BOOK OF ABSTRACTS

2019 IFT-NPD/EFFoST

Nonthermal Processing Workshop

November 3-6, 2019

Espiricueta-Candelaria, R.
Morales de la Peña, M.
Tejada-Ortigoza, V.
Editors
BOOK OF ABSTRACTS

2019 IFT-NPD/EFFoST Nonthermal Processing Workshop

ORAL SESSION. MONDAY NOVEMBER 4

Predictive and simulation modeling of pulsed electric field processing – case studies on microbial and enzyme inactivation and process and equipment optimization

The effect of pressure on the kinetics of polyphenolics degradation – implications to hyperbaric storage using EGCG as a model (35)

New Applications for Food Safety Through UV-C LEDs (6)

Modeling and simulation of a continuous pulsed UV light system for processing of liquid foods (41)

Unleashing innovation potential of HPP to improve food shelf-life (23)

Development of packaging material for high pressure processed food (40)

Commercial Adaptation of UVC Preservation Processing of Opaque Beverages (07)

Combined effect of high hydrostatic pressure (HHP) and CO₂ on enzymatic activity and shelf life of Coho salmon (Oncorhynchus kisutch) (52)

Recent investigations in cold atmospheric plasma processing: up-scaling and product safety aspects

Recent developments in the light based technologies

Comparison of the compounds and characteristics of protein extracted from pressure-assisted and conventional solvent defatting pepper seeds (17)

Dielectric properties of foods for microwave-assisted processed (53)

Application of pulsed light on the quality and nutritional attributes of white grapes (Vitis vinifera L.) (33)

Effect of ultrasound transducer design on the ultrasound-assisted supercritical fluid extraction of phytochemicals (19)

Pulsed light treatment for Salmonella inactivation on chicken breast meat (15)

Inactivation of Ataulfo mango pulp polyphenol oxidase treated by ohmic heating (21)

ORAL SESSION. TUESDAY NOVEMBER 5

Pulsed light treatment for Salmonella inactivation on chicken breast meat (15)

Inactivation of Ataulfo mango pulp polyphenol oxidase treated by ohmic heating (21)
Application of high-pressure carbon dioxide on purple sweet potato (*Ipomoea batatas* L.) pigments extraction: anthocyanin quality and stability evaluation as comparing to traditional aqueous and ethanolic extraction (09) 40

Ultrasound assisted extraction of dietary fiber from fruit and vegetable by-products (51) 41

Employing microwave-vacuum combination in the pasteurization mode to valorize food-waste as a functional food ingredient (34) 42

Effect of pulsed electric field on milk fat globule membrane, lipase activity and lipolysis in whole milk (60) 43

Carotenoid stability of Maradol papaya (*Carica papaya*) puree during development and ripening stages and high hydrostatic pressure processing (83) 44

Effect of atmospheric cold plasma on the degradation of deoxynivalenol (63) 45

Nonthermal technologies for the production of food ingredients with prebiotic potential (38) 46

New innovative dehydration processing of freeze drying / multi-flash autovaporation (MFA) (32) 47

How HPP can play a role in the growth of plant based protein product innovation (64) 51

Incorporation of iron microparticles in pineapple during pre-treatment with ethanol and ultrasound (50) 52

Individual and combined application of postharvest stresses and nonthermal preservation technologies to enhance the nutraceutical content of fruits and vegetables (24) 53

High hydrostatic pressure modulate the folate and ascorbic acid accumulation in papaya (*Carica papaya* cv. Maradol) fruit (62) 54

Microstructural analysis of betalain and phenolic liberation mechanisms in prickly pear cells subjected to high hydrostatic pressure (03) 55

Starch-based hydrogels produced by high pressure processing (HPP) for innovative applications: Evaluation of human in vitro starch digestibility (73) 56

High hydrostatic pressure: A highly efficient and novel assistant technique in pectin deesterification (102) 57

**POSTER SESSION 1. MONDAY NOVEMBER 4** 58

Two effects of compression and swelling in high hydrostatic pressure gelatinization (01) 64

Impact of high hydrostatic pressure on the stability and bioaccessibility of betalains and phenolic compounds in prickly pears (02) 65

High hydrostatic pressure-assisted extraction of carotenoids from papaya (*Carica papaya* var Maradol) tissues using vegetable oils (04) 66
Identification of aroma compounds in four Chinese mango juices, and effects of thermal and high-pressure processing on the mango juice aroma profiles (05)  67

Effect of high hydrostatic pressure processing on sorption isotherms of fruit peels used as sources of dietary fiber (08)  68

Effect of high pressure processing on microbial inactivation of NFC apple juice (10)  69

Selenium distribution in clear and cloudy Se-enriched kiwifruit juices during high hydrostatic pressure and high temperature short time processing (12)  70

Effects of high hydrostatic pressure and pasteurization on processing and qualities of fresh pepper sauce (16)  71

Changes in yield and coagulation time of Oaxaca cheese produced with acidified and non-acidified milk treated with High Hydrostatic Pressure (HHP) (27)  72

High pressure processing as elicitor to induces the biosynthesis of bioactive compounds biosynthesis in carrots (36)  73

Effect of high-pressure processing and heat treatment on the gelation properties of blue crab meat proteins (43)  74

Effect of high hydrostatic pressures on aqueous two-phase systems for the extraction of betaxanthins from (Stenocereus pruinosus) (44)  75

Retention of biocomponents of interest to consumers in HPP-treated red fruit juices during their refrigerated storage (48)  76

Evaluation of physical and microbiological stability of starch-based hydrogels produced by high pressure processing (HPP) (74)  77

HIPEF-processing influence on the in vitro bioaccessibility of isoflavones from a soymilk-based beverage (100)  78

Time reduction of freeze-drying process & physicochemical characterization of Uchuva (Physalis Peruviana l.) treated by Electric Field (EF) (26)  79

Pulsed electric fields to enhance carotenoids bioaccessibility in low-fat carrot purees (56)  80

Optimization of pulsed electric field treatments for extraction of astaxanthin from Xanthophyllomyces dendrorhous (78)  81

Effect of high hydrostatic pressure and pulsed electric field on microorganisms, total phenolic content and enzyme activity on a mamey beverage (Pouteria sapota) (85)  82

Effects of pulsed electric field treatments on cold-pressed extraction and antioxidant capacity of pecan nut oil (92)  83
Pasteurization of carrot juice by combining UV-C radiation and heat (103) 84

UV-C treatments against *Salmonella* Typhimurium ATCC 14028 in almonds and peanuts (31) 85

Low-moisture foods treated with UV-C: inactivation of microorganisms and aflatoxins (39) 86

Effect of UV-C, UHPH treatments and its combination on the antioxidant and physicochemical properties of apple juice added with chia (84) 87

Effects of UVB light, wounding stress and storage time on the biosynthesis of betalains in red prickly pears (*Opuntia Ficus-Indica* cv. Rojo vigor) (89) 88

Electrosynthesis approach to improve some functional properties of starches (42) 89

Nonthermal, selective deodorization of Concord grape juice for use in premium winemaking (57) 90

Non-thermal alternatives assessment for enzymatic processing of enriched-in- Omega-3 fish oil (58) 91

Gas chromatography–mass spectrometry combined with multivariate data analysis as a tool for discriminating between orange juice samples according to the processing technique (11) 92

Influence of alternative sweeteners on the osmotic dehydration of papaya (*Carica papaya* L.) assisted by power ultrasound: Mass transport kinetics and physicochemical properties of the final product (67) 93

Effect of active packaging with orange blossom essential oil (*Citrus aurantium*) on the shelf life of corn tortillas (82) 94

Multi-flash autovaporization (MFA) as an innovative deodorization unit operation for vegetable oils (94) 95

Refrigerated distribution assessment of preservation for nonthermally pasteurized products (104) 96

POSTER SESSION 2. TUESDAY NOVEMBER 5 97

Ultrasound treatments for oil extraction from amaranth and canary seeds (13) 103

Ultrasound pretreatment to enhance moisture diffusivity during infrared drying of peas (*Pisum sativum*) (14) 104

High power ultrasound of modified starch/ κ-carrageenan blends for edible film preparation (18) 105

Functional properties modification of whey protein/kappa carrageen coacervates elaborated with WPI previously treated by high intensity ultrasound (20) 106

Effect of ultrasound on protein yield and fate of alkaloids during lupin alkaline extraction process (25) 107

Shelf life, physicochemical and microbiological properties on *pulque* processed by thermosonication (45) 108

Maize starch modification using a combination of two emerging non-thermal technologies: ultrasound and ozone (47) 109
Ultrasound to incorporate microencapsulated carotenoid into food (49)

Ultrasound-generated intensity changes due to solvent composition for the extraction of bioactives from agave bagasse (Agave salmiana) (59)

Understand the effect of low-frequency ultrasonication on microbial destruction of Pseudomonas Aeroginosa and quality loss in bovine milk (61)

Nanoemulsions as encapsulating systems in foods (70)

Ultrasound-assisted extraction of bioactives compounds from mango Manilila peels (65)

Ultrasound assisted extraction process to obtain extracts rich in antioxidant biocompounds from Mediterranean vegetables wastes (72)

Ultrasound-assisted supercritical CO$_2$ treatment in continuous regime: Application in Escherichia coli inactivation (75)

Astaxanthin extraction from Xanthophylomyces dendrorhous by ultrasound under pressure (79)

Effect of thermosonication or thermal pasteurization on phenolic compounds and antioxidant capacity of apple juice made from ultrasound-treated apples (80)

Effect of Ultrasound treatment on physicochemical parameters in Opuntia ficus Indica cladodes (81)

Ultrasound and ozone for fresh food treatment, what is next? (90)

Comparison of technologies for food preservation: Inactivation of horseradish peroxidase by ultrasound and thermal treatment (91)

Shelf life of fresh-cut mango scalded by ohmic heating (22)

Thermal and non-thermal methods for stabilization and preservation of milk and dairy products (69)

Detrimental effects of cold plasma processing on nutrients within food: a critical review (95)

Membrane technology applications in the dairy industry (37)

Ozone technology to modify arracacha starch properties (46)

Applications and limitations of dense phase carbon dioxide in the food industry: a review (87)

Green technologies as a sustainable approach to the extraction of bioactive compounds from coffee and cocoa industry by-products: A review (71)

Oil extraction in mamey seeds (Pouteria sapota) assisted by continued and pulsed high hydrostatic pressure (86)
Sanitizing procedures applied before storage of fresh-cut carrots affect the wound-induced biosynthesis of chlorogenic acid (54) 130

Effect of wounding stress and chitosan treatment on chlorogenic acid and β-carotene contents of harvested carrots (55) 131

Emerging pre-treatments as promising strategies for increment of nutraceutical content and extraction yield in plant foods: lycopene from tomato by-products as case study (68) 132

Wounding and UVB light induce the biosynthesis of phenolic compounds and ascorbic acid in red prickly pears (Opuntia Ficus-Indica cv. Rojo Vigor) (88) 133

Effect of water on microstructure and thermo-mechanical properties of phosphatidylcholine organogels (66) 134

Avocado seed acetogenins as a hurdle to control mycelial growth and conidia germination of Botrytis spp. for the preservation of strawberry puree (98) 135

Use of freeze dried harina mango seed as a compounds source of antioxidant activity in mexican tortilla making (93) 136
ORAL SESSION. Monday November 4

Location: Tec Lounge

Guests of Honor:
- Roberto Russildi Montellano, Chem. Eng. & MBA (Nuevo Leon Secretary of Economy)
- Mario Adrian Flores Castro, Campus VicePresident, North Region, Tecnologico de Monterrey
- Manuel Zertuche Guerra, Dean, School of Engineering and Sciences, Tecnologico de Monterrey
- Joaquín Acevedo, Regional Dean, School of Engineering and Sciences, Tecnologico de Monterrey
- J. Antonio Torres, Distinguished Professor & NTP Workshop Coordinator, Tecnologico de Monterrey
- Jorge Welti Chanes, Academic Dean, School of Engineering and Sciences & NTP Workshop Coordinator, Tecnologico de Monterrey

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30-8:00</td>
<td>Registration &amp; Coffee Break</td>
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<tr>
<td>8:00-8:05</td>
<td>Welcome &amp; Presentation of Presidium</td>
<td>Jorge Alejandro Benavides Lozano (Tecnologico de Monterrey, Mexico)</td>
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<tr>
<td>8:05-8:15</td>
<td>Workshop Description and Objectives</td>
<td>J. Antonio Torres (Tecnologico de Monterrey, Mexico)</td>
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<tr>
<td>8:15-8:23</td>
<td>Welcome to Nuevo Leon State</td>
<td>Roberto Russildi Montellano (Nuevo Leon Secretary of Economy)</td>
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<tr>
<td>8:23-8:30</td>
<td>Institutional Welcome &amp; Official Event Opening</td>
<td>Manuel Zertuche (Tecnologico de Monterrey, Mexico)</td>
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</tbody>
</table>

**Oral Session A. Nonthermal Processing Food Applications by HPP, PEF, and UV-C**

Viridiana Tejada-Ortigoza & Luis Eduardo Garcia-Amezquita, Co-Chairs

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:35-8:40</td>
<td>Invited Speaker Introductions: Viridiana Tejada-Ortigoza (Tecnologico de Monterrey, Mexico)</td>
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<tr>
<td>8:40-9:10</td>
<td>Predictive and simulation modeling of pulsed electric field processing – case studies on microbial and enzyme inactivation and process and equipment optimization</td>
<td>Roman Buckow (CSIRO, Australia)</td>
</tr>
<tr>
<td>9:10-9:40</td>
<td>Edible coating and pulsed light to increase the shelf life of fresh produce: the VIPACFOOD project</td>
<td>Giovanna Ferrari (University of Salerno, Italy)</td>
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<th>Time</th>
<th>Event</th>
<th>Presenter</th>
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<tr>
<td>9:40-9:45</td>
<td>Contributed talks program: Luis Eduardo Garcia-Amezquita (Tecnologico de Monterrey, México)</td>
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<td>9:45-10:00</td>
<td>35 - The effect of pressure on the kinetics of polyphenolics degradation – implications to hyperbaric storage using EGCG as a model</td>
<td>Avi Shpigelman Technion, Institute of Technology, Israel</td>
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<tr>
<td>10:00-10:15</td>
<td>06 - New applications for food safety through UV-C LEDs</td>
<td>Molly McManus AquiSense Technologies LLC, USA</td>
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<tr>
<td>10:15-10:30</td>
<td>41 - Modeling and simulation of a continuous pulsed UV light system for liquid food processing</td>
<td>Ronit Mandal University of British Columbia, Canada</td>
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<tr>
<td>10:30-10:45</td>
<td>23 - Unleashing innovation potential of HPP to improve food shelf-life</td>
<td>Jasna Ivanovic Uhde High Pressure Technologies GmbH, Germany</td>
</tr>
<tr>
<td>10:45-11:00</td>
<td>Coffee Break</td>
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<tr>
<td>11:00-11:15</td>
<td>40 - Development of packaging material for high pressure processed food</td>
<td>Ting Li China Agricultural University, China</td>
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<td>11:15-11:30</td>
<td>07 - Commercial adaptation of UVC preservation processing of opaque beverages</td>
<td>Tatiana Koutchma Agriculture and Agri-Food Canada</td>
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<td>Time</td>
<td>Session Title</td>
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<tr>
<td>11:30-11:45</td>
<td>52 - Combined effect of high hydrostatic pressure (HHP) and CO₂ on enzymatic activity and shelf life of Coho salmon (<em>Oncorhynchus kisutch</em>)</td>
<td>M. Perez-Won</td>
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<tr>
<td>11:45-12:00</td>
<td>28 - PATP technology: Part 1. Safety risk challenges and solution</td>
<td>J. Antonio Torres</td>
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<tr>
<td>12:00-12:15</td>
<td>30 - PATP Technology: Part 2. Effects on vitamins and flavor volatiles in refrigerated ESL and shelf-stable milk</td>
<td>Reynaldo de la Cruz Quiroz</td>
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</tbody>
</table>
Roundtable 1: Nonthermal Food Processing Industry Research Needs
Manuel Zertuche (Tecnologico de Monterrey, Mexico), Moderator

<table>
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<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenter, Affiliation</th>
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<tr>
<td>12:30-12:35</td>
<td>Introductory comments</td>
<td>Manuel Zertuche (Tecnologico de Monterrey, Mexico)</td>
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<tr>
<td>12:45-12:55</td>
<td>Industry Research Needs</td>
<td>Eduardo Galindo (Alpura, Mexico)</td>
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<td>13:05-13:30</td>
<td>Roundtable Conversation</td>
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Brown Bag Lunch & Poster Session 1: La Carreta

Oral Session B. Nonthermal Processing Food Applications Beyond HPP, PEF, and UV-C Technologies
Cristina Chuck-Hernández & Mariana Morales De la Peña, Co-Chairs

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<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenter, Affiliation</th>
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<tr>
<td>15:00-15:05</td>
<td>Invited Speaker Introductions</td>
<td>Cristina Chuck-Hernández (Tecnologico de Monterrey, Mexico)</td>
</tr>
<tr>
<td>15:05-15:35</td>
<td>Recent investigations in cold atmospheric plasma processing: up-scaling and product safety aspects</td>
<td>Oliver Schlüter (Leibnitz Inst Agr Eng &amp; Bioecon, Germany)</td>
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<tr>
<td>15:35-16:05</td>
<td>Recent developments in light-based technologies</td>
<td>Kathiravan Krishnamurthy (IIT, USA)</td>
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<td>16:05-16:10</td>
<td>Contributed talks program: Mariana Morales De la Peña (Tecnologico de Monterrey, México)</td>
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<td>16:10-16:25</td>
<td>17 - Comparison of the compounds and characteristics of protein extracted from pressure-assisted and conventional solvent defatting pepper seeds</td>
<td>Lian Zhao</td>
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<td><em>China Agricultural University, China</em></td>
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<td>16:25-16:40</td>
<td>53 - Dielectric properties of foods for microwave-assisted processed</td>
<td>Maria Elena Sosa-Morales</td>
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<td><em>Universidad de Guanajuato, México</em></td>
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<td>16:40-16:55</td>
<td>Coffee Break</td>
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<tr>
<td>16:55-17:10</td>
<td>33 - Application of pulsed light on the quality and nutritional attributes of white grapes (<em>Vitis vinifera</em> L.)</td>
<td>Anubhav Pratap Singh</td>
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<td><em>The University of British Columbia, Canada</em></td>
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<tr>
<td>17:10-17:25</td>
<td>19 - Effect of ultrasound transducer design on the acoustically assisted supercritical fluid extraction of phytochemicals</td>
<td>Liliana Santos-Zea</td>
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<td><em>Tecnológico de Monterrey, México</em></td>
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| 17:25-17:40  | 15 - Pulsed light treatment for Salmonella inactivation on chicken breast meat | Daniela Mengarda Buosi  
*Federal University of Santa Catarina, Brazil* | daniela.mengarda@gmail.com |
|              |                                                                          | Daniela Mengarda Buosi¹, Yifan Cheng², Carmem Moraru²,  
Bruno A. M. Carciofi³  
(1) *Federal University of Santa Catarina, Brazil*; (2) *Cornell University, USA* |               |
| 17:40-17:55  | 21 - Inactivation of Ataulfo mango pulp polyphenol oxidase treated by ohmic heating | Oscar Yael Barrón García  
*Instituto Politécnico Nacional, CICATA Querétaro unit, Mexico* | yabaga@gmail.com |
|              |                                                                          | O.Y. Barrón-García³, E. Morales-Sánchez³, M. Gaytán-Martínez²  
(1) *Instituto Politécnico Nacional, CICATA Querétaro unit, Mexico*; (2) *Universidad Autónoma de Querétaro, México* |               |
| 17:55-17:57  | Invited Speaker Introduction                                              | Cristina Chuck-Hernández  
(Tecnologico de Monterrey, Mexico) |                |
| 17:57-18:25  | Equivalent processing to pasteurize selected juice blends by nonthermal technologies | Gustavo Barbosa-Cánovas  
*Washington State University, USA* |                |
| 18:25-18:30  | Workshop updates                                                         | J. Antonio Torres  
(Tecnologico de Monterrey, Mexico) |                |
|              |                                                                          | J. Antonio Torres  
(Tecnologico de Monterrey, Mexico) |                |
Predictive and simulation modeling of pulsed electric field processing – case studies on microbial and enzyme inactivation and process and equipment optimization

Roman Buckow (CSIRO, Australia)

Pulsed electric field (PEF) processing has been established as an effective method to inactivate microbial cells at low to moderate temperatures without compromising the quality of liquid foods. Mild heat often has synergistic effects on PEF treatment efficiency, but the temperature should be kept low to avoid unwanted heat damage to labile components and to prevent off-flavours.

The efficiency of microbial inactivation by PEF is dependent on the applied electric field strength, exposure time and treatment temperature. Thus, an in-depth knowledge of the distribution of these process parameters in PEF systems is essential for a successful and sustainable application of the technology for the preservation of liquid foods. Numerical simulation of the Multiphysics phenomena (i.e., fluid dynamics coupled with the electric and thermal fields) within the treatment chamber can provide this information at high spatial resolution. Furthermore, the up-scaling of microbial inactivation studies performed commonly used PEF systems at laboratory-scale is challenging due the non-uniform nature of treatment conditions.

This presentation will discuss examples of inactivation kinetics for a range of microorganisms in fruit juices or milk determined under various PEF conditions at CSIRO. Furthermore, details of Multiphysics models developed for continuous co-linear laboratory- and pilot-scale PEF systems, respectively, will be presented. These platform models have been successfully validated for both their predictions of temperatures and microbial inactivation. This procedure was successfully repeated for the inactivation of lactic acid bacteria in apple juice, which was used as a surrogate bacterium for inactivation of pathogens in apple juice. These coupled models can then be used for parametric and scale-up studies and enables identification of process conditions for effective microbial destruction where energy consumption and processing costs are at a minimum whilst ensuring product quality and safety.
The effect of pressure on the kinetics of polyphenolics degradation – implications to hyperbaric storage using EGCG as a model (35)

Hani Shkolnikov, Valeria Belochvostov, Zoya Okun, Avi Shpigelman

Faculty of Biotechnology and Food Engineering, Technion, Israel Institute of Technology, Haifa, 3200003, Israel

Reaction kinetics at elevated pressures is of importance for the development of pressure-based technologies and especially for hyperbaric storage (HS), a potential alternative for the energy-consuming refrigeration. While the effect of pressure on reactions in equilibrium is well reported, the effect on reaction kinetics in foods is less studied. Degradation of polyphenolic compounds is a set of reactions often resulting and numerous degradation products. The effect of pressure on degradation kinetics of a polyphenol, EGCG (Epigallocatechin-gallate), was explored at pressures up to 200 MPa (HS levels) for several hours, with and without fructose. In a baro-resistant buffer, pressure enhanced EGCG degradation, due to a negative activation volume, while in in phosphate buffer the pH decreased (as is also expected to occur in a superposition of accelerating and protective effects. A previously undescribed protective, pressure-level dependent, effect of fructose was identified. Novel in-situ spectroscopy and HPLC analysis revealed that in addition to the effect on EGCG degradation rate, pressure also modifies the ratios between the numerous degradation products, likely due to a varying effect on the steps involved in the degradation pathway. High-pressure enhanced the degradation rate of EGCG compared to storage at an identical temperature at atmospheric conditions, possibly negatively affecting quality under HS, yet due to other co-occurring effects, such as pH changes and the presence of co-solutes, different outcome may prevail in foods. The effect of pressure was found to go beyond the influence on the degradation of the original compound, as likely further steps in the degradation pathway (that are not fully described even at atmospheric pressure) are differently influenced, resulting, at the end of the storage, in different ratios between the degradation products, with possibly varying combined (bio)functionality.
New Applications for Food Safety Through UV-C LEDs (6)

Molly McManus, Mitch Hansen

AquiSense Technologies LLC, 4400 Olympic Blvd, Erlanger, KY 41018, USA

Reacting to infections can be costly, time-consuming, and stressful. Avoiding pathogen growth via preventative maintenance is significantly cheaper and easier than treating it. Food safety is becoming a growing concern with real effects felt when an outbreak is found in a product. New UV-C Light Emitting Diode (LED) systems allow UV disinfection to be used in Point-of-Use (POU) applications. UV-C LEDs have been combined with a compact reactor to result in a UV system that does not require a warmup time and can endure infinite on/off cycles. This new technology is easy to use, requires little electricity, and can be incorporated into any POU systems. There is no need for a large POE disinfection system when disinfection can be done in milliseconds. There are only a few UV-C LED disinfection units commercially available now, but this technology is expected to replace all mercury-based systems in the future. This paper will provide a detailed review of the possibilities UV-C LEDs offer for food and beverage safety. With a variety of new characteristics, UV LED devices allow for integratable disinfection for components, processes, and commercial products.
Modeling and simulation of a continuous pulsed UV light system for processing of liquid foods (41)

Ronit Mandal, Anubhav Pratap Singh

Food Nutrition and Health, Faculty of Land and Food Systems, University of British Columbia, 2205, East Mall, Vancouver, BC V6T 1Z4

Pulsed UV light is a non-thermal technology that uses short intensity, high-duration pulses of UV-rich broad-spectrum light from a lamp source to inactivate various microorganisms in food and food contact surface. In the recent days it has emerged as a cutting-edge technology for food preservation. However, it faces challenges on its way for commercialization due to designing and understanding problems. Modeling and computational simulation of pulsed UV process is therefore necessary. Researchers have previously attempted to model the fluence distribution around the lamp and connect microbial destruction with fluence distribution. The objective of the study is to understand the dynamics of pulsed UV light treatment by integrating the microbial inactivation kinetics, fluid dynamics and fluence distribution model for a continuous system for treating liquid foods using computational fluid dynamics (CFD) approach. A continuous treatment chamber for treating liquid foods like milk, fruit juices, puree has been designed, which includes a coiled tube with tube diameter of 1 cm, coil diameter of 6 cm and horizontal length of 60 cm. Fluence distribution models and flow field were generated based on the dose-response analysis to develop an integrated model. Simulation for the process was carried out in commercial CFD package Ansys 2019 R2 software by constructing a model chamber and assigning boundary conditions for liquid, flow rate under a realizable κ-ε turbulence model. Fluence distribution was mapped using Discrete Ordinate (DO) model. By solving the governing equations for flow and radiation field in CFD Fluent, computational simulations were carried out. Thus, overall performance of the system was assessed. This will help in understanding the governing process and designing pulsed light systems for processing of liquid foods.
Unleashing innovation potential of HPP to improve food shelf-life

(23)

Jasna Ivanovic

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

Increasing consumer demand for fresh-tasting, clean label and convenience food has been followed by growing of market requirements for large-scale commercial distribution thereof. Over the last years, a variety of non-thermal processes have emerged as alternatives for processing of premium food with longer shelf-life. High hydrostatic pressure processing (HPP) has been accepted worldwide by consumers and industry as clean label technology for improving microbiological safety and extending shelf-life of food with retained original organoleptic and nutritive attributes. By short exposure of food in flexible packaging to a high hydrostatic pressure (typically 300-700 MPa) at room temperature, microorganisms and spoilage-catalyzing enzymes can be inactivated. Small molecules such as nutrients (vitamins, pigments, flavor compounds) are, on the other side, hardly affected by high pressures. The shelf-life is determined by duration of overall acceptance of a product in terms of microbiological levels, organoleptic properties and functionality. These are mainly predestined by microorganism and enzyme activity. Present review is aimed to discuss actual and emerging fields of HPP applications including conservation, improved functionality and added-value of food products in terms of shelf-life extension of different food categories. Cold-pressed juices and meat products are still the fastest growing market for HPP but other food categories including pet food are getting more attention lately for HPP preservation. In addition, innovative applications of HPP relevant for food shelf-life such as pressure-assisted freezing and thawing of food, salt reduction in meat products, blanching, cheese ripening or product enrichment with antioxidants have been recently investigated. Resistance of bacterial spores in low acidic food to HPP at room temperature, difficult prediction of microbial inactivation due to temperature increase during adiabatic compression, necessity of preventing undesired structural food changes during HPP and further progress in process automatization are some of the remaining hurdles for more efficient and cost-effective commercial applications.
Development of packaging material for high pressure processed food (40)

Ting Li, Xiaomeng Wu, Xiaojun Liao

Beijing Key Laboratory for Food Nonthermal Processing, National Engineering Research Centre for Fruit and Vegetable Processing, College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China

High pressure processed (HPP) food has increasingly attracted the attention of food processors and consumers for its improved quality, increased added-value, and reduced environmental impact. The packaging material and packaging process for HPP food must be carefully selected as it has to withstand the rigors of rapid pressure and temperature change during the process. As the market of HPP food increases, the lack of suitable packaging material has delayed the further development of the industry. The aim of the work was to review the need and recent research development on the packaging specific to HPP food. The effect of HPP on the mechanical properties, barrier properties, integrity, and appearance of various common material is discussed in this work. From the results obtained, we find that HPP does not significantly affect the structure of the polymers but compromises the oxygen and water vapor barrier properties of some laminate films. The development of delamination would aesthetically preclude some metal-containing films from being used for HPP. The interaction between food components and packaging material is also assessed, to elaborate the impact of migration on the flavor, color, and safety of the food products. In addition, we focus on the efficiency of combining HPP and antimicrobial packaging technologies to control microbial growth as well as antioxidant packaging to prevent oxidation during shelf-life. Future research should focus on the use of active packaging and intelligent packaging to improve the safety and quality of HPP products.
Ultraviolet (UVC) treatment of beverages at 253.7 nm has an advantage of continuous mode, lower investment, instant energy savings and packaging flexibility. Despite these obvious benefits and successful application of UVC for municipal and wastewater treatment, commercialization of UVC for opaque beverages has been slow. Food processors interested in using UVC technology have not only to select the appropriate system for their application but also establish processing conditions and dose to achieve their safety, quality and shelf-life objectives and properly integrate UVC system in the existing processing line. Very limited microbiological and quality validation and sensory studies were conducted and reported in commercial scale.

This paper will discuss the lessons of adaptation of commercial AseptoRay UVC technology during last 5 years worldwide including process development and validation for a variety of opaque beverages in high and low acid categories. The effectiveness of commercial UV treatment was demonstrated against indicator organisms, natural micro-biota, moulds and yeasts in milk, cold pressed juices and liquid sugars. Also, better product quality, higher nutritional content and fresh-like sensory attributes were shown compare to thermal processing. Additionally, the commercial scale study of thermal (75°C, 90 s), UVC (100 %, 412 mJ/cm², 1000 L/h) and high hydrostatic pressure (HPP, 600 MPa, 5 min) processing of 3 juice blend products (citrus, green and lemonades) was conducted to measure the effects on quality, nutritional and sensory attributes and compare with untreated juices. UV treatment of green juices resulted in the lowest reduction of vitamin C, polyphenols and color and the highest overall liking and acceptance. Thermal processing was more suitable for citrus juice and HPP for lemonade and green juice. The research allowed identifying important aspects of the interaction of juice formulation and UV exposure to establish UV dose and flow regime for specific product categories as well as pre-treatment and filling conditions in commercial scale to accelerate UV processing implementation.
Combined effect of high hydrostatic pressure (HHP) and CO\(_2\) on enzymatic activity and shelf life of Coho salmon (\textit{Oncorhynchus kisutch}) (52)

M. Perez-Won\(^1\), G. Tabilo-Munizaga\(^1\), J. Reyes-Parra\(^1\), A. Palma-Acevedo\(^2\), C. Herrera-Lavados\(^1\), R. Lemus-Mondaca\(^3\), T. Roco-Bugueño\(^2\)

\(^1\) Department of Food Engineering, Universidad del Bío-Bío, Av. Andrés Bello 720, Chillán, Chile. \(^2\) Department of Food Engineering, Universidad de la Serena, Av. Raúl Bitrán, 1305 La Serena, Chile. \(^3\) Department of Food Science, Universidad de Chile, Santos Dumont 964, Santiago, Chile.

