimolar of Trolox equivalents (mM TE)) was carried out according to the method previously described by Re et al. (1999). The results were expressed in millimolar of Trolox equivalents (mM TE) Barba et al. (2013). Peroxide value (PV) (expressed as milliequivalents O_2/kg oil) was determined following the procedure previously described by AOAC (2007). PV was expressed as milliequivalents O_2/kg oil. The determination of *p*-Anisidine value of the oil samples was carried out following an IUPAC method IUPAC (1987). The samples with and without *p*-Anisidine solution were measured in an UV spectrophotometer (UV-1800, Shimadzu Corporation, Kyoto, Japan) at 350 nm. The Totox value, which indicates the overall oxidation state of the oil, was determined according to Wanasundara et al. (1995). The values of total antioxidant activity (TAC) increased as the pressure conditions of the SC-CO_2 extraction increased, presenting a linear adjustment of the data (TAC = 1.051·Pressure + 21.675; R^2 = 0.945). Regarding lipid oxidation, the lower oxidation indexes were obtained when the SC-CO_2 pressure increased. In conclusion, our results confirmed the potential application of SC-CO_2 as an alternative to conventional extraction to obtain oils rich in bioactive compounds from "horchata" by-products.

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(165) TEMPERATURE-TIME-SOLVENT OPTIMIZATION FOR THE RECOVERY OF ANTIOXIDANT BIOACTIVE COMPOUNDS FROM "HORCHATA DE CHUFA" BY-PRODUCTS

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During "Horchata de Chufa" production process, a typical beverage consumed in Spain, obtained from tiger nuts, a great amount of by-products are produced. These by-products contain a high amount of antioxidant bioactive compounds, which can be used as potential food additives, and/or nutraceuticals. Thus, the objective of this work was to evaluate the influence of temperature, time and type of solvent used in the extraction of antioxidant compounds (total phenolic compounds (TPC) and total flavonoids (TF)), from by-products obtained during "horchata de chufa" production process. For the determination of TPC, and TF the methods described by Singleton et al. (1999) and Jara-Palacios et al. (2016) were used, respectively. In order to evaluate the total antioxidant capacity, the Trolox Equivalent Antioxidant Capacity (TEAC) method was used, according to the protocol previously established by Roselló-Soto et al. (2015). For the extraction of antioxidant bioactive compounds, a conventional extraction was carried out using hydroethanolic mixtures (ethanol: water at different concentrations: 0%, 25% and 50% v/v), with temperatures of 40, 50 and 60 ºC and using extraction times of 1, 2 and 3 hours. The results show that the type of solvent, temperature and time influenced significantly ($p<0.05$) the extraction of antioxidant bioactive compounds. The maximum extraction of total phenolic compounds and total flavonoids was 16.02 mg gallic acid equivalent/100 g dry matter and 30.09 mg catechin/100 g dry matter, respectively, after using ethanol at 25% during three hours with temperatures of 60 ºC and 50 °C, respectively. The values of antioxidant compounds were 1,759.81 µM Trolox/g dry matter, with 50% ethanol at 60 °C during 3 hours of extraction. From the results obtained it is possible to conclude that the by-products of "Horchata de Chufa" can be used as a source of bioactive antioxidant compounds.

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(166) RELATIONSHIP BETWEEN THE TOTAL ANTIOXIDANT CAPACITY, PHENOLIC COMPOUNDS AND TOTAL FLAVONOIDS OF EXTRACTS OBTAINED FROM TIGER NUTS BY-PRODUCTS USING BINARY MIXTURES OF ETHANOL AND WATER

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Tiger nuts by-products coming from “Horchata de Chufa” production process contain a high amount of health-related compounds. Most of these beneficial properties are attributed to their antioxidant capacity. Although it is true that over the last years the *in vitro* determination of antioxidant capacity is losing attention from researchers, there are some studies that still show that the consumption on antioxidant rich products are associated with a prevention in non-communicable diseases. Therefore, screening the specific target compound with stronger antioxidant potential is of interest. In this work, the relationship between total phenolic compounds (TPC), total flavonoids (TF) and total antioxidant capacity (TAC) was determined in order to ascertain which compounds can contribute more to the antioxidant potential of tiger nuts by-products extracts obtained after conventional extraction using hydroethanolic mixtures (ethanol: water at different concentrations: 0%, 25% and 50% v/v), with temperatures of 40, 50 and 60 ºC and using extraction times of 1, 2 and 3 hours. TPC, TF and TAC were determined according to the methods previously established by Singleton et al. (1999), Jara-Palacios et al. (2016) and Roselló-Soto et al., (2015), respectively. To identify if there is any correlation between TAC, TPC and TF, a Pearson correlation analysis was performed. The Pearson correlation coefficient measures the degree of covariation between different linearly related variables. The range of the coefficients of variation ranges from -1 to +1 and measures the strength of the linear relationship between the variables. A positive correlation was observed between total antioxidant capacity (TEAC) and total phenolic compounds ($r = 0.712$, $p < 0.05$). Correlations were also observed between the total phenolic compounds (TPC) and the flavonoids ($r = 0.314$, $p < 0.05$). However, the correlations between total flavonoids and total antioxidant capacity (TEAC) were not significant ($r = 0.194$, $p > 0.05$).

