Book of Abstracts of the 8th International Symposium on "Delivery of Functionality in Complex Food Systems"

Sheraton Porto Hotel Conference Centre, Porto, Portugal

7-10 July 2019

This volume contains the abstracts presented at the **8th International Symposium on "Delivery of Functionality in Complex Food Systems"**, held in Sheraton Porto Hotel Conference Centre, Porto, Portugal, 7-10 July, 2019.

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Preface

Dear colleagues,

Be very welcome at DOF2019, the 8th International Symposium on "Delivery of Functionality in Complex Food Systems", in Porto, Portugal!

This series of Symposia have managed to gather, throughout the years, an interdisciplinary team of scientists from different research areas (food science and engineering, biophysics, applied soft matter, food technology, applied human nutrition) and very different proveniences (from academia, industry and young researchers) and places around the World.

Being the 8th symposium of the series, DOF2019 is not an exception to this rule and we have prepared an exciting program that addresses the most recent developments in the area. This edition features three main themes:

Food Structures for Delivery of Functionality

Safety and efficacy of delivery systems

Healthy food design: is multi-functionality the right way forward?

Topics addressing issues such as the Personalized Nutrition approach, natural and biomimetic food systems or food synergy to delivery of functionality have been included.

Overall participation has resulted in 1 plenary and 8 keynote lectures, 49 oral presentations and over 103 posters, in a total of 30 countries represented.

We sincerely hope that you enjoy DOF2019, not only at the scientific and technical levels, but also at the cultural level, with the prize-winning city of Porto being chosen as its venue!

Sintam-se em casa!

António A. Vicente

(Chair of the Organising Committee)

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Table of Contents

PLENARY LECTURE

24758 - HOW CAN WE BE SURE THAT OUR FUNCTIONAL PRODUCTS REALLY WORK? FROM HUMAN STUDIES TO REGULATORY APPROVAL

***David Richardson*[1]**

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Keywords: Scientific substantiation, Health claims, Regulatory authorization

Abstract

The substantiation of health claims is based on generally accepted scientific evidence, an evaluation of the totality of the available scientific data and weighing of the evidence. The different lines of evidence comprise human intervention studies, randomised controlled trials (RCTs) including the use of validated biomarkers, human observational/epidemiological studies, national/international expert consensus reports, authoritative statements and supportive evidence of biological mechanisms from animal and *in vitro* studies. The analysis and integration of the information requires an assessment of the biological relevance, consistency, statistical significance and reliability of each line of evidence to support the physiologically beneficial effect(s) for human health.

The presentation will cover a synopsis of pertinent scientific data, the scientific and technical guidance for the preparation and presentation of a health claim application, the EFSA guidance documents for scientific requirements for health claims and the best approaches to avoid rejection by EFSA. Globally, the structure and process for scientific substantiation and authorisation of health claims on foods is based on the principles and guidelines set out by the Codex Alimentarius Commission. Using Codex as a reference point, international regulatory frameworks for nutrition and health claims are converging, and the development of a scientifically robust and proportionate framework for the assessment of health claims is a critical regulatory and policy issue. As well as achieving a high degree of consumer protection, regulatory frameworks need to promote and protect innovation and ensure fair trade. However, more work is needed on consumer understanding of health claims to ensure that claims are truthful and meaningful.

The paper will also address the strengths and limitations of different sources of evidence, the need for identification and validation of relevant biomarkers that can detect early signs of homeostatic disturbance and provide examples of successful health claims related to cardiovascular health.

SESSION 1: FOOD STRUCTURES FOR DELIVERY OF FUNCTIONALITY


8th International Symposium on
"Delivery of Functionality in Complex Food Systems"
7 - 10 July, 2019 | Sheraton Porto Hotel Conference Centre

KEYNOTES

24879 - FUTURE FOODS: HOW MODERN SCIENCE IS TRANSFORMING THE WAY WE EAT

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Abstract

We are in the midst of an unprecedented era of rapid scientific and technological advances that are transforming the way our foods are produced and consumed. *Food architecture* is being used to construct healthier, tastier, and more sustainable foods. *Functional foods* are being created to combat chronic diseases such as obesity, cancer, diabetes, stroke, and heart disease. These foods are fortified with *nutraceuticals* or *probiotics* to improve our mood, performance, and health. The dissimulation of foods inside our guts and assimilation by our bodies is being controlled to increase their healthiness. *Precision nutrition* is being used to tailor diets to person's unique genetic profile, microbiome, and metabolism. *Gene editing*, *nanotechnology*, and *artificial intelligence* are being used to address challenges such as feeding the growing global population, reducing greenhouse gas emissions, and improving sustainability. This presentation highlights some of the interesting scientific advances being made in the food area and the role of structural design to create a better food future.

25401 - TUNING FUNCTIONALITY OF SEMI-FLEXIBLE FIBRILS IN EMULSIONS: FROM BRIDGING AND DEPLETION FLOCCULATION TO KINETIC STABILISATION

Jinfeng Peng[1]; Paul Venema[1]; Krassimir Velikov[2,3]; Erik van der Linden[1]

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Abstract

We have studied three types of systems. The first consisted of protein based semi-flexible fibrils with oil droplets. It was observed that above a minimum concentration of fibrils depletion flocculation occurred. Above a certain concentration of fibrils, the emulsion was stabilised, and small oil droplet aggregates with single droplets were observed. The aggregate size is independent of the fibril concentration. The droplet aggregation was reversible upon dilution with an equally concentrated fibril solution and a solution without fibrils. No emulsion droplet networks nor fibril networks were observed. The viscosity of the emulsions was similar to that of the fibril solution. The second system consisted of monodisperse polystyrene latex particles with protein fibrils. Similar observations to the emulsion systems were gathered, and in addition within a certain concentration regime also bridging flocculation occurred. The third systems consisted of protein fibrils and Bacterial Cellulose (BC) microfibrils with oil droplets. When only BC microfibrils are added to an emulsion, oil droplet creaming is slowed down, and eventually arrested above a certain concentration of BC microfibrils. Adding both protein fibrils and BC microfibrils to an emulsion may lead to an antagonistic effect: at low concentration of protein fibrils the destabilising effect of the protein fibrils can be counteracted by the stabilising effect by the BC microfibrils.

ORAL COMMUNICATIONS

OC01 - 24991 - PRODUCTION OF OLIVE OIL ORGANOGELS: INFLUENCE OF BEESWAX CONCENTRATION ON PHYSICOCHEMICAL PROPERTIES

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Keywords: Beeswax, Olive Oil, Organogel Gelation, Texture, Rheology

Abstract

Edible oils have potential health benefits in comparison to saturated and/or trans fats employed in food products. Conferring structure to these oils allows a greater range of applications, improving its applicability, such as spreadable products. The aim of this work was developing an olive oil organogel, foreseeing its application in the food industry.

Olive oil and beeswax (BW) as organogelator (1% to 6% (w/w)) were used for the production of the organogels, solubilized at 90 °C and cooled to room temperature. Systems were evaluated for their oxidation stability through peroxide values (PV), mechanical and rheological (flow curves and non-isothermal oscillatory sweeps) and thermal (DSC) properties. Olive oil and commercial butter were used as controls.

Results showed that an increase in BW concentration increased the textural parameters. Compared to values of commercial butter, organogels values were lower, indicating a less structured organogel (highest values: firmness 4.99 N and 17.76 N; spreadability 3.87 N/sec and 18.98 N/sec for organogel and butter respectively). Rheological and DSC results showed an increase in all parameters evaluated (thixotropy, initial viscosity, onset temperature, enthalpy) with BW concentration increase. Melting point of organogels was also determined by non-isothermal rheology and compared with DSC results. There was a similar trend with increasing concentration, however, a gap was observed since different mechanisms are involved. Oxidative stability was assessed (63 days), and results showed that, while an increase with time exists, it is within normal values (maximum PV value (63 days) of 1.43 milliequivalents/kg), and all organogel samples were below pure olive oil.

In short, results showed that by changing the concentration of gelator, physicochemical properties can be easily changed and tailored, possibly creating a wide range of products. Thus, an industrial application can be easily projected, since olive oil is a healthier alternative to commercial butter and other spreadable products.

Acknowledgements

This study was supported by the Portuguese Foundation for Science and Technology (FCT) under the scope of the strategic funding of UID/BIO/04469/2019 unit and BioTecNorte operation (NORTE-01-0145-FEDER-000004) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte.The author Pedro Silva is the recipient of a fellowship (SFRD/BD/130247/2017) supported by Fundação para a Ciência e a Tecnologia, (FCT, Portugal). Artur Martins is the recipient of a fellowship supported by a doctoral advanced training (call NORTE-69-2015-15) funded by the European Social Fund under the scope of Norte2020 - Programa Operacional Regional do Norte.

OC02 - 24919 - LIPOSOME ENCAPSULATION OF A OLEUROPEIN-RICH OLIVE LEAF EXTRACT AND STUDY OF THE EFFECT OF OLEUROPEIN ON MODEL LIPID MEMBRANE

***Rodrigo González Ortega*[1]; *Paola Pittia*[2]; *Carla Di Mattia*[2]; *Natasa Poklar Ulrih*[1]**

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Keywords: Olive leaf, Oleuropein, Liposomes, Encapsulation, Lipid membranes

Abstract

The large increase in number of food products enriched with bioactive compounds having health promoting properties while relatively unstable, has been promoted by the development of encapsulation technologies allowing protection and targeted delivery. Olive leaves are a waste product of olive oil processing with high concentration of phenolic compounds, being oleuropein the most representative, with remarkable health promoting properties.

In this study, OLE was encapsulated into liposomes by a simple and food grade method. Liposomes were characterized using TEM and z-size/potential. Stability and release of oleuropein from liposomes was studied at 5 °C and 90 °C in model systems at different pH values and time, and in a model/commercial lemonade drink kept at different temperature. Furthermore, the effect of oleuropein on the fluidity of a model lipid liposome membrane at different oleuropein/lipid molar ratios was evaluated by means of differential scanning calorimetry and fluorescence anisotropy.

OLE-liposomes presented a diameter ranging from 100 to 600 nm as observed with electron TEM and, with an average diameter of 485 ± 9 nm. Encapsulation efficiency of oleuropein, main OLE compound, was 33.8 ± 1.5%, while that of verbascoside encapsulation efficiency was 75.0 ± 0.8%. An early release of 15-20% oleuropein during the first hour followed by a slow sustained release was observed at 5 °C.

Liposome encapsulation slowed down oleuropein degradation in acidic pH 2, while slightly enhanced oleuropein stability in the model lemonade drink at 90 °C; however, it did not have an effect on OLE stability at 5 °C and in the commercial lemonade drink.

The main phase transition of model lipid membranes showed a splitting and gradual shift to lower temperatures and a decrease on the pre-melting transition enthalpy when oleuropein was present at a 1:1 oleuropein/lipid molar ratio or higher, indicating that oleuropein is likely to be partially inserted into lipid bilayer.

Acknowledgements

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement Nº 713714

OC03 - 24689 - FORMATION AND CHARACTERISATION OF FLAVONOID-MILK PROTEIN CO-PRECIPITATES; NOVEL DELIVERY VEHICLES FOR HIGH DOSAGE OF HYDROPHOBIC FLAVONOID COMPOUNDS

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Keywords: Bioactive delivery, Polyphenols, Milk proteins, Rutin, Trehalose, Functional food

Abstract

Proteins can be used for delivery of hydrophobic flavonoids, such as rutin, which show several therapeutic and pharmacological effects. However, due to the poor water solubility and bioavailability of rutin, its incorporation into functional foods at high concentrations is a real challenge. Moreover, rutin can interfere with the food matrix and result in some undesirable changes in physicochemical and sensorial properties of the food. In this study, a cost-effective, biocompatible, and biodegradable oral delivery system was developed for delivery of high concentrations of flavonoid rutin for incorporation into functional foods.

A concentrated solution of sodium caseinate (NaCas) was brought to alkaline pH, and rutin and trehalose (as a cryo-protectant) were added. The mixture was then acidified and the precipitated product was lyophilised.