The use of the high hydrostatic pressure (HHP) and modified atmosphere technologies has been successful to preserve seafood products; therefore, combining these technologies could efficiently inactivate detrimental enzymes and increase shelf life in salmon fillets. The objective was to determine the combined effect of HHP and CO\(_2\) on microbial shelf life and collagenase, protease, and lipase enzymatic activity of Coho salmon (\textit{Oncorhynchus kisutch}). Fillets were subjected to HHP at 50 and 150 MPa with 0% and 70% CO\(_2\). Samples were kept at 4°C and changes in microbiological (aerobic mesophilic and psychrophilic microorganisms) and enzymatic activity were recorded for 25 and 10 days, respectively. The HPP had no effect on extending shelf life, but all CO\(_2\) treatments delayed microbial spoilage in salmon fillets; this significantly increased shelf life from 9.72 ± 1.04 days to between 15.87 and 16.71 days. Extended shelf life was achieved by the increased microbial lag phase and decreased maximum specific growth rate of the microorganisms. After 10 days of refrigerated storage, protease activity only decreased compared with the control using the 70% CO\(_2\) - 50 MPa treatment. All treatments significantly reduced collagenase activity compared with the control, especially when applying 0% CO\(_2\) - 150 MPa, thus obtaining a 9-fold decrease in enzymatic activity. This treatment was also the most efficient in reducing lipase activity at the end of storage; however, treatments with 70% CO\(_2\) - 0 MPa and 70% CO\(_2\) - 150 MPa were also effective. Collagenase activity was more sensitive to HHP and CO\(_2\) treatments than protease and lipase activity. In conclusion, the combined use of HHP and CO\(_2\) is an effective technique to decrease enzymatic activity and increase shelf life of Coho salmon during refrigerated storage.
PATP technology: Part 1. Safety risk challenges and solution (28)

J. Antonio Torres\textsuperscript{a}, Reynaldo De la Cruz Quiroz\textsuperscript{a}, Jesús Alejandro Aldrete-Tapia\textsuperscript{b}.

\textsuperscript{a} FEMSA Biotechnology Center, School of Engineering & Sciences, Tecnológico de Monterrey, NL, México.
\textsuperscript{b} Laboratorio para la Evaluación y Control de Riesgos Microbianos en Alimentos, Universidad Autónoma de Querétaro. Qro, México.

High pressure processing (HPP) is now an established pasteurization alternative with worldwide applications since HPP food products were first commercialized in Japan in the early 1990s. However, pressure-assisted thermal processing (PATP) at elevated temperature and pressure is required to inactivate bacterial spores at acceptable levels. Although adiabatic heating during pressurization increases temperature almost instantaneously, which in combination with fast decompression cooling can lower the thermal contribution to product damage, the extent of chemical changes varies greatly depending on whether pressure lowers or increases the rate of a chemical reaction. Therefore, the extent of nutrient losses, flavour changes, and toxic compound formation (e.g., acrylamide) should be determined for all PATP products. However, elucidating the mechanisms of reactions in PATP-treated foods is challenging due to limitations when performing in situ measurements under high pressure. However, if the activation volume value ($V_a$) of a chemical reaction is experimentally determined, we can predict whether that reaction will be accelerated ($V_a<0$) or inhibited by pressure ($V_a>0$). For example, acrylamide can be formed in foods subjected to conventional thermal treatments above 100°C while the risk is reduced under PATP conditions. This presentation will review this and other chemical reactions under PATP conditions and conclude with the need to reduce the temperature severity of PATP treatments. A germinating-agents hurdle technology approach lowering the PATP treatment severity could achieve this goal and will also be presented. Food-grade agents can trigger the germination of dormant spores greatly diminishing their pressure resistance.
PATP Technology: Part 2. Effects on vitamins and flavor volatiles in refrigerated ESL and shelf-stable milk (30)

Reynaldo De la Cruz Quiroz³, Jesús Alejandro Aldrete-Tapia³, J. Antonio Torres⁴.

³FEMSA Biotechnology Center, School of Engineering & Sciences, Tecnológico de Monterrey, NL, México. ⁴Laboratorio para la Evaluación y Control de Riesgos Microbianos en Alimentos, Universidad Autónoma de Querétaro. Qro, México.

Conventional thermal treatments cause nutrient degradation, color changes, flavor and aroma losses, and even formation of toxic compounds, whereas high pressure processing (HPP) retains nutrients, phytochemicals and food sensory attributes. 400-500 MPa for 3-15 min at room temperature delivers “fresher” flavor with microbial reductions similar to thermal pasteurization. However, pressure-assisted thermal processing (PATP) would be required to produce refrigerated extended-shelf life (ESL) or shelf-stable milk. While milk could be PATP-treated to ensure microbial safety, information on thermal nutrient degradation reactions at high pressure is scarce. Ascorbic acid (AA) losses reach 10-25% during thermal milk pasteurization, while in fruits and vegetables, AA is stable if HPP-treated below 65°C. Cilla reported milk losses of 2% AA, 6% β-carotene and 27% α-tocopherol when treated at 400 MPa/40°C but information at more severe PATP treatments of milk was not available. The work here presented focuses on pressure (100-700 MPa), temperature (30-75°C) and time (1-10 min) effects on flavor volatiles, AA, retinol, β-carotene, and α-tocopherol in milk, including comparison with thermal pasteurization. PATP (45-75°C/482-655 MPa) inhibited the formation of most volatiles reported to be factors of the consumer rejection of “cooked” milk flavor. While thermal pasteurization resulted in 6% AA loss, 20% was lost even at the lowest-temperature PATP treatment (31°C/400 MPa). Moreover, up to 50% was lost in more severe treatments (75°C, 95-705 MPa). Temperature showed more effect on AA than pressure and time. PATP resulted in lower retinol, α-tocopherol and β-carotene losses than for AA and were similar to losses in conventional pasteurization. Even though PATP reduced more AA in milk than thermal processing, the improved flavor of PATP-ESL milk could be attractive to consumers. A germinating-agents hurdle technology approach lowering the PATP treatment severity required to inactive bacterial spores should be evaluated as a strategy for shelf-stable milk.
High hydrostatic pressure (HHP) technology, a thermal processing alternative, retains the sensory and nutritional value of foods and inactivates spoilage/pathogenic microorganisms and quality-degrading enzymes. However, bacterial spores are extremely baroresistant and can survive even long treatments (Sarker et al., 2015). Spores of Bacillus and Clostridium, which comprise several species of pathogenic and spoilage relevance show resistance even at >100°C and >600 MPa (Margosch et al., 2006). A multiple hurdle technology including spore-germinating agents as additional hurdles, is a promising alternative. Food-grade germinating agents can trigger the germination of dormant spores diminishing greatly their pressure resistance. This would reduce the severity of the combined pressure and temperature level required to reach the recommended 5-decimal reduction in the spore load. In this work, the use of the germinants L-amino acids, D-sugars, purine nucleosides, peptidoglycan fragments, bryostatin, nisin, dodecylamine, ceragenin-13, carvacrol, among others, against spores of some species of Bacillus and Clostridium in combination with high pressure and temperature are reviewed. While the application of these agents seems promising, they have challenges to be resolved: 1) What are the chemical, sensorial, nutritional changes in the food matrix caused by these agents? 2) Could some spores remain dormant and thus viable but not counted by traditional microbial enumeration methodologies? This presentation will close with a successful application of the hurdle concept to reduce the severity of a PATP treatment for the inactivation of *Clostridium perfringens* spores in poultry meat. An efficient strategy consisted of: 1) Addition of 50 mM L-asparagine and KCl; 2) Pasteurization heat treatment (80°C, 10 min) denaturing meat proteins and activating *C. perfringens* spores for germination; 3) Cooling to 55°C in ~20 min; 4) Incubation at 55°C for ~15 min for spore germination; 5) PATP inactivation of germinated spores (586 MPa, 73°C, 10 min).
Recent investigations in cold atmospheric plasma processing: up-scaling and product safety aspects

Dr.-Ing. habil. Oliver Schlüter

Leibniz Institute for Agricultural Engineering and Bioeconomy, Quality and Safety of Food and Feed,
Max-Eyth-Allee 100, 14469 Potsdam, Germany

Cold atmospheric pressure plasma (CAPP) offers a potential for improvements in hygienic processing. CAPP techniques have been used in food-related industries since the 19th century for disinfecting water based on the generation of ozone. In recent years, the interest in cold plasma processing as an emerging nonthermal technology in food production has increased. Plasma is defined as an (at least partially) ionized gas and is sometimes called the fourth state of matter. Depending on the system configuration and the feed gas used, plasma consists primarily of different reactive components such as ions, free electrons, photons and atoms. Due to the wide variety of cold plasma systems, CAPP opens up fundamentally new possibilities for food processing and can be applied at different points along the food chain; for production, modification, and preservation, as well as in packaging of plant- and animal-originated food.

The objective of a German research project on plasma-based decontamination of dried plant-related products is to ensure the safety of dry products using CAPP, while maintaining product quality. A prototype containing a microwave based plasma source was constructed and tested on a pilot scale regarding feasibility. Among others, wheat grains, pepper, and oregano are exemplary tested products for the research study on tailored plasma processes and the recent status of the project work will be presented. Additionally, the regulatory issues and further requirements for successful implementation of cold plasma technologies in food processing will be discussed. According to EFSA an approach should not only consider the quality and reliability of the data on genotoxicity itself, but also take into account toxico-kinetics and the outcomes of any repeated-dose toxicity studies.
Recent developments in the light based technologies

Kathiravan Krishnamurthy
IIT, USA

Light based technologies such as UV light processing, pulsed light processing, and LED light processing can effectively inactivate microorganisms. These technologies are effective for surface decontamination of solid foods and pasteurization of liquid foods which are transparent to the germicidal wavelengths. In addition, some of the light based technologies can also be used for other applications such as enrichment of nutrients such as vitamin D and polyphenols. This talk will focus on the recent advancements in the light based technologies and will shed light on the challenges which need to be overcome for successful implementation of the technologies.
Comparison of the compounds and characteristics of protein extracted from pressure-assisted and conventional solvent defatting pepper seeds (17)

Yan Ma, Xiaojun Liao, Liang Zhao

College of Food Science and Nutritional Engineering, China Agricultural University, National Engineering Research Centre for Fruit and Vegetable Processing, Key Laboratory of Fruit and Vegetable Processing, Ministry of Agriculture and Rural Affairs, Beijing Advanced Innovative Center for Food Nutrition and Human Health, Beijing, China

The aim of this study was to optimize the extraction process of protein from defatting pepper seed and compare the chemical composition and characteristics of protein extracted from pressure-assisted and conventional solvent defatting pepper seed. Dissolution capacity is expressed using the nitrogen solubility index detected by Bradford method. And the determination of water holding, foaming and emulsifying capacity were measured by weighing method, volume measuring, and spectrophotometry, respectively. The extraction parameters of protein optimized by response surface methodology was pH 9.5, material to liquid ratio 1:39, temperature 50°C, and time 38 min, which achieved the highest protein of 6.30 g/100 g from pressure-assisted defatting pepper seeds. The protein extracted from pressure-assisted defatting pepper seeds showed higher dissolution capacity (84.94%), water holding capacity (3.10 g/g), oil holding capacity (2.80 g/g), emulsifying activity (117.00 m²/g), emulsification stability (126.20%), foaming ability (10.00%) and foam stability (50.00%) compared with the protein extracted from conventional solvent defatting pepper seeds. The trypsin digestion ability of pressure-assisted defatting pepper seed protein was better than conventional solvent defatting pepper seed protein as well. Therefore, protein extracted from pressure-assisted defatting pepper seed could be a more efficient method to extract higher quality for pepper seed protein.
Dielectric properties of foods for microwave-assisted processed (53)

M.E. Sosa-Morales¹, T. Kaur Kataria², A. Corona-Chávez³, J.L. Olvera-Corona³, R. Rojas-Laguna²

¹ Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Irapuato, Guanajuato, 36500 México. ² Departamento de Ingeniería Electrónica, División de Ingenierías, Campus Irapuato-Salamanca, Universidad de Guanajuato, Salamanca, Guanajuato, 36600 México. ³ Instituto Nacional de Astrofísica, Óptica y Electrónica, Santa María Tonantzintla, Puebla, 72840 México

Dielectric properties are key parameters for microwave heating. They refer to both real and imaginary parts of the permittivity, known as dielectric constant \((\varepsilon')\) and dielectric loss factor \((\varepsilon'')\), respectively. Physically, \(\varepsilon'\) is related to the ability of the material to store energy, while \(\varepsilon''\) is related to electromagnetic energy dissipation into heat. Both \(\varepsilon'\) and \(\varepsilon''\) are affected by diverse factors: material composition, frequency, and temperature. Due to diverse applications of microwave heating for foods, such as pasteurization, disinfection, drying and thawing processes, the DP are important to know the behavior of the food under the heating. With the measured DPs, the penetration depth \((d_p)\) can be calculated. \(d_p\) is the distance within the material at which the power density decays to \(1/e\) (about 37%) from the value observed in the surface of the material. It is useful to know the \(d_p\) values for frequencies of 915, 2450 and 5800 MHz, which are the allocated values by the FCC (Federal Communications Commission of US) for industrial, scientific and medical purposes. In this review, DPs and \(d_p\) values for different foods will be presented, which were applied to microwave-assisted heat processes. The DPs were determined in the microwave with the open-ended coaxial probe, which is recognized as an easy and quick test. In general, dielectric constant increased with increasing temperature, and decreased with increasing frequency. Loss factor decreased with increasing temperature and increased with increasing frequency. With the valued, the \(d_p\) was calculated to recommend conditions for microwave-assisted processes, mainly at 2450 MHz.
Application of pulsed light on the quality and nutritional attributes of white grapes (Vitis vinifera L.)

Anubhav Pratap Singh¹, Artur Wiktor¹,², Ronit Mandal¹, Anika Singh¹, David D. Kitts¹

¹Faculty of Land & Food Systems, The University of British Columbia, Vancouver, BC, Canada.
²Department of Food Engineering and Process Management, Faculty of Food Sciences, Warsaw University of Life Sciences (WULS-SGGW), 02-787, Warsaw, Poland.

Pulsed light (PL) involves application of short-duration, high-intensity broad-spectrum (ultraviolet, visual and infrared regions) light pulses primary for microbial inactivation and shelf-life extension of food products. Although the food safety aspect of PL is well-documented and accepted, its' effect of various food products is still largely undocumented [2]. Earlier we conducted the effect of PL on model gallic acid solution to understand effect of PL on phenolic compounds [3]. Herein, we aim to analyze the impact of PL treatment on selected properties of white grapes (Vitis vinifera L.) during their storage. Raw grapes were subjected to pulsed light treatment with different energy dose (0.4-36.6 J/cm²) varying the treatment time (4-90 s) and frequency (3-11 Hz). After the treatment the grapes were stored in dark at 23±1°C for up to 17 days. The quality of fruits was evaluated by the means of mass loss, color (in CIE L*a*b system) and total phenolic content (analyzed by Folin-Ciocalteu method). Students’ t-test & Duncan’s multiple range test were conducted for grouping of means for statistical analysis. While a low-fluence PL treatment resulted in improvement in quality due to improvement in shelf life, a higher fluence resulted in decrease of overall quality, except phenolic content. Color changes were significant over the storage time for both treated and untreated samples. The mass loss of grapes after 17 days of storage was equal to 28% and 24-35% in the case of untreated and pulsed light treated material, respectively. Pulsed light treated grapes at the beginning of the experiment contained 1.6 to 65% more phenolic compounds than the untreated grapes. Our results present effects of PL on white grape quality. A possibility of increasing phenolic content in grapes by PL application is suggested.
Effect of ultrasound transducer design on the ultrasound-assisted supercritical fluid extraction of phytochemicals (19)

Liliana Santos-Zea¹, Janet A. Gutiérrez-Uribé², José Benedito³.

¹Tecnologico de Monterrey, Centro de Biotecnología-FEMSA, Escuela de Ingeniería y Ciencias. Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Mexico. ²Tecnologico de Monterrey, Campus Puebla, Escuela de Ingeniería y Ciencias. Vía Atlixcáyotl 5718, 72453, Puebla, Mexico. ³Dpto. Tecnología de Alimentos, Universitat Politècnica de València, Valencia, España.

Supercritical-fluid extraction (SFE) was developed as a green alternative to conventional extraction processes, minimizing the need of organic solvents for the recovery of phytochemicals. However, SFE has disadvantages, including slow extraction kinetics and low yields. Disadvantages can be overcome by ultrasound application during SFE (USFE) to enhance mass transfer and cell disruption. We analysed how changes in transducer geometry affected the intensification effect of USFE. Ultrasound transducers used (original model was a cylindrical headmass (T1), larger cylindrical headmass (T2), stepped circular sonotrode (T3) and multiplate headmass (T4)) were designed by the ASPA group of the Universitat Politècnica de València, Spain. Ultrasonic power of each transducer was evaluated by calorimetry and hydrophone methods. USFE were carried out in a supercritical fluid pilot-scale plant designed by the same group. Experimental matrices were oregano (*Origanum vulgare*) and agave bagasse (*Agave salmiana*), using 5 g samples during 60 min. For oregano, conditions were 35 MPa, 35 °C, and co-solvent ratio 2.3% using the four transducers; and 45 MPa, 60 °C and 10% co-solvent for agave bagasse using transducers 2 and 4. The highest power density according to the calorimetric method was for T4 (151.6 ± 7.1 W/L), but T2 produced a more uniform acoustic field and a higher acoustic pressure (150.6 ± 20.5 kPa). With respect to extraction efficiency, initially evaluated using oregano, the highest amount of total phenols (6.86 ± 0.46 GA mg/g) and antioxidant capacity (42.5 ± 2.3 TE μmol/g) was obtained with T2 and T4. These two transducers were evaluated using agave bagasse, and T4 generated a stronger intensification effect, obtaining twice as much antioxidant capacity and and steroidal saponins in the extracts obtained with T4 with respect to T2. These results showed how changing the transducer geometrical design could affect the acoustic field distribution and the power density delivered to the medium, enhancing USFE efficiency.
Pulsed light treatment for *Salmonella* inactivation on chicken breast meat (15)

Daniela Mengarda Buosi¹, Yifan Cheng², Carmem Moraru², Bruno A. M. Carciofi¹

¹Department of Food Engineering, Federal University of Santa Catarina, Brazil. ²Department of Food Science, Cornell University, USA.

*Salmonella* contamination on chicken meat can be occur during deboning and/or cutting processing, even due the best manufacturing practices in industry. Ultraviolet (UV) irradiation has gained interest as a decontamination method for food. Pulsed Light (PL) treatment is rich on UV light and it can be used to decontaminate food surfaces and raw meat (fresh). Previous data about PL demonstrates great impact to inactivate *Salmonella*. This study investigated how PL affected the microbial load of chicken breast meat, inoculated with *Salmonella*. A cocktail mix of 04 serotypes of *Salmonella* (*S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg and *S*. Minnesota) was worked in the experiments, as they are particularly interesting for poultry industry in Brazil. Both side of fresh Chicken breast meat (top and bottom) were focus of the investigation for comparison results. All experiments were done in XENON X-1100, at 1.9inch distance from quartz window. Input voltage, pulse width and fluence level were parameters combined for PL treatment. Eleven different conditions of PL were studied at 3000 V, 420us (1 to 6 pulses), 1260μs (1 to 3 pulses) and 2520 μs (1 and 2 pulses). After PL treatment, micro analysis has been done in XLD agar, and incubated for 24h at 37°C, then colonies were enumerated. The log reduction (cfu/cm²) has been considered the survivors between treated and control. All experiments were done as triplicate. About 2 log reductions of *Salmonella* for 10.8 J/cm² has been reached for top side of chicken breast and only 1,2 log reduction has been achieved to bottom side at the same fluence level. In contrast to this, *in vitro* experiments with same bacterial suspensions showed that at fluence 2 J/cm² resulted in about 6.0 log10 reduction. The results are interesting and promising to get further industrial scale up application.
Inactivation of Ataulfo mango pulp polyphenol oxidase treated by ohmic heating (21)

O.Y. Barrón-García 1, E. Morales-Sánchez 2, M. Gaytán-Martínez 2

1 Instituto Politécnico Nacional, CICATA-IPN Unidad Querétaro, Cerro Blanco No. 141, Colinas del Cimatario, 76090 Santiago de Querétaro, México.  2 Posgrado en Ciencia y Tecnología de los Alimentos, Research and Graduate Studies in Food Science, School of Chemistry, Universidad Autónoma de Querétaro, Cerro de las Campanas S/N. Col. Centro, 76010 Santiago de Querétaro, México.

Polyphenol oxidase is a metallic binuclear enzyme that contains copper and catalyzes the oxidation of phenolic compounds to quinones in presence of oxygen, which polymerized to dark brown pigments and it is widely found in microorganisms, animals and fruits like Ataulfo Mango. The total production for 2018 of mango in Mexico was around 1.86 million tons with an estimated value of 418 million dollars; the Ataulfo variety being the one with the highest production with 24.78%. Therefore, finding means of preserving the fruit, specially inactivating enzymes responsible for the loss of fruit quality, is of great importance. Ohmic heating (OH) is a potential alternative technology of preservation and enzyme inactivation based on Joule effect, which consists in the passage of an alternating current through a food, resulting in an increase in the internal temperature of the food. In the present study to evaluate the effect OH on the inactivation of Ataulfo mango pulp polyphenol oxidase a moderate electric field strength was used (15 V/cm) at different temperatures (40, 50, 60, 70, 80, and 90°C). Once temperature was reached, 15 ml aliquots were taken at 0 and 5 min. The samples were cooled in an ice bath to subsequently measure the residual polyphenol oxidase activity. The conventional thermal treatment (CT) was used as a control. The results showed that the electric field strength decreased the time required to obtaining the same degree of polyphenol oxidase inactivation at a target temperature compared with the CT. This suggest that electric field has a synergistic effect with temperature to inactivate polyphenol oxidase. Results demonstrated that OH is an effective technology to inactivate Ataulfo mango pulp polyphenol oxidase, allowing it to be used in thermal process such as pasteurization or blanching.
**ORAL SESSION. Tuesday November 5**

**Location: Tec Lounge**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenter</th>
<th>Authors</th>
<th>Corresponding Author email</th>
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<tbody>
<tr>
<td>8:00-8:05</td>
<td>Workshop Updates</td>
<td>J. Antonio Torres (Tecnologico de Monterrey, Mexico)</td>
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<td>8:00-8:05</td>
<td>Oral Session C. Other Nonthermal Technology Applications</td>
<td>Perla Ramos-Parra &amp; Daniel Guajardo-Flores, Co-Chairs</td>
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<td>8:05-8:10</td>
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<td>8:10-8:40</td>
<td>Shaping proteins under pressure</td>
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<td>Jorge A. Saraiva (University of Aveiro, Portugal)</td>
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<td>8:40-9:10</td>
<td>Potential novel biotechnological and food preservation applications of low to moderate pressure</td>
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<td>9:10-9:40</td>
<td>Bacterial injury and recovery induced by high hydrostatic pressure treatment</td>
<td>Kazutaka Yamamoto (National Agr &amp; Food Res Organization, Japan)</td>
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<td>9:40-9:45</td>
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<td>9:45-10:00</td>
<td>09 - Application of high-pressure carbon dioxide on purple sweet potato (<em>Ipomoea batatas</em> L.) pigments extraction: anthocyanin quality and stability evaluation as comparing to traditional aqueous and ethanolic extraction</td>
<td>Fei Lao</td>
<td>Fei Lao¹, Zhenzhen Xu², Jihong Wu¹, Xiaojun Liao¹</td>
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<td>10:00-10:15</td>
<td>51 - Ultrasound assisted extraction of dietary fiber from fruit and vegetable by-products</td>
<td>Karla C. Martínez Solano</td>
<td>Karla C. Martínez-Solano, Tomas A. García-Cayuela, Viridiana A. Tejada-Ortigoza, Luis E. Garcia-Amezquita</td>
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<td>10:15-10:30</td>
<td>34 - Employing microwave-vacuum combination in the pasteurization mode to valorize food-waste as a functional food ingredient</td>
<td>Anika Singh</td>
<td>Anika Singh, Anubhav Pratap Singh</td>
<td><a href="mailto:anubhav.singh@ubc.ca">anubhav.singh@ubc.ca</a></td>
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<td>10:30-10:45</td>
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<td>10:45-11:00</td>
<td>60 - Effect of pulsed electric field on milk fat globule membrane, lipase activity and lipolysis in whole milk</td>
<td>Shuailing Yang</td>
<td>Shuailing Yang, Shyam Suwal, Jeanette Otte, Lilia Ahrné</td>
<td><a href="mailto:lilia@food.ku.dk">lilia@food.ku.dk</a></td>
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<td>11:00-11:15</td>
<td>83 - Carotenoid stability of papaya (Carica papaya cv. Maradol) puree during development and ripening stages and high hydrostatic pressure processing</td>
<td>Raúl Villarreal Lara</td>
<td>Raúl Villarreal-Lara, Perla A. Ramos-Parra, Rocio I. Diaz de la Garza, Carmen Hernández-Brenes</td>
<td><a href="mailto:cbrenes@tec.mx">cbrenes@tec.mx</a></td>
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<td>11:15-11:30</td>
<td>63 - Effect of atmospheric cold plasma on the degradation of deoxynivalenol</td>
<td>Ehsan Feizollahi</td>
<td>Ehsan Feizollahi, Muhammad Arshad, Aman Ullah, M. S. Roopesh</td>
<td><a href="mailto:roopeshms@ualberta.ca">roopeshms@ualberta.ca</a></td>
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| 11:30-11:45  | 38 - Nonthermal technologies for the production of food ingredients with prebiotic potential | Alejandra Hurtado-Romero  
*Tecnologico de Monterrey, Mexico*  
Alejandra Hurtado-Romero, Luis Eduardo García-Amézquita, & Tomás García-Cayuela  
*Tecnologico de Monterrey, Mexico* | tomasgc@tec.mx |
| 11:45-12:00  | 32 - New Innovative Dehydration Processing of Freeze Drying / Multi-Flash Autovaporization (MFA) | Sabah Mounir  
*Zagazig University, Egypt*  
Sabah Mounir¹, Carmen Téleléz-Pérez²,³, Maritza Alonzo-Macías², Anaberta Cardador-Martínez², Colette Besombes³, Karim Allaf³  
(¹Zagazig University, Egypt; ² Tecnologico de Monterrey, México; ³ La Rochelle University, France) | mcardador@tec.mx |

**Roundtable 2: Commercialization and Regulation of Nonthermally Processed Products**

*Gustavo F. Gutiérrez-López (ENCB-IPN, México), Moderator*

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<td>12:00-12:05</td>
<td>Introductory comments</td>
<td>Gustavo F. Gutiérrez-López (ENCB-IPN, México)</td>
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<td>12:05-12:15</td>
<td>Commercialization and Regulation</td>
<td>Alejandra Salas (Public Affairs Manager, Coca Cola FEMSA, Mexico)</td>
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<td>12:15-12:25</td>
<td>Commercialization and Regulation</td>
<td>Edmundo Romo (JBT- Avure Technologies, USA)</td>
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<td>12:25-12:35</td>
<td>Commercialization and Regulation</td>
<td>Xiaojun Liao (China Agriculture University, China)</td>
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<td>12:35-13:00</td>
<td>Roundtable Conversation</td>
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<td>13:00-14:30</td>
<td>Brown Bag Lunch &amp; Poster Session 2</td>
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### Oral Session D. Modification of Functional/Nutraceutical Properties by Nonthermal Technologies

Zamantha Escobedo-Avellaneda & Tomás García-Cayuela, Co-Chairs

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<th>Authors</th>
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<tr>
<td>14:30-14:35</td>
<td><strong>Invited Speaker Introductions:</strong> Zamantha Escobedo-Avellaneda</td>
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<td>14:35-15:05</td>
<td>Designing next generation foods: Nonthermal processing technologies</td>
<td>Daniel A. Jacobo-Velázquez (Tecnologico de</td>
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<td>and postharvest abiotic stresses as tools to modify the functional/</td>
<td>Monterrey, Mexico)</td>
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<td>nutraceutical properties of raw materials</td>
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<td>15:05-15:35</td>
<td>Innovative technologies and functionality of plant foods and</td>
<td>M. Pilar Cano (Instituto de Investigación en</td>
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<td>ingredients. Recent advances and future perspectives</td>
<td>Ciencias de la Alimentación (CIAL), CSIC-UAM, Spain)</td>
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<td>15:35-16:05</td>
<td>Pulsed electric field technologies for safe and healthy food products</td>
<td>Olga Martín Beloso (Universitat de Lleida,</td>
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<td>16:05-16:10</td>
<td><strong>Contributed talks program:</strong> Tomás García Cayuela</td>
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<td>16:10-16:25</td>
<td>64 - HPP can play a role in the growth of plant-based protein product</td>
<td>Marcia Walker</td>
<td>Marcia Walker</td>
<td><a href="mailto:marcia.walker@tofurky.com">marcia.walker@tofurky.com</a></td>
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<td>16:25-16:40</td>
<td>50 - Incorporation of iron microparticles in pineapple during pre-treatment with ethanol and ultrasound</td>
<td>Gisandro Reis de Carvalho</td>
<td>University of São Paulo, Brazil</td>
<td><a href="mailto:gisandro_carvalho@usp.br">gisandro_carvalho@usp.br</a></td>
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<td>Gisandro Reis de Carvalho(^1), Izabela Dutra Alvim(^2), Pedro Esteves Duarte Augusto(^1)</td>
<td>(1) University of São Paulo, Brazil; (2) Technology Center of Cereal and Chocolate, Food Technology Institute (ITAL), Brazil</td>
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<td>16:40-16:55</td>
<td>Coffee Break</td>
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<td>16:55-17:10</td>
<td>24 - Individual and combined application of postharvest stresses and nonthermal preservation technologies to enhance the nutraceutical content of fruits and vegetables</td>
<td>Jesús Santana-Gálvez</td>
<td>Tecnologico de Monterrey, Mexico</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
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<td>Jesús Santana-Gálvez, Daniel A. Jacobo-Velázquez</td>
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<td>17:10-17:25</td>
<td>62 - High hydrostatic pressure modulate the folate and ascorbic acid accumulation in papaya (Carica papaya cv. Maradol) fruit</td>
<td>Perla A. Ramos-Parra</td>
<td>Tecnologico de Monterrey, Mexico</td>
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<td>17:25-17:40</td>
<td>03 - Microstructural analysis of betalain and phenolic liberation mechanisms in prickly pear cells subjected to high hydrostatic pressure</td>
<td>Andrea Gómez-Maqueo</td>
<td>Instituto de Investigación en Ciencias de la Alimentación (CIAL), CSIC-UAM, Spain</td>
<td><a href="mailto:mpilar.cano@csic.es">mpilar.cano@csic.es</a></td>
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<td>Andrea Gomez-Maqueo(^1,2), Jorge Welti-Chanes(^2), M. Pilar Cano(^1,2)</td>
<td>(1) Instituto de Investigación en Ciencias de la Alimentación (CIAL), CSIC-UAM, Spain; (2) Tecnológico de Monterrey, México</td>
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| 17:40-17:55 | 73 - Starch-based hydrogels produced by high pressure processing (HPP) for innovative applications: Evaluation of human in vitro starch digestibility | D. Larrea-Wachtendorff  
*University of Salerno, Italy* | g ferrari@unisa.it |
| 17:55-18:10 | 102 - High hydrostatic pressure: A highly efficient and novel assistant technique in pectin deesterification | Jihong Wu  
*China Agricultural University, China* | wjhcau@hotmail.com |
| 19:00-19:30 | Closing Event Talk  
*Critical Mars Mission Challenge: Pleasant, Diverse & Stable Foods* | Dr. Michele Perchonok  
2018-19 IFT President  
Introduction by J. Antonio Torres |
High hydrostatic pressure effects on biological macromolecules were known since the early 1900s, however, for nearly a century, high-pressure biophysics research has been carried out by a relatively small number of enthusiasts who were brave enough to build their own equipment. Nevertheless, fundamental studies to date have demonstrated that pressure causes perturbation of protein structure that leads to unfolding of proteins orthogonal to the action of temperature and chaotropic reagents. Pressure effects on protein conformation are explained by hydration of solvent-excluded cavities that are eliminated upon unfolding. As a result, highly reproducible, and frequently reversible, control of protein conformation can be achieved. Pressure Biosciences is one of the pioneer companies manufacturing research-scale high pressure instrumentation for life sciences. Our products help hundreds of laboratories worldwide to prepare biological samples for biomarker discovery, control enzyme activity and protein structure for development and manufacturing of biologics, studying pressure-inactivation of pathogens and pressure effects on living piezophilic organisms. This presentation will give an overview of high pressure effects on protein structure and function and highlight utility of high pressure as a precise thermodynamic perturbation tool in a variety of research areas, ranging from food safety to cancer research, development and manufacturing of biopharmaceuticals.
Potential novel biotechnological and food preservation applications of low to moderate pressure

Jorge Manuel Alexandre Saraiva
University of Aveiro, Portugal

High pressure processing has assumed an undeniable role in food processing, allowing obtaining pasteurized fresher-like food products with extended shelf life, by applying hydrostatic pressures up to 600 MPa, at/below room temperatures. As no heat is applied, most of the nutritional value of products is maintained, such as vitamins, aromas, etc., that could be reduced by thermal pasteurization. Nevertheless, the potential use of hydrostatic pressure goes beyond these food processing applications and novel possibilities are being studied.