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(167) *CHLORELLA AND SPIRULINA* AS A USEFUL PROTEIN SOURCE FOR PARTIAL REPLACEMENT OF MEAT PROTEIN IN COOKED TURKEY BREAST. IMPACT ON AMINO ACID PROFILE

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Nowadays, many meat products are made with soy protein in order to obtain more healthy foods. This is an inconvenience for people allergic to soy, and therefore it is necessary to look for alternatives to this protein to improve their quality of life. In this study, *Chlorella* and *Spirulina* were used to partially replace meat protein and obtain healthier turkey breast products. Moreover, changes in the amino acid content in cooked turkey breast made with *Spirulina* and *Chlorella* were evaluated. Amino acids were extracted following the method proposed by Lorenzo et al. (2011). A derivatization of amino acids was carried out using 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate (Waters AccQ-Fluor reagent kit) and analyzed by RP-HPLC (Waters 2695 Separations Module + Waters 2475 Multi Fluorescence Detector + Waters AccQ-Tag amino acid analysis column). The hydrolyzed amino acid profile of cooked turkey breast included 15 amino acids out of the 20 amino acids constituting food proteins. The predominant amino acid was glutamic acid (Glu), with its highest value in *Spirulina* batch (1.95 g/100g) and control (1.92 g/100g). Next, lysine (Lys) and aspartic acid (Asp) also presented the highest values in *Spirulina* and soy batches (1.22 and 1.14 g/100 g for lysine; 1.16 and 1.13 g/100g for aspartic acid, respectively). From the results obtained, it can be suggested that the soy proteins can be replaced with the algal proteins taking into account the amino acids profile. Moreover, the essential (E)/non-essential (NE) ratio of *Spirulina* and *Chlorella* was > 1, which indicates that, proportionally essential amino acids content was higher than in control samples, while the non-essential amino acids content was lower. Essential amino acids are those that cannot be synthesized *de novo* by the organism, and thus must be supplied in human diet. Thus, our results indicated that *Chlorella* and *Spirulina* would be a good source of essential amino acids.

Lorenzo, J. M.; Purriños, L.; Temperán, S.; Bermúdez, R.; Tallón, S.; Franco, D. Poult. Sci. 2011, 90, 931–940.

(168) EFFECTS OF *CHLORELLA* AND *SPIRULINA* PROTEIN EXTRACTS ON PHYSICOCHEMICAL AND SENSORIAL PROPERTIES OF BEEF BURGERS

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Hamburgers are very popular food worldwide. Regardless of a quality, color, texture and nutritive value, the taste properties are still often a key driver for a consumption of a product. A current focus of food industry is the enrichment of various products to improve a healthy lifestyle. Therefore, the addition of soy to the meat products has been found to positively influence the nutritional profile. However, soy can promote allergic reactions. Therefore, there is a need for new protein sources. Following a technological trend, the objective of this work was to determine the changes in physicochemical and sensorial properties of beef hamburgers after using *Chlorella* and *Spirulina* as protein sources. In addition, a sensory evaluation was performed to examine the sensory acceptance of these products. Colour was measured using a portable colorimeter (Konica Minolta CM-600d, Osaka, Japan) with pulsed xenon arc lam, 0° viewing angle geometry and 8 mm aperture size, to estimate patties colour in the CIELAB space: lightness, (L*); redness, (a*); yellowness, (b*). pH of burgers was measured using a digital portable pH-meter (HI 99163, Hanna Instruments, Eibar, Spain) equipped with a penetration probe. Water-holding capacity (WHC) was measured as cooking loos (%), and textural profile analysis (TPA) test was conducted using a texture analyser (TA-XT2, Stable Micro Systems, Godalming, UK). From the results obtained, pH, colour, hardness, gumminess, ash content and total essential and non-essential amino acids were significantly ($P<0.001$) different among the beef burgers studied. In this regard, beef burgers with *Spirulina* protein presented the highest values for pH (6.32); whereas beef burgers with soybean showed the highest values for lightness, redness, and yellowness. Similarly, higher hardness and gumminess were observed in beef burgers manufactured with soybean compared to the burgers prepared with *Spirulina* and *Chlorella*.