A very high entrapment efficiency and a great loading capacity of rutin (98% and 49%, respectively) were observed. Dispersibility of rutin powders in water was improved dramatically, due to the pH treatment as well as the addition of NaCas and trehalose. The scanning electron microscopy revealed some considerable structural changes to rutin structure, because of the pH-treatment and NaCas addition so that some rod-shaped crystals of rutin appeared in the microstructure of the manufactured products. The addition of trehalose also resulted in a different microstructure of rutin surrounded by trehalose, owing to the cryo-protection properties of this disaccharide. X-ray diffraction and solid-state nuclear magnetic resonance spectroscopy analyses revealed an amorphous structure of rutin after pH-treatment and trehalose addition, which explains its improved dispersibility in water.

Overall, these findings demonstrated the feasibility of the development of an efficient food-grade delivery system for high concentrations of hydrophobic flavonoids, such as rutin. The co-

precipitates have a possible application for the incorporation of high doses of such bioactive compounds in various functional foods, or as a rutin supplement in the nutraceutical industry.

OC04 - 24909 - DUAL DELIVERY OF WATER-SOLUBLE COMPOUNDS AND WATER-INSOLUBLE POLYPHENOLS USING COMPLEX INTERFACES

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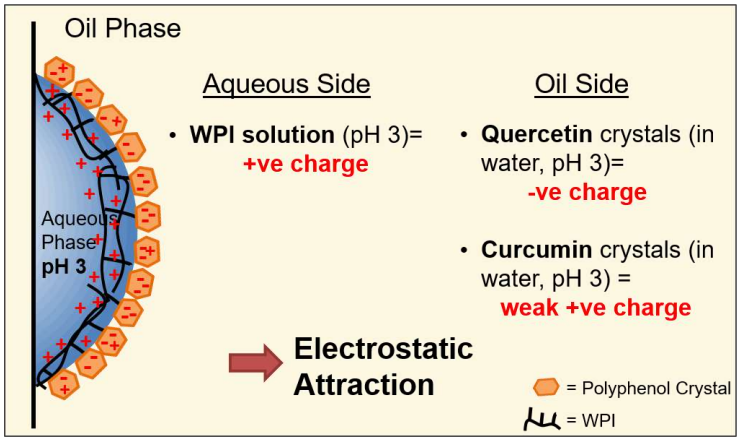
Keywords: Water-in-oil emulsions, Pickering stabilizers, Biocompatible particles, Quercetin, Curcumin, Whey protein, Interfacial complexation, Interfacial shear viscosity

Abstract

A strong scientific consensus exists that orally administrated polyphenol compounds have poor bioavailability due to their poor water solubility and limited absorption in physiology. Here, we demonstrate a new technique of how we can deliver water-insoluble polyphenols by using them as Pickering stabilizers at an emulsion interface rather than as polyphenols in bulk phase. We have previously shown that water-in-oil (W/O) emulsions can be stabilized by crystals of naturally occurring water-insoluble polyphenols that allow delivery of water in the form of droplets[1]. The aim of this study is to investigate the complexation of such polyphenol crystals (quercetin or curcumin) with a biopolymer at the interface in order to deliver efficiently both water-soluble compounds *within* the droplets and water-insoluble polyphenols at the interface. A range of complementary techniques, such as light scattering, microscopy, interfacial shear rheology and zeta-potential was used to understand the stabilization mechanism. Incorporation of a biopolymer such as whey protein isolate (WPI) into the aqueous phase caused the formation of a polyphenol-WPI complex at the water-oil interface and generated pronounced improvement in the stability of the water droplets. Complex formation at the interface can be attributed to electrostatic attraction between the oppositely-charged polyphenol crystals and WPI at the interface. Interfacial shear viscosity measurements showed that there was strong complex formation between polyphenol crystals and protein at the interface.
By changing the nature of the protein through a physical modification, the stability of water droplets was further improved. This novel stabilization mechanism allowed incorporation of up to 20 wt% water droplets into the oil continuous phase. In this way, we demonstrate a unique strategy to allow dual delivery i.e. water-soluble compounds within droplets plus water-insoluble polyphenol compounds at the interface, via complexing the latter with protein.



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Acknowledgements

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OC05 - 24996 - PHYSICOCHEMICAL PROPERTIES OF CAPSICUM OLEORESIN EMULSIONS USING MODIFIED MALT AS NOVEL ENCAPSULATING AGENT FOR FOODSTUFFS APPLICATION

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Keywords: Chilli, Encapsulation, Arabic Gum, modified starch, Barley malt, Capsaicin

Abstract

Capsicum oleoresin is a great source of capsaicin, pungent compound of low solubility that plays an important role in the prevention of chronic diseases. This study proposes the evaluation of the effect of *Capsicum* oleoresin encapsulation, using commercial materials and modified malt as a novel encapsulating agent by oil-in-water emulsion. Malt was modified by ultrasound (45 W/5 min) using stearic acid (2% w/w) as catalyst (MM), Arabic Gum (GA) and modified OSA-starch (EMCAP) were used as encapsulating agents in emulsions containing 15% of total solids (5% of oleoresin oil and 95% of wall material) and homogenized in a rotor-stator at 15000 rpm for 5 min. After that, all emulsions were characterized by droplet diameter and size distribution, optical microscopy, stability index (TSI), zeta potential, apparent viscosity, and encapsulation efficiency of capsaicin by HPLC (High Performance Liquid Chromatography). All emulsions exhibited spherical droplet size, low polydispersity (from 1.03±0.080 to 1.66±0.194) and the formulation containing MM, MM:GA and MM:EMCAP showed the largest particle size (from 13.7±0.377 to 17.7±0.414 µm). The formulations presented a destabilization index lower than 6% after 24h of storage at 25 °C, except for the MM:GA:EMCAP formulation. Treatments containing modified malt presented high apparent viscosity and zeta potential lower than 30 mV, indicating incipient instability of the emulsion. The presence of modified malt in the emulsion promoted a great encapsulation efficiency of capsaicin with retention higher than 90%. Therefore, the novel encapsulating agent (MM) used in these formulations presented good emulsifying properties, resulting in emulsions rich in capsaicin and with different physicochemical properties for foodstuff application.

Acknowledgements

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support, and scholarship conceded to Ana Gabriela da S. Anthero (Process number: 2018/02132-5). and Talita A. Comunian (Process 2018/01710-5).

OC06 -24949 - INFLUENCE OF SOLID LIPID TYPE ON THE STABILITY AND DIGESTIBILITY OF B-CAROTENE-LOADED NANOEMULSIONS

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Keywords: Solid lipid nanoparticles, Nanoemulsions, β-carotene, Stability, Digestibility, Bioaccessibility

Abstract

Solid lipid nanoparticles (SLNPs) arise as emulsion-based delivery systems of lipophilic bioactive compounds, such as carotenoids. They are typically formulated with solid fats forming crystalline triglyceride structures, thus potentially protecting carotenoids against degradation. Nevertheless, the solid state of the lipid nanoparticles might influence their digestibility hence determining the release and bioaccessibility of carotenoids. The aim of this work was to study the β-carotene stability loaded in SLNPs formulated with different ratios of solid lipids (glyceryl sterate, GS; or hydrogenated palm oil, HPO) and a liquid lipid (medium chain tryglycerides, MCT) under different environmental conditions (T, pH and light) and their *in vitro* lipid digestibility in relation to the β-carotene bioaccessibility. On the one hand, the β-carotene retention decreased at increasing the storage temperature from 4 to 37 °C, at decreasing the pH from 7 to 3 and after the exposure to light. Nevertheless, the β-carotene stability in SLNPs was lower when the concentration of GS used for their formulation increased from 0.5 to 5 % (*w/w*). In this regard, emulsions formulated with MCT (100 %) and stored at 4 °C showed a β-carotene retention of 73 % after 50 days of storage while in SLNPs with MCT:GS (95:5 %) was of 35 %. This suggests that β-carotene might be expelled from the lipid core of SLNPs thus being more easily degraded. Oppositely, SLNPs formulated with HPO at increasing concentrations presented a higher β-carotene retention in comparison with those formulated with GS. On the other hand, SLNPs with GS showed similar *in vitro* digestibility kinetics in comparison with MCT emulsions with high bioaccessibility values, while SLNPs with HPO showed a slower and lower FFA release yet similar β-carotene bioaccessibility. This work evidences that the type of solid fat in SLNPs determines the retention of encapsulated bioactive compounds and their digestibility.

Acknowledgements

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OC07 - 24989 - PARTICLE GEOMETRY FOR REDUCED GLYCAEMIC IMPACT

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Keywords: Food, Particles, Shape, Glycemia, Digestion, *In vitro*

Abstract

Against a backdrop of the global epidemic of diabetes, reducing glycaemic impact has become a priority for the food industry. Starch is the major source of glycaemic carbohydrate in the human diet. One approach to reducing the glycaemic impact of human diets is to ingest starch in the form of dense structures that require predominantly superficial enzymolysis to be converted to absorbable digestion products. Then, rate of digestion will depend on surface area, allowing the geometry of simple shapes to be used to configure particles of defined glycaemic impact, using equations relating the proportion (P) of particle digested after T minutes of digestion to initial particle diameter (D_0 mm) and average rate of superficial volume erosion (E mm^3/min) over time T:

(a) Spherical particles:

$P = 6TE/(\pi D_o^3)$

(b) Cylindrical particles of initial length L_0:

$P = 4TE/(\pi L_0 D_o^2)$

(c) Flat structures of depth D, length L and width W:

$P = TE/(LD_oW)$

By using spreadsheets based on the equations, erosion rate may be continuously adjusted from its initial value in response to the shape-dependent, non-linear, progressive reduction in surface area during digestion. Then for a given digestibility particle dimensions required to yield time-dependent nutritionally distinct carbohydrate fractions, - rapidly digested (RDS), slowly digested (SDS) and inaccessible digestible (IDS) starch, or a simulated glycaemic response curve, may be determined.

The functionality of the spreadsheets was tested by in vitro digestion of spherical (sago), cylindrical (spaghetti) and flat (lasagna) particles, which provided digestion curves that matched spreadsheet predictions. Applications in food product development are discussed.

Acknowledgements

New Zealand Institute for Plant & Food Research. Riddet Institute, Massey University

OC08 - 25011 - EFFECTS OF MODERATE ELECTRIC FIELDS IN BETA-LACTOGLOBULIN THERMAL DENATURATION – STRUCTURAL CHANGES AND BINDING PROPERTIES

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Keywords: Moderate electric field, Ohmic heating, Protein functionality, Retinol, Nano-complex

Abstract

Innovative and emerging technologies involving the direct application of external electric fields are attracting the attention of research and the industry due their unique processing advantages. The particular case of ohmic heating and its associated moderate electric fields (MEF) have demonstrated potential to control protein functionality. However, the putative effects of MEF on biomaterials have raised questions about their specific interaction pathways, while few answers have been provided. In this study, we aimed at evaluating the effects of MEF presence in beta-lactoglobulin (β-lg) structure and interactions upon thermal denaturation. Simultaneously to the MEF treatments, control experiments (without the presence of electric field) were performed to stablish a background for the thermal related effects. Secondary structure analysis based on the far-UV-CD spectra confirmed that the application of MEF resulted in different structural features of the protein, consistent with the loss of α-helix and β-strand and increase of random coil fractions. The assessment of the endogenous tryptophan fluorescence confirmed different local conformations resultant form the MEF exposure. The use of ANS - as fluorescent hydrophobic probe - also shown that MEF was able to increase accessibility to β-lg hydrophobic sites. The impact of the observed structural changes were evaluated on the formation of β-lg – retinol nano-complex, where a higher binding constant was observed for the MEF exposed samples. These results provide evidences for the MEF action during the unfolding of β-lg, which in turn results in important modifications at structural and functional level. Application of MEF open new perspectives for the application of processing strategies aiming to control protein functionality and develop novel protein-based delivery systems.

Acknowledgements

This study was supported by the Portuguese Foundation for Science and Technology (FCT) under the scope of the strategic funding of UID/BIO/04469/2019 unit and BioTecNorte operation (NORTE-01-0145-FEDER-000004) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte. Rui M. Rodrigues gratefully acknowledge FCT for their financial grant with reference SFRH/BD/110723/2015.