Hydrostatic pressure (up to ~ 50 MPa) can also be applied during fermentative processes to induce sub-lethal stresses in microorganisms, such as metabolic changes, with potential to obtain food products with different characteristics than those produced at atmospheric pressure, as it is the case of yoghurt.

Lately, a new preservation methodology, called hyperbaric storage (HS), is being investigated as a possible replacement/improvement of refrigeration. It states storage pressure control (in the range of 50-100 MPa), inasmuch temperature control as in refrigeration, to preserve food products. The main advantages of HS rely on energetic costs reduction and lower carbon footprint, along with possible considerable microbial shelf-life extensions by hindering vegetative microbial growth (with inactivation also for ≥ 100 MPa). Recent results also point for the potential of HS to control bacterial spores development.
Bacterial injury and recovery induced by high hydrostatic pressure treatment

Kazutaka Yamamoto
National Agr & Food Res Organization, Japan

High hydrostatic pressure (HHP) has been applied to foods primarily for inactivating pathogenic and spoilage bacteria. Bacterial inactivation is lethal or sublethal for all intervention technologies including thermal, chemical, and HHP treatments. Sublethal inactivation is referred to as injury. However, bacterial injury is not sufficiently understood, and the mechanisms of injury are technology dependent. For extending knowledge on HHP-induced bacterial injury, model liquids of nutrient-free /-rich formulations were adopted to suspend bacterial cells. The suspensions were subjected to 400 – 500 MPa treatments, which generated HHP-injured cells of Escherichia coli, Listeria monocytogenes, and lactic acid bacteria in a reproducible manner. Injured cells were stored, and their behaviors evaluated by plate counting and other techniques.
Application of high-pressure carbon dioxide on purple sweet potato (*Ipomoea batatas* L.) pigments extraction: anthocyanin quality and stability evaluation as comparing to traditional aqueous and ethanolic extraction (09)

Fei Lao¹, Zhenzhen Xu², Jihong Wu¹, Xiaojun Liao¹

¹College of Food Science and Nutritional Engineering, China Agricultural University, National Engineering Research Centre for Fruit and Vegetable Processing, Beijing 100083, China. ²Institute of Quality Standard & Testing Technology for Agro-Products, Chinese Academy of Agricultural Sciences, Beijing 100081, China.

High-pressure carbon dioxide (HPCD) is an emerging environment-friendly technique for food functional compounds recovery. This study was designed to evaluate the impacts of extraction methods (HPCD-assisted, classical acidified water, 70% aqueous ethanol) and their respective matrices on purple sweet potato (PSP) anthocyanins quality and stability. Pigments yield, monomeric and polymeric anthocyanins, total phenolics content, color properties (CIELch), and pigments HPLC profiles at 4-week dark room temperature storage period were tracked to investigate the advantages of applying HPCD. The yield, color quality and stability of PSP anthocyanins were affected (p<0.05) by the choice of extraction and storage matrices. HPCD-assisted extraction produced significantly higher monomeric anthocyanins, total phenolics, and less polymeric color with more stable storage property (over 300 days half-life at 25°C, dark) pigments than others. Alcoholic matrix tended to accelerate PSP pigments degradation as compared to aqueous ones. Anthocyanin structure, especially their degree of acylation, played critical role in pigment storage stability. Majority of PSP pigments’ stability followed the order of di-acylated > mono-acylated > non- acylated. During the storage, PSP extract color fading was slower than its anthocyanin degradation, which could be the result of the protection and hysteresis effect of phenolic co-pigments. In summary, the PSP HPCD anthocyanins extract produced in this study presented satisfactory pigment yield, as well as good color quality and stability, which could represent high quality natural color alternatives generated via novel HPCD technology, to be applying in new generation of clean-label beverage and other food products.
Ultrasound assisted extraction of dietary fiber from fruit and vegetable by-products (51)

Martínez-Solano, Karla C. a, García-Cayuela, Tomas a, Tejada-Ortigoza, Viridiana b, García-Amezquita, Luis E. a

a Tecnológico de Monterrey – Campus Guadalajara. b Tecnológico de Monterrey – Campus Querétaro

Dietary fiber (DF) is a promising ingredient that provides several technological functionalities to foods. Fruit and vegetable by-products generated from the agricultural industry have the potential to obtain DF-based functional ingredients. DF is usually extracted using hot water, solvents, and alkali; however, these methods require high temperatures, the use of chemical reagents, long extraction times, and usually low extraction yields are obtained. In this context, ultrasound-assisted extraction (UAE) has proved to increase the extraction yield of different polysaccharides, as well as a significant reduction in the processing time. Some studies have demonstrated that the same extraction yields could be achieved by applying treatments of up to 900W in bagasse of different by-products, decreasing the treatment temperature and time. Low-Intensity treatments (140W) could reduce the processing time from 900 to 156 min at 20°C, obtaining the same yields as that with conventional methods, or even higher yields (from 4.7 to 8%). The use of UAE also improves the extracted DF functionality. Regarding this, recent studies have shown that treatments ≤525W increased cholesterol-binding properties, glucose adsorption and oil retention capacities in some by-products. Additionally, UAE provides better thermal stability to polymers bounding less water, decreasing the thermal effect when using mild to high temperatures. Microscopic studies have shown that the surface’s morphology of ultrasonic-treated cells is looser and porous due to the disruption of the crosslinks between polysaccharides resulting in enhanced functional and rheological properties. The aim of this work is to present the advances and recent studies comparing UAE and other conventional extraction methods for specific fiber compounds from fruit and vegetable by-products not only to evaluate the extraction yields and processing variables but to compare the composition and functionality of the extracted compounds and its benefits in food applications.
Freeze drying (FD) and Microwave-vacuum dehydration (MVD) at low-vacuum levels (between 20-40 mmHg that correspond to 22-33°C critical temperature due to lowering of boiling point of water) have garnered recent attention non-thermal alternatives for reducing water-content of food of functional food. Recycling food-waste into functional food ingredients presents an interesting ‘process problem’ that could benefit from such technologies. An example is the brewer’s spent grant (BSG), which forms > 80% by-products of brewing industry but is rich in protein and fibre. However, large amounts of BSGs are discarded as, like other food-wastes, it is a high water-activity material that supports microbial spoilage. Whereas both MVD and FD techniques result in high retention of nutritional attributes, they suffer the common disadvantage of being non-acceptable as a pasteurization method by regulatory authorities, as they do not supply the required minimum lethality. This work theorizes an attempt to employ innovative drying techniques to introduce snacks with protein sources derived from leftover BSGs. We employed MVD at elevated vacuum-levels (from 150 to 250 mmHg, representing critical temperature range of 60-72°C) to reach pasteurization levels while dehydrating wet BSG (77% water-content; 0.99 water-activity). The temperature evolution during MVD of thin-layer (about 1cm thick layer of 5g BSG) BSG was first documented. Products were dehydrated until a target lethality of 30 minutes at 63°C reference temperature was delivered or a final water activity of 0.75 was achieved. The final products were compared with each other and a freeze-dried sample for protein content and functionalities. Dried products were milled and used for making baked chips, whose sensory results will also be presented. Tukey’s test was used to compare means. Increasing vacuum-levels from 150 to 300 mmHg resulted in elevated temperatures closely corresponding to the critical temperature, with a come-up time ranging from 4-6 min. In terms of protein functionality of dried BSGs, there was significant difference (p < 0.05) between different dried samples for WHC and OHC. On the contrary, FS and FC were almost same for each other. For the sensory analyses of baked chips, the MVD samples attained higher scores than FD samples. We successfully demonstrated the application of MVD at elevated temperature as a technology for valorize food-waste as a functional ingredients in food products.
Effect of pulsed electric field on milk fat globule membrane, lipase activity and lipolysis in whole milk (60)

Shuailing Yang, Shyam Suwal, Jeanette Otte, Lilia Ahné

*Department of Food Science, Faculty of Science, University of Copenhagen, Rolighedsvej 30, DK-1958, Frederiksberg C, Denmark*

The milk fat globule membrane (MFGM) is very important for milk fat stabilization and protection against lipolysis. The aim of this study was to investigate the effects of pulsed electric field (PEF) on the structure of milk fat globule (MFG) and lipase activity in whole milk. Whole milk with MFG of different sizes, R1 (< 5 μm) and R2 (> 1 μm), were prepared and compared to raw milk (RM) with intact MFG. Subsequently, RM, R1 and R2 were subjected to PEF treatment at 20 and 35 kV/cm (50 Hz, bipolar square wave pulses with 5 μs width) at a start temperature of 25 °C for 30 μs. The microstructure and protein profiles of the MFGM were studied by confocal laser scanning microscopy (CLSM) and SDS-PAGE, respectively. Lipase activity and free fatty acid (FFA) profiles in milk were also investigated. After PEF treatments, the pH and electrical conductivity of milk were not significantly changed (P > 0.05), but PEF-treatment affected the structure of MFG. The CLSM and SDS-PAGE results revealed that depending on the separation and PEF treatments the MFGM was slightly damaged and repaired by adsorbing milk proteins. SDS-PAGE showed that after PEF treatments, xanthinoxidase and butyrophilin were found to disappear from the R1 MFGM protein profiles. Moreover, lipase activity depended on the intensity of the PEF treatment and separation method. Lipase activity was significantly lower (P < 0.05) in R2 milks compared with RM and R1, while PEF treatment caused a significant increase in RM at 35 kV/cm and in R2 both at 20 and 35 kV/cm. Additionally, C6:0 and some long-chain FFAs were increased in the PEF-treated samples. These results have provided new insight into the effects of PEF on MFGs and lipolysis which can be further explored by dairy industry.
Carotenoid stability of Maradol papaya (Carica papaya) puree during development and ripening stages and high hydrostatic pressure processing (HHP)


Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., México, 64849. *These authors contributed equally to this work.

Papaya (Carica papaya) cultivar Maradol, known as the Mexican papaya, has gained popularity due to its flavor, nutritional and economic value. Previous reports in different papaya cultivars have observed high concentrations of carotenoids, including vitamin A precursors and lycopene. Since carotenoids are thermolabile compounds, it is relevant to investigate an industrial process for maintaining its nutritional quality and extended shelf life. Therefore, the aim of this study was to identify and quantify individual carotenoids in papaya cv. Maradol and their stability during high hydrostatic pressure processing (HHP). Carotenoids were characterized by HPLC-DAD and HPLC-APCI (+) Mass spectrometry. First, three different developmental stages (0.3, 0.5 and 0.8 of the full fruit size) and 5 fully developed ripening stages were characterized. For HHP study a 4 staged ripening (80 % orange skin) papaya was used. A full factorial design was applied, including three pressure conditions (400, 500, and 600 MPa), two processing times (1 and 3 min), and two processing temperatures (25 and 40 °C). A total of 26 carotenoids were identified including 4 biosynthetic precursors, 11 xanthophylls and 11 carotenoids, where all-trans-lycopene was the most abundant carotenoid in all studied stages. HHP processing significantly retained and increased total carotenoids in papaya puree. The highest carotenoid increments were observed at processing conditions of 500 and 600 MPa at 25 °C with 209 and 195 %, respectively; whereas treatments at 40 °C, including controls, increased between 168 and 187 %. To the best of our knowledge for the first time, a complete carotenoid profile of Maradol papaya was characterized and HHP processing showed to be an efficient non-thermal alternative to retain carotenoids in papaya.
Effect of atmospheric cold plasma on the degradation of deoxynivalenol (DON)

Ehsan Feizollahi, Muhammad Arshad, Aman Ullah, M. S. Roopesh*

Department of Agricultural, Food & Nutritional Science, University of Alberta, Edmonton, Canada.
*Corresponding author

Atmospheric cold plasma (ACP) is a novel non-thermal technology that has the potential to be used as a post-harvest treatment for mycotoxin mitigation in grains. Deoxynivalenol (DON), a major trichothecene mycotoxin is a big threat to human health and agricultural economy worldwide. In this work, we assessed the effect of ACP treatment (at 30 kV, 3.5 kHz) alone or in combination with thermal (80°C) or light emitting diode (LED) (395 nm light) treatment on DON degradation. Furthermore, the effects of the initial concentration of DON and the presence of water on the degradation efficacy during ACP treatment were evaluated. High performance liquid chromatography (HPLC) was used to quantify DON and thin layer chromatography (TLC) and Fourier transform infrared spectroscopy (FTIR) were used to understand the structural changes in DON after ACP treatment. When the water content (WC) was 80% (wet basis), DON was completely degraded within 5 min of ACP treatment. However, it was reduced by 75.8 % in the dry condition (0% WC) after 60 min ACP treatment. Presence of water influenced the DON degradation efficacy and with 2 min ACP treatments, 14.06, 100, 100, and 84.81 % reductions in DON were observed when the WC were 0, 5, 20, and 80 %, respectively. TLC analysis was not able to differentiate between control and treated samples, but FTIR analysis revealed major changes in functional groups of DON structure after ACP treatment in solution form. No direct correlation between DON degradation and its initial concentrations of 4, 20 and 100 μg/mL was observed during ACP treatment. Thermal treatment did not result in any degradation of DON. LED treatment for 30 and 60 min reduced DON concentration by 10.69 and 36.99 %, respectively. This study shows that ACP is a promising technology that can be used for DON degradation.
Nonthermal technologies for the production of food ingredients with prebiotic potential (38)

Alejandra Hurtado-Romero, Luis Eduardo García-Amézquita, & Tomás García-Cayuela

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramón 14 Corona 2514,
Zapopan, Jalisco, Mexico

A prebiotic is a selectively fermented food ingredient metabolized by gastrointestinal microbiota. It is capable of maintain intestinal health reducing the symptoms associated with inflammatory bowel disease, enhancing the bioavailability and uptake of minerals, also preventing colon cancer and cardiovascular diseases and promoting a positive modulation of the immune system. Moreover, prebiotics influence the sensory and organoleptic characteristics of the food products, improving textural, rheological, sensory and nutritional properties adding value to the industry foods. Non digestible oligosaccharides, such as inulin, galactooligosaccharides (GOS), and fructooligosaccharides (FOS), are the most studied prebiotics; they are commonly obtained by enzymatic synthesis, isolation from vegetable resources, microbiological production or enzymatic degradation of polysaccharides. Because prebiotics need to be chemically stable to food processing treatments, such as heat, low pH, Maillard reaction conditions and due to the increased demand for foods with prebiotics because of the health benefits demonstrated in various studies, different industrial alternatives for the production of prebiotic ingredients and formulations including them without altering its characteristics are being explored. Non-thermal technologies, such as high hydrostatic pressure (HHP), pulsed electric fields (PEF), UV-light (UV) and ultrasound (US) among others, can ensure nutrient values of food in shorter processing times and lower temperature conditions extending the shelf life of food products preserving sensory quality and safety; making them attractive technologies for the extraction and maintenance of prebiotic ingredients. Some approaches have been made increasing yields in extraction of prebiotic oligosaccharides from fruits and vegetables using US, incorporating FOS to formulations applying HHP or using cold plasma to process formulations containing oligosaccharides. The aim of this work is to present the advances and recent studies in the implementation of non-thermal technologies at the extraction and processing of food ingredients such as fibers with prebiotic potential from plant sources and how prebiotic properties are affected in these processes.
New innovative dehydration processing of freeze drying / multi-flash autovaporization (MFA) (32)

Sabah Mounir¹, Carmen Téllez-Pérez²,³, Maritza Alonzo-Macías², Anaberta Cardador-Martínez², Colette Besombes³ and *Karim Allaf³

¹ Food Science Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. ² Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Campus Querétaro. Epigmenio González 500, Fracc. San Pablo. Querétaro, Querétaro, 76130, México. ³ La Rochelle University, Intensification of Transfer Phenomena on Industrial Eco-Processes, Laboratory of Engineering Science for Environment LaSIE - UMR-CNRS 7356, 17042 La Rochelle, France.

Freeze-drying (FD) is the only method that allows food materials to dry without any noticeable shrinkage or collapse, which means great preservation of quality. However, FD is not widely adopted because of its low drying kinetics and high cost. Therefore, in order to intensify this drying operation, this study defines a new innovative dehydration process, which combines the FD with the multi-flash Autovaporization MFA. The latter is a drying operation of subjecting the product to a series of short compression/decompression cycles. Each cycle consists of an oscillation between a high-pressure stage \((P^+)\) and a vacuum stage \((P^-)\), with defined durations \((t^+\) and \((t^-)\), respectively. While compression is progressive, decompression is characterized by an instantaneous pressure drop to the vacuum, which inevitably leads to autovaporization. This study focuses on the operation of FD/MFA in its application to yoghurt. Drying kinetics, cycle efficiency and functional properties of dried yoghurt were evaluated. The effects of \((P^+)\) and \((t^+)\) on the response variables were studied using a two-factor composite central design of experiment. To create the high pressure \((P^+)\) in the treatment chamber, dry, filtered and compressed air was used at room temperature (~ 25 °C). The high pressure \((P^+)\) ranged between 0.1 and 0.5 MPa and the treatment duration \((t^+)\) between 5 and 50 s. The vacuum pressure level \((P^-)\) and the vacuum time \((t^-)\) were kept constant at 10 kPa and 20 s, respectively. By using the sublimation step of FD to prevent shrinkage and MFA stage to intensify the drying kinetics, FD/MFA has allowed the product to get preserved structure and functional quality and the drying time to reduce to about 8 h against 24 hours for the classic FD.
Fruits and vegetables contain high levels of nutraceuticals, and thus their consumption is associated with the prevention of different chronic diseases. The application of postharvest abiotic stresses (i.e. wounding stress, UV light) induces the accumulation of bioactive compounds and modify the functional properties of fresh produce. In this context, previous reports in literature suggest that nonthermal processing technologies (i.e. ultrasound (US), high pressure processing (HPP), and pulsed electric fields (PEF)) activate the biosynthesis of nutraceuticals in crops by a similar mechanism exerted by wounding stress. In this presentation, the combined application of postharvest abiotic stresses and nonthermal processing technologies as innovative strategies to modify the functional/nutraceutical properties of plant foods will be discussed. Likewise, their further processing to obtain next generation foods with enhanced health-promoting properties will be presented.
Innovative technologies and functionality of plant foods and ingredients. Recent advances and future perspectives

M. Pilar Cano

Institute of Food Science Research (CIAL), CSIC-UAM, Spain

In this presentation, a review of the recent advances in the use of innovative technologies to improve the extractability of bioactive compounds from plant foods will be made, focusing in the influence of the modification of the food matrix structure due to the applied process and the potential improvement in bioactive bioaccessibility and bioactivity.

Likewise, this revision will include the latest published studies reporting that the application of innovative technologies for the improvement of plant food functionality or bioactive extraction with a multifactorial approach, where parameters such as the food matrix (microstructure and composition), the processing conditions, and the design of the adequate system of encapsulation, transport and delivery of the extracted (or isolated) bioactive compounds (functional ingredients) are involved.
Pulsed electric field technologies for safe and healthy food products.

Martín-Belloso, O.; Soliva-Fortuny, R.

Department of Food Technology. University of Lleida – Agrotecnio Center. Rovira Roure, 191, E-25198 Lleida, Spain

Pulsed electric fields (PEF) have been shown to avoid the negative effects on food quality of conventional processing techniques while enhancing the healthy properties of foods, among other commercial applications. The application of high intensity PEF treatments to pasteurize liquid foods has been studied for the last couple of decades. As a result, PEF-treated safe and nutritious fruit and vegetable juices are currently produced by a few processing companies. In the last few years, the feasibility of moderate intensity PEF processing to induce stress reactions in metabolically active plant foods, thus stimulating the production of secondary metabolites and the increase in their antioxidant potential has been proven. In addition, moderate intensity PEF may be used to induce food matrix structural modifications that have an impact on the bioaccessibility of health-related compounds. Electropermeabilization, cell wall disruption and other structural changes caused by PEF treatments lead to an enhanced release and better bioaccessibility of phytochemical compounds from the food matrix and, consequently, can be considered as a strategy to tune the characteristics of plant-based processed food products. This presentation will provide the state-of-the-art of the application of PEF treatments for the design of safe, nutritious and convenient plant-based foods.
How HPP can play a role in the growth of plant based protein product innovation (64)

Marcia Walker

Tofurky

The increasing demand for healthy food and beverage products has spurred a double-digit growth in the plant-based protein market. The increasing instance of obesity and related diseases has made consumers turn to a flexitarian diet that is focused on making non-meat choices. This provides an opportunity for HPP to play a role in creating clean label and fresh like plant-based food products. With changes to the food choices that consumers are making, new product trends will be explored. Traditionally, vegan or vegetarian products have been formulated to appeal to a small population or eating pattern, however with more consumers demanding products that match meat counter parts the microbiology, ingredients and formulations have changed and the opportunity that HPP can offer in developing these products will be explored.
Incorporation of iron microparticles in pineapple during pre-treatment with ethanol and ultrasound (50)

Gisandro Reis de Carvalho¹, Izabela Dutra Alvim², Pedro Esteves Duarte Augusto¹

¹Agri-food Industry, Food and Nutrition (LAN), Luiz de Queiroz College of Agriculture (ESALQ), University of São Paulo (USP). ²Technology Center of Cereal and Chocolate, Food Technology Institute (ITAL)

The incorporation of microencapsulated nutrients is a technique which can be used to produce healthy food products. However, it is a challenge in structured foods, such as plant tissues. The present work aimed to study the incorporation of microparticles containing iron in pineapple pulp, which was further dried. Ferrous sulphate was microencapsulated in maltodextrin through spray drying. Pineapple pulp was cut in cylinders and the microparticles were dispersed in ethanol (0.05 g/100 mL). The incorporation was made during pre-treatments where the cylinders were immersed in the suspension of ethanol (ET), with and without the application of high-intensity ultrasound (ET+US) (25 kHz and 14.90 W/L). The treatments were carried out for 7.5, 15 and 30 minutes. After the treatments, the samples were submitted to convective drying at 50 °C in an oven with air circulation (0.86 ± 0.1 m/s), thus obtaining stable pineapple chips. The iron content was determined by an energy dispersive X-ray fluorescence spectrometer. The residue of ethanol in the samples were measured by gas chromatography coupled with mass spectrometry. The experiments were realized in triplicate and obtained results analyzed by ANOVA. Utilization of ethanol as pre-treatment accelerates drying. The application of high-intensity ultrasound did not affect drying. The pineapple iron content increased 1100% with the impregnation process: starting from 28.3 mg/kg (d.b.) in the in natura sample, it passed to 141.12, 217.47 and 321.20 mg/kg (d.b.), for 7.5, 15 and 30 minutes of treatment, respectively. Longer treatments resulted in higher residual ethanol in the sample. However, the treatment of 7.5 minutes was effective to provide satisfactory amount of iron and a content of ethanol close to the natural present in the fruit. As conclusion, the combination of microencapsulation, ethanol and ultrasound technologies was efficient to obtain pineapple chips fortified in iron.
Individual and combined application of postharvest stresses and nonthermal preservation technologies to enhance the nutraceutical content of fruits and vegetables (24)

Jesús Santana-Gálvez¹, Daniel A. Jacobo-Velázquez¹

¹ Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Av. General Ramón Corona 2514, C.P. 45138, Nuevo México, Zapopan, Jalisco, Mexico

Nowadays, consumers are demanding healthier foods that are at the same time fresh, safe, and long lasting. However, traditional food processing technologies apply thermal treatments to foods, which leads to modifications of their sensory properties and big losses of health-promoting compounds, including nutrients and nutraceuticals. Therefore, novel technologies have been increasingly researched and developed to overcome these problems, including postharvest stresses (PS) and nonthermal preservation technologies (NTPTs). PS are harsh conditions caused by biological and nonbiological agents to which plants respond by synthesizing secondary metabolites as a defense mechanism. Many of these secondary metabolites are nutraceuticals. On the other hand, NTPTs can extend the shelf-life of foods without the need of using high temperatures, allowing the retention of their sensory, nutritional, and nutraceutical quality. However, NTPTs can also enhance the nutraceutical content of foods through physical, chemical, and metabolic changes. This paper reviews the most recent research in applying PS and NTPTs alone or in combination to enhance the nutraceutical content of fruits and vegetables, including solid form and juices. The use of these improved fruits and vegetables as ingredients to enrich or fortify commonly consumed foods is also discussed with examples. The PS covered are wounding stress, UV light, modified atmospheres, and phytohormones, while NTPTs include high pressure processing (HPP), pulsed electric fields (PEF), irradiation, ultrasound, and cold plasma. Many nutraceuticals have been reported to be increased by PS and NTPTs, including phenolic compounds, carotenoids, glucosinolates, betalains, dietary fiber, and vitamin C in a wide range of fruits and vegetables. Some of these technologies can serve as both PS and NTPTs, while other PS and NTPTs can complement each other. Combining PS and NTPTs is an emerging field; therefore, more research is needed to establish which combinations are most suitable and cost-effective to satisfy the aforementioned consumer demands.
High hydrostatic pressure modulate the folate and ascorbic acid accumulation in papaya (Carica papaya cv. Maradol) fruit (62)

Perla A. Ramos-Parra, Carmen Hernández-Brenes, and Rocío I. Díaz de la Garza

Tecnologico de Monterrey, Escuela de Ingenieria y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., México, 64849.

We have previously shown that High Hydrostatic Pressure (HHP) in papaya fruit tissue triggers de novo carotenoid biosynthesis, possibly as a response to the oxidative stress generated immediately after HHP treatments1. Apart from provitamin A, papaya fruit is an excellent source of other vitamins, such as tetrahydrofolate (THF) and its derivatives, (folates, vitamin B9)1 and ascorbic acid (vitamin C). This work evaluated the immediate effects of HHP treatments (50-400MPa for 3-60min) on folate and ascorbic acid contents of fresh-cut papaya fruit. A full factorial design was used with 4-pressure magnitudes (0, 50, 100 and 400 MPa) and 4-processing times (0, 3, 30 and 60min). Folates were characterized by HPLC-electrochemical detector, and ascorbic acid by HPLC-DAD. Ascorbic acid, a powerful antioxidant, which synthesis is known to respond to oxidative stress in plants, had increases in all conditions tested, ranging from 4-28% higher levels when compared to non-treated controls. 5-CH3-THF (73%) and THF (22%) were the main folate species characterized in papaya fruit. HHP treatments at mild (50-100MPa) and commercial (400MPa) conditions for 30 min of processing time increased 35 and 25% the 5-CH3-THF and total folate contents, respectively. Folate molecule also contains a glutamyl tail, which is involved in its function as cofactor, its localization, and stability. 5-CH3-THF from papaya fruit exists with a very long polyglutamyl tail (Glu1-17) 2. The interaction of both time and magnitude of the pressure increased significantly the 5-CH3-THF Glu1 up to 250%, mainly in 100 and 400MPa/30min conditions; whereas the polyglutamyl forms (Glu2-17) did not show changes by the effect of HHP-treatments. Longer processing times (60min) decreased the polyglutamylation degree up to 60% less than controls. This study evidences for the first time that HHP treatments are also able to positively modulate vitamin C and B9 metabolism to increase micronutrient contents in a plant food.
Microstructural analysis of betalain and phenolic liberation mechanisms in prickly pear cells subjected to high hydrostatic pressure (03)

Andrea Gómez-Maqueo1,2, Jorge Welti-Chanes1, M. Pilar Cano1,2

1Departamento de Biotecnología y Microbiología de Alimentos, Instituto de Investigación en Ciencias de la Alimentación CIAL (CSIC-UAM), Madrid, Spain. 2Tecnologico de Monterrey, Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, Monterrey, NL, Mexico.

High hydrostatic pressure (HHP) promotes the release of bioactive compounds from their intracellular compartments making them more bioaccessible. We studied the effect of HHP on cell microstructure, cell morphology, betalain and phenolic liberation mechanisms and cell viability in prickly pear fruits. HHP was applied at 100, 350 and 600 MPa at 20°C during the come-up time (CUT) and 5 min holding time. Prickly pear chlorenchyma cells (in peels) and parenchyma cells (in pulps) were analysed by transmission electron microscopy, confocal laser scanning microscopy and optical microscopy. In chlorenchyma cells, HHP ruptured betalain-storing vesicles located in the cytoplasm and increased the activity of endogenous enzymes occasionally resulting in the browning of betalain aggregates. Contrarily, HHP released betalains from the vacuoles of parenchyma cells due to breaking of the tonoplast and presented higher stability. Phenolic compounds were released from cell walls with increasing pressure and enhanced by cell wall ultrastructural modifications (100 MPa), cell wall rupture (350 MPa) and the rearrangement of microfibrilated cellulose (600 MPa). Prickly pears fruits submitted to HHP presented advanced senescence marked by considerable ethylene increase and the gradual loss of CO2 production after 6 h. Prickly pear cells were only viable at 100 MPa by conserving intact cell membranes and after 24 h their respiration rates presented no significant differences compared to controls although their ethylene rates were the highest as a response to abiotic stress. Finally, processing at 350 MPa/5 min caused enough cell membrane rupture to enhance the extractability of phenolic compounds while preserving the more pressure-labile betalains. Further studies should determine if HHP may enhance their bioaccessibility by promoting the release of bioactives and by modifying the food matrix.
Starch-based hydrogels produced by high pressure processing (HPP) for innovative applications: Evaluation of human in vitro starch digestibility (73)

Larrea-Wachtendorff, D1.; Pulgarin, M1.; Ferrari, G1,2.