(169) PROXIMATE COMPOSITION AND AMINO ACID PROFILE OF BEEF BURGERS PARTIALLY REPLACED WITH PROTEIN RICH EXTRACTS OF CHLORELLA AND SPIRULINA

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For several decades, consumers interest in healthy and nutritious foods with balanced macro- and micronutrients from both animal and vegetal origins has triggered researchers and food industries to explore products from diverse sources. Meat and meat products are important sources of a great variety of nutrients, such as lipids, proteins, minerals, and vitamins, which make them an important group of foods consumed by a wide range of people worldwide. Since the consumers demands are changing and the market is constantly growing, the improvement of the quality and image of the meat is needed, as well as the development of products with health beneficial properties. In this study, the impact of the replacement of animal protein using alternative protein sources (*Chlorella* and *Spirulina*) on amino acid profile of the new beef burgers was evaluated. Moisture, protein and ash were determined following by the ISO recommendations (ISO 1442:1997, ISO 937:1978 and ISO 936:1998, respectively). Moisture content was determined by measuring sample (3 g) weight loss at 105 °C in an oven, until constant weight. Kjeldahl total nitrogen method was used to determine protein percentage. Ash content was assessed by weight loss by maintaining the sample in a muffle furnace. Fat content was extracted according to the AOCS Official Procedure Am 5-04. Amino acids were extracted following the method proposed by Lorenzo et al. (2011). Regarding ash content, a significant higher content was observed in the beef burgers with soybean compared to the hamburgers replaced with protein from *Chlorella* and *Spirulina*. On the other hand, the beef burgers with seaweeds showed the highest values for both total amino acids (23.0 and 21.37 mg/100 g of meat for *Chlorella* and *Spirulina*, respectively) and non-essential amino acids. Finally, sensory evaluation indicated that the incorporation of seaweed protein did not affect the sensory properties of burgers.

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(170) NEW STRATEGIES TO OBTAIN HEALTHIER PROTEIN AND AMINO ACID PROFILE OF FERMENTED SPANISH "CHORIZO" SAUSAGES: REPLACEMENT OF MEAT PROTEIN USING VEGETAL AND MICROALGAE PROTEIN SOURCES

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The most commonly used protein source for "chorizo" (Spanish sausage) protein partial replacement consists of whey protein concentrates, however the cost is high compared to other protein sources. Other potential protein alternative sources are algal proteins and protein hydrolyzates from pulses. Moreover, soy protein isolates are also widely used in food industry as they have a wide range of applications. The main disadvantage of the vegetable proteins is the presence of anti-nutritional factors, allergens and off-flavours. Therefore, there is a need for researching alternative proteins such as proteins extracted from microalgae. The objective of this study was to evaluate and compare the effects of the addition of vegetable (beans, lentils and broad beans) and algae (*Chlorella* and *Spirulina)* protein sources on protein and amino acid profile of the new developed sausages. Amino acids were extracted following the method proposed by Lorenzo et al. (2011). A derivatization of amino acids was carried out using 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate (Waters AccQ-Fluor reagent kit) and analyzed by RP-HPLC (Waters 2695 Separations Module + Waters 2475 Multi Fluorescence Detector + Waters AccQ-Tag amino acid analysis column). From the results obtained, it was observed that protein content was significantly higher in the "chorizo" sausages with protein from soy (35.62%), *Chlorella* (34.66%), *Spirulina* (34.89%) and broad beans (34.66%) compared to the "chorizo" samples enriched with protein from bean and lentil, being lysine (≈19%), arginine (≈17.5%) and leucine (17.5%) the predominant essential amino acids, while glutamic acid (≈32%) and aspartic acid (≈19%) were the most abundant non-essential amino acids. Therefore, taking into account the amino acid profiles of the different "chorizo" samples, it can be concluded that protein extracted from beans, lentils, broad beans, *Chlorella* and *Spirulina* can be used to enrich "chorizo" as an alternative to soy protein.

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(175) MODELING POLYPHENOLOXIDASE INACTIVATION IN GREEN COCONUT WATER PASTEURIZED BY OHMIC AND MICROWAVE HEATING

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Green coconut water is a nutritious drink with increasing worldwide demand, but its sensorial characteristics are sensitive to the high temperatures needed to inactivate the endogenous degrading enzyme polyphenoloxidase (PPO). Focused microwave heating and ohmic heating are promising for promoting rapid volumetric heating with possible non-thermal effects due to electric fields. The objective of this ongoing project is to study PPO inactivation kinetics in green coconut water by conventional, ohmic and microwave heating. Small samples of coconut water were submitted to conventional and focused microwave heating with similar time-temperature histories and heating rates. Temperature ranged from 60 to 90 °C, microwave power was between 100 and 200 W during come-up time and 1-6 W during holding. Residual PPO activity (measured through spectrophotometric assays) was best described by the non-linear Weibull model, with a R^2 of 0.93 and a RMSE of 7%. Monte Carlo resampling simulations of predicted PPO inactivation showed significant differences between heating methods, with focused microwave heating more effective at pasteurization temperatures used for coconut water. Since microwave power seems to have enhanced PPO inactivation, a system that allows cooling during direct electric field application through ohmic heating is currently under design. This would allow applying strong electric fields during holding, providing better understanding of their effect on the enzymatic activity.