OC09 - 25001 - ASSESSMENT OF ELECTRICAL EFFECTS OF OHMIC HEATING ON STRUCTURAL AND IMMUNOREACTIVITY PROPERTIES OF BOVINE BETA-LACTOGLOBULIN

***Ricardo Pereira*[1]; *Joana Costa*[2]; *Rui Rodrigues*[1]; *Caterina Villa*[2]; *José Teixeira*[1]; *Isabel Mafra*[2]; *António Vicente*[1]**

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Keywords: Protein aggregates, Electric fields, Secondary structure, Immunoblotting, Digestion, Allergen

Abstract

Whey proteins are used as novel structures for the delivery of bioactives due to their excellent functional and nutritional properties; however they are also recognized as a major food allergen. Several studies have been struggling to evaluate the effects of heat on the allergenic potential of whey proteins, but to our knowledge none of them addressed the impact of Ohmic Heating (OH) – an emergent electro-thermal processing technology in food industry - on the function of these molecules. Therefore, this work aimed at establishing an integrated assessment of the effects of OH on physicochemical properties and immunoreactivity of beta-lactoglobulin (b-LG). OH treatments were performed on pure b-LG using different time-temperature binomials – i.e. 65 °C /30 min, 72.5 °C /15 s and 90 °C /1 s. Different OH electrical variables – electric field (20 to 90 V/cm) and frequency (50 to 25000 Hz) - were combined and further assessed. Results from immunoblotting in native page conditions have shown that OH does not change antibody affinity, but drastically changes the pattern of protein aggregation, depending on heating kinetics and electrical variables applied. Fast heating seems to have the ability to reduce protein unfolding (analysed by tryptophan fluorescence) and to preserve more native secondary protein structure (assessed by circular dichroism) thus favouring the appearance of aggregates of low high molecular weight (< 75 kDa). OH performed with a thermal profile similar to that of a conventional heating in concomitance with low frequency (50 Hz) and high electric field (> 60 V/cm) resulted in the formation of large protein aggregates (> 250 kDa). Therefore OH can be used to modulate molecular unfolding and aggregation of b-LG. These different outcomes can in turn change the path of allergic sensitization and allergic response via the intestinal mucosa, depending upon the resistance of these aggregates to gastrointestinal digestion.

Acknowledgements

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OC11 - 25439 - ENCAPSULATION USING PLANT PROTEINS: THERMODYNAMICS AND KINETICS OF WETTING FOR SIMPLE ZEIN COACERVATES

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Abstract

Traditionally, complex coacervates of oppositely charged biopolymers have been used to form coatings around oil droplets for encapsulation of oil-soluble active ingredients, such as in the classic gelatin-Gum Arabic system. Hoevever, many proteins can form coacervates by themselves, under certain conditions. Well known examples that have been studied in the past are for example lens crystallins and zein in mixed water/ethanol solvents, or seed globulins at low temperatures and low salt. Such “simple” protein coacervates are currently raising much attention in biophysics with the discovery that living cells use droplets of such simple protein coacervates as dynamic microcompartments. Here we revisit the well known simple coacervates of prolamins such as zein in mixed solvents, to explore whether they can be used for plant-based encapsulation systems. We show that for zein in mixed solvents, we can encapsulate oil droplets, but only under specific conditions. We show that this is due to the very different physical properties of the simple zein coacervates as compared to those of classic polysaccharide/protein complex coacervates. In particular we show that wetting of the coacervate at the oil-water interface is generally thermodynamically favored, but the kinetics of coacervate droplet deposition and the interactions between coacervate droplets are highly pH dependent, leading to a sharp pH optimum (around pH 8) for capsule formation.

OC12 - 24877 - INTERFACIAL RHEOLOGY AS A TOOL FOR DESIGNING INTERFACES IN EMULSION-BASED DELIVERY SYSTEMS

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Keywords: Dilatational rheology, Interfacial rheology, Emulsions, Protein adsorption, SAOS measurements

Abstract

Interfacial rheology can be used to characterise the adsorption of proteins at interfaces and the formation of the interfacial film. The understanding of these complex layers should help to evaluate some complexes mechanisms which govern the protein-adsorption process, the further protein denaturation and the development of protein-protein interactions[1]. The development of these interactions can be modulated by changing the pH value of the aqueous phase, as well as by modifying the protein concentration. The control of the interfacial properties is essential to achieve an appropriate emulsion-based delivery system, which may be used in food products[2]. Competitive adsorption between different proteins has been reported to be a critical factor in the final properties of the interfacial film formed[3]. In this sense, an analysis of the interfacial film using the combination of dilatational and shear measurements can directly provide relevant information on protein-protein interactions and therefore on emulsion stability. Interfacial tension data of Faba bean protein adsorbed at O/W interfaces were determined in the present study, as well as interfacial rheological properties by Small Amplitude Oscillatory Shear (SAOS) and Dilatational measurements. Emulsions were processed by using a two-step method. The characterisation of emulsions was performed by means of SAOS, droplet size distribution and CLSM techniques. Moreover, Backscattered light measurements were also carried out to study the destabilization mechanisms of emulsions. Results confirmed the relevance of both interfacial tension and viscoelastic measurements to select optimal conditions for emulsification, and for a potential enhancement of emulsion stability.

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OC13 - 24929 - WHEY PROTEIN TEMPLATES TO PRODUCE OLEOGELS WITH TAILOR MADE FUNCTIONALITY

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Keywords: Aerogel, Cryogel, Freeze-drying, Supercritical-CO_2-drying, Oil structuring

Abstract

Indirect strategies for oil gelation exploiting hydrocolloid structuring properties have been recently proposed as alternative to conventional direct processes. To obtain an oleogel, preliminary hydrocolloid gelation in water is required. The obtained hydrogel is then dried to produce a highly porous template, in which oil can be subsequently absorbed, leading to the oleogel. The drying process is the critical step to steer the final oleogel properties.
In this work, the possibility to exploit freeze-drying and supercritical-CO_2-drying to produce whey protein oleogel templates, called cryogels and aerogels, respectively, was investigated.
Monolithic hydrogels were prepared by thermal treatment (90 °C, 15 min) of a whey protein solution (15% w/w, pH 5.7). These systems were then ground (600 g, 60 s) to obtain microparticulate hydrogels. Monolithic and microparticulate hydrogels were freeze-dried or supercritical-CO_2-dried (11 MPa, 45 °C, 3.5 NL/min). The obtained cryogels and aerogels were then turned into oleogels through oil absorption. Oleogels were compared in terms of structural shrinkage, rheological properties, oil content and oil holding capacity (OHC).
Monolithic cryogels led to firm fragile oleogels, presenting 70% (w/w) oil content, but only 50% OHC. Reversely, microparticulate oleogels obtained *via* freeze-drying presented a liquid-like structure and no oil release. Monolithic oleogels obtained *via* supercritical-CO_2-drying presented 60% (w/w) oil content and an OHC higher than 95%. However, the high firmness, possibly due to the 40% volume contraction, and the low plasticity would limit their food applications. By contrast, plastic oleogels, presenting a soft-gel behaviour, 60% (w/w) oil content and no oil release were obtained from supercritical-CO_2-drying of microparticulate hydrogels.
It can be concluded that freeze-drying and supercritical-CO_2-drying can be exploited to prepare whey protein templates intended for the production of oleogels with tailor made functional properties.

OC14 -24864 - HETEROPROTEIN COMPLEXES AS NEW ENCAPSULATION SYSTEM FOR POLYPHENOL-RICH PLANT EXTRACTS

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Keywords: Heteroprotein aggregates, Lysozyme-WPI coacervates, Encapsulation, Grape seed extract, pH

Abstract

The characteristics of heteroprotein solutions from whey protein isolate (WPI) and lysozyme (Lyz) regarding the formation of heteroprotein aggregates were analyzed and their application as an encapsulation system for polyphenols from grape seed extract (*vitis vinifera;* GSE) was assayed. The main focus was on the protein ratios WPI to Lyz of 1:1, 1:2, 1:3, 1:4 (v/v) and the pH range (pH 5.5, 6.5, 7.5) in which the two proteins had opposite charges. The protein solutions (1 g/L) with mixing ratio 1:1 (v/v) at pH 7.5 exhibited, with the highest turbidity (94.9 ± 0.4%) and a mean diameter of aggregates of 17.9 ± 8.6 µm, the optimal conditions for complex coacervation, as determined by spectrophotometer and static light scattering, respectively. Using a protein precipitation method[1], the phenolic content in the protein solutions with GSE was assessed and the encapsulation efficiency of the protein structures was calculated. As a result, an encapsulation efficiency of 75.1 ± 0.9% was achieved under optimal conditions (pH 7.5, 1:1). With higher proportion of Lyz in the protein ratio (1:3 and 1:4) and a low pH value (5.5), the encapsulation efficiency decreased to 50%. The order of addition (Lyz or WPI to GSE), particle charge, and the size of the heteroprotein aggregates were identified as important factors for the entrapment of polyphenols. Therefore, the heteroprotein complexes of WPI and Lyz could be used as an encapsulant for polyphenolic extracts such as GSE. The various health benefits of GSE would be complemented by its formulation consisting exclusively of proteins and offering additional nutritional benefits. The application as a food supplement or as a pharmaceutical product is considered.

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OC15 -25018 - OIL-IN-WATER EMULSIONS INSPIRED IN MIXED-COMPONENT OLEOGELS

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Keywords: Oil structuring, Emulsion, Lecithin, Wax

Abstract

Oil-in-water (O/W) emulsions are present in many food products such as milk, dressings, desserts, and beverages. In the light of consumers' awareness towards healthier food products, oleogels emerge as an alternative for saturated and *trans* fats replacement. Oleogel-inspired oil-in-water emulsions were fabricated above the melting temperature of the oleogels by submitting a pre-heated emulsion to a high-pressure homogenization. Emulsions formulated with oleogel as dispersed phase that was comprised of fruit wax (FW), soybean lecithin (LEC) and sunflower oil (SFO) were studied. Two different emulsifiers – whey protein (WPI) and Tween 80 (T80) – were tested to evaluate the formation of a viscoelastic interface aiming to form stable O/W emulsions. FW-LEC oleogels were able to form emulsions without emulsifiers addition. Two different storage temperatures (5 and 25 °C) were evaluated considering the wax crystallization. It was hypothesized that by structuring the surface of the oil droplets, systems with interesting properties could be created. Oleogel-based emulsions showed smaller droplet size compared to SFO-based emulsions, which could be explained by the lower interfacial tension for samples with FW. Turbidimetric measurements showed an occurrence of a slight destabilization mechanism by creaming. However, no visual phase separation could be observed indicating a good kinetic stability after a 7-day storage. Emulsions formulated with FW or FW-LEC and T80 as emulsifier showed lower destabilization throughout storage at 25 °C, whereas emulsions maintained at 5 °C showed no difference in stability index apart from FW-LEC systems without emulsifier. Emulsions exhibited a Newtonian behaviour and the viscosity was modulated by the interface composition and temperature. The understanding of stabilization mechanism of these emulsions would allow tailoring emulsified foods based on the choice of ingredients and by transposing oil-structuring approach. Further investigation on digestibility of these samples can provide insights on effect of partial structured oil interfaces in lipase accessibility.

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OC16 - 24980 - THE CREATION OF NOVEL CRYSTALLINE COCOA BUTTER STRUCTURES BY SHEARED CRYSTALLIZATION

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Keywords: Cocoa butter, Rheology, Crystalline structure

Abstract

Many fatty systems are created by sheared crystallization. However, much research has been focused on the study of quiescent systems. Therefore we have developed novel rheological techniques in order to create and probe the performance of new systems. By this means we have been able to probe and understand the crystallization behaviour of cocoa butter in quiescent and sheared systems. This understanding has enabled us to be able to control the crystallization to create different structures with varying properties. Therefore novel opportunities for structured cocoa butter based systems exist. In particular control of nucleation and polymorphic transformation by control of the processing gives interesting structures. We have compared this work with previous work on palm oil and contrast the differing structures obtained. The fundamental understanding developed should present opportunities for different researchers to build upon. Work has been based on rheology, DSC, X-ray diffraction, microscopy and NMR.