1Department of Industrial Engineering, University of Salerno, Fisciano (SA), Italy 2ProdAI Scarl, Fisciano (SA), Italy

Starch-based hydrogels offer the possibility of providing natural biopolymeric structures for innovative applications. The aim of this work was to evaluate the digestibility of HPP hydrogels based on different starches in an in vitro system simulating human digestion. These novel structures were characterized according to their digestion behaviour in view of future applications. To this purpose, rice and tapioca starches were suspended in distilled water and subsequently treated at 600 MPa for 15 min at 25°C. For the sake of comparison, starch-based hydrogels obtained by thermal treatments were also produced. In vitro digestion tests were carried out simulating the oral, gastric and intestinal phases of the human digestion and the hydrogels disintegration, the total hydrolysed starch and some nutritional aspects were determined. Experimental results demonstrated that hydrogels based on rice and tapioca starch are characterized by different behaviours during the in vitro digestion process. Rice starch hydrogels showed a more pronounced disintegration and a higher extent of starch hydrolysis than tapioca starch hydrogels, being this trend more evident in HPP hydrogels (p<0.05). Mastication and intestinal phases were identified as the critical steps for rice and tapioca hydrogels digestion, respectively. However, both starch-based hydrogels were almost completely digested at the end of the in vitro digestion phases, with values of hydrolysed starch higher than 94% and 88% for rice and tapioca starch, respectively, irrespective of the production method. As far as nutritional aspects were concerned, tapioca hydrogels showed high values of slowly digestible starch, while rice hydrogels showed high values of resistant starch, being this trend more pronounced in hydrogels produced by HPP. In conclusion, in vitro digestibility of starch-based HPP hydrogels was strongly influenced by the type of starch and the preliminary information obtained in this study could be considered the baseline for future applications of these structures.
High hydrostatic pressure: A highly efficient and novel assistant technique in pectin deesterification (102)

Jihong Wu\textsuperscript{1,2*}, Wenting Zhao\textsuperscript{3}

\textsuperscript{1}College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083
\textsuperscript{2}National Engineering Research Center for Fruits and Vegetables Processing, Beijing 100083
\textsuperscript{3}Beijing Vegetable Research Center, Beijing Academy of Agriculture and Forestry Science, Beijing 100097

In order to find out the effect of enzymatic treatment assisted with high hydrostatic pressure on the properties of pectin and promote the industrial development of this technology, the physicochemical properties, rheological characteristics and molecular structure of pectins de-esterified by this treatment were investigated and compared with enzymatic under atmospheric pressure (E-AP). The main results and conclusions are summarized as follows. The deesterification reaction of enzymatic method was enhanced by high hydrostatic pressure significantly (p<0.05). There was no significant difference (p>0.05) in the degree of esterification, galacturonic acid content and viscous flow activation energy of the pectins prepared by E-HHP and E-AP, while the apparent viscosity of pectins prepared by E-HHP was higher significantly than that by E-AP (p<0.05). It was also showed that HHP-pectin had much higher viscosity and could induce a rapid and homogeneous gelation, leading to the formation of gel with better viscoelastic properties. From the profile of molecular weight distribution and viscosity average molecular weight, E-HHP and E-AP showed no degradation action on the pectin molecular. The composition of chemical groups were not influenced notably by different deesterification methods. From the results of monosaccharide composition and immuno-dot assay, HHP-pectin contained relatively lower amounts of neutral sugar side chains. It could be concluded that high hydrostatic pressure is a highly efficient and novel assistant technique in pectin deesterification.
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<th>Title</th>
<th>Authors</th>
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| 01 - Two effects of compression and swelling in high hydrostatic pressure gelatinization | Wang Chao, Xue Yong, Hu Jinrong and Shen Qun  
China Agricultural University, China; Key Laboratory of Plant Protein and Grain Processing, China; Key Laboratory of Fruit and Vegetable Processing, China | shenqun@cau.edu.cn                                               |
| 02 - Impact of high hydrostatic pressure on the stability and bioaccessibility of betalains and phenolic compounds in prickly pears | Andrea Gómez-Maqueo$^{1,2}$, Sara Lara-Abia$^{1,2}$, Jorge Welti-Chanes$^2$, M. Pilar Cano$^{1,2}$  
(1) Instituto de Investigación en Ciencias de la Alimentación (CIAL), CSIC-UAM, Spain; (2) Tecnologico de Monterrey, Mexico | mpilar.cano@csic.es                                               |
| 04 - High hydrostatic pressure-assisted extraction of carotenoids from papaya (Carica papaya var Maradol) tissues using vegetable oils | Sara Lara-Abia$^{1,2}$, Andrea Gómez-Maqueo$^{1,2}$, Jorge Welti-Chanes$^2$, M. Pilar Cano$^{1,2}$  
(1) Instituto de Investigación en Ciencias de la Alimentación (CIAL), CSIC-UAM, Spain; (2) Tecnologico de Monterrey, Mexico | mpilar.cano@csic.es                                               |
| 05 - Identification of aroma compounds in four Chinese mango juices, and effects of thermal and high-pressure processing on the mango juice aroma profiles | Wentao Zhang$^{1,2,3,4}$, Fei Lao$^{1,2,3,4}$, Xiaojun Liao$^{1,2,3,4}$, Jihong Wu  
(1) China Agricultural University, China; (2) National Engineering Research Center for Fruit and Vegetable Processing, China; (3) Key Laboratory of Fruit and Vegetable Processing, Ministry of Agriculture, China; (4) Beijing Key Laboratory for Food Non-thermal Processing, China | wjhcau@hotmail.com                                               |
| 08 - Effect of high hydrostatic pressure processing on sorption isotherms of fruit peels used as sources of dietary fiber | Viridiana Tejada-Ortigoza$^2$, Luis Eduardo Garcia-Amezquita$^1$, Vinicio Serment-Moreno$^2$, J. Antonio Torres$^3$, Jorge Welti-Chanes$^5$  
(1) Tecnologico de Monterrey, Mexico; (2) Hiperbaric USA | viri.tejada@tec.mx                                               |
<p>| 10 - Effect of high-pressure processing on microbial inactivation of NFC apple juice | Shan Li, Qinqin Chen, Shuyan Li, Shuai Han, Yuanying Ni | China Agricultural University, China |
| <a href="mailto:17801035462@163.com">17801035462@163.com</a> |
| 12 - Selenium distribution in clear and cloudy Se-enriched kiwifruit juices during high hydrostatic pressure and high temperature short time processing | Xinxing Xu¹, Jingjing Deng¹, Dongsheng Luo¹, Yejun Bao¹, Xiaojun Liao¹, Haiyan Gao², Jihong Wu³ |
| (¹) China Agricultural University, China; (²) Shanghai University, China |
| <a href="mailto:wjhcau@hotmail.com">wjhcau@hotmail.com</a> |
| 16 - Effects of high hydrostatic pressure and pasteurization on processing and qualities of fresh pepper sauce | Sijia Peng, Liang Zhao, Xiaojun Liao |
| China Agricultural University, China; National Engineering Research Centre for Fruit and Vegetable Processing, China; Key Laboratory of Fruit and Vegetable Processing, Ministry of Agriculture and Rural Affairs; Beijing Advanced Innovative Center for Food Nutrition and Human Health, China |
| <a href="mailto:liaoxjun@hotmail.com">liaoxjun@hotmail.com</a> |
| 27 - Changes in yield and coagulation time of Oaxaca cheese produced with acidified and non-acidified milk treated with high hydrostatic pressure (HHP) | Rosa Selene Espiricueta-Candelaria, Zamantha Escobedo-Avellaneda, Samantha Calvo-Segura, Cristina Chuck-Hernández |
| Tecnológico de Monterrey, Mexico |
| <a href="mailto:cristina.chuck@tec.mx">cristina.chuck@tec.mx</a> |
| 36 - High pressure processing as elicitor to induces the biosynthesis of bioactive compounds biosynthesis in carrots | Fernando Viacava, Verónica Rodríguez-Martínez, Perla Ramos-Parra, Jorge Welti-Chanes, Daniel A. Jacobo-Velázquez |
| Tecnológico de Monterrey, México |
| <a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a> |
| 43 - Effect of high-pressure processing and heat treatment on the gelation properties of blue crab meat proteins. | Migue Angel Martinez-Maldonado¹, José Alberto Ramírez-de Léon², Jorge Welti³, Ma. Guadalupe Méndez-Montealvo³, Gonzalo Velazquez³ |
| (¹) Instituto Politécnico Nacional. CICATA unidad Querétaro. México; (²) Universidad Autónoma de Tamaulipas, México; (³) Tecnológico de Monterrey, México |
| <a href="mailto:gvelazquezd@ipn.mx">gvelazquezd@ipn.mx</a> |</p>
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<th>Page</th>
<th>Title</th>
<th>Authors</th>
<th>Email</th>
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<tbody>
<tr>
<td>44</td>
<td>Effect of high hydrostatic pressures on aqueous two-phase systems for the extraction of betaxanthins from <em>Stenocereus pruinosis</em></td>
<td>Luisaldo Sandate-Flores¹, José Rodríguez-Rodríguez¹, Gonzalo Velazquez², Karla Mayolo-Deloisa³, Marco Rito-Palomares⁴, J. Antonio Torres⁵, Roberto Parra-Saldívar¹</td>
<td><a href="mailto:r.parra@tec.mx">r.parra@tec.mx</a></td>
</tr>
<tr>
<td>48</td>
<td>Retention of biocomponents of interest to consumers in HPP-treated red fruit juices during their refrigerated storage</td>
<td>E.M. Salinas-Almanza¹*, G. Fernández-Villanueva¹*, K.A. Tapia-Cervantes¹*, J.A. Torres², J.A. Gómez-Salazar¹, M.E. Sosa-Morales¹</td>
<td><a href="mailto:msosa@ugto.mx">msosa@ugto.mx</a></td>
</tr>
<tr>
<td>74</td>
<td>Evaluation of physical and microbiological stability of starch-based hydrogels produced by high pressure processing (HPP)</td>
<td>D. Larrea-Wachtendorff¹, G. Ferrari¹,²</td>
<td><a href="mailto:dlarrea-wachtendorff@unisa.it">dlarrea-wachtendorff@unisa.it</a></td>
</tr>
<tr>
<td>100</td>
<td>HIPEF-processing influence on the in vitro bioaccessibility of isoflavones from a soymilk-based beverage</td>
<td>María Janeth Rodríguez-Roque¹, Rogelio Sánchez-Vega¹, Pedro Elez-Martínez², Olga Martín-Belloso²</td>
<td><a href="mailto:omartin@tecal.udl.es">omartin@tecal.udl.es</a></td>
</tr>
<tr>
<td>26</td>
<td>Time reduction of freeze-drying process &amp; physicochemical characterization of Uchuva (<em>Physalis Peruviana L.</em>) treated by electric field (EF)</td>
<td>Luis Segura-Ponce, Rodrigo Diaz-Álvarez, Johanna Lagos-Aguilera, Saida Llávenes-Valdebenito</td>
<td><a href="mailto:lsegura@ubiobio.cl">lsegura@ubiobio.cl</a></td>
</tr>
<tr>
<td>56</td>
<td>Pulsed electric fields to enhance carotenoids bioaccessibility in low-fat carrot purees</td>
<td>G. López-Gámez, P. Elez-Martínez, O. Martín-Belloso, R. Soliva-Fortuny</td>
<td><a href="mailto:glopezgamez@tecal.udl.cat">glopezgamez@tecal.udl.cat</a></td>
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<tr>
<td>78</td>
<td>Optimization of pulsed electric field treatments for extraction of astaxanthin from <em>Xanthophyllomyces dendrorhous</em></td>
<td>Diederich Aguilar¹,², Carla Delso¹, Juan Manuel Martínez², Lourdes Morales Oyervides³, Julio Montañez³, Javier Raso¹</td>
<td><a href="mailto:diederichaguilarmac@uadec.edu.mx">diederichaguilarmac@uadec.edu.mx</a></td>
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<tr>
<td>85</td>
<td>Effect of high hydrostatic pressure and pulsed electric field on microorganisms, total phenolic content and enzyme activity on a mamey beverage (<em>Pouteria sapota</em>)</td>
<td>Erick Eduardo Cano Monge¹, Iván Alejandro Rico-Alderete¹, Saira Mayret Cano Monge¹, Eduardo Borges², Deyanira Moguel², Jorge Welte-Chanes², Mayra Cristina Soto-Caballero¹, Zamantha Escobedo-Avellaneda³</td>
<td><a href="mailto:zamantha.avellaneda@tec.mx">zamantha.avellaneda@tec.mx</a></td>
</tr>
<tr>
<td>92</td>
<td>Effects of pulsed electric field treatments on cold-pressed extraction and antioxidant capacity of pecan nut oil</td>
<td>L.M. Rábago-Panduro¹, M. Morales-de la Peña¹, O. Martín-Belloso¹, J. Welte-Chanes¹</td>
<td><a href="mailto:A00821713@itesm.mx">A00821713@itesm.mx</a></td>
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<tr>
<td>103</td>
<td>Pasteurization of carrot juice by combining UV-C radiation and heat</td>
<td>Elisa Gayan</td>
<td><a href="mailto:elisgayan@gmail.com">elisgayan@gmail.com</a></td>
</tr>
<tr>
<td>31</td>
<td>UV-C treatments against <em>Salmonella Typhimurium</em> ATCC 14028 in almonds and peanuts</td>
<td>E.F. Meza-Plaza, N.Z. Ramírez-Rojas, K. Ruiz-Hernández, C. García-Mosqueda, M.E. Sosa-Morales</td>
<td><a href="mailto:ezequielmezaplaza@gmail.com">ezequielmezaplaza@gmail.com</a></td>
</tr>
<tr>
<td>39</td>
<td>Low-moisture foods treated with UV-C: inactivation of microorganisms and aflatoxins</td>
<td>C. García-Mosqueda, A. Cerón-García, J.A. Gómez Salazar, M.E. Sosa-Morales</td>
<td><a href="mailto:c.garciamosqueda@ugto.mx">c.garciamosqueda@ugto.mx</a></td>
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</tr>
<tr>
<td>84</td>
<td>Effect of UV-C, UHPH treatments and its combination on the antioxidant and physicochemical properties of apple juice added with chia</td>
<td>Abad Arturo López-Hernández(^1), Ana Sofia Ortega-Villarreal(^1), Artur Xavier Roig-Sagués(^2), Maria Manuela Hernández-Herrero(^2), Jezer Noé Sauceda-Gálvez(^2), Blanca Edelia González-Martínez(^1)</td>
<td><a href="mailto:blanca.gonzalezma@uanl.mx">blanca.gonzalezma@uanl.mx</a></td>
</tr>
<tr>
<td>89</td>
<td>Effects of UVB light, wounding stress and storage time on the biosynthesis of betalains in red prickly pears (<em>Opuntia Ficus-Indica</em> cv. Rojo vigor)</td>
<td>Erika Ortega-Hernández(^1), Vimal Nair(^2), Jorge Welti-Chanes(^1), Luis Cisneros-Zevallos(^2), Daniel A. Jacobo-Velázquez(^1)</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
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<tr>
<td>42</td>
<td>Electrosynthesis approach to improve some functional properties of starches</td>
<td>Julian de la Rosa Millan</td>
<td><a href="mailto:juliandlr@tec.mx">juliandlr@tec.mx</a></td>
</tr>
<tr>
<td>57</td>
<td>Nonthermal, selective deodorization of Concord grape juice for use in premium winemaking</td>
<td>Ana G Ortiz Quezada(^1), Demi M. Perry(^1), David J. Gomes(^2), John Pacheco(^1), Gavin L. Sacks(^1)</td>
<td><a href="mailto:gls@cornell.edu">gls@cornell.edu</a></td>
</tr>
<tr>
<td>58</td>
<td>Non-thermal alternatives assessment for enzymatic processing of enriched-in-Omega-3 fish oil</td>
<td>Rafael Monsiváis-Alonso, Alicia Román-Martínez, Jorge F Toro-Vázquez, Alejandro Rocha-Uribe.</td>
<td><a href="mailto:alicia.romanm@uaslp.mx">alicia.romanm@uaslp.mx</a></td>
</tr>
<tr>
<td>11</td>
<td>Gas chromatography–mass spectrometry combined with multivariate data analysis as a tool for discriminating between orange juice samples according to the processing technique</td>
<td>Shuang Bi, Sicheng Sun, Fei Lao, Xiaojun Liao, Jihong Wu</td>
<td><a href="mailto:wjhcau@hotmail.com">wjhcau@hotmail.com</a></td>
</tr>
<tr>
<td>67 - Influence of alternative sweeteners on the osmotic dehydration of papaya (<em>Carica papaya</em> L.) assisted by power ultrasound: Mass transport kinetics and physicochemical properties of the final product</td>
<td></td>
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<td></td>
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<td>José Isabel Martínez-Castillo¹, Román Cardona-Herrera², Luis Rey Castañeda-Rodríguez³, César Ozuna¹,³</td>
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<td>(1) Universidad de Guanajuato, Mexico; (2) Instituto Tecnológico de la Piedad, Mexico; (3) Universidad de Guanajuato, Mexico</td>
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<tr>
<td>82 - Effect of active packaging with orange blossom essential oil (<em>Citrus aurantium</em>) on the shelf life of corn tortillas</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>A.P. Ibarra Valenzuela, D. López Ortiz, E. Peralta, A.R. Islas Rubio, R. Troncoso Rojas, H. Soto Valdez</td>
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<td>Centro de Investigación en Alimentación y Desarrollo A.C (CIAD), Mexico</td>
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<tr>
<td>94 - Multi-flash autovaporization (MFA) as an innovative deodorization unit operation for vegetable oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colette Besombes¹, Cherif Jablaoui¹, Carmen Téllez-Pérez¹,³, Maritza Alonzo-Macías², Anaberta Cardador-Martínez², Karim Allaf¹</td>
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<tr>
<td>104 - Refrigerated distribution assessment of preservation for nonthermally pasteurized products</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Daniela Gonzalez de la Garza¹, Enrique Martinez Martinez², Veronica Rodriguez Martinez³, Reynaldo de la Cruz Quiroz³, J. Antonio Torres¹</td>
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<td><a href="mailto:dr.j.antonio.torres@gmail.com">dr.j.antonio.torres@gmail.com</a></td>
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Two effects of compression and swelling in high hydrostatic pressure gelatinization (01)

Wang Chao, Xue Yong, Hu Jinrong and Shen Qun

College of Food Science and Nutritional Engineering, China Agricultural University, Beijing, 100083, China Key Laboratory of Plant Protein and Grain processing, Beijing, 100083, China National Engineering Research Center for Fruit and Vegetable Processing, Key Laboratory of Fruit and Vegetable Processing, Beijing, 100083, China

In this study, we aimed to determine the mechanism of high hydrostatic pressure (HHP) gelatinization. That is, whether HHP gelatinization can keep starch granules intact or not comparing with heat gelatinization. We investigated the changes in starch granule size, specific surface area and porosity, and swelling factors of HHP- (HHGS) and heat-gelatinized rice starch (HGS) at a similar degree of gelatinization (DG) by using scanning electron microscope, a laser diffraction particle size analyzer, low-temperature N adsorption/desorption and ultraviolet spectrophotometer. Results showed that HHGS and HGS swelled and collapsed, pore diameters increased, and specific surface area decreased as gelatinization proceeded. However, under similar DG, the extent and the speed of distortion of HHGS were smaller than those of HGS, the pore structure of HHGS was comparatively denser, and the swelling factors of HHGS were larger than that of HGS. HHP gelatinization possesses simultaneous compression and swelling.
Impact of high hydrostatic pressure on the stability and bioaccessibility of betalains and phenolic compounds in prickly pears (02)

Andrea Gómez-Maqueo1,2, Sara Lara-Abia1,2, Jorge Welti-Chanes2, M. Pilar Cano1,2*

1Departamento de Biotecnología y Microbiología de Alimentos, Instituto de Investigación en Ciencias de la Alimentación CIAL (CSIC-UAM), Madrid, Spain. 2Tecnologico de Monterrey, Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, Monterrey, NL, Mexico.

High hydrostatic pressure promotes the release of betalains and phenolic compounds in prickly pears and may enhance their antioxidant and anti-inflammatory activities (Gómez-Maqueo, García-Cayuela, Welti-Chanes & Cano, 2019). However, ultrastructural changes made to the food matrix during pressurization such as modifications to microfibrilated cellulose, mucilage, pectin and other macronutrients may further influence their bioaccessibility. An adaptation of the INFOGEST protocol (Brodkord et al., 2019) for in-vitro gastrointestinal simulations was used to assess the stability and bioaccessibility of betalains and phenolic compounds in pressurized red-skin and purple-skin prickly pears (350 MPa/5 min/20°C and 600 MPa/CUT/20°C). Betalains and phenolic compounds were quantified in each digestive phase by high performance liquid chromatography (HPLC-DAD-MS/MS) and further observed by optical and confocal laser scanning microscopy (CLSM). Betalains were most susceptible to degradation in the oral + gastric phase due to low pH conditions, where indicaxanthin presented a higher stability than betanin. The bioaccessibility of isorhamnetin glycosides was significantly improved (2-fold) in pulps when processed at 600 MPa/CUT/20°C compared to the control. Microscopical analysis of the digestive phases showed that due to the microstructural modification of the cell walls during pressurization, phenolic compounds were more easily released into the medium during digestion. Piscidic acid presented no significant differences regarding stability, however, pressurization exerted a beneficial effect on its bioaccessibility. Finally, in HHP-treated prickly pears, betalain and phenolic compounds were more bioaccessible because of the modification of secondary constituents in the food matrix. High hydrostatic pressure and other non-thermal technologies should be deeply explored for the future development of vegetable-based functional foods with proven health benefits.
High hydrostatic pressure-assisted extraction of carotenoids from papaya (Carica papaya var Maradol) tissues using vegetable oils (04)

Sara Lara-Abia¹ 2, Andrea Gomez-Maqueo¹ 2, Jorge Welti-Chanes¹, M. Pilar Cano¹ 2

¹Departamento de Biotecnología y Microbiología de Alimentos, Instituto de Investigación en Ciencias de la Alimentación CIAL (CSIC-UAM), Madrid, Spain. ²Tecnológico de Monterrey, Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, Monterrey, NL, México

High hydrostatic pressure increases the permeability of vegetable cells allowing solvent diffusion and increasing the extraction of bioactive compounds such as carotenoids. Carotenoids are integrated in chromoplasts within the cell, making their extraction relatively difficult. The objective of this work was the use of high hydrostatic pressure-assisted extraction (HHPE) using vegetable oils (green solvents) to extract carotenoids from papaya tissues in order to obtain antioxidant-rich oils using a bio-refinery concept. Soybean oil and sunflower oil were used as green solvents and the effects of temperature, pressure and time (20-40°C, 300-500 MPa and 2-8 min) on the extraction yield were studied applying a central composite design. The solid/oil ratio was established as 2/10 (g/mL). Carotenoids and carotenoid esters were analysed by high performance liquid chromatography (HPLC-DAD-MS/MS) in non-saponified extracts. Response surface design methodology was used for the optimization of carotenoid extraction. The main carotenoids found in papaya extracts were lycopene, γ-carotene and β-carotene and xanthophyll esters. In HHPE, we observed that the carotenoid extraction efficiency improved with increasing pressure. Colorimetric determinations (CIE L*a*b*) showed a positive significant correlation with carotenoid content. We expect to contribute to the further exploration of high hydrostatic pressure-assisted extraction of carotenoid-rich matrices for the obtaining of functional ingredients of high quality and improved functional characteristics through the use of green solvents.
Identification of aroma compounds in four Chinese mango juices, and effects of thermal and high-pressure processing on the mango juice aroma profiles (05)

Wentao Zhang\textsuperscript{a,b,c,d}, Fei Lao\textsuperscript{a,b,c,d}, Xiaojun Liao\textsuperscript{a,b,c,d}, Jihong Wu\textsuperscript{a,b,c,d}

\textsuperscript{a} College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China. \textsuperscript{b} National Engineering Research Center for Fruit and Vegetable Processing, Beijing 100083, China. \textsuperscript{c} Key Laboratory of Fruit and Vegetable Processing, Ministry of Agriculture, Beijing 100083, China. \textsuperscript{d} Beijing Key Laboratory for Food Non-thermal Processing, Beijing 100083, China

Volatile components, especially the aroma active components, impact the overall flavor profile of mango strongly. Identification of aroma active components and study the effect of processing on aroma compounds is significant for controlling the flavor quality of the mango products. The volatile compounds and aroma active components of four cultivars of mango juices, namely Tainong, Xiangya, Keitt, and Pingguo, which were harvested in Sichuan province, China, were studied. Compounds were identified by solid phase microextraction-gas chromatography-mass spectrum/olfactometry (SPME-GC-MS/O) and odor activity value (OAV). In addition, changes of Keitt mango juice aroma profiles after pasteurization and ultra-high-pressure (UHP) processing were further investigated. The electronic nose and electric tongue were applied to discriminate the overall aroma of different cultivars and processing. Sixty-seven components were identified in four cultivars of mango juices, including monoterpenes, lactones, aldehydes (C6 and C9 aldehydes), alcohols, and acids. Twenty-two aroma compounds, such as β-myrcene, (E)-2-hexenal, (E)-2-nonenal, (Z)-3-hexenol, geraniol, (E)-β-ionone, ethyl butyrate, and γ-lactone, were characterized as primary mango aroma contributors by odor activity value (OAV) and frequency detection analysis (FDA). Pasteurization diminished C9 key mango aroma compounds significantly (p<0.05), such as (E,Z)-2,6-nonenadienal and (E)-2-nonenal. UHP had shown to have various effect on terpenoids. For example, compared to fresh juice, 3-carene, terpinolene and caryophyllene in the UHP juice increased significantly (p<0.05) while β-myrcene and D-limonene decreased significantly. Fresh juice, pasteurized juice and UHP juice could be distinguished efficiently by electronic nose and electronic tongue, suggesting that electronic nose and tongue have great potential could be served as options to distinguish juices undergone different processing. This current work is of great significance for identification of mango cultivars and processing methods by volatile components and aroma active components, as well as controlling of flavor quality in mango juice processing.
Effect of high hydrostatic pressure processing on sorption isotherms of fruit peels used as sources of dietary fiber (08)

Viridiana Tejada-Ortigoza¹, Luis Eduardo Garcia-Amezquita², Vinicio Serment-Moreno³, J. Antonio Torres⁴, Jorge Welti-Chanes⁴

¹ Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Santiago de Querétaro QRO 76130, Mexico. ² Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, General Ramón Corona 2514, Zapopan, JC, Mexico, 45138. ³ Hiperbaric USA, 2250 NW 84th Ave Unit 101, Miami, FL 33122. ⁴ Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Centro de Biotecnología FEMSA, Monterrey NL 64849, Mexico

Orange, mango, and prickly pear peels are potential food fiber formulation sources with differentiated hygroscopic and functional properties. High hydrostatic pressure (HHP) treatments can improve the potential of these peels as food formulation fiber sources. HHP (600 MPa/10 min/22 and 55°C) effects on moisture isotherms expressed as relative water sorption content change with respect to controls (RWSCaw) showed that in the 0.1 0.93 aw range HHP improved the adsorption water retention of orange peels. The same was true for the desorption water retention for all HHP treated fruit peels except for prickly pear HHP treated at 22°C and >0.35 aw. The area under the hysteresis curve (AH) in the 0.15 0.51 aw range showed that HHP increased hysteresis for all fruit peels tested. All this illustrates the HHP potential to modify the hygroscopic properties of fruit peels with the advantage of shorter processing times and lower temperatures than conventional technologies used to treat food fibers.
Effect of high pressure processing on microbial inactivation of NFC apple juice (10)

Shan Li, Qinqin Chen, Shuyan Li, Shuai Han, Yuanying Ni*

College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China

More and more attention has been paid on the NFC juices in recent years, especially the NFC apple juices is more popular in the market. To maintain the nutritional and functional properties of NFC apple juices, high pressure processing (HPP) is widely used in the industry. To explore the microbial inactivation effect of HPP on NFC apple juices, the numbers of total bacteria, mold and yeast in NFC apple juices were measured after high pressure treatment at 300, 400, 500 or 600 MPa for 5, 10, 15, 20 min and 25 min, respectively. The results showed that the bactericidal effect was significantly improved with the increase of pressure level and pressure-holding time. Mold and yeast were more sensitive to high pressure and could be inactivated at 500 MPa for 5 min. The Weibull model was used to fit the survival curve of microorganisms. The correlation coefficients ($R^2$) were more than 0.900 determined at four pressure levels, which proved that Weibull model was suitable for the kinetic analysis of microbial inactivation. The values of scale factor b in the model were increased with the increase of pressure, while the values of shape factor n were stable in the pressure range of 400 to 600 MPa.
Selenium distribution in clear and cloudy Se-enriched kiwifruit juices during high hydrostatic pressure and high temperature short time processing (12)

Xinxing Xu1, Jingjing Deng1, Dongsheng Luo1, Yejun Bao1, Xiaojun Liao1, Haiyan Gao2, Jihong Wu1*

1 College of Food Science and Nutritional Engineering, China Agricultural University, Beijing, China. 2 School of Life Sciences, Shanghai University, Shanghai, China

Se-enriched kiwifruit juice is a promising Se-enriched beverage product which has high nutrition and economic value. Se distribution was investigated and a comparative study was carried out into the effects of high hydrostatic pressure (HHP) and high temperature short time (HTST) treatments on quality for both clear and cloudy Se-enriched kiwifruit juice (clear-SKJ, cloudy-SKJ). Organic Se which accounted for 62.32% has a wider distribution than inorganic Se in kiwifruits and mainly comprising Se-protein and Se-polysaccharide. The process of separating kiwifruit pomace from juice caused significant decline in Se content with 43.07% and 49.04% in cloudy and clear juices respectively, and the sterilization process of HHP and HTST significantly decreased the Se contents from 50.46 ± 0.42 μg/kg to 39.63 ± 0.51 μg/kg and 37.93 ± 0.08 μg/kg in cloudy-SKJ, respectively. During the storage period, HTST- and HHP-processed juices showed no significant differences in total Se content. The results obtained underline the different effects of HHP and HTST on quality and storage stability of Se retention, microorganisms, color, total phenols, chlorophyll and other quality-related aspects. This study may provide technical support for the application of HHP or HTST in the Se-enriched kiwifruit juice industry. Furthermore, a non-thermal technique which can improve functional juice properties to meet the demand of consumers for healthier products is provided in this study.
Effects of high hydrostatic pressure and pasteurization on processing and qualities of fresh pepper sauce (16)

Sijia Peng, Liang Zhao, Xiaojun Liao

College of Food Science and Nutritional Engineering, China Agricultural University, National Engineering Research Centre for Fruit and Vegetable Processing, Key Laboratory of Fruit and Vegetable Processing, Ministry of Agriculture and Rural Affairs, Beijing Advanced Innovative Center for Food Nutrition and Human Health, Beijing, China

Changes in microorganisms and qualities of fresh pepper sauce were assessed after high pressure processing (HPP) at 400 MPa/5 min, 500 MPa/5 min and pasteurization at 80°C/2 min in this study. The effect of microorganisms was determined by total plate count method. And the determination of total phenol, ascorbic acid and capsaicinoids content were Folin-Ciocalteu and HPLC method, respectively. The aerobic plate count was decreased by 3.41, 3.56 and 3.27 log10CFU/mL after 400 MPa/5 min, 500 MPa/5 min and pasteurization treatment, separately the yeast and molds were not detected after HPP and decreasing to 0.83 log10CFU/mL after pasteurization. The fresh pepper sauce processed by HPP could maintain better color and suspension stability compared with pasteurization sauce, retained higher level of total phenol, ascorbic acid, capsaicin and dihydrocapsaicin. During 28 days of storage at 4°C, the count of microorganisms grew up, however the HHP-treated fresh pepper sauce was lower than pasteurization samples which exceeded the minimum acceptable standard 3.18 log10CFU/mL at the 21th day. HPP-treated fresh pepper sauce showed better qualities than pasteurization sauce with 3.34%-11.90% higher than that of pasteurization treatment in total phenol, 4.45%-9.27% higher in ascorbic acid, 10.82%-12.34% higher in capsaicin, and 8.09%-8.5% higher in dihydrocapsaicin. Therefore, HPP effectively retained the quality of the fresh pepper sauce.
Changes in yield and coagulation time of Oaxaca cheese produced with acidified and non-acidified milk treated with High Hydrostatic Pressure (HHP) (27)

Rosa Selene Espíricueta-Candelaria, Zamantha Escobedo-Avellaneda, Samantha Calvo-Segura and Cristina Chuck-Hernández

Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Eugenio Garza Sada 2501. Col. Tecnológico. Monterrey, N.L. Mexico. Phone: +52(81)83581400 ext. 4895. E-mail: cristina.chuck@tec.mx

Oaxaca cheese is a fresh cheese produced from unpasteurized cow milk originated from Mexico. It is obtained by the pasta filata method in which the curd is immersed in hot water (50-75°C/10-60 min) to stretch it making strands2,3. Due to economic reasons, the cheese industry is interested in increasing the product yield while reducing coagulation time (CT). In this work, the changes induced in Oaxaca Cheese when using HHP (150 and 500 MPa, 10 and 30 min) in milk before or after acidification (20 and 42°C, respectively) were evaluated. The effects on CT, cheese yield (CY), melting point (MP), microstructure and general composition are presented. Acidified milk showed CT 66% lower when compared to the non-acidified milk, whereas the higher the pressure level, the higher the CT with 90s at 500MPa/30min compared with 18s in the control. The use of HHP on non-acidified milk had a negative effect on CY: a non-treated milk yielded 11% its weight in cheese while HHP-treated milk ranged from 5.8 to 9.5%. Cheese made with milk treated at 500 MPa/30 min decreased 47% its fat content when acidified milk was used and 12% for the non-acidified counterpart, compared to control cheese. MP measured by DSC was not affected by the different treatments applied. CLSM was used to study the microstructure of cheese. Results showed a decrease in size of the fat globules in 500MPa/10 and 30 min treatments. The CT increase and fat content decrease with HHP, suggests modification in the structure of milk proteins. HHP treatment in milk before Oaxaca cheese manufacturing is detrimental at 300 and 500MPa with 10 and 30 min treatments. It has a negative effect on CY, fat content and CT. It is recommended to explore lower pressure and time levels in order to obtain better results.
High pressure processing as elicitor to induce the biosynthesis of bioactive compounds biosynthesis in carrots (36)

Fernando Viacava¹, Verónica Rodríguez-Martínez², Perla Ramos-Parra², Jorge Welti-Chanes², Daniel A. Jacobo-Velázquez¹

¹Tecnológico de Monterrey, Campus Guadalajara, México. ²Tecnológico de Monterrey, Centro de Biotecnología FEMSA, México

Nonthermal technologies such as high-pressure processing (HPP) are tools to prevent microbial and enzymatic spoilage of food and commonly applied between 300 – 600 MPa. However, the effect of milder hyperbaric treatments (<150 MPa) as abiotic stress remains unexplored. The objective of this work was to determine the effect of HPP on the accumulation of carotenoids, free and bound phenolics in carrots. Whole carrots were treated using 2 HPP intensities (60 and 100 MPa) applied as come-up-time (CUT), 2, 3, 4 and 5 pulses (P) and for 5 min. HPP-treated samples were stored at 15°C for 48 h, to determine the immediate (0 h) and late effects (48 h) of the treatments. Chlorogenic acid and caffeic acid were the major free and bound phenolics identified in carrots, respectively. As an immediate response, 60MPa/4P treatment exhibited the highest increment in concentration of chlorogenic (45.65%) and caffeic (34.28%) acids as compared with the control. As a late response, 60 MPa/4P treatment showed highest accumulation of chlorogenic acid (16.96%), whereas 100 MPa/5 min treatment showed increment in caffeic acid (34.28%) as compared with control samples. Regarding carotenoids, as an immediate response, carrots processed at 60 MPa/3P showed increases in lutein (18.63%), while samples processed at 60 MPa/4P showed increases in α-carotene (4.8%) and β-carotene (10.68%) as compared with the controls. Accumulation of α-carotene (7.09%) and β-carotene (20.27%) was also observed after storage of carrots treated at 100 MPa/3P, whereas increment in lutein (11.75%) was detected in samples treated at 100 MPa/3P. Results suggest that applying multi pulse HPP in carrots favors the extractability and biosynthesis of health-promoting compounds in whole carrots.
Effect of high-pressure processing and heat treatment on the gelation properties of blue crab meat proteins

Miguel Angel Martinez-Maldonado, José Alberto Ramírez-de Léon, Jorge Welti, Ma. Guadalupe Méndez-Montealvo, Gonzalo Velazquez

1 Instituto Politécnico Nacional. CICATA unidad Querétaro. Cerro Blanco 141. Colinas del Cimatario, CP 76090. Santiago de Querétaro, Querétaro, México.