(177) AN ENGINEERING MODEL FOR INFILTRATION OF BACTERIA INTO LEAF STOMATAL OPENING DURING VACUUM COOLING PROCESS

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Vacuum cooling is considered as an efficient approach to extend the shelf-life of fresh produce. However, this popular process can promote passive infiltration of bacteria into the produce through available openings at the leaf surface, such as wounds and stomata. Therefore, there is a need for better understanding infiltration mechanisms and identification of contributing factors to the amount and depth of infiltration. Looking at one stomatal opening, a coupled multiphase transport model was developed to simulate infiltration of pathogenic bacteria into fresh leafy greens during re-pressurization stage of the vacuum cooling process. The model includes convective and/or diffusive transport of free water, bound water, vapor, bacteria and heat into/out of a leaf section driven by the large pressure gradients occurred during vacuum cooling process. The results showed that the prolongation of re-pressurization duration and larger stomatal opening size can promote infiltration of water into the leaf which can further transport bacteria. The depth of the infiltration was significantly increased for higher bacterial motility, and longer re-pressurization durations. The mechanistic understanding obtained from this work should help better design and operate vacuum cooling processes to enhance microbial safety of minimally-processed leafy vegetables.

(187) MECHANISM OF *BACILLUS SUBTILIS* SPORES INACTIVATION INDUCED BY MODERATE ELECTRIC FIELDS

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Bacterial endospores are sometimes implicated with problems of food safety. In this work, the inactivation of *Bacillus subtilis* spores (10^7 CFU/mL) using moderate electric fields (MEF, 300 v/cm) under different temperature (<30, 55, 65 and 75 ℃) was investigated. Studies at temperatures below 30 ℃ showed that MEF treatment resulted in slightly inactivation of spores. However, the inactivation effect of *B. subtilis* spores by MEF was improved significantly when the treatment temperature was 55, 65 and 75 ℃. For example, MEF at 65 ℃ caused the reduction of 0.8, 1.3 and 2.0 log10 cycles of *B. subtilis* spores in 20, 40 and 60 min, respectively. Result from the germination of spores revealed that MEF, mild heat (55, 65 and 75 ℃) or MEF-mild heat treated spores scarcely lost heat resistance, suggesting that spores did not germinate during MEF or heat treatment. Recovery analysis showed the viability of MEF-treated spores did not increase by addition of lysozyme (3 mg/L) in recovery plates, preincubation for 1 h in a 1:1 mixture of 60 mM Ca^{2+} and DPA, or lysozyme treatment in hypertonic medium. Confocal laser scanning microscopy photomicrographs showed that exposure to MEF induced a marked increase in the permeability of inner membrane and cortex of *B. subtilis* spores. These findings suggested that damage of the cortex and inner membrane, rather than spore nutrient germinant receptors or cortex lytic enzymes, are the possible reasons for inactivation of *B. subtilis* spores by MEF. This study indicated that combination of MEF with mild heat have the potential for inactivation of spores by itself or as a complement of the traditional heat-dependent techniques.

(188) EFFECTS OF HIGH VOLTAGE ATMOSPHERIC COLD PLASMA (HVACP) ON YEAST

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HVACP was explored as a way to prevent yeast infections in foods and beverages. Yeast were exposed to plasma in dry air at varying voltages for varying times. Viability was determined by plate counts. The effect of plasma on yeast cell walls was tested by exposure to Concanavalin-A and zymolyase. Protein release was measured using the BCA method. Invertase was assayed by the release of reducing sugar from sucrose. Yeast are killed by exposure to HVACP. Mortality is affected by plasma dosage, exposure time, cell volume, and is less at neutral pH. Plasma causes protein leakage from cells and protein denaturation as shown by loss of invertase activity in treated yeast. Yeast survival was higher in grape juice vs. water, likely due to a protective effect by the organic constituents in juice. TEM shows that treated cells contain empty regions in cytoplasm that is less dense vs. that in untreated yeast. HVACP-treated yeast appear slightly smaller and misshapened, and have a “roughened” appearance vs. control cells, indicative of cell wall damage. Zymolyase, an enzyme that hydrolyzes yeast cell wall polysaccharides, completely lyses untreated yeast; however, lysis of plasma-treated cells averaged only ~42%. SEM shows that zymolyase severely damages cell walls of treated yeast; however, sufficient cell wall fabric remains to prevent lysis. Plasma may alter yeast cell wall polysaccharides, reducing their susceptibility to enzymatic hydrolysis. Although zymolyase causes more extensive hydrolysis of the cell wall polysaccharides of untreated- vs. plasma-treated yeast, the amount of carbohydrate solubilized from both cell types is approximately the same. Concanavalin-A, which binds to yeast cell wall polysaccharides, binds about equally to both control- and plasma-treated yeast. HVACP has the potential to extend the shelf life of foods and beverages without the deleterious effects of heat.