Acknowledgements
Cargill

OC17 – 25012 - CO-MILLING AS INNOVATIVE ENCAPSULATION OF BIOACTIVES IN GLASSY MATRICES

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Keywords: Co-milling, Bioactives, Glassy matrices, Encapsulation

Abstract

Encapsulation at micro- or nano-scale is an innovative strategy to enhance the functionality of bioactive and liable compounds by both increasing their stability under stressing conditions, and controlling their delivery and release in food matrices. Various conventional (freeze-drying, spray-drying) and novel (e.g. liposome encapsulation, spray drying, spray chilling) technologies, also in combination, allow to produce low moisture-to-dry encapsulates with enhanced functionalities (e.g. solubility) and shelf-life longer than the corresponding native or in aqueous systems. The achievement of powders in a glassy/ amorphous state has been recognized as a critical factor for both stability and technological functionality of encapsulated bioactives, generally obtained by the use of high molecular weight carbohydrates (starch, maltodextrins, cyclodextrins) as coating or dispersing materials.

Milling is a largely used process in the pharmaceutical drug formulation aimed at reducing drug particle size and performances at usage. However, starting from a stable crystalline state, the mechanical stresses during processing may also induce structural changes and the formation of metastable polymorphic forms or amorphous materials. Co-milling, where two compounds are subjected together to the same milling process, is also used in the development of pharmaceutical ingredients with physical and physico-chemical properties different from those of the individual compounds, alloys or nano- or micro-dispersions, scarcely used in the food sector.

In this presentation the application of co-milling as solid-state technology to obtain micro- and nano-encapsulates of bioactive compounds of different nature and functionality (limonene, phycocyanin and olive leaves extracts) will be presented. Physical and structural properties of the obtained powders will be presented and related to the encapsulation efficiency and stability. Results will be also compared with those of encapsulates obtained by conventional technologies (spray-drying, freeze-drying).


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POSTERS

PO65 -24900 - CONTROL OF VISCOELASTICITY AND THERMAL PROPERTIES OF LOW VISCOSITY GELATINS THROUGH FUNCTIONALIZATION AND PHOTOCROSSLINKING

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Keywords: Low viscosity gelatin, Controlled viscosity, Photocrosslinking

Abstract

The production of low viscosity gelatins from fishing byproducts is an excellent opportunity to contribute to the so called circular economy. Their subsequent functionalization can broaden their applications were tight control of viscosity is required. The aim of this work was to produce gelatin from salmon skin (SG) with different molecular weights and to assess the functionalization by the addition of anhydride methacrylic (M) and further crosslinking by UV or visible light (VL) using riboflavin (Rf) as natural photoinitiator. The extractions conducted produced three molecular weight gelatins (pH 3, 4, 5) and were derivatized by 2, 5, 8% p/v M (SGelMa). SG and SGelMa suspensions (7% p/v) were mixed with 0.025% p/v Rf with/without pH adjustment (pH 8.5) and exposed to UV (360 nm) or VL (450 nm) for 2 min. SG and SGelMa were characterized in terms of average molecular weight (Mw) by capillary viscometry, gel strength and viscosity. After photopolymerization rheology and thermal properties were determined. SGelMa showed lower Mw (48.5 – 21.1 KDa) and gelling temperature (5.5 – (-4.6) °C) for pH 5 M2% - pH 3 M8%, respectively) than SG. These results correlated with a decrease in G', viscosity and gel strength as the M increased. UV notoriously increased G' of the suspensions, mostly to the higher Mw gelatins. Whereas, VL crosslinked more effectively at pH 8.5 for SG but did not enhance the effect for SGelMa. This behavior was consistent with the thermal transitions resulting in higher gelling and melting temperatures for gelatins polymerized by UV and VL. In conclusion, functionalization and photopolymerization of low viscosity gelatins would allow to tune viscoelasticity and the thermal properties of the material favoring the development of novel applications for but not limited to the food industry. One such application is development of novel inks for 3D printing.

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PO66 - 25017 - SODIUM CASEINATE CHAPERONE ACTION ON WHEY PROTEINS UNDER ULTRASONIC TREATMENT

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Keywords: Sodium caseinate, Whey protein, Ultrasound process, Functionalization of proteins

Abstract

Faced with the need to develop non-thermal technologies, several new processes have emerged and explored such as electric and magnetic fields, high pressure and ultrasound. Ultrasound technique can be classified in two different groups as low power/high-frequency and high power/low-frequency. The first group has been widely used in processes as emulsion production, depolymerization and extraction. Caseins are proteins widely used as emulsifiers that also show the capacity to protect some globular proteins against loss of structure in heating processes, acting as chaperones. In this study we used ultrasound approach to observe chaperone effect of sodium caseinate on whey proteins (1:1) submitted to ultrasound process at high power (nominal power: 450, 600 and 750 W) at low fixed frequency (20 kHz). Aiming to identify the protection effect above mentioned, we analyzed particle size distribution, SDS-PAGE electrophoresis at reducing and non-reducing conditions, surface hydrophobicity, circular dichroism and FTIR-ATR. We noticed slight or no significant changes in charge density, particle size distribution and electrophoretic patterns after ultrasound process. However, in SDS-PAGE, the absence of changes in electrophoretic patterns could indicate that non-covalent interactions occurred between proteins. Surface hydrophobicity reduced after ultrasound process, indicating that a more pronounced interaction between proteins. To best understanding of proteins interaction, we analyzed secondary structure of them separately and together (1:1) and it was possible to visualize protection effect of sodium caseinate on whey proteins and identify process conditions that promoted the best chaperone activity. This study allowed opening new insights for researches involving the functionality of proteins interactions and its advantage over conventional thermal processes.

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PO67 - 24872 - INTERFACIAL PROPERTIES OF DRY HEATED WHEY PROTEINS ARE HIGHLY AFFECTED BY THEIR PH BEFORE TREATMENT

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Keywords: Whey protein, Dry heating

Abstract

Whey is a byproduct of cheese making that contains proteins (mainly b-lactoglobulin and a-lactalbumin), lactose, minerals and residues of fat. Whey protein isolate (WPI) is useful as functional and techno-functional ingredient, due to its nutritional value and technological properties. When submitted to different processes, whey proteins undergo structural changes affecting their techno-functional properties, such as solubility and interfacial activity. Even if conventional heat treatments are commonly used in food industries, dry heating is an emerging technology that may control Maillard reaction and denaturation kinetics when applied to protein-rich powders. Therefore, this study focus on understanding the effect of pH, lactose content and temperature on the interfacial properties of dry heated WPI. Commercial WPI (94% of protein) added or not of lactose was rehydrated on ultra-pure water, followed by pH adjustments to 3, 5, 7 and 9. Solutions were than frozen and lyophilized. The resulting powders were dry-heated at 333.15 and 353.15 K for 48 h and then had their structure and some techno-functional properties analyzed. Despite of reduced water activity (less than 0.1), browning indexes and free lactose content pointed consumption of the reducing sugar by Maillard reaction, as expected. Samples treated at pHs 5, 7 and 9 were darker than the one at pH 3. Results indicated that the highest temperature used reduced emulsion activity of proteins. Samples dry-heated at pH 9 had their solubility significantly reduced by the treatments applied. This alkaline pH, also induced to a diminished foaming capacity, distinguishing this group from the other samples. This work surely contributes to understand how emerging treatments may affect techno functional properties of whey proteins positively or negatively.

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PO69 - 24904 - COMPLEXATION OF BROWN RICE AND MILK PROTEINS WITH RASPBERRY PHENOLICS

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Keywords: Brown rice proteins, Milk proteins, Raspberry, Phenolics, Structural changes

Abstract

Dry, flour-like matrices were produced by complexation of brown rice or milk (80% of caseins) proteins with raspberry juice in order to prepare functional food ingredients. Prepared ingredients can be added to bakery, fruit and dairy products in order to enrich them with phenolics, improve antioxidant potential, and enhance color. For preparation, amount of juice was constant and the amount of proteins varied (2, 6 and 10%). Content of phenolics and anthocyanins were determined and capabilities of two different proteins to bind those compounds were compared. With an increase in the amount of milk proteins, the amounts of adsorbed phenolics (11, 44 and 65%) and anthocyanins (22, 51 and 61%) increased. In the case of brown rice proteins amounts of adsorbed phenolics were 36, 51 and 51% and anthocyanins 24, 42 and 47%, i.e. there was no or slight difference between the 6 and 10 % levels of proteins used. Adsorption capacity of proteins was also calculated and expressed as mg of adsorbed compound per g of protein (mg/g). The highest adsorption capacity for phenolics was achieved by 2% of brown rice proteins (17.9 mg/g) and 6% of milk proteins (8.8 mg/g). Anthocyanins adsorption capacity decreased with the increase of protein content. The highest anthocyanin adsorption capacity was achieved by 2% of proteins, 3.7 mg/g and 2.5 mg/g for milk and brown rice proteins, respectively. FTIR spectra of dried matrices were recorded in order to compare the structures of proteins and loaded proteins. Some structural changes were observed on both proteins. Peaks at 1,390 cm^{-1} and 1,310 cm^{-1} that were observed in proteins, in loaded proteins disappeared, and two additional peaks appeared at 820 cm^{-1} and 780 cm^{-1}. Additionally, loaded milk proteins missed the peak at 990 cm^{-1} and had a shift of peak from 1,070 cm^{-1} to 1,050 cm^{-1}.

PO71 - 24999 - EFFECTS OF HYDROTHERMAL AND HIGH-PRESSURE PROCESSING ON STRUCTURAL AND PHYSICOCHEMICAL PROPERTIES OF STARCHES FROM CHESTNUTS

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Keywords: Hydrothermal processing, High-pressure processing, Chestnuts, Starch

Abstract

This study was conducted to compare the effects of hydrothermal and high-pressure processing (HPP) on structural properties and thermal behavior of starches from chestnuts (*Castanea sativa*). Three treatments were carried (i) Unprocessed chestnuts (native starch), (ii) Hydrothermal processing (50 °C, 45 min), (iii) High-pressure processing (541 MPa, 15 min). Then, native and treated starches were isolated from chestnut flours, in an aqueous-ethanol solution and their morphological, mechanical, thermal and pasting properties were evaluated. Scanning Electron Microscopy images showed granules of starch with a round, irregular, oval, and elliptical shape with smooth surface. Particle size analysis showed native and hydrothermally treated starches had smaller granules with an average diameter <5 µm, while HPP starch showed the biggest granules with an average diameter ranging between 5 and 10 µm. The results also highlighted differences in mechanical properties between starch gels. Native and HPP starch gels showed similar stress at rupture, however native starch was the most deformable (higher deformation at rupture). On the other hand, HPP had the strongest structure with higher elastic modulus, which means that this gel can resist to higher stress before permanent deformation. Peak viscosity obtained was ≥ 24.94 cP, with starch granules displaying more stability between swelling and rigidity states, in both native and hydrothermally processed samples. Moreover, setback viscosity was higher for HPP and native starch, which could be related to higher retrogradation degree and associated to lower digestibility of these starches. These results are helpful for understanding better how these processes could influence technological properties of chestnut starches. They also indicated that HPP is an alternative for non-thermal processing of chestnut starches, which can eventually useful as a functional ingredient with possible industrial applications especially for celiac disease patients.

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PO72 - 25015 - NANOSPRAYDRYER FOR THE PRODUCTION OF SUB-MICRO PARTICLES BASED ON BOVINE LACTOFERRIN

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Keywords: Protein, Nanotechnology, Nanostructures

Abstract

Lactoferrin is a single chain glycoprotein isolated from the bovine milk, and it has been considered a multifunctional protein with a lot of benefits for human's health. Lactoferrin structure is composed by two globular lobes, the N-lobe and C-lobe, and has a molecular weight of 80 kDa. Lactoferrin can also be used as a carrier of bioactive compounds, such as iron (due to its iron-binding properties). However new methods are needed to guarantee their processability without losing their unique characteristics. One of the possibilities is to use the nanospraydrying (NSD). NSD consists in a quick one-step process that transforms different types of solutions into dry sub-micro particles, by spraying the solutions in a hot medium that causes efficient evaporation of the solvent and produces the particles with controlled morphology.
In this work lactoferrin (Lf) nanoparticles were produced by nanospraydryer with an atomized head with the small nozzle size. Lf solutions were sprayed after centrifugation (4,000 rpm, 20 min) and filtration (syringe filter of 0.45 mm) to avoid NSD clogging. Different processing conditions were tested such as Lf concentration (1%, 5% and 10% (w/v)) and temperatures (80 °C and 100 °C). The dried particles were evaluated by Fourier-transform infrared spectroscopy and Scanning Electron Microscopy. Afterwards the particles were hydrated and the particle size determined by Dynamic Light Scattering, Nanoparticle Tracking Analyses and Transmission Electron Microscopy, being also evaluated the polydispersity and zeta potential. The chemical structure of the particles was evaluated by electrophoresis and circular dichroism in order to evaluate the effect of the drying process on the Lf chemical structure.
Results shows that it is possible to use high concentrations of Lf to produce sub-micro particles without changing the main structure of Lf. The particles size of dried particles ranged 100-2,000 nm (determined by SEM), being the hydrated particles 100-200 nm.