2 Dirección General de Innovación Tecnológica, Universidad Autónoma de Tamaulipas. Edificio Centro de Excelencia, Centro Universitario. CP 87040, Ciudad Victoria, Tamaulipas, México.

3 Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, NL, Mexico

This study was carried out to evaluate the effect of high pressure processing (HPP) on the gelation of blue crab proteins. Crab meat proteins were HPP treated at 100, 300 and 500 MPa (10°C/5 min) with and without previous heating (90°C/20 min). The treated samples were analyzed using differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR) and dynamic rheometry measurements and the protein interactions were also studied. Protein gelation after HPP is based on physical (non-covalent) interactions which increases the availability of ionic and hydrophobic bonds, meanwhile thermal gelation is based on the formation of covalent (disulfide) bonds. DSC showed that HPP treatments resulted in a reduction of the myosin denaturation temperature (Tpeak) indicating protein unfolding. FTIR results indicated that the secondary protein structures exhibited a reduction in α-helix along with an increase in β-sheet as a result of the protein denaturation caused by pressure. The combination of HPP and heating stabilized the protein network in the protein gels from blue crab meat.
Effect of high hydrostatic pressures on aqueous two-phase systems for the extraction of betaxanthins from *Stenocereus pruinosus* (44)

1Luisaldo Sandate-Flores, 1José Rodríguez-Rodríguez, 2Gonzalo Velazquez, 1Karla Mayolo-Deloisa, 3Marco Rito-Palomares, 1J. Antonio Torres**, 1Roberto Parra-Saldívar*

1Tecnologico de Monterrey, School of Engineering and Sciences, FEMSA Biotechnology Center, Avenida Eugenio Garza Sada 2501, Monterrey, NL, 64849 México. 2Instituto Politécnico Nacional, CICATA Unidad Querétaro, Cerro Blanco 141, Santiago de Querétaro, QRO, 76090 México. 3Tecnologico de Monterrey, Escuela de Medicina y Ciencias de la Salud, Av. Ignacio Morones Prieto 3000, Sertoma, Monterrey, NL, 64710 México.

Pitaya (*Stenocereus pruinosus*), a native fruit of Mexico, has high betaxanthins (yellow) and lower betacyanins (red) content. Betalains extractions have been carried out using aqueous two-phase systems (ATPS). High hydrostatic pressure (HHP) assisted extraction have been used to obtain antioxidant and pigments preparations. This work focuses on two process alternatives to increase pigment yield by combining HHP (400-600 MPa, 25°C, come up time (CUT) and 3 min) and a previously optimized ATPS (polyethylene glycol (MW 1000; PEG1000), phosphate salts (KH$_2$PO$_4$ and K$_2$HPO$_4$), 45% tie line (TLL), 33% phase volume ratio ($V_r$), 10% crude extract percentage). The two alternatives were: 1) Apply ATPS on an HPP-pretreated pitaya extract (HPP+ATPS); 2) Conduct ATPS of the same pitaya extract under HPP (HPP-assisted ATPS). Betaxanthin yield ($Y_{betaxanthins}$) and sugar yield ($Y_{sugars}$) in the top phase (control, ATPS optimized under atmospheric pressure) were 64±0.01 and 5.5±0.01, respectively. Multivariate analysis of variance (MANOVA, $\alpha=0.05$) showed that pressure and process were statistically significant (P<0.05) whereas HPP time was not (P>0.05). Using HPP-assisted ATPS and HPP+ATPS, an increase with respect to the control was observed in $Y_{betaxanthins}$ ranging from 3 to 14%. A second MANOVA was carried out with the two best conditions (maximum $Y_{betaxanthins}$ and minimum $Y_{sugars}$ in the top phase) and control showing that $Y_{betaxanthins}$ and $Y_{sugars}$ in top and bottom were statistically significant (P<0.05) with an increase in $Y_{betaxanthins}$ observed when HHP is used. However, $Y_{sugars}$ also increased so this extraction combination should be used in applications where sugar content is not important (e.g., beverage industry).
Retention of biocomponents of interest to consumers in HPP-treated red fruit juices during their refrigerated storage (48)

E. M. Salinas-Almanza1, G. Fernández-Villanueva1, K. A. Tapia-Cervantes1, J.A. Torres2, J.A. Gómez Salazar1, M. E. Sosa-Morales1

1Departamento de Ingeniería en Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, México. 2 Tecnológico de Monterrey, México

High hydrostatic pressure (HHP) treatments at 400-600 MPa and refrigeration or moderate (<45°C) temperature inactivate enzymes such as pectin methyl esterase (PME) and reduce microbial counts, while retaining the physicochemical and sensory characteristics of fruit juices. This critical review focuses on the preservation of biocomponents of HHP-treated red juices to support juice producer claims meeting the consumer demand for healthy, nutritious, and “natural” products. Biocomponents found in red fruits include phenolic compounds with strong antioxidant activity and can prevent cancer and other deteriorative processes. Anthocyanins are water-soluble glycosides, which appear orange, red, blue or purple depending on pH, oxygen presence and temperature. Vitamin C (ascorbic and dehydroascorbic acids) is a water-soluble vitamin, valuable for its antioxidant activity and stimulation of the immune system. Effects of HHP on total phenolics content, anthocyanins or vitamin C have been evaluated mainly in pomegranate and strawberry juices, and in mixed juices, during cold storage studies typically conducted at 4°C. In general, HHP treatments did not affect biocomponents in these red fruit juices. However, refrigerated storage is a key factor affecting their retention after HHP treatment. Future research should focus on the preservation of these components during the shelf-life of HHP-treated juices under realistic cold storage conditions. For instance, the investigation of vitamin C retention has been followed in pasteurized orange juice stored in a residential refrigerator. Variables as compressor technology, ambient temperature, refrigerator load, door openings and removal for consumer use affect the retention of this quality indicator. In addition, interactive intelligent displays should be developed to encourage consumers to lower temperature settings and reduce the frequency and time-length of door openings.
Evaluation of physical and microbiological stability of starch-based hydrogels produced by high pressure processing (HPP) (74)

Larrea-Wachtendorff, D; Ferrari, G

1Department of Industrial Engineering, University of Salerno, Fisciano (SA), Italy 2ProdAl Scarl, Fisciano (SA), Italy dlarrea-wachtendorff@unisa.it

The aim of this work was to evaluate the physical and microbiological stability of starch-based HPP hydrogels using conventional and accelerated methods. To this purpose, rice, wheat, corn and tapioca HPP hydrogels, packaged in flexible pouches, were stored at 20 °C for three months. Appearance, water holding capacity, water activity (a_w), swelling power, colour, textural properties and total count were measured every 4 weeks. Rheological measurements and temperature cycling tests were also carried out to predict the physical stability of starch-based hydrogels in accelerated conditions. The stability of starch-based hydrogels was strongly influenced by microbiological contamination. Rice HPP hydrogels did not show any modifications of microbial count during storage (<1 log CFU/g), whereas wheat HPP hydrogels showed a microbial load up to 3 log CFU/g after the third month of storage. Corn and tapioca HPP hydrogels showed a microbial load of 4 log CFU/g after the second month of storage and of 5 log CFU/g after the first month of storage, respectively. The latter samples evidenced important organoleptic modifications with a slight reduction of the swelling stability. However, corn, rice and wheat HPP hydrogels did not exhibit any change of firmness during storage while tapioca HPP hydrogels evidenced a strong firmness reduction (1.36 N to 0.38 N) after the first month of storage, as a consequence of the increase of the microbial population. Accelerated methods demonstrated different network strength of starch-based HPP hydrogels (tapioca > corn > wheat > rice). Textural properties of samples were influenced by temperature cycling test with a reduction of firmness values (tapioca > rice > corn > wheat). Temperature stress tests allowed to conclude that phase separation occurred at 58°C in corn HPP hydrogels, at 54 °C in rice and wheat HPP hydrogels and at 46 °C in tapioca HPP hydrogels. In conclusion, accelerated methods could provide, in a short period compared to conventional methods, useful information on the physical stability of gel structures. Further investigations on the microbiological stability should be planned and completed to draw more relevant conclusions.
HIPEF-processing influence on the in vitro bioaccessibility of isoflavones from a soymilk-based beverage (100)

María Janeth Rodríguez-Roque\textsuperscript{a}, Rogelio Sánchez-Vega\textsuperscript{b}, Pedro Elez-Martínez\textsuperscript{c} and Olga Martín-Belloso\textsuperscript{c}

\textsuperscript{a}Faculty of Agrotechnological Sciences, Autonomous University of Chihuahua. \textsuperscript{b}Faculty of Zootechnics and Ecology. Autonomous University of Chihuahua, Chihuahua, México. \textsuperscript{c}Department of Food Technology, University of Lleida, Lleida, Spain.

Functional beverages are receiving increasing consumer attention because they naturally provide a great variety of health-promoting compounds such as isoflavones. High-intensity pulsed electric fields (HIPEF) is a non-thermal food preservation technology that has been developed for obtaining products with high stability, as well as improved nutritional, healthy and tasty features. On the other hand, nutrients must be released from the food matrix into the gastrointestinal tract once ingested, and thus become available for intestinal absorption (bioaccessibility). Bioaccessibility is usually evaluated through in vitro gastrointestinal digestion by representing a useful and fast approach. Even though the impact of processing on soymilk isoflavones has been investigated, there is scarce information dealing with non-thermal processing influence on isoflavone bioaccessibility. This research aimed evaluating the effect of HIPEF processing (35 kV/cm with 4μs bipolar pulses at 200 Hz for 1800μs) on the concentration and bioaccessibility of isoflavones from a soymilk and fruit juice (orange, kiwi, pineapple and mango) beverage before and after being subjected to in vitro gastrointestinal digestion (gastric phase: pepsin and pH=2; and intestinal phase: pancreatin-bile solution and pH=7.5). The concentration of glucosides (daidzin, genistin and glycitin) from HIPEF processed beverage showed increases between 9.02 and 25.32% as compared with untreated beverage. On the other hand, daidzein was the unique aglycone that showed a statistically significative increment in its concentration after HIPEF processing (2.96%) with respect to untreated beverage. HIPEF-beverages displayed higher bioaccessibility of the glucosides daidzin (31.3%) and genistin (31.82%) in comparison with untreated beverages (26.13 and 23.5%, respectively). The bioaccessibility of aglycones genistein, daidzein and glycitein from untreated beverages was 30.39, 33.70 and 32.97%, respectively; while in HIPEF treated beverages reached up to 45.27%. These results demonstrate that HIPEF processing is a suitable technology for obtaining high quality and nutritious beverage by improving the isoflavone bioaccessibility from a soymilk-based beverage.
Time reduction of freeze-drying process & physicochemical characterization of Uchuva (*Physalis Peruviana I.*) treated by Electric Field (EF) (26)

Luis Segura-Ponce, Rodrigo Díaz-Álvarez, Johanna Lagos-Aguilera, & Saida Llévenes-Valdebenito

*Food Engineering Department, Universidad del Bío-Bío, P.O. Box 447, Chillán, Chile*

Vacuum freeze-drying (VFD) process allows obtaining high-quality food products. However, its use in fruits with thick peel such as blueberries, cherries and Uchuvas, among others produce shrinkage, long operating times and loss of quality. Electric field (EF) is a new technology that could be used to solve these kinds of problems. The aim of this study was to evaluate the effect of EF pretreatment on the freeze-drying kinetics, and physical and nutritional properties of freeze-dried Uchuvas. Uchuvas samples were pre-treated at constant electric field strength (12 kV/cm) and at two operational times (45 and 50 s) and then freeze-dried until a constant weight at two vacuum pressure (0.1 and 0.021 mBar). Sample weight and freeze-drying time were recorded during all the process by a balance located inside of the Lab. VFD equipment. Freeze drying curves, drying kinetics, shrinkage, nutritional content, color, texture and rehydration capacity were measured to evaluate the effectiveness of the whole process. Main results as follows: freeze-dried times of Uchuvas EF treated were reduced in 29% compared with not treated samples; Uchuva shrinkage was diminished in samples EF treated. Minimum color difference was obtained for the treatment of 45 s of EF and 0.1 mBar. Higher values of phenols content were reached with the for the treatment of (50 s of EF and 0.021 mBar. Application of EF improves the efficiency of freeze-drying process and the quality of the dried Uchuvas and could be used in other products with thick peel.
Pulsed electric fields to enhance carotenoids bioaccessibility in low-fat carrot purees (56)

López-Gámiz, G., Elez-Martínez, P., Martín-Bellosa, O., Soliva-Fortuny, R.

*University of Lleida, Department of Food Technology, Av. Alcalde Rovira Roure, 191, Spain*

Carrots are an excellent source of carotenoids; however, these antioxidant compounds must be first released from the food matrix to exert their positive effects. Pulsed electric fields (PEF) is a nonthermal technology that may facilitate the disruption of cell membranes, thus leading to the release of carotenoids during digestion. Besides, oil presence may enhance their solubilization into micelles, hence improving their bioaccessibility. The aim of this study was to assess the effect of PEF application and oil addition on the content and bioaccessibility of carotenoids in carrot purees. Purees were produced by blending carrot pieces with water [1:1 (w/w)]. Different purees were obtained depending on the stage at which PEF treatments (5 pulses of 3.5 kV·cm⁻¹) were applied: 1) PEF-treated purees with 5%(w/w) added olive oil; 2) purees with added olive oil obtained from PEF-treated whole carrots; 3) purees without added oil obtained from PEF-treated carrots. Carrot purees were subjected to in vitro digestion and carotenoid content was determined by HPLC. Additionally, particle size was measured in each puree. ANOVA and Tukey test were used to compare treatment mean values (α=0.05). Purees obtained by crushing PEF-treated carrots exhibited similar carotenoid content than those untreated. However, carotenoid content in PEF-treated purees doubled that found in untreated purees. This increase is probably due to a greater damage to cell membranes promoted by a combination of blending and electroporation. The highest bioaccessibility was also obtained in PEF-treated purees (9.36±0.54%). Increased bioaccessibility is likely due to structural modifications, as suggested by the reduction of particle size (D=4.67±0.55μm), and better release of carotenoids from cells. These changes along with oil presence would favor carotenoids micellarization. Results suggest that PEF treatments are more effective when applied to carrot purees than to whole carrots in order to promote carotenoids extractability and bioaccessibility.
Optimization of pulsed electric field treatments for extraction of astaxanthin from Xanthophyllumyces dendrorhous (78)

Diederich Aguilar¹,², Carlota Delso¹, Juan Manuel Martínez¹, Lourdes Morales Oyervides², Julio Montañez², Javier Raso¹

¹Food Technology, Facultad de Veterinaria, Universidad de Zaragoza, Spain. ²Department of Chemical Engineering, Universidad Autónoma de Coahuila, México.

Carotenoids are lipophilic pigments with widely industrial applications. Xanthophyllomyces dendrorhous produces high yields of carotenoids, being astaxanthin a high value-added molecule with broad applications in food and pharmaceutical sectors. This yeast has an indigestible and rigid cell wall that makes it difficult for the extraction of intracellular compounds. Recent studies have demonstrated that PEF-electroporation followed by aqueous incubation of the cells triggers an enzymatic process that facilitates the extraction of these compounds. The objective of this work was to establish the PEF-treatment conditions to achieve the maximum carotenoid extraction with the lowest energy requirements. X. dendrorhous ATCC 74219 was cultured in potato-dextrose broth at 25 °C for 6 days. Central Composite Design was applied to evaluate the effect of treatment time (60-140 μs), temperature (20-40 °C), electric field strength (15-25 KV cm⁻¹) and pH (4-7) on cells inactivation. The conductivity of treatment media was adjusted to 1 mS cm⁻¹ and the inactivation was quantified by the plate count of surviving cells. After the treatments, cells were incubated in McIlvaine buffer (pH 7) at 25 °C for 12 h. Finally, PEF-treated and untreated cells were resuspended in ethanol during 24 h for carotenoids extraction. The effect of PEF treatment conditions on the inactivation and carotenoids extraction was determined. The inactivation of X. dendrorhous ranged between 0.008 to 3.11 log reduction under the conditions evaluated. According to the ANOVA (Data not shown), the linear contributions of all evaluated factors and the quadratic contribution of the temperature presented a significant effect (p<0.05) on the inactivation of the cells. The obtained model presented a good correlation coefficient (R²=0.89). This model was used to select the required PEF conditions to achieve 0.5, 1.0 and 2.0 of inactivation cycles in order to determinate the effect of the inactivation degree in the carotenoids extraction. It can be seen that, the extraction is 40.0 % higher using 1.0 log cycle reduction than 0.5. However, the extraction using 2.0 log cycle was only 7.0 % higher than 1.0. Such extraction increment is not as high to justify the additional energy required. The PEF treatment of 16 kV cm⁻¹, 140 μs at 20 °C and pH4, resulted in 1.0 log reduction with the highest carotenoid extractability (75%) considering the lowest energy consumption.
Effect of high hydrostatic pressure and pulsed electric field on microorganisms, total phenolic content and enzyme activity on a mamey beverage (*Pouteria sapota*) (85)

Erick Eduardo Cano Monge¹, Iván Alejandro Rico-Alderete¹, Saira Mayret Cano Monge¹, Eduardo Borges², Deyanira Moguel², Jorge Welti-Chanes², Mayra Cristina Soto-Caballero³, Zamantha Escobedo-Avellaneda²

¹Facultad de Ciencias Agrotecnológicas, Universidad Autónoma de Chihuahua, Mexico. ²Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Mexico

Mamey (*Pouteria sapota*) is a tropical fruit mainly consumed as fresh product. It is highly prized for its flavour, texture, colour, nutritional and antioxidant compounds. The acceptance of mamey on the worldwide market is growing. High hydrostatic pressure (HHP) and pulsed electric field (PEF) can be used as alternatives to thermal treatments to increase the shelf-life of mamey products without causing significant changes in general quality. A beverage prepared with mamey pulp was treated by HHP (400, 500 and 600 MPa during the come-up time (CUT), 2, 5 and 10 min) and PEF (50 and 100 Hz at 15, 20 and 25 μs). Immediately after treatments, the native microorganisms, mould and yeasts, total phenolic content, and pectinmethylesterase (PME) and polyphenoloxidase (PPO) were evaluated. Most HHP treatments conditions were equally effective to destroy native microorganisms in the beverage achieving about 6 log reduction, while PEF inactivated 0.4–1.5 log cycles. The application of HHP increased the phenolic content by 24.9% at 400 MPa/2 min and by 64.4% at 500 MPa/2 min compared with the untreated sample, probably due to improvement on the extraction yield. PEF treatments did not affect total phenolic content. PPO activity increased by 9.6% at 500 MPa/2 min while at 600 MPa treatments it decreased from 18.2% to 32.2%. PEF was not effective to inactivate PPO showing similar activities than the untreated samples. The PME activity decreased 57.3% after 500 MPa/CUT and by 72.4% at 400 MPa/5 min, while PEF decreased this activity from 16.9% to 34.8% showing an inverse relationship between treatment time and residual activity. HHP was more effective than PEF to destroy microorganisms, while HHP generates products with lower residual PME and PPO activities. More studies are necessary to increase the enzymatic inactivation levels on mamey beverage with both technologies.
Effects of pulsed electric field treatments on cold-pressed extraction and antioxidant capacity of pecan nut oil (92)

L.M. Rábago-Panduro¹, M. Morales-de la Peña², O. Martín-Belloso¹², J. Welti-Chanes¹

¹ Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Centro de Biotecnología FEMSA, Av. Eugenio Garza Sada 2501 Sur, Tecnológico, 64849 Monterrey, México. ² Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Centro de Bioingeniería, Av. Epigmenio González 500, Santiago de Querétaro, 76130 Querétaro, México. ³ Universidad de Lleida, Departamento de Tecnología de Alimentos – Centro AGROTECNIO, Av. Rovira Roure 191, 25198 Lleida, España.

Pecan nut oil has a similar phytochemical profile to olive oil drifting in the increment of its production to suit the demand for specialty oils. However, its extraction by conventional processing only yields among 65-75%. Currently, pulsed electric fields applied at moderate-intensity (MI-PEF) have been used to improve extraction processes in different food matrices with favorable results. Hence, the objective of this work was to apply MI-PEF treatments to pecan nuts prior to cold-pressed extraction and evaluate its effects on oils extraction yield, antioxidant capacity, and acidity. MI-PEF process was applied to pecan nut kernels at different energy inputs (0.5-17.6 kJ/kg) using a stainless-steel parallel-plate treatment chamber (Physics-International, San Leandro CA). Next, oil was extracted by cold-pressing to determine extraction yields, antioxidant capacity, and acidity. Results were compared with a reference oil extracted from kernels soaked for 20 min. Extraction yields of MI-PEF oils ranged from 59.1±0.0 to 65.0±2.2%. The highest yield was obtained at 0.5 kJ/kg treatment, while control oil yielded 54.2±2.0%. Furthermore, kernels treated at 0.8 kJ/kg lead to the highest oil antioxidant capacity (61.4±6.1 mg TE/100 g oil) being superior to control oil (56.5±1.4 mg TE/100 g oil). Acidity of extracted oil from pecan nuts treated at 1.8 kJ/kg and 0.8 kJ/kg were 0.21±0.01 and 0.38±0.01 mg KOH/g oil, respectively. The acidity of control oil was 0.28±0.01 mg KOH/g oil. Observed changes in oils from MI-PEF treated pecan nut kernels could be due to electroporation phenomena causing a disruption of cellular membranes facilitating oil extraction and degradation of triglycerides by chemical or enzymatic reactions. Based on these results, MI-PEF is a potential technology to increase pecan nut oil yield by cold-pressing by at least 5%, approximately; maintaining its antioxidant capacity with no significant changes. Although, more research is needed to comprehend the mechanisms involved in MI-PEF application.
Pasteurization of carrot juice by combining UV-C radiation and heat (103)

Elisa Gayán

*Universidad de Zaragoza*

UV-C radiation is one of the most promising non-thermal processing technologies to replace conventional pasteurization of liquid foods. However, UV-C treatment is limited for high turbid and colored foods because of their low UV penetration depth, unless combined with other mild technologies in a hurdle-type approach. In this context, we previously demonstrated that simultaneous combination of UV-C radiation with mild heat (so-called UV-H treatment) was able to synergistically improve microbial inactivation even in low UV-transmitting foods. In this research, we explored the feasibility of UV-H treatment to sufficiently inactivate spoilage and pathogenic microorganisms in fresh-squeezed carrot juice, and the impact of the combined treatment on its shelf life and quality compared to that of thermal pasteurization. The combination of UV-C radiation (3.9 J/ml) with mild heat (60°C, 3.5 min) enabled to reach more than 5 log reductions of *Escherichia coli* O157:H7, *Salmonella Typhimurium*, *Listeria monocytogenes*, *Staphylococcus aureus* and the spoilage-associated *Lactobacillus plantarum* and *Saccharomyces cerevisiae*. In addition, UV-H treatment reduced the spore population of *Bacillus coagulans* and *Alicyclobacillus acidocaldarius* by ca. 90%, while individual UV-C and heat treatment barely changed spore viability. Upon storage at 4°C for 22 days, total aerobic counts, lactic acid bacteria, yeasts and molds remained undetected in the UV-H treated juice, while native flora rapidly grew in the untreated control. Furthermore, pH, °Brix, viscosity, cloudiness and color appeal were better preserved by UV-H treatment than by thermal pasteurization (80°C, 1 min) throughout storage. This demonstrates the feasibility of UV-H treatment as an alternative for carrot juice pasteurization.
UV-C treatments against *Salmonella* Typhimurium ATCC 14028 in almonds and peanuts (31)


*Posgrado en Biociencias, Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Irapuato, Guanajuato, 36500 Mexico.*

Ultraviolet light C-region (UV-C) has been used for the disinfection of surfaces, water and different foods. Microbial inactivation by UV-C light is achieved by DNA damage. Some diseases caused by *Salmonella* have been related to the consumption of low moisture products, such as wheat flour, almonds and other nuts. The objective of this study was to evaluate UV-C treatments against *Salmonella enterica* subspp. *enterica* serovar Typhimurium in almonds. Treatments were applied with UV-C (254 nm, 10 mW/cm², 10 cm between food and lamp) with different exposure times, in almonds and peanuts inoculated intentionally with *Salmonella* Typhimurium ATCC 14028, in order to have initial populations around $10^7$ CFU/g. No reduction in the bacterium population was observed after 2.5, 5 and 10 min in peanuts, while for 15, 20 and 30 min, a reduction of 0.6, 0.41 and 0.68 log-cycles was determined, respectively. On the other hand, for almonds were achieved 1.01, 1.92, 2.12 and 2.3 log-cycles reductions after 10, 15, 20 and 30 min of treatment. The temperature of the peanut samples increased 6.03, 6.3 and 7.26 °C after 15, 20 and 30 min, while for almonds increased 5.7, 6.36 and 8.03 °C after 15, 20 and 30 min, respectively. These small changes in temperature demonstrated UV-C keeps as a non-thermal method. Water activity, moisture content (% w.b.), color and peroxides values were no affected by the UV-C treatments (p>0.05). However, treatments with UV-C did not reach the level of pasteurization (reduction of 5 log-cycles) under the studied conditions.
Low-moisture foods treated with UV-C: inactivation of microorganisms and aflatoxins (39)

C. García-Mosqueda, A. Cerón-García, J.A. Gómez Salazar, M. E. Sosa-Morales

Posgrado en Biociencias, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, México

Low-moisture foods (LMFs) are defined as those food products with a water activity below 0.85. They comprise a wide range of foods products, including cereals, dried fruits and vegetables, flour, milk powder, pasta, tree nuts and peanuts, seeds, grains and others. LMFs are considered less susceptible to microbial spoilage, including foodborne pathogens. However, in recent years outbreaks linked to LMFs have increased. Spores are produced by fungi, and them are acutely toxic, causing effects in diverse animal species, including humans. Thermal processing is the most used method of food preservation and destruction of microorganisms and so extending its shelf life. But, some undesirable biochemical changes and loss heat-labile nutrients are produced besides thermal treatments. Non-thermal processing methods, such as ultraviolet-C light radiation (UV-C) has been studied and proposed as an alternative to traditional thermal processes. UV-C radiations are lethal to bacteria, viruses, mold spores, yeast and algae, with different doses depending on the kind of microorganism. The objective of this review is to show studies of UV-C technology as disinfection method in LMFs. UV-C is able to degrade aflatoxins at low costs, without residues, and minimizing loses of quality and nutritional value. The future research in this issue should be the determinate practical aspects of the use of this technology, develop new technologies with the combination of other methods for minimizing damage in the products and keep physicochemical characteristics and nutritional values as much as possible, including the biocompounds present in these foods.
Effect of UV-C, UHPH treatments and its combination on the antioxidant and physicochemical properties of apple juice added with chia (84)

Abad Arturo López-Hernández¹, Ana Sofía Ortega-Villarreal¹, Artur Xavier Roig-Sagués², María Manuela Hernández-Herrero², Jezer Noé Sauceda-Gálvez², Blanca Edelia González-Martínez¹

¹Universidad Autónoma de Nuevo León | UANL · CINSP, Food Laboratory. ²Universitat Autònoma de Barcelona | UAB · Department of Animal and Food Sciences

Non-thermal treatments manage to eliminate pathogens without causing major changes in the organoleptic characteristics of products. The most common include high pressures, ultrasound and radiation. The simultaneous use can enhance their effects and reduce the adverse impact observed in treated foods. The aim of the study was to evaluate the effect of different treatments (UV-C, UHPH and UHPH+UV-C) on the phenolic compounds content, antioxidant activity and physicochemical parameters in apple juice added with chia seed extract. The juice was elaborated using Golden apple, added with chia extract (1.25 g/L) and clarified. The sterilization treatments were carried out in a pilot plant of Universitat Autònoma de Barcelona. The UHPH employed 200 MPa of pressure and an inlet temperature of 50 °C, in the UV-C treatment, 48 J/mL were supplied in one dose. The combined treatment was performed immediately after UHPH treatment with the same dose of UV-C. After the treatments, physicochemical evaluation was made. In PPO activity, a decrease of 27, 42 and 92% was observed for UV-C, UHPH and UHPH+UV-C, respectively. TPC presented a significant increase when undergoing the treatments, the content of chlorogenic acid, gallic acid and myricetin presented changes, however, these did not reach statistical significance; in the case of quercetin, UV-C and UHPH treatments individually showed a significant increase. Regarding antioxidant activity, similar results were observed in both methods without showing statistical difference. This research shows that the UHPH and UV-C methods, as well as their coupling, did not affect negatively the bioactive compounds content and the antioxidant capacity of the juice. More studies using higher pressures (300-400 MPa) in the process are needed to ensure the obtention of a safe and a good nutritional quality product.
Effects of UVB light, wounding stress and storage time on the biosynthesis of betalains in red prickly pears (Opuntia Ficus-Indica cv. Rojo vigor) (89)

Erika Ortega-Hernández¹, Vimal Nair², Jorge Welti-Chanes³, Luis Cisneros-Zevallos² and Daniel A. Jacobo-Velázquez ¹,³*

¹Tecnologico de Monterrey, Escuela de Ingenieria y Ciencias, Av. Eugenio Garza Sada 2501 Sur, C.P. 64849 Monterrey, N.L., Mexico. ²Texas A&M University, Department of Horticultural Sciences, College Station, TX, 77843-2133, United States. ³Tecnologico de Monterrey, Escuela de Ingenieria y Ciencias, Av. General Ramón Corona 2514, Nuevo México, C.P. 45138, Zapopan, Jal., Mexico