(189) PRODUCTION OF LOW DENSITY AND FREE-FLOWING HOLLOW MICROPARTICLES FROM BUTTER AND FRACTIONATED PALM OIL MIXTURE

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The use of solid fats is challenging due to difficulty incorporating into foods, handling during industrial food production, and relatively high calorie contributions. The objective of this study was to form free-flowing and low density hollow microparticles from nonhydrogenated fats, namely, low moisture butter and fractionated palm oil, using a novel method based on atomization of a carbon dioxide (CO_2)-expanded lipid mixture.

Melting point of the fractionated palm oil decreased from 66.2 to 47.3 °C above 120 bar in the presence of pressurized CO_2. The density of the particles decreased 5 folds compared to that of the original oils. The average particle size D [4,3] decreased from 67.0 µm to 27.1 µm when the concentration of fractionated palm oil was increased from 50 to 100%. Particle size decreased with increasing fractionated palm oil content. The hollow structure was more pronounced for the particles obtained from higher melting oils/oil blends, as well as with more spherical uniformity. Ten percent (d10%) and fifty percent ($d_{50\%}$) of the palm oil particles were smaller than 4.49 µm and 23.0 µm, respectively, whereas they were 14.5 µm and 58.3 µm when mixed with 50% butter, respectively. Polymorphic form of α was more pronounced in the solid lipid particles, indicating that they had a less ordered crystalline structure than the original oil.

This new method forms low density and free-flowing lipid powders that make the handling and storage of solid lipids feasible and convenient. The particles have a much higher ratio of surface area to mass due to their hollow nature and small size than common forms of fat. Nonhydrogenated lipid particles could also have unique applications in the food industry including easier handling, uniform fat incorporation into foods, reduced fat usage, reduced calorie intake, and more rapid oil melting in mouth.

(190) HIGH VOLTAGE ATMOSPHERIC COLD PLASMA ON INACTIVATION OF *LISTERIA INNOCUA* ON QUESO FRESCO CHEESE

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High Voltage Atmospheric Cold Plasma (HVACP) is a novel, non-thermal technology, which can be used to treat packaged food products and achieve significant reduction of pathogenic and spoilage microorganisms without compromising products' qualities. Queso Fresco cheese (QFC), a type of Hispanic-style soft and fresh cheese, is a popular food in Latin-American diet. Due to its high moisture content, near neutral pH and moderate salt content, QFC provides an optimal environment for the growth of spoilage and pathogenic microorganisms. Currently, there are no effective commercial technologies to reduce microorganisms in soft cheeses such as QFC.

In this study, the potential of HVACP treatment on *Listeria* reduction in QFC was examined, in which two types of gases, dry air and MA50 (50% CO_2, 50% N_2), were evaluated for inactivation of *Listeria innocua* (LI), a non-pathogenic surrogate for *Listeria monocytogenes*, in QFC. Survival LI after HVACP treatments was enumerated on *Listeria* selective agar and by thin agar layer method. Quality effects after HVACP treatments were analyzed for lipid peroxidation, pH, and moisture content. Plasma characterization was done using optical emission spectrometry.

The results have shown that HVACP treatment was able to achieve a maximal of 4.9 Log_{10} CFU/g LI reduction after dry air treatment and 1.7 Log_{10} CFU/g reduction after MA50 treatment. Higher lipid oxidation was found in samples after dry air treatment than MA50 treatment due to the presence of O_2 in dry air. Negligible changes were observed in moisture content and pH after HVACP treatments. LI reductions were found to be dependent on the gas composition and treatment time. The results demonstrate the efficacy of HVACP treatment for LI inactivation in QFC. This study has shown the potential of HVACP technology to process delicate dairy products such as QFC leading to improved food safety.

(191) HIGH VOLTAGE ATMOSPHERIC COLD PLASMA INACTIVATION OF *LISTERIA INNOCUA* AND *ESCHERICHIA COLI* K-12 ON QUESO FRESCO CHEESE