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PO73 - 24962 - INFLUENCE OF THE MICROENCAPSULATION OF ANTHOCYANINS FROM CULTIVATED POTATO PURPLE FLESH DURING IN VITRO GASTROINTESTINAL DIGESTION

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Keywords: Microencapsulation, Coloring food, Purple potato

Abstract

Cultivated potato purple flesh (*Solarum tuberosum*) has high nutritional value, containing starch and anthocyanins (AT). Anthocyanins are responsible for the purple color and antioxidant activity. However, the stability of AT has been shown to be affected by environmental, food and gastrointestinal conditions, limiting their application as food ingredients. Therefore, the stabilization of AT could be improved by microencapsulation technology as spray-drying. The aim of this work was to study the microencapsulation of concentrated potato purple flesh by spray-drying using a mixture of maltodextrin (MD) and starch (S) as encapsulating agent on the AT encapsulation efficiency and bioaccessibility in *in-vitro* digestion model. Concentrated potato purple flesh (CPP) was obtained by separation of starch and then concentration of AT solution until 65°Brix. Delphinidin-3-glucoside and petunidin-3-glucoside were the main AT identified by HPLC. The microencapsulation of CPP with MD-S by spray drying was performed applying Taguchi L9 experimental design. The air inlet temperature (100–180 °C), MD-S content (8–23%) and starch content (0–25% respect to MD) were evaluated as independent variables. AT encapsulation efficiency (EE) and yield (Y) were the response variables. A linear regression analysis was applied to each response variable, and then Response Surface Methodology was used to determine the optimal conditions maximizing responses variables using desirability function. The AT EE and Y ranged from 60 to 93% and 24 to 81%, respectively. The optimal conditions were 100 °C, 21 % MD-S and 25% starch. Microparticles obtained under optimal condition were characterized according to EE (94%), moisture (3.5%), AT (1.6 mg equivalent to cy-3-glu/g) and morphologically by scanning electron microscopy (SEM). The bioaccessibility (BA) of AT was evaluated for CPP-MD-S; CPP-MD; CPP non-encapsulated (control) in *in-vitro* digestion model. The BA of AT was significantly higher for encapsulated AT than non-encapsulated AT.

Acknowledgements

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PO74 - 24964 - CHARACTERIZATION OF EDIBLE OIL FOAMS AND FAST INLINE MEASUREMENT USING ACOUSTIC AND ULTRASOUND SPECTROSCOPY

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Keywords: Foam, Lipid, Pickering, Ultrasound, Fat

Abstract

Because of the dramatic rise of obesity in UK in the last three decades, several food companies have committed to design and manufacture healthier foods with reduced caloric content. A critical food sector that needs improvement is confectionery since sweets, candies and chocolate contain substantial amounts of sugars or fats. An effective way of reducing calories is to use edible oil-based foams (oleofoams) to prepare aerated confectionary food (*e.g.*, mousses). The main constituents of edible oleofoams are a liquid oil phase, air bubbles and a further high-melting, crystalline fat phase, which stabilizes the bubbles via a Pickering effect. Such complex microstructure determines the macroscopic physical and nutritional properties of oleofoams. Therefore, a correct characterization and continuous monitoring and control of oleofoams microstructure during process design and manufacturing is essential to ensure the quality of the final food product. Ultrasound spectroscopy is a fast and affordable monitoring technique, which is particularly promising for online, in situ characterization of oleofoams. The aims of this work are: (1) development of a methodology based on multiple offline techniques to characterize the microstructure of oleofoams and (2) determination of a robust correlation between the physical properties of oleofoams and specific acoustic measurements.
Melted cocoa butter was mixed to sunflower oil and recrystallized (oleogel phase) by cooling in a jacketed vessel equipped with temperature control. Aeration was performed using a Kitchen Aid whipping machine. The structures of oleogels and oleofoams were characterized using offline techniques including polarized and confocal microscopy (crystals and bubbles detection and size), X-ray scattering (crystal polymorphism) and tomography (porosity and air distribution) and differential scanning calorimetry (melting behavior). Acoustic measurements were carried out using an airborne acoustic microscope, with two focused transducers at three variable frequencies. Initial findings showed the applicability of acoustic spectroscopy in detecting and quantifying fat crystals within oleofoams.

Acknowledgements

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PO75 - 24955 - DEVELOPMENT OF CHITOSAN-BASED MICROPARTICLES BY POLYELECTROLYTIC COMPLEXATION FOR ENCAPSULATION OF VITAMIN D

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Keywords: Mucoadhesion, Complex Coacervation, Associative Phase Separation, Polysaccharides

Abstract

Chitosan-based microparticles have gained special attention in recent years because they can be an interesting alternative for encapsulating unstable and hydrophobic compounds, such as vitamin D (VD). These particles act both as a protective barrier and as an alternative to increase the interaction of active compound with intestinal mucosa. Thus, the gastrointestinal absorption of active compound could be enhanced. In this work, the self-assembly of particles was mediated by polyelectrolytic complexation of CHI with anionic polymers: gum Arabic (GA), sodium alginate (ALG) and κ-carrageenan (CRG). The molecular weight of polymers was determined by size exclusion chromatography. An estimation of the negative to positive (-/+) charge ratios was made from the zeta-potential values and the stoichiometry of each formulation was defined from analyses of zeta-potential and isothermal titration calorimetry. After defining the conditions for polysaccharide complexation, the particles were used to encapsulate VD, and the mucoadhesion of each system was evaluated by dynamic oscillatory rheology tests in order to determine the rheological synergism with mucin. Due to the crystallinity of VD and its reduced solubility in water, this compound was dispersed in oleic acid to produce the particles. The pH values that promoted higher encapsulation efficiency (EE%) ranged from 3.5 up to 4.0, which correspond to condition where both polymers that composed the complexes showed ionization degree >90%. The formation of particles was an exothermic ($\Delta H<0$) and spontaneous ($\Delta G<0$) process. The sulfated polysaccharides (CRG → $Ka > 10^{10}$) interacted more strongly with CHI than with carboxylate polysaccharides (GA and ALG → $Ka = 10^7$ and 10^8, respectively). The particles were mononuclear, spherical and with particle size around 10 µm. The complex GA:CHI was the system with higher EE (>65%) and rheological synergism with mucin, demonstrating a greater ability to carry VD and to increase its residence time in the intestinal mucosa.

Acknowledgements

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PO76 - 24832 - ACTIVE ADDITIVE BASED ON ENCAPSULATED CITRAL OIL-ALGINATE: EFFECT OF MALTODEXTRIN AS WALL MATERIAL ON ACTIVE PROPERTIES AND RELEASE KINETIC DURING STORAGE TIME

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Keywords: Citral oil, Active additive, Antimicrobial activity

Abstract

New natural additives are critical to improve food shelf life, which also depends on storage conditions. Citral oil demonstrated antimicrobial activity, however, is necessary to encapsulate them considering their volatility and lipophilic characteristics. The aim was to develop active additives powders based on citral oil (CIT), analyzing maltodextrin effect on antimicrobial properties against Escherichia coli and the release kinetic during storage time at different temperatures.

Active emulsions were prepared adding 1%w/w sodium alginate-ALG, 3%w/w CIT, Capsul® (CAP) as encapsulating agent and Maltodextrin (MD) as wall material, where rate concentration were 1:1 w/w (CIT:CAP) and 1:1:2 (CIT:CAP:MD). Control sample contains only ALG-CIT. Powders were obtained by spray-drying (120 °C inlet temperature) and stored at 4, 25 and 35 °C, for two months at 33% relative humidity. Measurements were performed: water activity (aw), moisture content (%Hdb), FTIR, color, antimicrobial activity against E.coli ($1x10^3$ UFC/mL) by inhibition halo and release kinetic on 50% ethanol (simulant medium for dairy matrices).

Results showed that water activity and moisture content were constant after 2 weeks of storage (aw=0.378; %H=15% db) independently of temperatures analyzed. MD not affected powder colors but after storage, control-sample showed an increase of yellowness index attributed to oil release. MD addition showed a diminution of CIT characteristic peaks by FTIR, assuming protection principally at 4 °C. Rehydrated samples (5% w/w) showed a low antimicrobial activity diminution after storage, being the highest inhibition halo on 1:1:2CIT:CAP:MD sample (t0=1.1±0.1 cm; t2months=0.7±0.1 cm). Release kinetic showed that CIT release diminished among storage time. Both results are attributed to citral volatility, independently of temperature, however, storage at 4°C and MD addition maintain both antimicrobial activity and prolonged release of the active compound.

In conclusion, MD addition showed greater protection and antimicrobial activity of active compound during the storage time, being the most adequate temperature to preserve these properties at 4 °C.

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PO77 - 24921 - INFLUENCE OF PROCESSING PARAMETERS ON PERMEATE FLOW AND RETENTION OF AROMA AND PHENOLIC COMPOUNDS IN RED WINE CONCENTRATED BY REVERSE OSMOSIS

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Keywords: Red wine, Reverse osmosis, Concentration, Permeate flow, Phenolic compounds, Aroma compounds

Abstract

Reverse osmosis concentration of red wine Cabernet Sauvignon, a rich source of polyphenols, at three different pressures (45, 50 and 55 bar) and two temperature regimes (with cooling and without cooling of the retentate) was studied. Reverse osmosis is a non-thermal process consisting of dewatering by the separation of pure water from liquid solutions (such as wine) by the application of an elevated pressure which causes the water to diffuse through a polymeric membrane. Concentration was carried out on a laboratory membrane unit with plates and frames on composite Alfa Laval membranes RO98pHt. Wine was concentrated up to 25.8% of total soluble solids content. The permeate flow highly depended on processing parameters and varied from 15.32 $L/m^{2}{\cdot}h$ at the beginning to 8.00 $L/m^{2}{\cdot}h$ at the end of processes. During the reverse osmosis concentration, color loss (total phenols and anthocyanins) occurred in concentrates. The highest retention of total phenols and anthocyanins was achieved with reverse osmosis process at 55 bar with cooling of the retentate. Twenty nine volatile compounds were identified by gas chromatography with mass spectrometry (GC-MS) in red wine Cabernet Sauvignon and concentrates. Process at 55 bar with cooling proved to be the best in terms of Cabernet Sauvignon aroma compounds retention. After concentration, the highest retention of terpenoids and acids was achieved in wine concentrates. Obtained wine concentrates can be used as food additives and in aceto balsamico production.

PO78 - 24941 - VACUUM SPRAY DRYER: NEW ALTERNATIVE FOR THERMO-SENSITIVE COMPOUNDS MICROENCAPSULATION

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Keywords: Orange essential oil, Thermo-sensitive compounds, Volatile compounds

Abstract

In this work, we investigated the effect of using of vacuum during the spray drying process for producing powders containing a volatile compound. Orange essential oil emulsion was produced with maltodextrin (dextrose equivalent = 10) and modified starch as wall materials, and then, it was atomized in the same equipment (nozzle diameter and drying chamber) operated under two different conditions: a) the conventional operation employs inlet temperature of 190 °C and b) the vacuum spray dryer (VSD) where vacuum pumps was coupled, is able to dry at around 30 °C. The particles recovered by both processes were characterized in relation to retention of volatile compounds (Limonene, myrcene, α-pinene and linalool) and porosity (bulk tapped and particle densities). In addition, the properties of the microcapsules were studied through Fourier transform infrared spectroscopy *(*FTIR) analysis, adsorption isotherms, X-ray diffraction, accelerated shelf life tests and reconstituted emulsions to the spray-dried and vacuum spray-dried particles. It was found that the retention of all volatiles analyzed was affected by the type process and reached higher values when vacuum spray drying was applied. All particles presented amorphous characteristics and no interaction between wall material and encapsulated oil was demonstrated. The powders produced by VSD showed the lowest water adsorption, while the samples produced by conventional process were the most hygroscopic ones. The particles produced by vacuum spray drying presented higher bulk tapped and particle densities, and therefore lower bed porosity than particles resulting from the conventional process. Preservation of thermo-sensitive components can be improved by the use of vacuum in the spray drying process.