In the present study, the effects of UVB radiation and wounding stress, alone or in combination, on the profile of individual betalains and the enzymes involved in their biosynthesis, in red prickly pear (Opuntia Ficus-Indica cv. Rojo Vigor) were evaluated. Whole and wounded-fruit samples were treated with UVB-radiation (6.4 W m⁻²) for 0 and 15 min, and stored for 24 h at 16 °C. The identification and quantification of betalains were conducted with reverse phase high-performance liquid chromatography-diode array detection (HPLC-DAD) coupled with mass spectrometry (MS). The hydroxylase and diphenol oxidase activities of tyrosinase, the key enzyme in the biosynthesis of betalains, were evaluated. The tyrosine hydroxylase activity was measured as the conversion of tyrosine to L-Dopa by HPLC-DAD based on their DAD spectra as compared with authentic standards. The oxidase activity of tyrosinase was measure as the conversion of L-Dopa to dopaquinone by increasing absorbance at 505 nm. The combination of UVB and wounding stress was the most effective treatment to induce the accumulation of betalains after 24 h of storage in both tissues, mainly muscuarin VII (56.5 % in pulp and 20.1 % in peel), indicaxanthin (447.1 % in pulp and 306.5 % in peel), betanin (60.9 % in pulp and 314.9 % in peel) and iso-betanin (113.5 % in pulp and 153.1 % in peel). The increment in the TYR hydroxylase (1091.4 % in pulp and 349.9 % in peel) and TYR oxidase activity (220.9 % in pulp and 94.3 % in peel) after 12 h of storage corresponds to the increment in content of betalains. The application of UVB light combined with wounding stress in red prickly pear can be used as an effective strategy to induce the accumulation of secondary metabolites with potential application in the food, dietary supplements and pharmaceutical industries.
Electrosynthesis approach to improve some functional properties of starches (42)

Julian de la Rosa Millan

Tecnologico de Monterrey. Campus Queretaro. Centro de Bioingenierias

The use of chemically modified starches is of great importance, with diverse uses from food to oil extraction. Such conversions involve the use of chemical reagents, that can be harmful if consumed or inappropriate disposed; for this, the adoption of greener alternatives is on the rise. From these, electrosynthesis (ES) have shown to improve some of starch physicochemical and functional properties, this by promoting molecular interactions among amylose and amyllopectin. In this study, starch dispersions (30% W/V) of potato, rice and corn were incubated for 6h under continuous mixing (150 rpm) at room temperature (≈25°C) and above their glass transition (Tg) temperature (56±2°C) (aimed to promote amylose leaching), that were subject to ES by supplying an electrical current (12V and 0.1A) by two chromnickel (H18N9) stainless steel probes (90 cm² contact area). After, dispersions were centrifuged (9000 xg); obtaining a light (LF) and heavy fractions (HF); that were spray dried (120 and 80°C inlet and outlet temperatures, flow= 500 mL/min) and vacuum dried (50°C, 24h), respectively. The morphology, amylose content, viscosity (by RVA) and thermal characteristics (by DSC) of powders were analyzed. The LF showed hollow-like particles, with diffuse birefringence; whilst HF promoted the agglomeration of crystalline structures. The amylose content did not show significant differences due to ES (P<0.05); however, a correlation between ES and viscosity values was observed, that could be related with higher complexation among amylose and amyllopectin. The ΔH (J/g) decreased in Tg incubated starches (from 11.05 to 2.89 and 4.66 J/g for native maize, and their LF and HF, respectively), reflecting partial disruption of crystalline structures, that may facilitate their molecular entanglement. The production of these materials may be of industrial interest and lead to new applications where amylose or amyllopectin rich ingredients are needed, without the use of chemical reagents or GMO crop sources.
Nonthermal, selective deodorization of Concord grape juice for use in premium winemaking (57)

Ana G. Ortiz Quezada¹, Demi M. Perry², David J. Gomes², John Pacheco², Gavin L. Sacks¹

¹ Department of Food Science, Cornell University, Ithaca, NY, 14853. ² Welch Foods, Inc., 300 Baker Avenue, Suite 101, Concord, MA, 01742

Concord (V. labruscana) is the most widely planted grape cultivar in New York state due in part to its high yield and low input requirements. A more profitable use of Concord is in wine production; however, “foxy” aromas render it unsuitable for premium wine production. Currently, thermal concentration (70 °C) is employed to increase Brix content for juice preservation with some deodorization as a secondary effect. The objective of this study was to develop a selective and nonthermal approach to reduce key flavor compounds (e.g. methyl anthranilate - MA) below sensory threshold in Concord grape juice to make it suitable for premium winemaking. Concord grape juice (16 °Brix, pH 3.15) was recirculated for 3 hours through a membrane filtration system. Permeate stream was passed through a non-polar resin cartridge prior to return to the balance tank. Temperature was kept ≤ 40 °C. Juice aliquots were analyzed by GC-MS. Three membrane pore sizes were tested (low, medium, and high). Thermally treated (flavor reduced juice) and single strength juice were processed. For flavor reduced juice, MA was decreased below sensory threshold (<0.1 mg/L) with only negligible changes to juice color and other key parameters (sugars, titratable acidity, pH). However, medium MWCO membrane required less than half the time to achieve this (60 min vs. >120 min). Greater fluxes could be achieved for a higher MWCO membrane, but anthocyanin pigments were able to pass through the membrane, resulting in color loss and resin saturation. For single strength juice, using a medium MWCO membrane, MA levels were reduced below sensory threshold after 180 min. The optimized membrane filtration process is appropriate for selective, non-thermal removal of Concord grape juice odorants prior to fermentation.
Non-thermal alternatives assessment for enzymatic processing of enriched-in-Omega-3 fish oil (58)

Monsiváis-Alonso, Rafael; Román-Martínez, Alicia; Toro-Vázquez, Jorge F.; Rocha-Uribe, Alejandro.

Facultad de Ciencias Químicas, UASLP, Av. Dr. Manuel Nava No 6, San Luis Potosí, S.L.P. México.

Fish oil is a product of high nutritional value mainly due to its Omega-3 polyunsaturated fatty acids (PUFA) content, currently attractive for their beneficial health effects. Consequently, the growing demand for Omega-3 requires the development of sustainable and profitable oil refining processes. Several methods for marine oils processing have considered biocatalytic technologies involving mild processing conditions that could easily incorporated at industrial level. Unfortunately, these technologies have not been evaluated in terms of efficiency, profitability and environmental impact. Within this context, process simulation is a useful tool for fast and reliable analysis of processing conditions. Therefore, in this work, three biotechnological process options have been studied and evaluated using SuperPro Designer® with the objective of assessing their productivity, the plant investment and operating costs, and the CO₂ equivalent emissions. The three biotechnological process involved a lipase-assisted concentration step.

The results indicated that a conventional chemical refining of fish oil with ethanolysis transesterification and supercritical CO₂ fractioning of the fatty acid ethyl esters provided good economic results with a Return on Investment (ROI) of 101.4% and 0.48 years of pay-out time (Base-Case Design). However, this option is highly energy demanding, involving the largest CO₂ equivalent emissions of all alternatives evaluated. The first alternative considered consecutive interesterification and solvent winterization steps with the advantage of avoiding high temperatures and maintaining PUFAs in their acylglycerol form. This option has a promising ROI and pay-out time with lower environmental impact (1082.4 tonCO₂/year). As a second alternative a liquid extraction method for the deodorizing step (Song et al., 2018), was incorporated instead of steam distillation. Nevertheless, despite avoiding high temperatures this option is slightly profitable and more environmentally harmful (1608.2 tonCO₂/year). Therefore, the first alternative resulted the option with the best compromise among all parameters evaluated.
Gas chromatography–mass spectrometry combined with multivariate data analysis as a tool for discriminating between orange juice samples according to the processing technique (11)

Shuang Bi, Sicheng Sun, Fei Lao, Xiaojun Liao, Jihong Wu*

College of Food Science and Nutritional Engineering, China Agricultural University, Beijing 100083, China

The contents of volatile aroma compounds in orange juice vary after high hydrostatic pressure (HHP) processing and pasteurization, and hence gas chromatography–mass spectrometry has potential for discriminating between orange juice samples according to the processing method. Effects of HHP processing and pasteurization on orange juice were investigated immediately after processing and after storage for 28 days at 4 °C. Processing decreased the contents of most terpenes and esters and increased those of alcohols and aldehydes. Volatile compounds that could serve as discriminant indicators of HHP processing and pasteurization were heptanal, (E)-2-heptenal, (E)-2- nonenal, and d-carvone and β-terpineol, p-mentha-1,5-dien-8-ol, carveol, and β-copaene, respectively. The discrimination abilities of pH, ascorbic acid, total soluble solids, and color were compared with those of volatile compounds, which were found to be lower. The compounds d-carvone and β-terpineol could be used as discriminant indicators of HHP-treated and pasteurized orange juice, respectively, throughout the storage period.
Influence of alternative sweeteners on the osmotic dehydration of papaya (Carica papaya L.) assisted by power ultrasound: Mass transport kinetics and physicochemical properties of the final product (67)

Martínez-Castillo José Isabel¹, Cardona-Herrera Román², Castañeda-Rodríguez Luis Rey³, & Ozuna César¹³*

¹ Posgrado en Biociencias, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Guanajuato, Mexico. ² Departamento de Ciencias Básicas, Instituto Tecnológico de la Piedad, Michoacán, Mexico. ³Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Guanajuato, Mexico. *cesar.ozuna@ugto.mx

Power ultrasound (PU) application represents a promising non-thermal technology to accelerate the mass transport phenomena in food processes, such as osmotic dehydration (OD). Several studies have reported the effective use of PU to improve mass transfer mechanisms in fruit during OD. However, despite this evidence, there are still very few studies that would evaluate the effect of sweetener type employed during PU-assisted OD. Therefore, the aim of this investigation was to evaluate the influence of sweetener type used in PU-assisted OD of papaya on mass transport kinetics and physicochemical properties of the final product. Samples (height: 2 cm, diameter: 2.6 cm) were osmo-dehydrated using hypertonic solutions (60°Brix, 30°C) of sucrose, agave syrup, and bee honey in an ultrasonic bath (20 kHz, 120 W) during different times: 0, 15, 30, 45, 60, 90, 120, 150, and 180 min. Solid gain and water loss kinetics were adjusted to an exponential model. Physicochemical properties (pH, total soluble solids, titratable acidity, and CIEL*a*b* chromatic coordinates) of dehydrated samples were evaluated at 180 min of osmotic treatment. Results showed that the exponential model described water loss and solid gain kinetics adequately (R²>0.96). PU application significantly increased (p<0.05) the mass transport during the OD process, these effects being more pronounced in alternative sweeteners than in sucrose. Similarly, PU induced significant changes (p<0.05) in the physicochemical properties of the final product, which were influenced by the sweetener type employed. In this sense, the use of bee honey and agave syrup increased the color differences in samples, whereas the use of sucrose favored changes in pH, total soluble solids, and titratable acidity. In conclusion, PU represents a technology capable of intensifying mass transfer in the OD of papaya. However, this effectiveness is modulated by the osmotic agent employed which can affect the product quality.
Effect of active packaging with orange blossom essential oil (Citrus aurantium) on the shelf life of corn tortillas (82)


Centro de Investigación en Alimentación y Desarrollo A.C. Carretera Gustavo Enrique Astiazarán Rosas, N°. 46, 83304. Hermosillo Sonora. C.P. 83304

Corn tortilla is a staple food in Mexico. This food has a water activity of 0.98, moisture of 45-50% and nutrients that makes it the ideal media for proliferation of microorganisms such as fungi and bacteria. The growth of these microorganisms in food causes deterioration in sanitary quality, color, taste, appearance, pH, etc. All these combined with absence of good manufacturing practices cause a limited shelf life of tortillas. The objective of this project was to evaluate the antimicrobial capacity of an active container added with orange blossom essential oil (OBEO), and its effect on the shelf life of corn tortillas. The minimum inhibitory concentration (MIC) of the OBEO was tested against 1.12X10^6 UFC of Escherichia coli (12.5 mg), 100,000 conidies of Aspergillus niger (8.5 mg) and 100,000 conidies of Penicillium sp (8.5 mg) which were isolated from the corn tortillas. The CMI found were used for the design and elaboration of two active packaging films, added with OBEO. Once manufactured, tortillas were packed in pouches manufactured with the films, plus a control without OBEO, and stored for 30 days at 5°C. The concentration of aerobic mesophilic bacteria and molds and yeasts in the tortillas of the active containers was significantly reduced p<0.05 in relation to the CFU/g quantified in the tortilla packed in the control pouches. The shelf life in the active containers was extended by 53-66%, compared to the control. Tortillas packed in the active containers showed acceptability at consumer label for smell and taste above 70 and 38%, respectively. In conclusion, the addition of OBEO to a bilayer container is an alternative to produce antimicrobial films, which in the shape of pouches, were able to extend the shelf life of corn tortillas.
Multi-flash autovaporization (MFA) as an innovative deodorization unit operation for vegetable oils (94)

Colette Besombes¹, Cherif Jablaoui¹, Carmen Téllez-Pérez¹², Maritza Alonzo-Macías², Anaberta Cardador-Martínez² and Karim Allaf¹.

¹La Rochelle University, Intensification of Transfer Phenomena on Industrial Eco-Proceses, Laboratory of Engineering Science for Environment LaSIE - UMR-CNRS 7356, 17042 La Rochelle, France. ² Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Campus Querétaro. Epigmenio González 500, Fracc. San Pablo. Querétearo, Querétaro, 76130, México

The volatility of a given compound C is defined as the pressure $p_C$, s at the exchange, surface separating the compound under a condensed phase (solid or liquid) and the surrounding gaseous medium. It strictly depends on the temperature independently of the pressure of the surrounding environment. The evaporation of the compound C is a process related to the volatility but depends on the characteristics of the surrounding environment:

$$m_c = k \rho_c A \frac{(p_{cs} - p_{ca})}{p_t} \quad \text{Eq. 1}$$

Thus, in the case of compound C, the evaporation of the product from the condensed compound C only occurs if $(p_{cs} > p_{ca})$, where an index is related to the surrounding-medium. Obviously, the higher the medium velocity, the higher the mass convective coefficient $k$. Nguyen et al. 2016 developed this notion and postulated that:

$$k = \frac{D_{c-a}}{d} \left(2 + 0.522 Re^{0.5} Sc^{0.33}\right) \quad \text{Eq. 2}$$

where $D_{c-a}$ is the vapor-in-surrounding-medium (air) Fick diffusivity $(m^2 \cdot s^{-1})$; the nondimensional Schmidt and Reynolds numbers are $Sc = \frac{V_c}{D_{c-a}}$ and $Re= \frac{v_a d}{\nu_a}$, respectively.

$$k = \frac{D_{c-a}}{d} \left(2 + 0.522 \left(\frac{v_{ad}}{V_a}\right)^{0.5} \left(\frac{V_c}{D_{c-a}}\right)^{0.33}\right) \quad \text{Eq. 3}$$

where $\nu_a$ and $\nu_c$ are the kinematic viscosities $(m^2 \cdot s^{-1})$ of air and C vapor, respectively; $v_a$ $(m^3 \cdot s^{-1})$ is the surrounding medium (airflow) velocity, and $d$ (m) is the body length parallel to such airflow. In this study, Multi Flash Autovaporization (MFA), which is repeated specific instantaneous pressure drops of liquids exhibiting weak-volatility compounds, was used as an innovative deodorization of vegetable oils. The pressure-drop ratio $\alpha=P_{final}/P_{initial}$, also reveals the part of the volatile molecules keeping at the exchange surface. Thus, at each pressure drop from 100 kPa towards 5 kPa, $\alpha=0.05$ and volatile molecules removed from the surface should reach $(1-\alpha=95\%)$. Thus, instead of carrying out conventional deodorization operations (3-5 hours at >200°C), MFA is the only deodorization operation achieved at low or even ambient temperature, triggering higher refined oil yield, better valorization of oils and lower operating cost.
Refrigerated distribution assessment of preservation for nonthermally pasteurized products (104)

Daniela Gonzalez de la Garza¹, Enrique Martinez Martinez², Veronica Rodriguez Martinez¹, Reynaldo de la Cruz Quiroz², J. Antonio Torres¹

¹ Tecnologico de Monterrey, Mexico; ² Universidad Autónoma de Coahuila

In spite of efforts to develop nonthermal technologies capable of inactivating bacterial spores such as Pressure-Assisted Thermal Processing (PATP), commercialized nonthermal technologies can deliver only pasteurized products. With exceptions such as low-pH products their distribution and storage requires refrigerated facilities. Moreover, their shelf-life is determined at constant temperature, typically 4°C, which is not a realistic assessment. Finally, efforts to improve the cold chain have focused on reducing the energy consumption. For example, even though residential refrigerators increased dramatically in size and can now deliver ice and chilled water, energy consumption has decreased my more than 80% since the first regulations were imposed in the 1970’s. Efforts are now required to assess whether the cold chain components are effectively contributing to the preservation of the high quality of nonthermal products. In this study, deterministic and probabilistic predictive microbiology procedures were used to estimate the cumulative exponential growth in 48h for pathogen and spoilage microorganisms as a refrigerated preservation indicator (PI). This was done for ten products stored in the door shelves, body shelves, and drawers of a customized high-end residential refrigerator. Experimental factors studied were refrigerator load, temperature setting, door openings, variable (VS)/single speed (SS) compressors, room temperature (T_{Chamber} = 32.2/21.1°C), and exposure to T_{Chamber} (replicating product use). A normalized indicator (RPI) was obtained by dividing the PI value for the realistic temperatures obtained experimentally by the value observed at the constant recommended temperature for the product. Values above 1 would indicate a poor performance which was the case for VS compressors developed to reduce energy consumption (see Table below). This indicates the need to optimize VS compressors for maximum food preservation while meeting energy requirements. Software developed to analyze temperature data, nearly 100 million time-temperature values, will be demonstrated.
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<thead>
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<th>Title</th>
<th>Authors</th>
<th>Corresponding Author’s Email</th>
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</thead>
</table>
| 13 - Ultrasound treatments for oil extraction from amaranth and canary seeds | S.E. Paniagua Camarena\(^1\), M. Morales Escamilla\(^1\), J. Ramírez Morales\(^1\), D.K. Baigts Allende\(^2\), J.A.Gómez Salazar\(^3\), M.E. Sosa Morales\(^1\)  
(1) Universidad de Guanajuato, México; (2) Universidad de las Américas Puebla, México | msosa@ugto.mx |
| 14 - Ultrasound pretreatment to enhance moisture diffusivity during infrared drying of peas (\textit{Pisum sativumse}) | P.F. Camarena-Beltrán\(^1\), L.P. Escobar-Escobar\(^1\), F. Castellanos-Galeano\(^2\), M.E. Sosa-Morales\(^1\), A. Cerón-García\(^1\), J.A. Gómez-Salazar\(^1\)  
(1) Universidad de Guanajuato, México; (2) Facultad Universidad de Caldas, Colombia | julian.gomez@ugto.mx |
| 18 - High power ultrasound of modified starch/\(\kappa\)-carrageenan blends for edible film preparation | Karla Gutiérrez-Pascual\(^1\), Genaro G. Amador-Espejo\(^2\), Edith Corona-Jiménez\(^2\), Irving I. Ruiz-López\(^2\), Héctor Ruiz-Espinosa\(^3\)  
(1) Benemérita Universidad Autónoma de Puebla, México; (2) Cátedras CONACYT-Centro de Investigación en Biotecnología Aplicada, Instituto Politécnico Nacional, México | hector.ruiz@ymail.com |
| 20 - Functional properties modification of whey protein/kappa carrageenan coacervates elaborated with WPI previously treated by high intensity ultrasound | Sara A. Vargas, G.G. Amador-Espejo, R.J. Delgado-Macuil, H. Ruiz-Espinosa  
(1) Cátedras CONACYT-Centro de Investigación en Biotecnología Aplicada, Instituto Politécnico Nacional, México; (2) Benemérita Universidad Autónoma de Puebla, México | genaroamador2014@gmail.com |
Tecnológico de Monterrey, Mexico | cristina.chuck@tec.mx |
<p>| 45 | Shelf life, physicochemical and microbiological properties on pulque processed by thermo sonication | Alejandra E. Alcántara-Zavala, Juan D. Figueroa-Cárdenas, Juan F. Pérez-Robles, Dalia E. Miranda-Castilleja. (1) Instituto Politécnico Nacional. CICATA unidad Querétaro. México; (2) Universidad Autónoma de Querétaro, México | <a href="mailto:aealcantarazavala@gmail.com">aealcantarazavala@gmail.com</a> |
| 47 | Maize starch modification using a combination of two emerging non-thermal technologies: ultrasound and ozone | Nanci Castanha, Dâmara Carvalho Lima, Manoel Divino da Matta Junior, Osvaldo H. Campanella, Pedro Esteves Duarte Augusto. (1) University of São Paulo (USP), Brazil; (2) The Ohio State University (OSU), USA | <a href="mailto:nanci.castanha@usp.br">nanci.castanha@usp.br</a> |
| 49 | Ultrasound to incorporate microencapsulated carotenoid into food | Meliza Lindsay Rojas, Izabela Dutra Alvim, Pedro Esteves Duarte Augusto. (1) University of São Paulo (USP), Brazil; (2) Food Technology Institute (ITAL), Brazil | <a href="mailto:mrojas@usp.br">mrojas@usp.br</a> |
| 59 | Ultrasound-generated intensity changes due to solvent composition for the extraction of bioactives from agave bagasse (Agave salmiana) | Liliana Santos-Zea, Janet A. Gutiérrez-Uribe, José Benedito. (1) Tecnologico de Monterrey, Mexico; (2) Universitat Politècnica de València, Spain | <a href="mailto:lilianasantos@tec.mx">lilianasantos@tec.mx</a> |
| 61 | Understand the effect of low-frequency ultrasonication on microbial destruction of Pseudomonas Aeroginosa and quality loss in bovine milk | Yuan Shi, Soumya Kumar, Anubhav Pratap Singh. The University of British Columbia, Canada | <a href="mailto:yuannnshii@gmail.com">yuannnshii@gmail.com</a> |
| 70 | Nanoemulsions as encapsulating systems in foods | Mayra Ramirez, Tomás García-Cayuela, Luis Eduardo García-Amezquita. Tecnologico de Monterrey, Mexico | <a href="mailto:garcia.amezquita@tec.mx">garcia.amezquita@tec.mx</a> |
| 65 | Ultrasound-assisted extraction of bioactive compounds from mango manililla peels | A.J. Borrás-Enríquez¹, E. Reyes-Ventura¹, S.J. Villanueva-Rodríguez¹, L. Moreno-Vilet¹,² | <a href="mailto:lmoreno@ciatej.mx">lmoreno@ciatej.mx</a> |
| 72 | Ultrasound assisted extraction process to obtain extracts rich in antioxidant biocompounds from Mediterranean vegetables wastes | R. Ibarz, R. Soliva-Fortuny, O. Martín-Beloso | <a href="mailto:ribarz@tecal.udl.cat">ribarz@tecal.udl.cat</a> |
| 75 | Ultrasound-assisted supercritical CO² treatment in continuous regime: Application in Escherichia coli inactivation | I. Paniagua-Martínez¹, L. Santos-Zea², M.A. García-Alvarado³, J. Benedito¹ | <a href="mailto:inpa1@alumni.upv.es">inpa1@alumni.upv.es</a> |
| 79 | Astaxanthin extraction from Xanthophyllomyces dendroideus by ultrasound under pressure | Diederich Aguilar²,³, Carlota Delso¹, Juan Manuel Martínez¹, Lourdes Morales Oyervides², Julio Montañez², Javier Raso¹ | <a href="mailto:jraso@unizar.es">jraso@unizar.es</a> |
| 80 | Effect of thermosonication or thermal pasteurization on phenolic compounds and antioxidant capacity of apple juice made from ultrasound-treated apples | M.C. Naranjo, O. Martín-Beloso, R. Soliva-Fortuny, P. Elez-Martínez | <a href="mailto:pelez@tecal.udl.cat">pelez@tecal.udl.cat</a> |
| 81 | Effect of ultrasound treatment on physicochemical parameters in Opuntia ficus Indica cladodes | C.L. Higuera-Orbe¹, H. M. Hernández-Hernández², T.A. Quiñones-Muñoz², L. Moreno-Vilet² | <a href="mailto:lmoreno@ciatej.mx">lmoreno@ciatej.mx</a> |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Author</th>
<th>Email</th>
</tr>
</thead>
</table>
| 90 - Ultrasound and ozone for fresh food treatment, what is next?   | Claudia Caballero-Cerón  
Tecnologico de Monterrey, Mexico | c.caballero@tec.mx         |
| 91 - Comparison of technologies for food preservation: inactivation of horseradish peroxidase by ultrasound and thermal treatment | Diego Alberto Rosas Gómez, Frida Sofía Punzo Garduño Elliston Vallarino Reyes, Javier Alejandro Belmont Díaz, Claudia Caballero Cerón  
Tecnologico de Monterrey, Mexico | diego.051195@hotmail.com    |
| 22 - Shelf life of fresh-cut mango scalded by ohmic heating         | Francisco Martín Flores García¹, Eduardo Morales Sánchez¹, Marcela Gaytán Martínez²  
(1) Instituto Politécnico Nacional. Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada, Unidad Querétaro, México; (2) Universidad Autónoma de Querétaro, México | matoymay688@gmail.com      |
| 69 - Thermal and non-thermal methods for stabilization and preservation of milk and dairy products | Beatriz Corvera, Luis Eduardo García-Amézquita, Tomás García-Cayuela  
Tecnologico de Monterrey, Mexico | tomasgc@tec.mx             |
| 95 - Detrimental effects of cold plasma processing on nutrients within food: a critical review | Maria Pamela Rodarte-Villalobos, Paul Martín-Navarro  
Tecnologico de Monterrey, Mexico | paulmarnav@hotmail.com      |
| 37 - Membrane technology applications in the dairy industry         | Mariano del Toro-Barbosa, Luis Eduardo García-Amézquita, Tomás García-Cayuela  
Tecnológico de Monterrey, México | tomasgc@tec.mx             |
| 46 - Ozone technology to modify arracacha starch properties         | Dâmaris Carvalho Lima¹, James Villar², Bianca Chieregato Maniglia³, Manoel Divino Matta Junior¹, Pedro Esteves Duarte Augusto¹  
(1) University of São Paulo (USP), Brazil; (2) Universidad Nacional de Moquegua (UNAM), Peru; (3) ONIRIS-GEPEA France | damaris.dcl@gmail.com
<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Authors</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Applications and Limitations of dense phase carbon dioxide in the food industry: a review</td>
<td>Alejandro Heredia Nieto, Minerva E Núñez Manjarrez Tecnológico de Monterrey, Mexico</td>
<td><a href="mailto:A01650991@itesm.mx">A01650991@itesm.mx</a></td>
</tr>
<tr>
<td>71</td>
<td>Green technologies as a sustainable approach to the extraction of bioactive compounds from coffee and cocoa industry by-products: A review</td>
<td>Luis Rey Castañeda-Rodríguez¹, Esaú Oseguera-Sánchez², Claudia Lorena Fernández-López³, José Isabel Martínez-Castillo⁴, César Ozuna¹²</td>
<td><a href="mailto:cesar.ozuna@ugto.mx">cesar.ozuna@ugto.mx</a></td>
</tr>
<tr>
<td>86</td>
<td>Oil extraction in mamay seeds (Pouteria sapota) assisted by continued and pulsed high hydrostatic pressure</td>
<td>Saira Mayret Cano Monge¹, Viridiana Chavez-Leal¹, Erick Eduardo Cano Monge¹, Deyanira Moguel²,Eduardo Borges², Jorge Welti-Chanes², José Rodríguez-Rodriguez², Mayra Cristina Soto-Caballero¹, Zamantha Escobedo-Avellaneda²</td>
<td><a href="mailto:mayrasotocaballero@gmail.com">mayrasotocaballero@gmail.com</a></td>
</tr>
<tr>
<td>54</td>
<td>Sanitizing procedures applied before storage of fresh-cut carrots affect the wound-induced biosynthesis of chlorogenic acid</td>
<td>Alejandro Gastélum-Estrada³, Alejandra Hurtado-Romero³, Arlette Santacruz², Luis Cisneros-Zevallos², Daniel A. Jacobo-Velázquez¹</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
</tr>
<tr>
<td>55</td>
<td>Effect of wounding stress and chitosan treatment on chlorogenic acid and β-carotene contents of harvested carrots</td>
<td>Luis Berumen-Guerrero, Alejandra Hurtado-Romero, Alejandro Gastélum-Estrada, Daniel A. Jacobo-Velázquez Tecnológico de Monterrey, México</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
</tr>
<tr>
<td>68</td>
<td>Emerging pre-treatments as promising strategies for increment of nutraceutical content and extraction yield in plant foods: lycopene from tomato by-products as case study</td>
<td>Luis Octavio Cano y Postigo, Tomás García-Cayuela, Daniel A. Jacobo-Velázquez Tecnologico de Monterrey, Mexico</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
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<tr>
<td>88</td>
<td>Wounding and UVB Light Induce the biosynthesis of phenolic compounds and ascorbic acid in red prickly pears (<em>Opuntia Ficus</em>-Indica cv. Rojo Vigor)</td>
<td>Erika Ortega-Hernández¹, Vimal Nair², Jorge Welti-Chanes³, Luis Cisneros-Zevallos³, Daniel A. Jacobo-Velázquez¹</td>
<td><a href="mailto:djacobov@tec.mx">djacobov@tec.mx</a></td>
</tr>
<tr>
<td>66</td>
<td>Effect of water on microstructure and thermo-mechanical properties of phosphatidylcholine organogels</td>
<td>M. Martinez-Avila¹, D. Van de Walle², K. Dewettinck², J.F Toro-Vazquez³</td>
<td><a href="mailto:toro@uaslp.mx">toro@uaslp.mx</a></td>
</tr>
<tr>
<td>98</td>
<td>Avocado seed acetogenins as a hurdle to control mycelial growth and conidia germination of Botrytis spp. for the preservation of strawberry puree</td>
<td>A A. Echenique-Martínez³, D.G. Rodríguez-Sánchez³, R. Troncoso-Rojas³, C.E. Hernández-Brenes³, L.E. Robles-Ozuna³, L.C Montoya-Ballesteros¹</td>
<td><a href="mailto:lmontoya@ciad.mx">lmontoya@ciad.mx</a></td>
</tr>
<tr>
<td>93</td>
<td>Use of freeze-dried mango seed flour as a compounds source of antioxidant activity in Mexican tortilla making</td>
<td>Manuel Bernal Maldonado, Alejandra San Martín Azócar</td>
<td><a href="mailto:alsmartin@tec.mx">alsmartin@tec.mx</a></td>
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</tbody>
</table>
Ultrasound treatments for oil extraction from amaranth and canary seeds (13)

S. E. Paniagua Camarena1, M. Morales Escamilla1, J. Ramírez Morales1, D. K. Baigts Allende2, J. A. Gómez Salazar1, M. E. Sosa Morales1

1 Departamento de Ingeniería en Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, México. 2 Departamento de Ingeniería Química y Alimentos, Universidad de las Américas Puebla, México

Canary seeds are almost exclusively intended for the feeding of birds; however, they are rich in proteins and oils, with benefits to human health. Amaranth seeds also have high nutritional value (protein in high amount and of good quality). Ultrasound (US) is considered an emerging technology used in the food industry. Its effect is based on cavitation, which detonates mechanisms such as diffusion, instability between interfaces, friction, mechanical breakage, among others. The objective of this study was to evaluate the effect of ultrasound treatments on oil extraction from canary and amaranth seeds. Seed-water dispersions (1:20) were treated with US using a water bath at 35°C, 40 kHz and 90 W for 3, 6, 9, 12 and 15 min. A sample was left without treatment, soaked by 15 min, as a control. After treatments, seeds were dried at 105°C for 24 h and milled. The seed flours (3 g) were subjected to Goldfisch extraction for four hours with 30 mL of petroleum ether. Among the US-treated samples, higher oil yields for both canary and amaranth seeds were obtained at 3 min of treatment (4.33 and 3.62% respectively). However, there was no significant difference (p>0.05) between US treatment and control samples for any of the materials (5 and 3.9% of oil content for control seeds). US treatment did not show changes in the oil composition (analyzed by gas chromatography) in comparison to control samples (p>0.05). The main fatty acids present in canary seeds were linoleic (50%), oleic (32%) and palmitic (12%), while for amaranth seeds were linoleic (34%), oleic (32%) and arachidonic (9.1%). Under the studied conditions, US treatments did not improve oil extraction from the seeds. More conditions should be studied, in order to analyze the effect of US on other components, such as proteins and biopeptides.
Ultrasound pretreatment to enhance moisture diffusivity during infrared drying of peas (Pisum sativum) (14)

Camarena-Beltrán, P.F. ¹, Escobar-Escobar, L.P. ², Castellanos-Galeano F. ², Sosa-Morales, M.E. ¹, Cerón-García A. ¹, Gómez-Salazar J.A. ¹

¹ Departamento de Ingeniería en Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, México. ² Facultad de Ingeniería, Ingeniería de Alimentos, Universidad de Caldas, Manizales, Colombia.