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Queso Fresco cheese (QFC) is a popular food in Latin-American diet with high moisture content, near neutral pH and moderate salt content, and thus provides an optimal environment for the growth of spoilage and pathogenic microorganisms. High Voltage Atmospheric Cold Plasma (HVACP) is a novel, non-thermal technology, which can be utilized to treat packaged food products and achieve significant reductions in pathogens and spoilage organisms without compromising the quality. In this study, HVACP inactivation efficiency at 60 kV, 80 kV and 100 kV was compared between QFC inoculated with gram negative bacteria, *Escherichia coli* K-12 and gram positive, *Listeria innocua*.
Survival microorganisms after HVACP treatments were enumerated by thin agar layer method. Quality effects after HVACP treatments were analyzed for lipid peroxidation, protein oxidation, pH, moisture content and color. Plasma characterization was done using optical emission spectrometry. The results have shown that HVACP treatment was able to achieve 3.0 Log_{10} CFU/g reduction of *Escherichia coli* K-12 and 1.0 Log_{10} CFU/g reduction of *Listeria innocua*. Higher lipid oxidation was found at lowest voltage treatment at 60 kV, while there was no significant difference between 80 kV and 100 kV. Even at 60 kV, the amount of malondialdehyde produced after HVACP treatment was less than 2.0 mg/kg, which is the acceptable limit for fresh meat. Similarly, higher protein oxidation was also observed at lower voltages. Minimal changes were observed in color, moisture and pH after HVACP treatments.
This study shows the efficacy of HVACP for microbial decontamination on soft cheese. In this study, microorganisms reductions were found to be dependent on the voltages, treatment time and plasma species. These findings would help to determine the optimal HVACP treatment conditions for dairy products. This demonstrate the potential of HVACP to be used for non-thermal processing of delicate food products.

(193) TIME REDUCTION OF FREEZE-DRYING PROCESSING BY CO2-LASER MICRO-PERFORATION ON A FOOD MODEL

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The unparalleled advantages of freeze-drying to dehydrate fruit without damaging it, are overshadowed by the high cost, because of the low pressure required for long periods of time. The main stage of the process is the primary drying, where the frozen fruit is subjected to vacuum, sublimating the ice and withdrawing an 85-95 % of the water.

The main resistance to the drying process is the vapor diffusion from sample inside to the chamber, indicated by the diffusion coefficient. This coefficient depends mainly on the pore diameter and the void fraction divided by the tortuosity of the media (effectivity factor). Therefore, a novel approach considers the utilization of micro-perforations made by CO_2-laser technology to make pores that increase the void fraction and reduce the tortuosity, reducing the resistance to vapor flow.

The main objective of this investigation is to determine the effect of micro-perforations on the primary-freeze-drying time of a starch food-model, through an experimental approach and their corresponding description by a mathematical simulation.

The experiments show a reduction of 25% of the time of the primary drying, and the model stay in the confidence interval, showing an increase of 60% of the effectivity factor with the micro-perforations.

(194) HIGH VOLTAGE ATMOSPHERIC COLD PLASMA (HVACP) DECONTAMINATION OF PRE-PACKAGED CHICKEN BREAST

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HVACP is a non-thermal technology effective against a wide range of pathogenic microorganisms. In this work, HVACP technology was evaluated for decontamination of chicken breast using dry air as the working gas. HVACP treatments were carried out using a dielectric barrier discharge set-up at 100 kV_{RMS} of applied voltage for 1 min, 3 min and 5 min of treatment time. The reduction in natural microflora of chicken, viz. the psychrotrophs, mesophiles, and Enterobacteriaceae was studied. In addition, the effects on quality parameters, viz. the L*-a*-b* colour, pH, water holding capacity (WHC), and lipid oxidation via thiobarbituric acid reactive substance (TBARS) assay, were also evaluated. The results indicated a maximum of 1.5 to 2 log_{10} reduction in the natural microflora of the chicken. The inactivation was attributed to the reactive oxygen and nitrogen species (RONS) generated inside the package. Acceptable changes in the quality parameters were observed as a function of treatment time. However, an increase in lipid oxidation was observed, that was statistically significant. Studies to evaluate the shelf-life of HVACP treated chicken are in progress.

(195) ENHANCED DRYING OF SENSITIVE FOODS VIA MULTI-PIN BARRIER DISCHARGE PLASMA

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This study explores high voltage cold plasma technology operating with alternating current (AC), for developing a rapid drying process for heat sensitive food materials. The drying of a simulated non-porous food system comprising of a model agar gel was explored using two different multi-pin high voltage electrode configurations at 20 kV_{RMS}, 30 kV_{RMS}, 40 kV_{RMS}, and 50 kV_{RMS} of applied voltages. Two different pins to barrier distance (i.e. discharge gap), with continuous air convection were explored for their effects on drying. The electrical discharge was found to be filamentary in nature, with multiple discharge peaks observed in the current-voltage measurements. Drying studies were carried out for a duration of 3.5 hours, and a significant increase in the drying rates in presence of the electrical discharge was observed in all cases. The enhanced drying was attributed to the electro-convective effect introduced by the discharge, and the resulting disturbance at the mass transfer boundary layer. A minor increase in temperature of the gel samples was recorded. Further work is required to decouple the thermal versus electro-convective effects, to assess the contribution of each phenomenon towards the drying enhancement, and to evaluate the applicability to real food systems.