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PO79 - 24976 - LOCATION-BASED ANTIOXIDANT PERFORMANCE IN DROPLET-STABILIZED OIL-IN-WATER EMULSIONS

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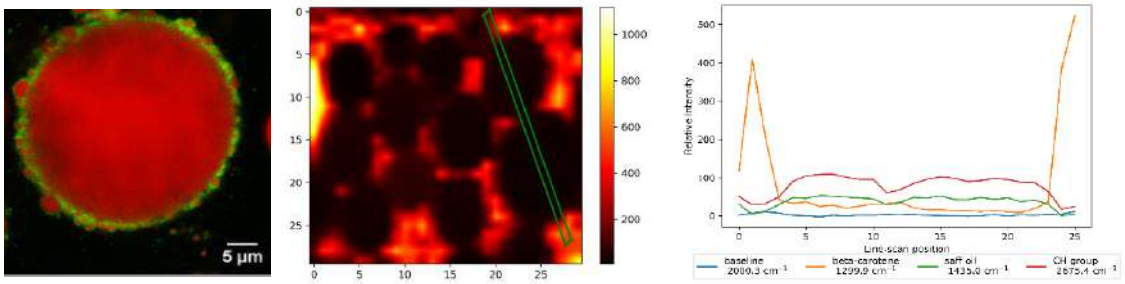
Keywords: Droplet-stabilized emulsion, Shell emulsion, Surface lipid, Core lipid, Oxidation, Butylated hydroxyanisole, Beta-carotene, Polyunsaturated fatty acid

Abstract

Droplet-stabilized' emulsions (DSEs) consist of lipid droplets (the core) stabilized by sub-micron protein-coated lipid droplets (the shell). This study investigated and compared performance of antioxidant (butylated hydroxyanisole- BHA) incorporated in shell droplets located at the interface of DSEs containing a core of polyunsaturated fatty acid (PUFA) oil emulsified with shell droplets of low melting lipid (olive oil) against incorporation in core PUFA oil at different antioxidant amounts (50 and 500 ppm). The study also probed the location and mobility of antioxidant (beta-carotene) incorporated in shell droplets of DSEs to determine if antioxidant remained localised at the interface. Oxidation of emulsions was accelerated with fluorescent lamp in the presence of ferrous iron (500 µM) for eleven days, and PUFA oxidation was monitored via conjugated dienes, lipid hydroperoxides and hexanal levels. At 500 ppm, oxidation was slower in droplet-stabilized emulsions with BHA-in-shell droplets than emulsions with BHA-in-core PUFA oil, a reverse trend was observed at 50 ppm. Results suggest incorporating BHA-in-shell droplets of DSEs may be more effective than incorporating in core PUFA oil, and BHA performance in DSEs may be dependent on its concentration, transfer mechanism and time to reaction sites.

Confocal Raman spectroscopy was used to probe the location and mobility of antioxidant (beta-carotene) incorporated in shell droplets of DSEs. Beta-carotene incorporated in shell droplets of olive oil remained mostly localised at the interface even after 3 days of production and results reveal that migration of beta-carotene between shell and core was minimal, and it may be possible to concurrently deliver two incompatible bioactives by spatially segregating them between shell and core compartments.



Acknowledgements

Riddet Institute

PO80 – 24914 - ENCAPSULATION OF PHENOLS RECOVERED FROM OLIVE BY-PRODUCTS INTO ALGINATE-BASED MICROSPHERES BY EMULSIFICATION-INTERNAL GELATION: BEADS CHARACTERIZATION AND EXPLOITATION IN REAL MATRICES

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Keywords: Olive leaves phenolic extracts, Alginate beads, Encapsulation

Abstract

Olive leaves represent one of main source of polyphenols, compounds exhibiting interesting nutraceutical properties but with poor stability and unpleasant taste. Encapsulation is one of the most applied technique to protect bioactive compounds towards degrading factors during utilization and storage. Among biopolymers, alginate is one of the most commonly used for encapsulation: it forms hydrogels primarily by ionotropic gelation with divalent ions (e.g., Ca^{2+}) at room temperature, thus under mild and safe conditions. This work was aimed at developing alginate-based microspheres to encapsulate olive leaf phenolic extracts by an emulsion/internal gelation technique and at exploiting such innovative ingredients in a real matrix (mayonnaise). Beads were formed using alginate by itself, and alginate in combination with other biopolymers (pectins, WPI, caseinates). The systems were characterized in terms of encapsulation efficiency (EE%), particle size, optical and confocal microscopy, FT-IR, swelling behavior and release kinetics. Mayonnaises were characterized by tribology and sensory analyses. Particles with a mean diameter lower than 100 µm were produced; the addition of biopolymers increased the EE% when compared to plain alginate; in particular alginate-pectin microspheres exhibited the highest EE% value (≈ 80%). FT-IR spectra (4,000–400 cm^{-1}) evidenced the presence of new - intermolecular interactions which weakened the covalent bonds shifting their absorption to lower energy. A correlation between swelling and release was observed; the main contribution for polyphenols release from the beads was given by diffusional processes, as confirmed by the diffusion and relaxation constants obtained by data modelling with Peppas-Sahlin equation. Results suggest that emulsification-internal gelation can be a promising technique to encapsulate bioactive compounds for food application, since it can provide enough small microspheres, a satisfying EE% and the possibility to achieve a tailored release of the bioactive compound.

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PO81 - 25003 - ALGINATE-BASED BEADS AND CORE-SHELL CAPSULES LOADED WITH CORN OIL FOR POTENTIAL DELIVERY OF FUNCTIONAL COMPOUNDS

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Keywords: Encapsulation, Beads, Core-shell capsules, Polysaccharides, Lipophilic compounds

Abstract

Alginate-based systems have been used to encapsulate and delivery a wide range of compounds in different applications, such as food and pharmaceutical products. However, their successful application requires a methodology with the capability to produce monodispersed, homogenous-shaped beads or capsules, with a high productivity [1]. In this work, alginate-based beads and core-shell capsules with or without whey protein isolate (WPI) were produced by ionic gelation and used to encapsulate different contents of corn oil. The two systems were evaluated in terms of size, weight, loading capacity, encapsulation efficiency, yield and productivity. Different concentrations of sodium alginate and WPI (Table I) were used to evaluate the capacity to encapsulate different amounts of oil. The encapsulation process was carried out using the Buchi Encapsulator B-395 Pro at flow rates of 8 and 10 mL/min for beads (using single nozzle) and capsules (using concentric nozzle), respectively. The beads and capsules obtained present a spherical and homogeneous form (Figure 1), with a high reproducibility. The sizes obtained for beads and capsules ranged from 3.5 to 5.2 mm and 4.2 to 4.9 mm, respectively. In terms of average weight, the beads and capsules showed values ranging from 23 to 51 mg and 32 to 49 mg, respectively. The results showed that for higher polymer concentrations the beads forming solutions are more difficult to stabilize and the beads obtained are more heterogeneous (formulation E and F) with a teardrop-shaped (formulation F). In contrast, higher polymer concentrations allows to obtain capsules with a higher yield of production (from 4–100%) and encapsulation efficiencies (from 5–100%), and with loading capacity values ranged between 25 and 65%. This work shows that is possible to obtain a high reproducible production of large spherical beads and core-shell capsules with high oil content and high productivities (9,000–16,000 beads/hour and 14,000–20,000 capsules/hour).

Table I. Experimental design

Formulation	[sodium alginate] (%, w/v)	[WPI] (%, w/v)
A	3	0
B	2	1
C	1.5	1.5
D	2	2
E	3	1
F	4	0

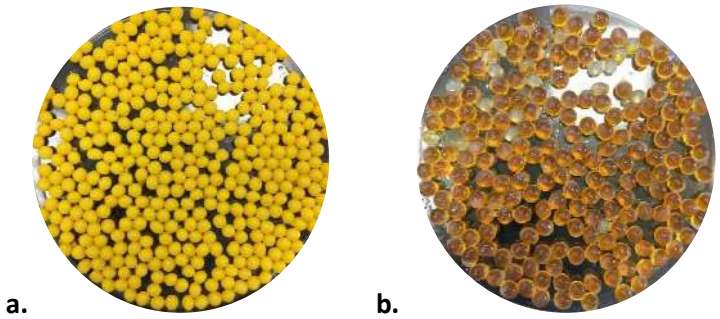

Figure 1. Beads of formulation A (**a**) and core-shell capsules of formulation F (**b**) produced using the Buchi Encapsulator B-395 Pro.

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Acknowledgements

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PO82 - 24967 - β-LG NANO DELIVERY SYSTEMS: SUSTAINED RELEASE OF RIBOFLAVIN INTO FOOD SIMULANTS UNDER VARIOUS TEMPERATURES

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Keywords: Hydrophilic compounds, Food grade, Whey protein, Gelling agent, Release kinetics

Abstract

β-Lactoglobulin (β-Lg), the main protein fraction of whey proteins, can be used to encapsulate bioactive compounds due to its gelation capacity, which allows forming nanostructures, and their affinity to bind to a wide range of molecules. Riboflavin is an essential vitamin for human growth and wellbeing, having thus been studied as hydrophilic model compound. Its use in food products is still limited by several issues including photodegradation and low solubility in water. Riboflavin encapsulation may overcome these issues and possibly display a controlled release behavior. Food-grade β-Lg nanostructures (β-LgN) were developed at pH 6, at 80 °C for 15 min to encapsulate 0.105 mg mL^{-1} of riboflavin. Release kinetics of riboflavin from β-LgN were assessed in hydrophilic (ethanol 10%) and hydrophobic (ethanol 50%) food stimulants (Commission Regulation EU No10/2011) at 4 and 25 °C. Kinetic models considering both Fickian and Case II transport (Linear Superposition Model - LSM) were fitted to release kinetics data. The impact of release conditions on particle size and surface charge of nanostructures was performed by dynamic light scattering (DLS). The LSM model was the most suitable to describe the release kinetics, which is mainly governed by a relaxation mechanism. These results were in agreement with DLS observations, which showed a decrease on surface charge and an increase on particle size. β-LgN were relaxed and weaker as a consequence of the riboflavin release until the equilibrium state was reached. It was observed that the contribution of relaxation to the release mechanisms increases with temperature. Riboflavin release kinetics on the hydrophobic food simulant provided a higher riboflavin retention when compared with the hydrophilic food simulant, independently of temperature. These observations indicate that food-grade β-LgN may represent suitable means for controlled delivery of hydrophilic compounds in food applications, however, further information is needed to clarify the mechanisms which are involved in it.

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PO83 - 24887 - MECHANICAL PROPERTIES OF SONICATED EMULSION FILED HYDROGELS AND IN VITRO DIGESTIBILITY

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Keywords: Sonication, Hydrogels, Digestibility, Target delivery

Abstract

The production of functional systems for protection of bioactive has increased the demand for natural emulsifiers and biopolymers, capable of promoting stability, protection and controlled delivery. Structures were produced with potato starch 3.0% (w/w), alginate 0.5% (w/w) and gelatin, concentrations of 0.1% and 1.0% (w/w), named $SAG_{0.1}$ and $SAG_{1.0}$, respectively. The sonication process at 375 W / 5 min (UP) and rotor-stator at 20,000 rpm / 4 min (RS) were used to produce emulsion filled hydrogels, which were evaluated through the *in vitro* digestibility, mechanical and morphological properties. The results indicated that $SAG_{0.1}$ presented insufficient gelatin concentration to cover the droplet interface and the sonication process resulted in larger pores, resulting in a soft and brittle structure. For $SAG_{1.0}$ the sonication process reduced the porosity and droplet size, forming a homogeneous and strong network, reflecting the increase in stress at fracture and Young's Modulus. Due to the low porosity, homogeneity, and strength, $SAG_{1.0}$ UP presented interesting characteristics for bioactive protection and target delivery. Thus, $SAG_{1.0}$ UP particles were submitted to *in vitro* tests to evaluate the microstructure and morphology along digestibility. Evident changes of the network were observed along the digestive tract. In the oral phase, the possible action of amylase on the starch structure caused an interface modification of the oil droplets. In the gastric phase, the stability of the matrix to acidity and gastric enzymes allowed to observe a more interconnected and uniform network, which changes to a porous structure with oil release at intestine, which was related to the sensitivity of the biopolymers to the pH, salts, enzymes and bile salts under these conditions. The results obtained may be useful for the development of foods fortified with hydrophilic and lipophilic bioactive, with delivery and protection properties at different stages of the digestive tract.