Drying is an ancient preservation method of foods, with a great effect on the quality of the dried products. Different drying methods have been used to reduce the water content of vegetables. Currently, to increase the dehydration, pretreatments have been applied in the raw material. Ultrasound (US) technology has been used as a pretreatment before drying, which accelerates the output of water from the food, due to increasing the mass transfer rate. The objective of the study was to investigate the influence of ultrasound pretreatments in water diffusion during infrared drying in peas. Infrared (IR) drying of peas (187 W and 18 cm of distance between sample and lamp) at different drying times (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 min) and their combination with ultrasound pre-treatments (5 and 15 min in US bath 40 kHz and 110 W) were carried out. The drying time in US-pretreated samples for 15 min was lower compared to control. Furthermore, drying data were fitted to Fick’s second equation of diffusion to calculate the effective diffusivity. The moisture diffusivity coefficient was higher at 15 min with US (7.95X10⁻⁸ m²/s), than the treated for 5 min (4.19X10⁻⁸ m²/s), p<0.05. No differences were observed between US-treated during 5 min and the control (4.7X10⁻⁸ m²/s), p>0.05. Overall color change (ΔE) ranged from 7.5 to 9.11, while the volume reduction percentage was 19, 20 and 56% for control, 5 min and 15 min with US application, respectively. Results showed that the pretreatment with US at 15 min had the most effect on increasing of moisture diffusivity, more conditions should be studied, in order to analyze the effect of US on the drying of peas.
High power ultrasound of modified starch/κ-carrageenan blends for edible film preparation (18)

Karla Gutiérrez-Pascual¹, Genaro G. Amador-Espejo², Edith Corona-Jiménez¹, Irving I. Ruiz-López², Héctor Ruiz-Espinosa¹

¹Colegio de Ingeniería en Alimentos, Facultad de Ingeniería Química, Benemérita Universidad Autónoma de Puebla, Puebla, Pue. México. ²Cátedras CONACYT-Centro de Investigación en Biotecnología Aplicada, Instituto Politécnico Nacional. Tlaxcala 90700, México.

Edible films (EFs) are green alternatives to plastics and effective barriers for increasing food shelf life while preserving relevant quality features. Recent evidence suggests power ultrasound (PU) could be used to alter structural features of EF polymers, modulating their rheological, sensory and functional properties thus possibly expanding their applications². Consequently, this study was aimed at elaborating EFs with PU- treated mixtures of aqueous dispersions of octenyl succinic anhydride modified starch (MS) and kappa-carrageenan (KC), evaluating its effects on selected film properties. 0.75% dispersions were prepared in a hot plate stirrer (70°C, 1h). Either one, both or none of them were treated in a probe ultrasonic processor (24 KHz, 400W, 22-mm diameter probe, 2.5-cm immersion depth). Four 3:1 MS:KC mixtures (A: control; B: MS-treated; C: KC-treated; D: Both treated) were made in duplicate according to a complete randomized design and used to prepare EFs by casting method. Tensile stress (TS) and elongation; hue and chroma color descriptors, film opacity, width and permeability were determined in triplicate and statistical differences were assessed by one-way ANOVA using Tukey’s test for pairwise comparisons (α=0.05) (Table 1). Statistical analyses revealed significant effects of PU pretreatment on film elongation and TS. EF elongation significantly increased up to three-fold for B and D films while also significantly augmenting TS on D film when compared to control. Although, PU significantly decreased chroma and hue in D and B films, respectively, no experimental treatment varied film opacity. Meanwhile film permeability was significantly reduced in B and C films, although augmented in D film. PU-pretreated components in MS-based EFs could be used to prepare firmer, more elastic films with modified permeability for selected food applications, without altering their appearance.
Functional properties modification of whey protein/kappa carrageen coacervates elaborated with WPI previously treated by high intensity ultrasound (20)

Vargas, Sara A.,1 Amador-Espejo G.G.,2 Delgado-Macuil R.J.,1 Rojas-López, M.,1 Ruiz-Espinosa H.3

1Centro de Investigación en Biotecnología Aplicada IPN, México. 2CONACYT-Centro de Investigación en Biotecnología Aplicada IPN, México. 3Benemérita Universidad Autónoma de Puebla, México.

Protein-polysaccharide complex coacervates (CC) play an important role in a wide range of food applications. Depending on the molecular structure of the biopolymer (BP) and pH, mixtures of whey protein isolate (WPI) -kappa carrageenan (kC) may undergo segregation or coacervation. High intensity ultrasound (HIUS) has been used to modify the protein molecular structure, achieving improvements on functional properties. The objective of this work was to evaluate the formation of CC between WPI-kC using HIUS for the previous modification of WPI structure and its effect on functional properties. Commercial kC (Ingredion, USA) and WPI (BiPro, USA), dispersed in distilled water (1% w / w) with regular stirring (24 h) were used. HIUS treatments were applied: Amplitude (%): 25, 50, 75, 100; Time: 2’, 4’. Coacervates were obtained after mixing 10’. FTIR-ATR (400-4000 cm\(^{-1}\)) and particle size (PS, nm) were used for structural characterization. Rheology (25 °C, D: 2000 1 / s) and foaming (60’, 25 °C) were evaluated as functional properties. FTIR-ATR analysis detected changes in WPI after HIUS treatment on protein secondary structure (1600-1700 cm\(^{-1}\)). For kC, in the region corresponding to the groups -OH, -COOH (1300-1400 cm\(^{-1}\)), electrostatic interaction between WPI positive regions, sulfate group and the anhydrous oxygen of the 3.6 anhydro-D-galactose of the kC were detected. A decrease on the WPI PS was detected with the most severe HIUS treatments (75-100% A, 2-4 min). The kC and the CC behaved as a pseudoplastic fluid with a significant reduction (55.2 and 20 mPa*\(\text{s}\), respectively), while the WPI presented a Newtonian behavior (1.5 mPa*\(\text{s}\)). HIUS CC foams were more stable than control and presented an important increment in overrun and foam expansion ability (Table 1). Nevertheless, more tests are necessary, HIUS probed to be efficient to improve functional properties in WPI-kC CC.
Effect of ultrasound on protein yield and fate of alkaloids during lupin alkaline extraction process (25)


Protein isolates (PI) from legumes are an efficient option to cover the daily protein requirement. *Lupinus* spp. is a legume with high protein content (20-50%), good amino acid profile and moderate protein digestibility (= 70%). However, the main withdraw is the presence of quinolizidine alkaloids (QA), which are toxicogenic to mammals. The most popular method for QA removal is inconvenient since its based in washing with high amounts of water and, besides, is time consuming. The aim of this work was to assess the reduction of QA during lupin protein extraction process assisted with ultrasound (US) and the evaluation of the nutritional and functional properties of the protein fraction. Proximal characterization, anti-nutritional compounds concentration, amino acid and protein solubility profiles from three lupin species were assessed: *L. albus*, *L. angustifolious* and *L. mutabilis*. The functionality (water absorption and nitrogen solubility), composition (protein yield and reduction of alkaloids during the extraction process) and resistance to thermal treatments (displacement of denaturation temperature, change in secondary structure and modification of the electrophoretic profile) of *L. mutabilis* and *L. angustifolious* proteins were studied. The 10 min US to *L. mutabilis* increased protein yield in 14%, and reduced QA associated to the bagasse and PI (81 and 50%, respectively). Changes in protein structure and composition modified the functional and thermal properties of the protein, making the PI a good candidate as food ingredient. *L. angustifolious* was more resistant to the US with no significant differences between the application of US for 10 or 15 min compared to the control. The PI of the control showed the lowest toxicity (3 ppm of QA), whereas the PI treated with 15 min US the best amino acid score (0.85). These results will be useful to design processes to assist and meet the protein demand of the population.
Shelf life, physicochemical and microbiological properties on *pulque* processed by thermosonication (45)

Alejandra E. Alcántara-Zavala¹, Juan D. Figueroa-Cárdenas¹, Juan F. Pérez-Robles¹, Dalia E. Miranda-Castilleja²


*pulque* is a Mexican alcoholic, probiotic, and non-distilled beverage. It is produced by the fermentation of the sap (*Aguamiel*) of an agave plant. The shelf life of *pulque* is 3 days due to the fermentation caused mainly by yeasts and lactic acid bacteria (LAB). Thermosonication reduces the microbial load in beverages for preserving sensory and nutritional quality. The aim of this study was to apply thermosonication in order to extend the shelf life of *pulque* without altering its properties. *Pulque* processed by conventional pasteurization (63°C, 30 min) was used as control. A study of shelf life on *pulque* was carried out during 22 days of storage at 4°C. *Pulque* was processed by ultrasound Hielscher with following conditions: 75% amplitude (5 and 7 min), 85% (4 and 6 min), and 95% (3 and 5 min) at 50°C. A bath of water was used for controlling temperature. The physicochemical parameters such as (pH, color, and alcohol content), sensory and microbiological properties (content of LAB and yeasts) were evaluated each 72h. The molecular identification of some LAB and yeast of raw and processed *pulque* was performed by DNA sequencing. *Pulque* processed by thermosonication at 75% (5 and for 7 min) and 85% (4 and for 6 min) exhibited a higher content of LAB in ranging from 6.58 to 6.77 log₁₀ CFU/mL, compare to conventional pasteurized (3.64 log₁₀ CFU/mL). After 22 days, physicochemical properties were stable for both methods of pasteurization, while the *pulque* treated with thermosonication had greater sensory acceptance. For the first time, thermosonication was used to process *pulque*, and results revealed that it is an effective technology for extending the shelf life until 22 days, preserving microbiological and physicochemical properties. Microorganisms as surviving the thermosonication treatments were identified as *Lactobacillus acidophilus*, *Lactobacillus kefiri*, and *Saccharomyces cerevisiae*. 
Maize starch modification using a combination of two emerging non-thermal technologies: ultrasound and ozone (47)

Nanci Castanha¹, Dâmaris Carvalho Lima¹, Manoel Divino da Matta Junior¹, Osvaldo H. Campanella² and Pedro Esteves Duarte Augusto¹,³

¹ Department of Agri-food Industry, Food and Nutrition (LAN), Luiz de Queiroz College of Agriculture (ESALQ), University of São Paulo (USP), Piracicaba, SP, Brazil. ² Department of Food Science and Technology (FST), College of Food, Agricultural, and Environmental Sciences (CFAES), The Ohio State University (OSU), Columbus, OH, 43210-1007, USA. ³ Food and Nutrition Research Center (NAPAN), University of São Paulo (USP), São Paulo, SP, Brazil

Starches are obtained from renewable sources and are inexpensive and versatile ingredients. Therefore, they are highly suitable for several industrial applications. However, native starches lack some functional properties, which can be achieved by modification processes. Nonetheless, these processes frequently involve the use of chemical agents, and are being inquired regarding their impacts on consumers and on the environment. Therefore, the search for new technologies is gaining attention in this field. Among the possible alternatives, ozone (O₃) and ultrasound (US) are two promising technologies, presenting the positive aspects of being non-thermal and leaving no residues on the product nor on the environment. In this work, maize starch was modified using both O₃ and US, alone and in combination. For that end, starch suspensions (10% m/m) were placed in the reactors, processed for different times, and their properties were evaluated. In general, the US treatment alone had no influence on the starch pasting properties, gel strength and paste clarity if compared to the control sample. On the other hand, the O₃, alone or combine with US, showed to significantly affect the starch’s apparent viscosity and gel strength (both increased). The paste clarity was particularly improved by the combination of the technologies, especially when US was used prior the O₃ treatment. This result illustrated the hypothesis that US, despite no apparent influence on the starch properties, was able to change its structure, improving the subsequent O₃ action [2]. In conclusion, at the conditions applied in this work, the US showed to be an inefficient choice to modify starch properties, despite being a good alternative to favor the O₃ action. On the other hand, the O₃ proved to be an effective technology to modify maize starch, alone or in combination with US.
Ultrasound to incorporate microencapsulated carotenoid into food

Meliza Lindsay Rojas¹, Izabela Dutra Alvim³, Pedro Esteves Duarte Augusto¹,²

¹ Department of Agri-food Industry, Food and Nutrition (LAN), Luiz de Queiroz College of Agriculture (ESALQ), University of São Paulo (USP), Piracicaba, SP, Brazil. ² Food and Nutrition Research Center (NAPAN), University of São Paulo (USP), Piracicaba, SP, Brazil. ³ Technology Center of Cereal and Chocolate, Food Technology Institute (ITAL), Campinas, SP, Brazil

Ultrasound technology has been used as a pre-treatment to improve drying. The present work proposes to take advantage of this pre-treatment to incorporate microencapsulated carotenoids into food matrix. Carotenoid microcapsules were obtained by hot emulsification and solidification using hydrogenated palm oil as wall material. Apple was selected as suitable food material to perform the carotenoid incorporation. Three treatments were performed: Control (blanched apple slices without any pre-treatment), W (apple slices immersed for 30 min in an aqueous dispersion containing carotenoid microcapsules (100g/L of water)), and W+US (apple slices immersed in an aqueous dispersion containing carotenoid microcapsules and simultaneously applying ultrasound (118 W/L) for 30 min). After pre-treatment, the samples were rinsed superficially with distilled water to eliminate the superficial carotenoid microcapsules. Pre-treated samples were placed to dry using air at 50 °C and 0.8 ± 0.1 m.s⁻¹. The carotenoid content was determined after Pre-treatments and after drying. In addition, microscopy analyses were performed to evidence the incorporation of carotenoid microcapsules. The fresh control samples presented a carotenoid content of 0.06 ± 0.01 mg/g dry matter. The carotenoid content increased in about 430% when ultrasound was applied. After drying, the carotenoid content highly decreased in control samples, which showed a retention of only 35%. In contrast, better carotenoid retention (86%) was obtained in ultrasound processed samples. The results show that pre-treatment with ultrasound can be used to incorporate nutrients into the food matrix, increasing not only the incorporated quantity but also promoting their preservation. Studies to determine the nutrient bioavailability and bioaccessibility are now recommended.
Ultrasound-generated intensity changes due to solvent composition for the extraction of bioactives from agave bagasse (Agave salmiana) (59)

Liliana Santos-Zea¹, Janet A. Gutiérrez-Uribe², José Benedito³.

¹Tecnologico de Monterrey, Centro de Biotecnología-FEMSA, Escuela de Ingeniería y Ciencias. Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Mexico. ²Tecnologico de Monterrey, Campus Puebla, Escuela de Ingeniería y Ciencias. Vía Atlixcáyotl 5718, 72453, Puebla, Mexico. ³Dpto. Tecnología de Alimentos, Universitat Politècnica de València, Valencia, España.

Extraction of bioactive compounds from food and medicinal plants generally requires the use of organic solvents, generating toxic emissions and with the risk of leaving solvent residues in the final product. Ultrasonically-assisted extraction (UAE) provides a greener alternative, allowing the use of green solvents, such as water or ethanol. In this work, the influence of solvent composition on the ultrasonically-assisted extraction of agave bagasse phytochemicals was evaluated, considering how solvent composition can affect to the intensity of the ultrasonic field. For saponins and antioxidant compounds, the best conditions for extraction were 60 °C temperature (X1), and 20 solvent to feed ratio (X3), both for conventional and UAE. However, for UAE the best solvent was water, while for conventional extraction mixtures ethanol-water were more efficient. In case of saponins, a similar amount was obtained without ultrasound in 58% ethanol (22.48±1.34 mg PE/g dw) than for UAE in water (24.41±0.84 mg PE/g dw). For antioxidants, a higher amount was obtained by UAE in water (96.79±2.29 μmol TE/g dw) than without ultrasound in 70% ethanol (71.60±6.10 μmol TE/g dw). Ultrasound intensity resulted higher when only water used (271.40±11.91 W/L) than when 58% (189.29±2.52 W/L) or 70% ethanol (170.44±3.89 W/L) was considered. Furthermore, a cavitation intensity test on aluminium foil and SEM images of exhausted bagasse showed a stronger effect when only water was used. Therefore, in spite of the lower chemical affinity of water for saponins and antioxidant compounds, its lower vapor pressure and viscosity and higher surface tension, compared to ethanol, provides this solvent a larger cavitation intensity, making it more suitable for UAE. Therefore, UAE presents a good potential for the extraction of phytochemicals from agave bagasse, using water as solvents.
Understand the effect of low-frequency ultrasonication on microbial destruction of *Pseudomonas Aeruginosa* and quality loss in bovine milk (61)

Yuan Shi, Soumya Kumar, Anubhav Pratap Singh

*Faculty of Land & Food System, The University of British Columbia, Vancouver, BC, Canada*

High-temperature short time pasteurization is the most common method used in the dairy industry to eliminate bacteria and extend the shelf life of milk products. However, physicochemical properties and bioavailability of nutrients change during the high-temperature process. Ultrasound, as an emerging disinfection technology has generated interest in its use with potential food-related applications. In dairy processing, power ultrasound (20 kHz) can be used for microbial destruction and homogenization purposes [1]. This study aims at understanding the microbial destruction kinetics and kinetics of quality loss of ultrasonication treatment in bovine milk products.

In this study, The microbial destruction kinetics of *Pseudomonas aeruginosa* under ultrasonication treatment is analyzed by standard plate count method, and the ultrasonic process efficiency is evaluated based on the corresponding D and Z values. The formation of malondialdehyde (MDA) as a by-product of lipid oxidation indicates the extent of milk quality loss. A heat sink is utilized to understand the thermal and non-thermal effects of ultrasound on microbial destruction and lipid oxidation kinetics. Results data is modeled by Weibull distribution and first-order dynamic method.

The experiment result shows that ultrasound treatment eliminates the microorganism at a significant level, and the optimum results are obtained by 50°C and 25 min treatment. In addition, the ultrasonic treatment performs a better result in skim milk than whole fat milk. It is noteworthy that the MDA level increases with the sample temperature increase, and the MDA level remains unchanged with water bath treated sample. This indicates that lipid oxidation is mainly caused by the thermal effect of ultrasound, while the non-thermal effect of ultrasound is limited in promoting lipid oxidation. The Weibull model fully describes the inactivation of bacteria by ultrasonic treatment and shows good adaptability. Further development will enable it to be industrially relevant.
Nanoemulsions as encapsulating systems in foods (70)

Mayra Ramirez, Tomás García-Cayuela, & Luis Eduardo García-Amezquita

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramón Corona 2514,
Zapopan, Jalisco, Mexico

The use of nanotechnology in food and pharmaceutical systems has recently gained attention due to the diversity of its applications. The development of colloidal delivery systems in the nanoscale, i.e. nanoemulsion technology (NT), have shown promising results to encapsulate, prevent the degradation, and improve the bioavailability of functional or nutraceutical compounds. Nanoemulsions as encapsulating systems in foods, are defined as two immiscible liquids, a lipophilic active substance dispersed as spherical droplets into a hydrophilic liquid, forming a system where the droplets’ radii fall within the range of 10 to 100 nm, and which is thermodynamically and kinetically metastable. NT is a very attractive technique since its implementation usually requires non-expensive equipment, and simple and low-energy processes. NT has proved to be effective in the encapsulation of natural antimicrobials, antioxidant compounds (such as phytosterols, quinones and carotenoids), vitamins, colorants and flavors, due to their relatively low water solubility and poor stability in food formulations. NT can be conducted using both, ultrasound and high pressure homogenization technologies; where treatment conditions of no more than 750W and 100 MPa, respectively are enough to produce the nanoemulsions. In this regard, several studies have demonstrated that nanoemulsions have higher stability compared to that in regular emulsions in terms of particle aggregation and phases separation. Besides, the use of particles within the nanoscale could be used in clarified beverages due to the low light scattering produced by the nanodroplets. Nevertheless, the application of NT in foods is not completely studied and therefore its use in commercial food products is limited. The aim of this work is to present the advances and recent studies of the use of nanoemulsions to encapsulate bioactive compounds in foods, as well as to show the potential benefits of the application of this technology to produce functional and nutraceutical foods.
Ultrasound-assisted extraction of bioactives compounds from mango *Manililla* peels (65)

A.J. Borrás-Enríquez, E. Reyes-Ventura, S.J. Villanueva-Rodríguez y L. Moreno-Vilet

Mango (*Mangifera indica* L.) is a tropical fruit with high nutritional and medicinal value. In México, Soconusco region in Chiapas state is an important mango producer. Exists around of 16 mangoes varieties for local consumption; one of them, mango manililla peel has bioactive compounds like polyphenols and flavonoids. The active ingredients could be extracted by several ways, such as maceration extraction, solid phase micro extraction and hydrodistillation. However, these conventional extraction methods are solvent- and time-consuming. Recent studies showed that ultrasonic assisted extraction is efficient extraction method, which may enhance the extraction efficiency due to the effect of acoustic cavitation’s produced in the solvent by the passage of an ultrasound wave. The objective of this work was to obtain bioactives compounds of mango manililla peel using ultrasound assisted extraction. Some parameters such water- ethanol concentration, extraction time and % amplitude in a sonic bath at 60°C under ultrasound irradiation of 37 kHz, were evaluated to bioactives compound (polyphenols and flavonoids) extractions. A factorial design with three central points was using. Mango Manililla peel’s showed polyphenols concentration between 284.5-1659 (mg EGA/mL) and flavonoids between 210.6-1989.6 (mg EQ/mL). In the figure 1, extraction time and the interaction of % amplitude -extraction time shows positive effects for bioactives compounds (polyphenols and flavonoids) extraction; while water: ethanol concentration and its interaction resulted negative. The better extraction conditions were 50:50 ethanol: water concentration, 60 % amplitude and 20 minutes. The results demonstrated that mango manililla peel presents important bioactives compounds, and also indicated that ultrasound assisted extraction is a very useful method for the extraction of bioactive compounds (polyphenols and flavonoids).
Ultrasound assisted extraction process to obtain extracts rich in antioxidant biocompounds from Mediterranean vegetables wastes (72)

Ibarz, R., Soliva-Fortuny, R., and Martín-Bellos, O.

Food Technology Department, University of Lleida – Agrotecnio Center Av. Alcalde Rovira Roure, 191, 25198 Lleida (Spain)

Ultrasound compression and rarefaction cycles may be used to facilitate cell wall disruption thus enhancing mass transfer phenomena. Ultrasound assisted extraction (UAE) is an advanced manufacturing technology that has been successfully used to recover valuable compounds from food matrices. UAE-process parameters need to be optimized in order to obtain extracts rich in antioxidant biocompounds that may be used as functional-food ingredients. The aim of this study was to evaluate the effect of UAE conditions on the solvent extraction recovery (70:30 v/v ethanol:water ratio) of antioxidant biocompounds from Mediterranean wastes (peach, apple, red-pepper and cucumber). Mediterranean wastes were sonicated using amplitudes of 25-125μm for 20-120s. A response surface methodology was used to maximize the total phenolic content (TPC) and antioxidant activity (AA), determined through the DPPH, FRAP and ABTS+ assays in the obtained extracts. The optimal processing conditions for Mediterranean wastes, calculated using a desirability function, were found to be 125μm-20s, 125μm-120s, 125μm-115s, and 25μm-120s for peach, apple, red pepper, and cucumber, respectively. Red-pepper extracts exhibited maximal TPC (10.22±42 mg GAE/g), followed by apple (4.72±19 mg GAE/g), peach (3.22±7 mg GAE/g), and cucumber (1.6±5 mg GAE/g). The highest DPPH (0.048±0.07 μmol Trolox/g) and ABTS+ (0.025±0.13 mmol Trolox/g) scavenging-activity values were found for cucumber extracts, whereas red-pepper exhibited the largest AA measured by FRAP assay (0.07±0.5 mmol Fe(II)/g). Proper adjustment of the amplitude-time binomial for each food matrix seems critical to increase the antioxidant value of the obtained extracts. However, the extractability of key compounds does not only depend on the specific UAE conditions but also on the structural and compositional characteristics of the waste tissues. The results obtained shown the potential of ultrasounds to assist the extraction of antioxidant biocompounds from Mediterranean wastes to enhance their valorisation, in order to reduce their environmental and economic impact in the agro-food industry.
Ultrasound-assisted supercritical CO$_2$ treatment in continuous regime: Application in *Escherichia coli* inactivation (75)

Paniagua-Martínez I.* $^1$, Santos-Zea L. $^2$, García-Alvarado M.A. $^3$, Benedito J. $^1$

$^1$Dpto. Tecnología de Alimentos, Universitat Politècnica de València, Camí de Viver s/n, 46022, Valencia, Spain. $^2$Tecnologico de Monterrey, Centro de Biotecnología-FEMSA, Escuela de Ingeniería y Ciencias, Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Mexico. $^3$Unidad de Investigación y Desarrollo de Alimentos, Instituto Tecnológico de Veracruz, Calz. Miguel Ángel de Quevedo 2779, 91860, Veracruz, Mexico

Supercritical carbon dioxide (SC-CO$_2$) inactivation technology represents a promising non-thermal processing method, as it promotes minimum impact on the nutritional food properties. However, in some cases high pressures or temperatures and too long treatment times are required to guarantee the food’s safety. In order to obtain the required lethality at shorter processing times, a combination of SC-CO$_2$ with high power ultrasound (HPU) has been studied. The results showed that the combination of both techniques in a batch system accelerated the death of *E. coli* compared with the use of only SC-CO$_2$. The main of this work was to study the combined effect of SC-CO$_2$ and HPU on *E. coli* inoculated in commercial apple juice, approximately 1-10x10$^7$ CFU and treated in a continuous system. The influence of the pressure, temperature and residence time on the inactivation process was evaluated. Experiments were performed at different temperatures (31-41 °C), pressures (100-300 bars) and residence times (3.06-9.2 min). The inactivation ratios were fitted to a hybrid (Boolean-real Eq. 1) model in order to study the effect of the process variables. The maximum inactivation achieved by the system was 7.9 log-cycles. The hybrid model demonstrated that HPU has a significant effect on inactivation after shorter residence times. Using SC-CO$_2$ (100 bar, 31 °C) 3.06 min was required to achieve 3.29 log-cycles of reduction while using SC-CO$_2$+HPU at the same conditions a reduction of 7.9 log-cycles was obtained. The results demonstrated the potential of the continuous SC-CO$_2$ +HPU inactivation technique, the use of mild process conditions could lead to an increase in the quality of the product treated under this technique.
Astaxanthin extraction from *Xanthophyllumyces dendrorhous* by ultrasound under pressure (79)

Diederich Aguilar¹,², Carlota Delso¹, Juan Manuel Martínez¹, Lourdes Morales-Oyervides², Julio Montañez², Javier Raso¹

¹Food Technology, Facultad de Veterinaria, Universidad de Zaragoza, Spain. ²Department of Chemical Engineering, Universidad Autónoma de Coahuila, México.