(201) TOMATO QUALITY AS INFLUENCED BY DIFFERENT PACKAGING MATERIALS AND PRACTICES

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In this study, the effect of retailing packaging material on tomato quality was investigated. Specifically, non-defective tomato fruits were selected after harvest and packed in four different packaging materials; open market bag, open box, sealed box and Xtend bag. A total of six treatments were prepared by storing the packaged fruits at 4 or 17°C for 10 days. Quality attributes of tomatoes such as calyx freshness, weight loss, fruit firmness, total soluble solids (TSS), colour and physiological damage were assessed. Generally, both packaging material and storage temperature affected the quality of the tomato fruits. The quality of tomato fruits stored at 4oC was generally superior to those stored at 17°C.Calyx of tomato fruits stored in open market bag (stored at 17°C) and open box (stored at 17°C) were very dry after storage compared to the tomato fruits stored at 4°C. Tomato fruits packed in Xtend bag and sealed box were firmer than those packed in open box and open market bag. The carbon dioxide (CO2) concentration in sealed box was substantially higher (8.25%) than that in Xtend bag (2.07%). In contrast, the oxygen (O2) concentration in the Xtend bag was higher (18.90%) than that in the sealed box (14.75%). Tomatoes packed in Xtend bag and sealed box had minimal changes in colour intensity (C*), showed lower TSS values compared to tomato fruits packed in other packaging materials. Xtend bag and sealed box seems to be better packaging material for storing tomato fruits for a period of 10 days.

(206) IMPREGNATION OF CURCUMIN INTO NANOPOROUS STARCH AEROGELS TO FORM LOW-CRYSTALLINITY CURCUMIN NANOPARTICLES: MATHEMATICAL MODELING AND SENSITIVITY ANALYSIS

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In recent years, food industry has prioritized the incorporation of bioactives into foods to prepare health-promoting products. Among hydrophobic bioactives, curcumin has received great attention due to its health benefits. However, curcumin is a crystalline compound that is insoluble in water and therefore has very low bioavailability. The objective of this study was to enhance the bioaccessibility of curcumin by impregnating into nanoporous starch aerogels (NSAs) and to model the impregnation process.

A new approach to producing low-crystallinity curcumin nanoparticles using NSAs and supercritical carbon dioxide (SC-CO_2) was developed. In this approach, nanopores of the NSA acted as a mold to produce curcumin nanoparticles and prevent the formation of large curcumin crystals. The impregnation of curcumin from ethanolic curcumin solution was investigated at 21 and 40 °C. A comprehensive mathematical model was developed for the impregnation of curcumin into NSAs based on mass conservation law. The model had two major parameters namely active porosity of the NSA and effective diffusion coefficient of curcumin into the NSA, which were determined using impregnation capacity data together with empirical correlations. A step by step solution strategy was then provided to solve the model numerically using both finite difference method and finite element method, and its accuracy was successfully confirmed against experimental data. Finally, a sensitivity analysis by the model showed that length per diameter ratio of the aerogel, and, more specifically, solution temperature and initial concentration of curcumin in the solution were three of the most critical factors affecting the impregnation performance. The model also revealed that aerogel with rectangular shape provides higher impregnation capacity compared to cylindrical and spherical shapes.

The prosed method enables the incorporation of curcumin into foods to produce functional foods and enhances the efficacy of curcumin. Optimized impregnation process minimize the bioactive wasting as well as energy consumption.

(210) IMPROVEMENTS IN STEAM GENERATION EFFICIENCY FOR FOOD MANUFACTURING

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Although a boiler is an essential operation for generation of steam in food manufacturing, significant amounts of thermal energy are wasted with flue gas exhausts. The use of heat exchangers deigned to recover thermal energy from flue gases provide opportunities for improvements in overall efficiency of steam generation. The overall objective of this study was to quantify efficiency improvements achieved with two types of thermal energy recovery systems.

An analysis of thermal energy recovery was conducted using data from a steam generation system in a food manufacturing operation. Various configurations of condensing and non-condensing economizers were evaluated. The analysis used a model to optimize thermal energy recovery, while meeting requirements for preheating of process water. The results of the analysis indicated that a non-condensing economizer in series with a condensing economizer increased the boiler combustion efficiency of the boiler from 79.2 % to 95% and decreased the fuel costs by 16.6%.

In summary, flue gas heat recovery systems provide significant improvement in steam generation efficiency, and reduce fuel costs for steam generation during food manufacturing.

(215) UTILIZATION OF INTENSE PULSED LIGHT FOR MICROBIAL DECONTAMINATION OF LOW-MOISTURE FOODS

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Introduction: Low-moisture foods have been implicated in multiple food-related recalls within the last few years. To address the need to produce safer powdered food products, novel technologies, such as intense pulsed light (IPL), have been developed to meet this need. Most of the research that involves IPL have been on liquids or surface inoculated agar plates, with little to no research conducted on inoculated food matrices.

Purpose: The aim of this study is to investigate the bactericidal effects of IPL on foodborne pathogens.