PO84 - 24894 - PROTEIN-BASED EMULSION GELS FOR EDIBLE OIL STRUCTURING

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Keywords: Emulsion gel, Oleogel, Protein, Oil, Rheology

Abstract

Oleogelation has recently gained popularity as strategy for transforming liquid oil into soft solid-like structured gels to obtain the functionality of fats in food products. The gel-like structure is achieved by oil entrapment within 3D network created by self-assembling molecules. Among food grade oleogelators, proteins offer the greatest potential as network-forming structurants since they are widely available, relatively cheap and are considered healthy ingredient in modern diet. However, utilization of protein as an oil structuring agent raise a great challenge due to its chemical composition.

The current research focus on the characterization of protein stabilized emulsion gel fabricated using a direct procedure at moderate temperature feasible for large-scale production. Microscopy images indicated on the formation of a composite system where the oil droplets are dispersed within continuous protein network composed of particulate protein aggregates. The emulsion gel stability at different protein and oil content was evaluated using thermal analysis. Mechanical analysis demonstrated a positive relation between the protein content and gel hardness while a reverse relation was observed with respect to the oil content and the hardness. Oscillatory temperature sweep analysis demonstrated the sol-gel transition of the emulsion gel from 4 to 90 °C with storage modulus (G') higher than loss modulus (G"). In addition, thermo-reversible behavior was observed during two cooling/heating cycles. Frequency sweep analysis at different temperatures confirmed the formation and breaking of hydrogen bonds between the particulate protein aggregates. The emulsion gel also exhibited excellent thixotropic behaviour with 100% recovery after high shear treatment. The current research demonstrates a thorough structure-function study providing a broad understanding of the gel building blocks. Such understanding can be used to further develop protein based oleogel systems with desirable characteristics.

PO85 - 25028 - PROLIPOSOMAL ENCAPSULATION OF QUERCETIN EXTRACTS FROM ONION PEEL

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Keywords: Proliposomes, Quercetin, Encapsulation, Onion peel

Abstract

Quercetin and typical flavonoids present in onion peel draw interest due to bioactive properties. They have numerous beneficial effects like anti obesity, antioxidant, anti-inflammatory and anticancer.

The aim of this research was to extract quercetin from onion peel and to increase its bioavailability and stability by liposomal encapsulation. Liposomes are made of bilayers of amphiphilic molecules (such as phospholipids) which enable encapsulation both hydrophilic and lipophilic particles. For utilizing quercetin from onion peel, conventional solvent (70% ethanol) extraction was used and the amount of quercetin in this extract was determined by HPLC-PDA. Both quercetin standard and onion peel extract were encapsulated in liposomes, using different ratios between standard/extract and liposomes (1:20 and 1:100), in order to compare their encapsulation efficiency. The greatest encapsulation efficiency was observed for the quercetin standard prepared with liposomes in ratio 1:20 (87.06±1.13%), while encapsulation efficiency of quercetin from onion peel extract, was lower (75.81±2.12%) at the same conditions. The stability of encapsulated quercetin was followed for 30 days using HPLC- PDA.

The interactions between quercetin and lipids were characterised by fluorescence polarisation measurements, electronic paramagnetic spectrometry and differential scanning calorimetry. Quercetin caused a small thermal destabilisation of DPPC transition which shows that the molecules interacted mainly with the polar headgroup regions of the bilayer.

Onion peel presents a rich source of quercetin which could be employed in the formation of stable functional dosage forms.

Acknowledgements

Slovenien Research Agency (P4-0121)

PO87 – 24912 - EFFICIENCY OF TPP-CHITOSOMES ON THE ENCAPSULATION OF VITAMIN D_3 AND THEIR APPLICATION IN RED GUAVA JAM

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Abstract

The objective of this study was evaluate the efficiency of TPP-chitosomes on vitamin D_3 encapsulation by the formation of a liposome hybrid systems recovered by chitosan nanoparticles through ionic gelatinization with sodium tripolyphosphate (TPP). The nano/microcapsules were added in red guava jam and the vitamin D_3 stability was evaluated. Vitamin D_3 and phospholipids was diluted in ethanol and mixed with the TPP solution. This suspension was dripped on the chitosan solution. The final suspension was homogenized using sonication (25 cycles of 5 s and 2 s pause) and the final concentrations were: 1.75 mg/mL of vitamin D_3, 0.6 mg/mL of phospholipids, 0.6 mg/mL of TPP and 2 mg/mL of chitosan. The colloidal systems presented zeta potential of +28 mV and encapsulation efficiency was about 62%. The jams were produced by the guava pulp concentration during 30 min at 97 °C, added of water (1:9), demerara sugar and pectin extracted from Fuji apple (both at 20 g/100 g of red guava pulp) and lemon juice (0.4 g/100 g of sugar). The pure vitamin D_3 suspension (Control) or the vitamin D_3-entrapped in TPP-chitossomes were incorporated after 25 min of the thermal treatment at the concentration of about 200 mg of vitamin/g of jam. Vitamin D_3 quantification was carried using High Performance Liquid Chromatography (HPLC) at the beginning and at the end of the jams'processing. Both samples showed a pH around 4.0, moisture content of 42% and soluble solids content between 43 and 46°Brix. It was observed a higher final concentration of vitamin D_3 in the jams added of TPP-chitossomes compared to the jam added with free vitamin D_3. The results obtained are promising, because they show that the encapsulating system is able to protect the vitamin D_3 during the jam process.

Acknowledgements

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PO88 - 24934 - EMULSION GELS WITH STRUCTURED OIL PHASE AND INTERFACE FOR IMPROVED DELIVERY OF BIOACTIVES

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Keywords: Emulsion gel, Solid fat, Interface, Texture

Abstract

Whey protein isolate based emulsion gels were prepared through a cold-set gelation process, and the effects of solid fat content (0, 20, 50, 80, 100%) in the oil phase and different proteins at the interface (whey protein isolate-WPI, lactoferrin-LF, sodium caseinate-CS) on the textural properties and stability of β-carotene of the gels were investigated. Increase in solid fat content resulted in smaller droplet size, higher viscosity and improved creaming stability of the emulsions. When glucono-d-lactone (GDL) was added to initiate gelation, higher solid fat content contributed to earlier onset of gelation and higher gel strength (higher storage modulus and hardness) of the emulsion gels. Emulsions using WPI as the emulsifier had the smallest particle size and highest stability, followed by the emulsions stabilized by CS and LF. When gelation occurred, gel strength of the emulsion gels with different proteins at the interface followed the order of: WPI>CS>LF. Emulsion gels were also subjected to UV light irritation or thermal treatment for the test of β-carotene stability, and the findings suggested that gels with higher solid fat content or using WPI as the emulsifier had improved stability. These findings indicated that the delivery functionality of the emulsion gels can be modulated by changing the structures of the oil phase or interface, which would be useful for the design of novel health food containing bioactive compounds.

Acknowledgements
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PO89 - 24981 - BIGELS AS A VEHICLE FOR BIOACTIVES COMPOUNDS: ASSESSMENT OF IN VITRO DIGESTION BEHAVIOR

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Keywords: Organogel, Hydrogel, Delivery, Curcumin, Gastrointestinal digestion

Abstract

Bigels are novel complex biphasic systems composed by organic and aqueous gelled phases that can act as texture modifiers, and vehicle for topical and gastrointestinal delivery of hydrophilic/lipophilic bioactives. However, its behavior through digestion has still not been assessed. Moreover, process conditions can change their structure and consequently the bioactive stability and release. Thus, the aim of this work was to evaluate the influence of the process on bigel's structure and behavior through gastrointestinal tract. Bigels were produced with gellan gum hydrogel (1.25% w/w) and high oleic sunflower oil+glycerol monostearate (10% w/w) organogel loaded with 0.1% curcumin. Gelling agents were solubilized separately (80 °C, 30 min) and then mixed by cold or hot-emulsification method. Cold-set was carried out mixing gelled systems by mechanical stirring (50 °C, 1,000 min^{-1}, 10 min). Hot-emulsification was performed with addition of 2% (w/w) Tween 80 by mechanical stirring (same conditions) or rotor-stator device (50 °C, 14,000 min^{-1}, 2 min). Bigels were submitted to an *in vitro* gastrointestinal digestion using the harmonized digestion method, and changes were assessed through fluorescent microscopy. At the end of digestion, free fatty acids (FFA) released and bioaccessibility and stability of curcumin were determined. Cold-set bigels showed W/O structure while hot-emulsification led to W/O bigels with smaller droplets when rotor-stator was used. The results from the *in vitro* digestion indicated that all bigels were stable after stomach conditions, however, they destabilized during intestinal conditions. Besides, O/W bigels showed higher stability with less droplet's coalescence, due to the surfactant presence. FFA and curcumin stability followed the same tendency, with higher values for O/W bigels. However, despite the higher stability, the effective bioavailability was similar for all bigels produced. Thus, independent of the structure and physical properties, bigels could be used for protection and oral delivery of hydrophobic bioactives and are promising systems for concomitant hydrophilic/hydrophobic loading.

Acknowledgements

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PO90 - 24876 - USE OF INTERFACIAL TECHNIQUES TO DESIGN TAILORED PROTEIN INTERFACES

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Keywords: Dilatational rheology, Interfacial rheology, Competitive adsorption, Protein crosslinking, SAOS measurements

Abstract

Encapsulation of lipophilic component may be carried out to increase the bioavailability and bioaccessibility of bioactive compounds which may be encapsulated in dispersed systems and released after their intake[1]. Related to the encapsulation of lipophilic compounds, the bioavailability of lipophilic functional components increases when the droplet size decreased. Moreover, small droplets exhibit a larger surface area and they may be digested faster[2]. The bioavailability of these systems is highly influenced by the interfacial properties of the protein film which covers the droplets and prevents them against destabilization phenomena. However, an excessive protection may difficult their final digestion and further adsorption, which may limit the bioaccessibility of the bioactive compounds introduced in the formulation. Interfacial techniques have been typically focused only on the stability of droplets against breakdown. However, traditional interfacial techniques could be now applied to tailored interfaces in order to achieve food products with enhanced bioactive properties. The present work used three whey protein concentrations (0.001, 0.08 and 0.25 wt%) at three different pH values (3.0, 5.0 and 8.0) to analyse the behaviour of the interfaces formed. Dilatational measurements and interfacial shear rheology techniques were used to follow the evolution of the interfacial film over protein adsorption, and also information after reaching the quasi-equilibrium state. Interfacial results were compared and related with the foam ability and stability of these protein dispersions, revealing that the interfacial adsorption process determines the functional properties of protein dispersions, which may have a potential use in delivering bioactive ingredients.

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Acknowledgements

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PO91 - 24954 - FORMATION OF DOUBLE (W1/O/W2) EMULSIONS WITH SOLID LIPID PHASE AS CARRIERS OF CHLOROPHYLLIN

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Keywords: Bioactive compounds, Double emulsions, Encapsulation efficiency, Solid lipid phase

Abstract

Double emulsions arise as potential delivery systems to encapsulate and protect bioactive compounds. Their formation with a solid lipid phase may be an interesting strategy to enhance their protective functionality. Thus, the aim of the present work was to study the formation of water-in-oil-in-water emulsions ($W_1/O/W_2$) with different surfactants (Tween 80 and lecithin) and oils (medium chain triglyceride, MCT and corn oil, CO) with or without a lipid solidifying agent (glyceryl stearate, GS) as carriers of chlorophyllin. The formation of double emulsions was evaluated by microscopy and particle size characterization and by determining their encapsulation efficiency (EE), while their stability was assessed in terms of particle size and creaming during storage (12 days). On the one hand, both CO and MCT-double emulsions were successfully formed using Tween 80 since the presence of oil droplets filled with a dispersion of W_1 phase (W_1/O) containing chlorophyllin was visually observed (Figure 1). Moreover, both Tween 80 and lecithin-stabilized double emulsions were formed containing the solidifying agent (GS) in the oil phase. Nonetheless, Tween 80-stabilized emulsions presented a higher W_1/O droplet size ($d_{3,2} \approx 8$ µm) in comparison with lecithin-stabilized double emulsions ($d_{3,2} \approx 4$ µm). With regards their encapsulation efficiency, all the double emulsion systems showed high chlorophyllin EE values, being higher than 98 %, regardless the type and state of the oil phase or the surfactant used. On the other hand, the stability of double emulsions was affected by the type of surfactant rather than the lipid type or state. Tween 80-stabilized emulsions showed higher and faster creaming phenomena in comparison with lecithin-stabilized double emulsions, which were stable during 12 days probably due to their smaller initial W_1/O droplet size. The current work provides relevant information about formation and stabilization of double emulsions with solid lipid phase as carriers of bioactive compounds.