Astaxanthin is a lipophilic ketocarotenoid of great interest due to its potent antioxidant activity. The yeast *Xanthophyllomyces dendrorhous* is one of the main sources of astaxanthin (between 80-90%) of carotenoids biosynthesized. Traditionally, intracellular carotenoid extraction is carried up by cell disruption and subsequent organic solvent extraction. This methodology results in a high cost and it is not eco-friendly. The objective of this work was to evaluate the potential of ultrasound under pressure for simultaneous cell disruption and aqueous carotenoids extraction from *X. dendrorhous*. The super producer yeast *X. dendrorhous* ATCC 74219 was cultivated in potato-dextrose broth for 6 days at 25 °C. McIlvaine buffer solution of pH7 was used as a treatment and extraction medium. A Box-Behnken design was used to evaluate the influence of pressure (50-200 kPa), amplitude (20-60%) and treatment time (30-120 s) on the carotenoids yield extraction. Applied treatments correspond to energies between 45 to 146 W. The carotenoids extraction was quantified spectrophotometrically by the difference between total carotenoid content and the remaining content in cells after treatment. The effect of the application of pressure during the ultrasound-assisted extraction was investigated. The percentage of total carotenoids extracted ranged from 19 to 80% depending on the intensity of the treatment applied, which corresponded to 1.2 and 3.0 mg.g⁻¹dw respectively. The extraction yield increased by the application of external pressure. For example, treatment of (200 kPa, 60% amplitude, 120 s) permitted to enhance a 150% the carotenoids extraction compared with the same condition without pressure. The synergistic effect of ultrasound combined with pressure enhanced the cavitation phenomena and it facilitated an emulsion formation. According to the ANOVA, the linear effect of pressure, amplitude and time were the most significant factors related to the aqueous carotenoids extraction. The application of ultrasound under pressure allowed the aqueous astaxanthin extraction as an emulsion from yeast *X. dendrorhous* ATCC 74219.
Effect of thermosonication or thermal pasteurization on phenolic compounds and antioxidant capacity of apple juice made from ultrasound-treated apples (80)

M.C. Naranjo, O. Martín-Beloso, R. Soliva-Fortuny, P. Elez-Martínez

Department of Food Technology, Agrotecnio Center, University of Lleida Av. Alcalde Rovira Roure 191, 25198 Lleida, Spain

Apples are an excellent source of phenolic compounds, which seem to be increased by ultrasound (US) technology. Apple juice is a popular drink that has to be pasteurized, usually by heat, to guarantee safety. The development of novel technologies, such as thermosonication (TS), may offer higher retention of nutritional and sensory properties than thermal treatments while microbial inactivation is maintained. The aim of this study was to evaluate the total phenolic contents (TPC) and antioxidant capacity of thermosonicated and thermal-treated juices made from US-treated apples. Apples were treated with an ultrasonic processor (UP400S) at amplitudes of 100 and 25 μm for 15 min. Apple juice from US-treated or untreated-apples was obtained by using a juice extractor and was processed by thermosonication (UP400S-D22K) for 2.8 min at 95°C or thermal treatment for 0.5 min at 95°C. TPC were determined by Folin-Ciocalteu method and antioxidant capacity was conducted by DPPH and FRAP assays. There were no significant differences in TPC between juices made from US-treated apples at 25 μm and those made from untreated apples. On the other hand, thermosonicated juice showed higher TPC (74.08 mg/100mL) and antioxidant capacity (FRAP: 77.93mg/100mL, 83.57% DPPH inhibition) than thermal-treated juice (p<0.05), which showed 45.45 mg/100mL of TPC, 43.44 mg/100mL (FRAP) and 60.36% DPPH inhibition. A better preservation of TPC was achieved in apple juices treated by TS. Hence, the combination of US and heat showed a synergic effect that enhanced the TPC rather than only heat in apple juices pasteurizations. This fact could be due to a higher enzyme inactivation achieved by TS and consequently, a lower phenolic degradation. The application of US on apples did not increase the TPC or antioxidant capacity in apple juices. On the other hand, thermosonication allowed higher TPC and antioxidant capacity than thermal treatment on apple juices.
Effect of Ultrasound treatment on physicochemical parameters in *Opuntia ficus* Indica cladodes (81)

C.L. Higuera-Orbe¹, H. M. Hernández-Hernández², T.A. Quiñones-Muñoz², L. Moreno-Vilet²

¹Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C. CIDEA. C.P.42163. San Agustín Tlaxiaca, Hgo. ²CONACYT- Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C., CIDEA. C.P.42163. San Agustín Tlaxiaca, Hgo

The *Opuntia ficus* Indica, also known as nopal is a cactus with great agronomic importance nationwide, it has been used as food and for some applications of traditional medicine. Nopal cladodes are an important source of bioactive compounds, among which organic acids, fiber, mucilage (hydrocolloid), pigments (betalains and carotenoids), minerals (calcium and potassium) and antioxidants (polyphenols and vitamin C), whose functionality on human health has been demonstrated. Current development trends in food processing indicate that the application of ultrasound can intensify and accelerate drying processes inhibiting the loss of bioactive compounds and quality. In order to evaluate the effect of ultrasound treatment on nopal cladodes, a full factorial experimental design with central point was carried out considering amplitude (20 and 100%) and sonication time (10 and 20 min) as factors. Changes in physicochemical parameters were investigated as total polyphenols by the Folin-Ciocalteu method, quantification of chlorophyll α and β, the color was measured with a Konica Minolta CR-20 colorimeter and morphological changes were analyzed through entropy measurement by image analysis. The results obtained were evaluated with the Addinsoft (2019) XLSTAT program. The ultrasound treatment causes significant changes in the parameters of ∆E, color a*, and chlorophyll α. For color change ∆E, the amplitude has a positive effect and time negative effect, where the color parameter a*, which varies from green to red, shows interaction between both factors (amplitude * time). In this sense the chlorophyll α, which is associated with the green color decrease by increasing the amplitude and time. No significant morphological changes in nopal samples were identified. The total polyphenol content in fresh nopal varied between 2.68 and 4.21 mgEAG/g and between 0.97 and 1.38 mgEAG/g in treated nopal samples.
Ultrasound and ozone for fresh food treatment, what is next? (90)

Caballero-Cerón, Claudia

Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Campus Ciudad de México

In recent years many emerging technologies have been studied and evaluated for fresh food treatment. Processes like High pressure, Pulsed Electric Field, Ohmic heated, Ultrasound, Ozone, and others have been tested in order to maintain nutritional and sensory aspects without additives or heating process. Sanitizers are widely used to prevent spoiling of fresh fruit, those disinfectant produce by-products that are potentially carcinogenic. Additionally, chemical disinfectants have been pointed out as contaminant agent for environmental groups. Thus, the food industry has been focused in emerging technologies to counter this. Focus on clean technologies, ultrasound and ozone have been shown efficient inactivation of pathogens in processed and fresh food, and more over ozone can eliminate pests while leaving no residues and without affecting quality. In recent studies it has been demonstrated significant reduction of pathogens in fresh food as cucumber, berry fruit and juices nearly to sterilization by ultrasonic and ozone treatment, in order to extend shelf life of these fresh food. Particularly, ozone treatment has shown effectiveness in post-harvest in pathogens destruction and preventing over ripening particularly in kiwi due to the ethylene of the packets in which they are stored, thus a great agent in preventing the kiwi from decaying. Additional studies need to be developed for scalability of this process to study the possibility of post- harvest treatment instead of traditional sanitizers. In the other hand, is necessary develop treatments combining these two technologies to increases their effectiveness in fresh food treatment.
Comparison of technologies for food preservation: Inactivation of horseradish peroxidase by ultrasound and thermal treatment (91)

Diego Alberto Rosas Gómez, Frida Sofía Punzo Garduño Elliston Vallarino Reyes, Javier Alejandro Belmont Díaz, Claudia Caballero Cerón

School of Engineering and Sciences, Monterrey Institute of Technology and Higher Education, Mexico City

Inactivation of the enzyme activity by ultrasound for food preservation has an advantage over thermal treatment due to the possibility of damaging the physical, chemical and nutritional characteristics of the treated food by this last methodology although it remains as the most cost-effective technique. Nevertheless, sonication offers the advantages of less energy consumption and less processing time. Moreover, it can be combined with other methods such as UV light irradiation to achieve better results in terms of the decrease of enzymatic activity. In this work, we demonstrate the capability of sonication compared to thermal treatment to decrease enzymatic activity. Horseradish peroxidase (HRP) was mixed with hydrogen peroxide (H₂O₂) and guaiacol to generate a colorimetric signal directly correlated to its activity. To determine the effect of sonication on HRP activity, the enzyme was subjected to ultrasound at 40 kHz while temperature was kept at 26 °C. Guaiacol and H₂O₂ were then added and absorbance was measured. Finally, to determine the effect of thermal treatment, HRP was placed on a water bath at 60°C and 70°C for different time periods. Absorbance was measured 5 minutes after the addition of guaiacol and H₂O₂. The enzymatic activity of HRP was 884.78 uM/min under normal conditions, this was considered the 100% of the enzymatic activity of HRP. In conclusion, we demonstrated that a similar degree of inhibition of enzymatic activity can be obtained by sonication and thermal treatment, being the first one a better option by not affecting the nutritional content of the food.
Shelf life of fresh-cut mango scalded by ohmic heating (22)

Flores García Francisco Martín¹; Morales Sánchez Eduardo¹, *; Gaytán Martínez Marcela²

¹Instituto Politécnico Nacional. Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada, Unidad Querétaro, departamento de Biotecnología, Querétaro, Querétaro, México, 76090.
²Posgrado en Ciencia y Tecnología de los Alimentos, Research and Graduate Studies in Food Science, School of Chemistry, Universidad Autónoma de Querétaro, Cerro de las Campanas S/N. Col. Centro, 76010 Santiago de Querétaro, México.

The effect of ohmic heating (OH) scalding was measured on the shelf life of fresh-cut mango minimally processed (Cubes of 2 X 3 cm). Conditions for OH were electric field intensities (60 and 75 V / cm), scalding immersion times (1, 3, 5, 10 and 15 min) and temperature of 65° and 75° C, these temperatures were given by the optimized treatment by conventional heat treatment (CT). Fresh-cut mango cubes scalded were characterized measuring the firmness, the total soluble solids, the pH, the titratable acidity, the colour change and the activity of polyphenoloxidase (PPO) during 20 days of storage in refrigeration (5° C). During storage OH showed better characteristics than conventional treatment (CT), the firmness value in the cubes remained stable until the 15th day of evaluation and no moulds or yeast growth was observed during storage. PFO activity was less in OH than CT. It is concluded that scalding cubes of mango fresh cut by OH is a feasible method to preserve minimally processed mango during storage.
Thermal and non-thermal methods for stabilization and preservation of milk and dairy products (69)

Beatriz Corvera, Luis Eduardo García-Amézquita, & Tomás García-Cayuela*

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramón Corona 2514, Zapopan, Jalisco, Mexico *email: tomasgc@tec.mx

Research for new and effective methods for stabilization and preservation of dairy products has emerged in recent years due to the consumers' increasing demand for palatable and safe dairy foods with long shelf-life. In almost all cases of industrial treatments, the most commonly used are the classic pasteurization and sterilization, based on the target microorganism of inactivation. However, these treatments can result in losses of nutritional and sensory quality. In an effort to design new technologies that cause minimum heat effects on sensorial and nutritional quality of dairy products, it is necessary to apply non-thermal technologies, or those using lower temperatures than conventional heat-based treatments. There are already several emerging processing technologies, some available for commercial applications, others still needing more development work. In this context, the objective of this review is present the state of the art research and technologies that have been proposed as sustainable replacements for classic thermal dairy processing. These technologies include new thermal methods as microwave, radiofrequency and ohmic; and non-thermal methods as pulsed electric fields, high hydrostatic pressure, high-pressure homogenization, microfiltration, pulsed light, UV light processing, and carbon dioxide processing. Likewise, the use of bacteriocins, which have the potential to improve the efficiency of the processing technologies, is examined. All these alternative milk processing techniques appeared as promising ways to improve the physical and functional properties of milk and dairy products.
Detrimental effects of cold plasma processing on nutrients within food: a critical review (95)

María Pamela Rodarte-Villalobos, Paul Martin-Navarro

Department of Bioengineering, Instituto Tecnológico y de Estudios Superiores de Monterrey, Mexico City, Mexico.

Cold plasma is a nonthermal emerging technology that is not only inexpensive, having an energy consumption similar to that of UV-C systems, but also ecological. Among its many advantages, it can be used for the sterilization of surfaces with multiple areas of shadowing that could prevent the product from being fully treated otherwise. In addition, atmospheric plasma can be generated directly from air in a short period of time, making it a fast, dry sterilization process that can operate at room temperature, achieving efficient enzyme inactivation and a considerable extension of shelf-life. In-package cold plasma technologies have an enormous potential for the processing of food products in continuous systems, although only pilot scale systems have been reported. Nevertheless, application of atmospheric plasma technologies (APT) may hinder the nutritional content of food, leading to a reduced antioxidant capacity in various meals including oranges, blueberries and apple juice. Moreover, in foods with a high carbohydrate content, degradation of reductive sugars such as fructose and glucose can occur. Furthermore, when oxygen is found to be a component of plasma, reactive oxygen species (ROS) may be produced that could, in turn, cause the oxidation of lipids. Although further disadvantages could be listed, such as the incompatibility with cellulose-derived materials, this critical review seeks to identify and analyze the wide range of degradation physical phenomena and chemical reactions that may happen in food products that undergo cold plasma processing. Key findings include increasing particle size in order to reduce surface area as a means to control exposition to plasma, which has a low penetrating power, as well as decreasing the processing time. Future research must focus on the development of formulations capable of suppressing undesirable effects.
Membrane technology applications in the dairy industry (37)

Mariano del Toro-Barbosa, Luis Eduardo García-Amézquita, & Tomás García-Cayuela

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramón 14 Corona
2514, Zapopan, Jalisco, Mexico

Membrane technology refers to the use of semi-permeable membrane filters to concentrate or fractionate a determined liquid, resulting in two different product streams that vary in their composition. Recently, the use of this non-thermal technology in the dairy industry has gained a lot of attention as it poses both an alternative to conventional unit operations and a novel method for processing ingredients and foods. Also, it is seen as well as a viable option to recover valuable products from wastewater while also making the latter more suitable for being discharged to the environment or for being reused back in the industry. The objective of this review is to assess different applications of membrane technologies being currently used in the dairy industry, as well as to identify different trends and perspectives regarding the recent advances of this unit operation. Some interesting applications in the recovery of valuable products include, the use of ultrafiltration in order to both isolate and concentrate whey proteins. As for the processing of dairy products, some applications were reviewed, such as cold sterilization through the use of membranes, and concentration by filtration instead of thermal evaporation to preserve flavor and integrity of nutrients. At last, regarding the treatment of wastewater, some interesting findings include reverse osmosis to purify water, and the use of membrane bioreactors followed by nanofiltration to effectively reduce the biochemical oxygen demand of waste effluents. Overall, it appears that membrane technology applications are gaining terrain in the dairy industry due to the advantages they portray against the usual methods and that this just started to acquire popularity in developing countries, where its use is perceived as highly promising.
Ozone technology to modify arracacha starch properties (46)

Dâmaris Carvalho Lima1, James Villar2, Bianca Chieregato Maniglia3, Manoel Divino Matta Junior1,
Pedro Esteves Duarte Augusto1

1Department of Agri-food Industry, Food and Nutrition (LAN), Luiz de Queiroz College of Agriculture (ESALQ), University of São Paulo (USP) - Piracicaba, SP, Brazil. 2Faculty of Agroindustrial Engineering, Universidad Nacional de Moquegua (UNAM) - Moquegua, Peru. 3ONIRIS-GEPEA UMR CNRS 6144 – Nantes, France.

Arracacha is a promising starch source for industrial use. However, arracacha starch present some drawbacks that limits its application in the industry, such as a weak gel formation. Modification technologies can overcome these drawbacks. Ozone technology is an attractive nonthermal chemical method of starch modification; it is considered an “environmentally friendly” and a “green” technology, since the ozone decomposes into oxygen. This work aimed to evaluate the effect of ozone technology in the arracacha starch properties. Arracacha starch suspensions (10% m/m in dry basis) were processed using ozone (46.7 mg O3/L) at a constant gas flow of 1 L/min for 15 and 30 min. The samples were analyzed in relation to pasting properties, paste clarity, gel strength, water absorption and solubility indexes. The peak apparent viscosity decreased, and the relative breakdown for ozonated samples increased with increasing processing time. The relative setback of the ozonated samples were higher than the native starch, which indicates a higher retrogradation tendency. The paste clarity was higher and more stable over storage time for ozonated samples than the native starch. The hydrogels of the ozonated arracacha starches were 250% stronger than the native one. The ozonation process improved the starch water solubility. On the other hand, the water absorption presented a reduction for the modified arracacha starches. Summarizing, the ozone process was able to change the arracacha starch properties, resulting in a promising technology to modify and improve arracacha starch for industrial application.
Applications and limitations of dense phase carbon dioxide in the food industry: a review (87)

Heredia Nieto, Alejandro; Núñez Manjarrez, Minerva E.

Monterrey Institute of Technology and Higher Education

Dense phase carbon dioxide (DPCD) is a non-thermal pasteurization technique whose main principle is the denaturation of pathogenic cell membranes and intracellular components. This in turn helps foods, typically beverages, preserve nutrients, antioxidants, and vitamins. The temperature and pressure ranges used in DPCD are around 20-60 °C and 7-40 MPa so carbon dioxide is kept at its supercritical phase, which are substantially more manageable conditions than other non-thermal counterparts like High Pressure Processing (HPP). Its use and experimentation on various beverages such as juices, dairy products as well as distilled products give it an upper hand against conventional thermal techniques that can modify the organoleptic properties of products or are incompatible with them. One of the main challenges this technology faces is its limited use in beverages. DPCD has not been able to transition to solid foods due to the complexity of the solid matrices. Moreover, it is not commercially used as conventional thermal treatment methods, as it requires expensive components to achieve high pressures. Lastly, even though CO₂ has a GRAS (Generally Recognized as Safe) status, it is still not regarded as sustainable due to CO₂ being a predominant greenhouse gas and its use promotes non-sustainable practices. This review focuses on the current advances, limitations and trajectories of this technology in the food industry.
Green technologies as a sustainable approach to the extraction of bioactive compounds from coffee and cocoa industry by-products: A review (71)

Castañeda-Rodríguez Luis Rey¹, Oseguera-Sánchez Esaú², Fernández-López Claudia Lorena³, Martínez-Castillo José Isabel², & Ozuna César¹²

¹Departamento de Alimentos, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Guanajuato, Mexico. ²Posgrado en Biociencias, División de Ciencias de la Vida, Campus Irapuato-Salamanca, Universidad de Guanajuato, Guanajuato, Mexico. ³Desarrollo de Investigación y Tecnología Aplicada, Universidad Politécnica de Huatusco, Veracruz, Mexico.

Mexico is one of the world leaders in the production of coffee and cocoa which are recognized by the “Protected Designation of Origin” distinction, regulated by the Mexican Industrial Property Law. Nowadays, cocoa and coffee consumption has been increasing due to their beneficial effects on human health, which have been correlated with their high-level concentrations of antioxidant compounds. Coffee and cocoa industries generate tons of solid by-products which may have a negative impact when discarded directly into the environment. Novel strategies for the recovery of high-added value compounds, such as bioactive compounds from these by-products, could be a sustainable approach to obtain low-cost ingredients. The aim of this review is to provide an exhaustive compilation and critical revision of research conducted on the implementation of green technologies (power ultrasound, microwaves, pulsed electric fields, supercritical carbon dioxide, etc.) as methods for extraction of natural bioactive compounds from coffee and cocoa industry by-products, paying special attention to antioxidants, antimicrobials agents, and essential oils. According to studies reviewed, green technologies have a great potential for the extraction of these compounds, achieving significant savings in time, solvents, and energy, and an increase in extract purity. However, future research in the area should focus on a systematic study of bioactive compound extraction by means of green technology combinations, always seeking the most efficient and cost-effective combinations and bearing in mind extract quality. The present review has also made evident the need for interdisciplinary research in the field of extraction of bioactive compounds from coffee and cocoa industry by-products. For instance, industrial implementation of green technologies and their combinations would benefit from collaborations between natural scientists and experts from the fields of engineering and industrial technology, in order to develop devices and pieces of equipment that would be suitable for cost-effective large-scale applications.
Oil extraction in mamey seeds (*Pouteria sapota*) assisted by continued and pulsed high hydrostatic pressure (86)

Saira Mayret Cano Monge¹, Viridiana Chavez-Leal¹, Erick Eduardo Cano Monge¹, Deyanira Moguel², Eduardo Borges³, Jorge Welti-Chanes³, José Rodríguez-Rodríguez², Mayra Cristina Soto-Caballero¹, Zamantha Escobedo-Avellaneda²

¹Facultad de Ciencias Agrotecnológicas, Universidad Autónoma de Chihuahua, Mexico. ²Centro de Biotecnología FEMSA, Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Mexico

Mamey (*Pouteria sapota*) is a tropical fruit native to southern Mexico and Central America. Seed of mamey, known for its oil content (35–49% dry matter), account for 15-25% of the total weight of the fruit, representing a substantial by-product with several applications including the development of cosmetic and pharmaceutical products. High hydrostatic pressure (HHP) is a nonthermal technology that has shown to increase the extraction yield of some food components. In this study, HHP at 600 MPa during 5, 10 and 20 minutes, and using 1, 3 and 5 pulses of high pressure was applied to previously grinded mamey seeds. The oil content after 4 h of extraction in Goldfish system with petroleum ether were determined as well as the fatty acid profile by GC-MS. The application of HHP increased oil yield extraction from 32.2 (600 MPa/5 min) to 64.7% (600 MPa/20 min) compared with the untreated sample. High pulse pressure favoured the extraction of oil up to 26% compared with the treatments during 5 and 10 min. Oleic, stearic, palmitic and linoleic acids were identified and quantified in all treated and control samples showing concentration that ranged from 2.7 to 28.3% of the total fatty acid content. Oleic acid was the main fatty acid accounting from 16.0 to 28.3%. HHP did not cause significant change in fatty acids profile and composition compared with the untreated samples. HHP application in mamey seeds proved to be an efficient alternative for oil extraction increasing the yield without any significant effect on the composition on the oil extracted.
Sanitizing procedures applied before storage of fresh-cut carrots affect the wound-induced biosynthesis of chlorogenic acid (54)

Alejandro Gastélum-Estrada, Alejandra Hurtado-Romero, Arlette Santacruz, Luis Cisneros-Zevallos, Daniel A. Jacobo-Velázquez

1 Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramon Corona 2514, Nuevo México, C.P. 45138, Zapopan, Jal., Mexico. 2 Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, NL, 64849, México. 3 Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX, 77843-2133, U.S.A.

To produce fresh-cut carrots, a process of sanitation is applied before processing (pre-shredding) and after peeling and/or cutting (post-shredding). During the production of fresh-cut products, crops are exposed to wounding stress, and as a stress-response antioxidant phenolic compounds are synthesized. This stress-response is induced by extracellular ATP (eATP), released from wounded cells and recognized by receptors of unwounded cells, eliciting the wound-response. However, during washing procedures applied in the industry, eATP is partially removed and thus the wound-induced accumulation of phenolics is decreased. In the present study, the impact of different washing/sanitizing procedures on the wound-induced accumulation of chlorogenic acid in shredded stored for 20°C at 48h was evaluated. Pre-wounding treatments were blanching (100°C, 45s) and chlorine (200 ppm, 2 min), whereas post-wounding treatments were chlorine (100 ppm, 2 min), hydrogen peroxide (1.5%, 3 min) and water soaking (2 min). All treatments showed the desirable antimicrobial effects. After 48h, the control showed the highest content of CHA (1,432 mg/kg), which presented a 4,000% of increase due to wounding as compared with time 0 h. All sanitizing procedures decreased the wound-induced accumulation of phenolic compounds. Samples with pre-wounding chlorine application (200 ppm) and 100°C blanching, showed increases of CHA by 2,700% and 1,012%, respectively, as compared with the control before storage; whereas Post-shredding treatments, water, chlorine (100 ppm) and hydrogen peroxide, showed increases of CHA by 2,600%, 2,280%, and 500%, respectively. No significant difference in β-carotene content was observes among treatments. These results demonstrated the partial removal of eATP affects the wound-induced biosynthesis of phenolics and thus it should be considered when treating raw material needed to produce processed food products.
Effect of wounding stress and chitosan treatment on chlorogenic acid and β-carotene contents of harvested carrots (55)

Luis Berumen-Guerrero, Alejandra Hurtado-Romero, Alejandro Gastélum-Estrada, Daniel A. Jacobo-Velázquez

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Av. General Ramón Corona 2514, Nuevo México, C.P. 45138, Zapopan, Jal., México

The application of postharvest treatments to fruits and vegetables that improves their health-promoting properties, prior to their processing into value-added foods, is an emerging topic of research. Chlorogenic acid (CA) is the main phenolic compound in carrots, is induced by wounding stress, and possess potent activity against the metabolic syndrome. Likewise, chitosan is another elicitor that induces the secondary metabolism of plants. In the present study, the effect of postharvest wounding stress applied alone and combined with chitosan, over the total phenolic content (TPC) and CA accumulation in carrots was investigated. Two consecutive experiments were performed. The fist experiment was done to determine the method of chitosan application (dipping and spraying) and concentration (0%, 1%, 2% w/v) that induced the highest accumulation of TPC in wounded tissue (whole and slices). The second experiment was performed to determine the optimum wounding intensity (whole, slices, pie-cuts, and shreds) that resulted on the highest accumulation of CA when treated with chitosan suspensions applied by spray (0%, 0.25%, 0.50%, 1.0%, w/v). Carrot samples (300 g) were treated with chitosan suspensions (200 mL), stored in 4L hermetic containers at 20°C for 48 h, and ventilated every 12h to avoid headspace CO2 concentration ≥ 0.5%. Results from the first experiment demonstrated that chitosan application (1% w/v) enhanced the wound-induced accumulation of phenolics and that the increase was higher when applied with spray. From the second experiment, it was demonstrated that pie-cuts was the wounding intensity that showed the highest accumulation of CA when chitosan was applied at 1.0%, showing increases of 130.7% and 369.9% as compared with the control 48 h and 0 h, respectively. The wounding and chitosan induced biosynthesis of CA in carrots was demonstrated by evaluating phenylalanine amino-lyase activity, which correlated with the accumulation of phenolics. Results demonstrated that wounding stress applied in combination with chitosan could be used as an effective alternative to enrich the content of carrots with CA prior to its transformation to processed foods using thermal and non-thermal processing technologies.
Emerging pre-treatments as promising strategies for increment of nutraceutical content and extraction yield in plant foods: lycopene from tomato by-products as case study (68)

Luis Octavio Cano y Postig, Tomás García-Cayuela, & Daniel A. Jacobo-Velázquez*

Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. General Ramón Corona 2514, Zapopan, Jalisco, Mexico *email: djacobov@tec.mx

Research for new and effective methods of bioactive compound extraction has seen a remarkable boost in recent years, thanks to the widespread increased attention to the nutraceutical market has acquired. In almost all cases of industrial scale extraction of nutraceuticals, the de facto method comes in the form of using organic solvents for the separation of active biological compounds from all sorts of plants and food materials. Plus, there has also been a push in the need to use greener alternatives to achieve the same yield results of the organic solvents, as in the case of super critical CO2. Still, the extraction results for all the newly applied technics are still behind in terms of raw effectiveness, which is where pretreatment methods come into play. Pretreatments help with the liberation of solutes of interest into the exterior layer where they are more readily extractable, as well as facilitate the contact of the solvent with the solutes accumulated on the interior layers, which combined, significantly increase the final extraction yield. With this in mind, the following review will present both classic and emerging pretreatment methods that can be combined with most of the already stablished extraction protocols. Some of these pretreatments are based on enzymatic degradation, heat treatment induced by microwaves and ultrasonic degradation, among others. Less explored options come in the form of applying a direct solid-state fermentation with fungus. Lycopene from tomato by-products will be used as the supporting nutraceutical compound that will help compare different pretreatment methods with the purpose of exemplifying realistic applications in plant food industry.
Wounding and UVB light induce the biosynthesis of phenolic compounds and ascorbic acid in red prickly pears (Opuntia Ficus-Indica cv. Rojo Vigor) (88)

Erika Ortega-Hernández¹, Vimal Nair², Jorge Welti-Chanes³, Luis Cisneros-Zevallos² and Daniel A. Jacobo-Velázquez ¹,³*

¹Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Av. Eugenio Garza Sada 2501 Sur, C.P. 64849 Monterrey, N.L., Mexico. ²Texas A&M University, Department of Horticultural Sciences, College Station, TX, 77843-2133, United States. ³Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Av. General Ramón Corona 2514, Nuevo México, C.P. 45138, Zapopan, Jal., Mexico

In the present study, the effects of UVB radiation and wounding stress, applied alone or combined, on the biosynthesis of phenolic compounds and ascorbic acid in red prickly pear (Opuntia ficus-indica cv. Rojo Vigor) was evaluated. Whole and wounded-fruit samples were treated with UVB-radiation (6.4 W•m⁻²) for 0 and 15 min, and stored for 24 h at 16 °C. Variables such as the individual identification of phenolics (by HPLC), quantification of ascorbic acid (by the α-α’-bipyridyl method), phenyalanine ammonia-lyase (PAL) activity (by spectrophotometry), and L-Galactono-γ- activity (GaiLDH, by spectrophotometry), were determined immediately after UVB radiation and after storage. Likewise, the respiration rate and volatile organic compounds (VOCs, associated with ethylene) production were evaluated. The highest phenolic accumulation occurred after storage of the whole tissue treated with UVB, where the main phenolics accumulated in the peel and pulp were quercetin (709.8%), sinapic acid (570.2%), kaempferol (442.8%), rosmarinic acid (427.8%) and sinapoyl malate (160.7%). PAL activity was increased after storage of the whole tissue treated with UVB light; however, when UVB light was applied in the wounded tissue lower PAL activity and phenolic accumulation was detected, suggesting an antagonistic effect. On the other hand, GaLDH activity and ascorbic acid biosynthesis was enhanced due to UVB radiation, and the effect was increased when UVB was applied in the wounded tissue showing 125.1% and 94.1% higher vitamin C content after storage as compared with the control. Respiration rate was increased due to wounding stress, whereas ethylene production was increased by wounding and UVB radiation in the prickly pears. Results allowed the generation of a physiological model explaining the UVB and wound induced accumulation of phenolics and ascorbic acid in prickly pears.
Effect of water on microstructure and thermo-mechanical properties of phosphatidylcholine organogels (66)

Martinez-Avila M.¹, Van de Walle², D., Dewettinck², K., Toro-Vazquez, J.F.³*

¹Tecnologico de Monterrey, Centro de Biotecnologia-FEMSA, Escuela de Ingenieria y Ciencias. Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, Mexico. ²Laboratory of Food Technology and Engineering, Department of Food Technology, Safety and Health, Ghent University, Coupure Links 653, 9000 Ghent, Belgium ³Facultad de Ciencias Quimicas-CIEP, Universidad Autónoma de San Luis Potosí Av. Dr. Manuel Nava 6, Zona Universitaria 78210, San Luis Potosí, México. *e-mail: toro@uaslp.mx

Phosphatidylcholine (PC) has been thoroughly investigated as a surfactant (i.e., to stabilize o/w or w/o emulsions) due to its amphiphilic structure. However, its use to develop self-assemble organic solvents (organogels), is focused mainly on single organic solvents or as a crystal habit modifier for different potential applications, like bioactive compound carriers and enzyme encapsulation. PC organogels have attracted attention as drug carriers in pharmaceutical technology, due to their great similarity with cell membrane, for transdermal drug delivery. The present study is focused on investigating the use of commercial PC’s with different unsaturation extent (saturated and unsaturated), on structuring sunflower oil, with the incorporation of high amounts of distilled water (up to 100%). We evaluate the microstructure of the PC organogels, through cryo-Scanning Electron Microscopy and polarized light microscopy. Then the melting profiles of this structures, were evaluated with Differential Scanning Calorimetry, and the mechanical properties associated to those structural changes, using an oscillatory rheometer. The results showed that the presence of water, independent of the amount or PC unsaturation extent, improve the structure stability, even at higher temperatures (85 °C). In the saturated PC, caused molecular shape transformation, from cylindrical to truncated cone, thus increasing their solubility by changing their structural organization from planar bilayers to multilamellar vesicles. In the unsaturated PC, increased the negative curvature of the structure thus, causing them to swell. Despite both types of PC developed multilamellar vesicles, they displayed different dissociation kinetics, directly related to their solubility in the solvents. The development of PC in sunflower oil organogels, with the addition of water at high concentrations, will lead to understand the PC molecular self-assembly at conditions closer to complex matrices, as the gel formation by PC’s, is argued to be a process similar to micellization rather than crystallization.
Avocado seed acetogenins as a hurdle to control mycelial growth and conidia germination of *Botrytis* spp. for the preservation of strawberry puree (98)

1Echenique-Martínez, A. A., 2Rodríguez-Sánchez, D. G., 2Troncoso-Rojas R., 2Hernández-Brenes, C., 1Robles-Ozuna L.E., 1*Montoya-Ballesteros, L.C

1Centro de Investigación en Alimentación y Desarrollo, A.C. Carretera Gustavo Enrique Astiazarán Rosas, No. 46, Hermosillo, Sonora, México, CP 83304. 2Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Monterrey, N.L., México, Eugenio Garza Sada 2501 Sur, CP 64849, Monterrey, N.L., México.

*Botrytis cinerea* is the causal agent of grey mould disease in more than 200 crops, including strawberry (*Fragaria × ananassa*), causing large losses before and after harvest (40-60%) worldwide. To combat this phytopathogenic fungus in processed products such as strawberry puree, synthetic preservatives such as potassium sorbate (SP) are used. However, SP is genotoxic and/or mutagenic, in this way the consumer chooses to consume natural products that replace synthetic preservatives. Avosafe® is a natural preservative, enriched in bioactive fatty acids from avocado seeds (acetogenins), whose antimicrobial activity has been demonstrated, however its antifungal activity is unknown. Therefore, the objective of this study was to investigate the effect of different concentrations of Avosafe® on mycelial growth (50-12000 mg/L) and the germination of conidia (250-7500 mg/L) of *Botrytis* spp. *in vitro* in strawberry puree. No significant differences (p <0.05) were observed at 7,500 mg/L of Avosafe® compared to 1,000 mg/L of SP, managing to reduce 1 log during the stationary phase of the fungus. The IC50 of 661 mg/L was determined and the MIC is greater than 12,000 mg/L for mycelial growth. Avosafe® caused swelling over the affected conidia and significantly reduced the germination rate of the conidia 1.31 times compared to SP. The IC50 (75.42 mg/L) was determined, affects morphology until causing cellular senescence in conidia and MIC (661 mg/L) inhibited 78% of germination. In addition, by inoculating 3.47 log of conidia in strawberry puree, Avosafe® reduced 1 log in 40 days at 4°C, without altering the concentration of total anthocyanins and physicochemical properties. Therefore, Avosafe® could be a possible alternative as a fungistatic agent and as a hurdle approach to assist high hydrostatic pressures.
Use of freeze dried harina mango seed as a compounds source of antioxidant activity in mexican tortilla making (93)

Bernal Maldonado, Manuel and San Martín Azócar, Alejandra

Departamento de Bioingenierias, Instituto Tecnologico de Monterrey, Campus Querétaro

Freeze drying is a low temperature dehydration process that involves freezing the product, lowering pressure, then removing the ice by sublimation, in contrast to the conventional methods that evaporate water using heat. Mango is a tropical fruit with a high degree of acceptance in the Mexican market. There are a variety of products in which the pulp is used exclusively, leaving the rest of the bagasse, seeds and skin fruits as waste. Mango seed has functional properties, such as the high content of polyphenols, phytosterols and compounds with antioxidant activity, which would be of great impact on the nutrition of Mexicans, helping to combat cardiovascular diseases and taking advantage of the waste of the large industries of Mango processing would reduce the contamination of organic matter in the environment. The objective is to evaluate the effect on the properties of a corn tortilla obtained by replacing the pulp meal of the mango seed (*Mangifera indica*) obtained by freeze drying, as a byproduct of the mango processing industries to improve its nutritional quality. Mango seeds were pretreated to inactivate the tannins present and prevent bitter flour from being obtained. A control and three experimental samples were prepared incorporating 20, 30 and 40 percent of dried mango seed pulp flour and their sensory attributes, total polyphenols and texture parameters were evaluated. The incorporation of mango seed meal in tortillas at a level of 30% was organoleptic acceptable. High amounts of polyphenols are present in tortillas with a 30% incorporation of mango seed meal with a total of 53.51 mg of gallic acid equivalents. The hardness increases as the concentration of mango seed grain flour increases, with the incorporation of 20% being the optimal choice.
School of Engineering and Sciences. Campus Monterrey.

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