Methods: Cronobacter sakazakii (ATCC 29544) and *Salmonella* surrogate *Enterococcus faecium* (NRRL B-2354) were inoculated onto different low moisture foods (non-fat dry milk, wheat flour, whole egg powder, egg whites powder, and black pepper). Inoculated low moisture foods were exposed to multiple passes of IPL (1 pass= 25 seconds). Each sample was diluted 1:10 in 0.1% [w/v] sterile peptone broth and serially diluted and surface plated.

Results: Cronobacter sakazakii results from IPL exposure resulted in a 4.5-log reduction in NFDM, 3-log reduction wheat flour, 1.2-log reduction whole egg powder, 5.1-log reduction egg whites powder, and 2.7-log reduction in ground black pepper. *Enterococcus faecium* IPL exposure resulted in a 3.6-log reduction in NFDM, 2.4-log reduction wheat flour, 1-log reduction whole egg powder, 2.8-log reduction egg whites powder, and 2.2-log reduction in ground black pepper.

Significance: The results indicate that with our first-generation IPL machine we can achieve up to a 5-log reduction of *C. sakazakii* and up to a 3.6-log reduction of *E. faecium* on various food matrices.

(216) BIOTECHNOLOGICAL POTENTIAL AND DRAFT GENOME SEQUENCE OF HYPER THERMOPHILIC, HALOTOLERANT *PARAGEOBACILLUS TOEBII* PW12 ISOLATED FROM A THERMAL HOT SPRING IN NORTH WEST HIMALAYAS.

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The objective of the study was to explore the genome of a thermophilic bacteria from a thermal hot spring, which may hold potential to convert cellulosic biomass into useful feed and food products. We isolated a novel hyper thermophilic and halotolerant Parageobacillus toebii strain PW12 (KJ509869), which showed optimum growth at 75°C (hyperthermophile) and in presence 4.2% NaCl and 5.4% KCl (halotolerant). The thermophilic bacterial strain produces a extracellular cellulase enzyme that exhibits optimum activity at 80- 90°C and pH 6 - 8.0. Metal ions such as Mn2+, Co2+ and Fe2+ significantly enhanced the cellulase activity by 2-5 folds. Even Hg2+ (1mM) and Cd2+ (5 mM) slightly enhanced the cellulose activity. Cellulase enzyme activity was increased by 1.6 folds in the presence of 1 mM EDTA. The cellulase enzyme activity was tolerant to toluene, cyclohexane, H2O2, n-butanol, and ethanol. The assembled genome sequence of Parageobacillus toebii PW12 consists of 3238931 bp, which is arranged into 232 scaffolds. The G+C content was 42.05%. A total of 3,382 CDS (coding sequences), 80 RNAs, 5 ncRNA and 4 CRIISPR arrays were predicted in the genome sequence of Parageobacillus toebii PW12. Molecular evolution and major features of Parageobacillus toebii PW12 genome will be presented. This Whole Genome Shotgun project has been deposited at DDBJ/ENA/GenBank under the accession QREZ00000000. The next generation genome sequencing could provide deeper insights into molecular processes that could potentially be harnessed to develop tailored and more robust metabolic pathways for bioconversion and mining the cellulosic biomass for valuable food and feed products. Genome fingerprints of thermophiles could be useful in developing new strategies to better control endospores and biofilms in the dairy industry by targeting unique and essential biological processes. The comparative genome analysis could be exploited to develop sensitive molecular makers for RAPD-PCR and biosensor (i.e, toxin genes) based methods to detect thermophilic spore contamination.

(217) THE APPLICATION OF GENOME SCALE METABOLIC MODELLING TO INVESTIGATE THE GLOBAL METABOLIC CAPACITY OF PATHOGENIC *ESCHERICHIA COLI*

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The significantly lower cost of genomic sequencing, coupled with the availability of high throughput computational analysis, has redefined the landscape of food safety. Whereas genome sequencing is primarily used to track and manage foodborne outbreaks, the data are available afterwards for further analyses. To this end, the present study applies genome scale metabolic modelling in Kbase (US department of energy knowledge base), to investigate the metabolic capabilities of four Shiga Toxin producing strains of *Escherichia coli* (O157:H7, O104:H4, O26:H11 & O121:H19). It is hypothesized that the differences in nutrient utilization confer a growth advantage to the four strains in the foods with which they have been previously associated. By performing Flax Balance Analysis, linear programming is utilized to predict the optimum growth (biomass production) of the four strains on carbon, sulfur, phosphorus, nitrogen and iron. Additionally, the *in vitro* nutrient utilization profiles are determined using the Biolog Microarray system. The predictions and *in vitro* data are compared to elucidate any differences between strains. Furthermore, the models are used to predict the essential metabolic genes and the differences between the strains compared with the nutrient utilization profiles to further understand the genomic basis of the observed phenotypic profiles. The results from this work will provide a better understanding of the four strains, with the potential for using this information in selective media formulation. Also, if it is determined that the models can effectively predict the *in vitro* phenotypic data, this would add value to the massive amounts of data obtained from the ongoing sequencing projects such as the GenomeTrakr.