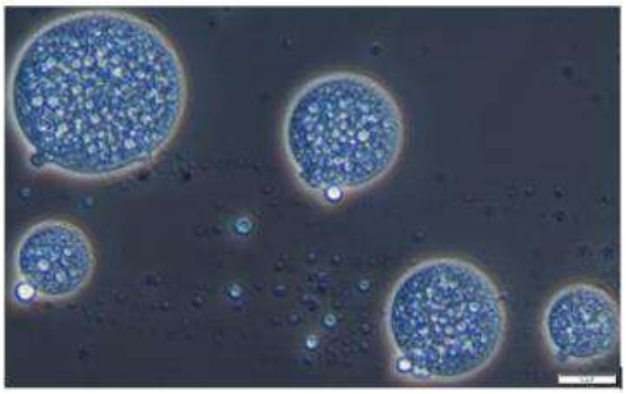

Figure 1. Optical microscopy images of double ($W_1/O/W_2$) emulsions formulated with MCT oil and stabilized with Tween 80. Scale bar represents 10 μm.

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PO92 - 24910 - MULTILAYER EMULSIONS AS A STRATEGY TO IMPROVE STABILITY AND β-CAROTENE BIOACCESSIBILITY

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Keywords: β-carotene, Multilayer emulsions, Environmental conditions, Bioaccessibility

Abstract

There is a growing concern related to healthy lifestyle particularly associated with nutrition habits. In this sense, food and beverages containing active substances, such as β-carotene, are of great interest considering their potential health benefits. Nevertheless, the incorporation of active substances to aqueous-based foodstuffs is limited because of their poor stability and bioavailability. Multilayer emulsions exhibit great physical stability against external factors as well as increase functionality of encapsulated active substances because of the layers covering the droplets. Thus, the aim of this study was to investigate physical stability [particle size, zeta potential and backscattering (BS) changes] under different environmental conditions (heat, pH, presence of salt and storage temperature) of a β-carotene-enriched multilayer emulsion prepared with lactoferrin, alginate and ε-polylysine as primary, secondary and third biopolymer layers, respectively. Furthermore, lipid digestibility and β-carotene bioaccessibility were determined. Particle size of multilayer emulsion substantially increased up to 13 µm after heating at 90 °C and adding salt. Moreover, zeta potential values close to 0 mV suggested a partial detachment of ε-polylysine from droplets. Under acidic conditions, extensive aggregation (9.3 µm) and positive zeta potential (34.01 mV) were observed, while those emulsions exposed to basic conditions presented small particle size (0.40 µm) and negative zeta potential (-35 mV). These results suggested desorption of ε-polylysine from droplets surface, being carboxyl groups of alginate responsible for the negative charge. No BS variation in emulsions stored at 4 °C indicated better resistance against destabilization processes than those stored at 25 °C, in which flocculation and sedimentation was detected. After *in vitro* digestion, multilayer emulsion presented a lipid digestibility of 84% and a β-carotene bioaccessibility of around 70%. These results provide valuable information about multilayer emulsions behaviour over environmental conditions for further design of delivery systems as functional ingredients.

Acknowledgements

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PO93 - 24871 - ROLE OF CELLULOSE CRYSTALS ON THE FORMATION OF O/W PICKERING EMULSION OBTAINED FROM ULTRASONIC PROCESS

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Keywords: Cellulose, Microcrystals, Nanocrystals, Stability of emulsions, Flaxseed oil, Ultrasound processing

Abstract

The pharmaceutical and food industries have increased their investments in the use of natural compounds as substitutes of synthetic additives. This study aimed to understand the stabilization mechanism of flaxseed oil-in-water emulsion using cellulose crystals (CCrys) as stabilizing particles. CCrys is a great option of *generally recognized as safe* (GRAS) compound for the food industry that can be used to protect the flaxseed oil, a rich source of α-linolenic acid. We prepared course emulsions stabilized by CCrys using rotor-stator (10,000 rpm/3 min) followed by ultrasonication process to obtain fine emulsions (535 W/ 4 min). An emulsion control was prepared under more intense process conditions in rotor-stator (10,000 rpm/ 3 min and 13,000 rpm/ 3 min).We evaluated the effects of the volume fraction of the oil phase (10, 15 and 20% w/w) and CCrys particles concentration (2.5, 3.75 and 5% w/w) on the emulsion properties. Particles used to prepare emulsions presented bimodal size distribution with a peak observed in the micrometric scale (5 mm) and another one on the nanometric scale (300 nm). All emulsions presented negative charge, high viscosity and good kinetic stability (28 days). No reduction on the interfacial tension between flaxseed oil and water was observed indicating that the effects of electrostatic repulsion (from -25 mV to -30 mV) and viscosity increasing (from 109 mPa.s to 469 mPa.s) with oil volume fraction and CCrys concentration were important mechanisms for emulsion stabilization. The largest microcrystals increased the viscosity of the continuous phase while small particles adsorbed on the oil-water interface prevented the droplets coalescence. The flaxseed oil droplets were surrounded by cellulose nanocrystals, which was a consequence of Pickering-type stabilization. Emulsions stabilized with cellulose crystals showed properties and characteristics for the protection of lipophilic compounds that could be applied in areas including food and cosmetics applications.

PO94 - 24907 - ARTIFICIAL CASEIN MICELLES - INSIGHTS IN STRUCTURE THROUGH ENZYMATIC CROSSLINKING

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Keywords: Artificial casein micelles, Microbial transglutaminase, Milk proteins, Nanocarrier

Abstract

Caseins, the major proteins of bovine milk, associate together with calcium phosphate to aggregates known as casein micelles. These aggregates have average diameters of 150 to 200 nm and consist of α_{s1}-, α_{s2}-, β- and κ-casein. By simulation of their natural formation in the Golgi system of the mammary gland, it is possible to synthesize their artificial counterparts. Recently, these artificial casein micelles were used for encapsulation of biological active nutraceuticals like vitamin D[1]. In spite of this application as nanocarriers, little is known about the inner structure of artificial casein micelles.

The aim of our study was to investigate artificial compared to natural casein micelles. It is reported, that enzymatic crosslinking of natural casein micelles differ from non-micellar casein, like sodium caseinate, because of their special inner network[2]. Hence, we determined the accessibility of individual caseins within artificial micelles by the enzyme microbial transglutaminase (mTG) (EC 2.3.2.13), which catalyzes an acyl transfer reaction among protein-bound glutamine and lysine resulting in a covalent isopeptide-bond. After treatment of casein micelle suspensions with mTG over 5 - 60 min (pH 6,7; 40 °C; 24 U/g Casein), we analyzed the remained monomeric caseins via RP-HPLC-UV.

For artificial casein micelles we observed a comparable reaction behavior like in natural micelles. Furthermore electron-microscopic images suggest a similar inner network, while the surface of artificial casein micelles seems smoother. Our results clarify the inner structure of these complex protein aggregates, which helps to understand the encapsulation process for biological active compounds.

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Acknowledgements

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PO95 - 24727 - STARCH-BASED MULTILAYER WITH PH-RESPONSIVE BEHAVIOR DRIVEN BY WHEY PROTEIN CONCENTRATE: THE EFFECT OF STARCH CONFORMATION

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Keywords: Layer-by-layer, Multilayer, pH-triggered release, Cationic starch, Whey protein concentrate, Anthocyanins

Abstract

Both normal (NC) and high amylose (hylon VII, HC) corn starches were dissolved in alkaline solution and modified with a cationic reagent (3-chloro-2-hydroxypropyl-trimethyl ammonium chloride, CHPTAC) according to the methods reported by Heinze et al. (2004) and Kuo & Lai (2007)[1,2]. Both cationized starches (NCS and HCS) with the degree of substitution (DS) of 0.6 were used to construct multilayers with whey protein concentrate (WPC) via layer-by-layer deposition. The pH-responsive behavior of multilayer dependent of the attraction/repulsion between cationic starch and WPC was hypothesized. As the result, the tendency of build-up and break-down of multilayers differed owning to the conformational differences between NCS and HCS could be examined. NCS tended to form the thick and porous layers which resulted in retaining more WPC. As the repulsive force emerges at pH < pI (4.3) of WPC, both starch-based multilayers disrupted near physiological ionic strength (0.1 M) obviously. The HCS-based multilayer showed a clear structural dissociation within a narrow pH range, while the entangled network of NCS-based multilayer seemed delaying the structural disruption triggered by pH. The WPC driven releases of the post-loaded anthocyanins from the NCS-based multilayer was confirmed. A potential of starch-based multilayers applying for the pH-triggered active coating is foreseen.

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PO96 - 24926 - FORMATION AND EVALUATION OF CHITOSAN NANOPARTICLES WITH ANTIBACTERIAL AND EMULSIFYING PROPERTIES FOR FOOD APPLICATION

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Keywords: Chitosan, Genipin, Sodium tripolyphosphate, Food preservative, Emulsifying property

Abstract

Chitosan (CS) is a natural polysaccharide with several functional properties, including antimicrobial and emulsifying activities. However, these properties are not intense enough to enable its use as food preservative or emulsifier. Through nanoscale aggregation, the functional properties of polymers can be enhanced, due to the huge increase of surface area. The present work studied the formation of chitosan nanoparticles with sodium tripolyphosphate (TPP) or genipin (GN), in order to enhance chitosan antimicrobial and emulsifying properties. The particles were synthesized via ionic and covalent crosslinking of chitosan (2 mg/mL, Sigma-Aldrich) with 1 mg/mL TPP or GN, respectively, under magnetic stirring at pH 3.5 for 1 h at 25 °C. The complexes were characterized by Dynamic Light Scattering (DLS), Fourier Transform Infrared Spectroscopy (FTIR) and Atomic Force Microscopy. Minimum Inhibitory Concentration (MIC) against *Staphylococcus aureus* was evaluated and the emulsifying property was studied by emulsification index in a model emulsion (10O:90W), prepared with the particles in suspension, soybean oil and 5% lecithin. The size and zeta potential stability over time of the complexes stored under refrigeration was also studied. The FTIR spectra confirmed the chemical interactions between the chitosan and TPP/genipin groups. The complexes showed hydrodynamic diameter of 87.8 and 953.7 nm to CS-TPP and CS-GN particles, respectively. The MIC results showed that the antimicrobial property was intensified for the smaller size particle (0.007 mg/mL, CS-TPP NPs), confirming the hypothesis that nanotechnology can improve polymer functional properties. Regarding the emulsifying property, the particles were also able to extend the stability of the emulsions, since the phases separation occurred slowly, especially for CS-TPP nanoparticles. The particles remained stable for 56 days. In this scenario, chitosan nanoscale structuration is a viable alternative to food application, once both functional properties were improved through nanotechnology.

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PO97 - 24969 - CARBOXYMETHYLCELLULOSE-COMMERCIAL PLANT PROTEINS COACERVATES TO DELIVERY LIPOPHILIC COMPOUNDS

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Keywords: Complex coacervation, Potato protein, Rice protein, Pea protein

Abstract

Plant proteins are cheaper, renewable, biodegradable, and an abundant alternative to animal-based proteins. However, the use of plant proteins as raw material on microencapsulation has been limited in the literature due to their low solubility, mainly those from commercial origin. In this manner, complex coacervation of carboxymethylcellulose (CMC) and commercial plant proteins (potato (PP), rice (RP), and pea (EP)) to encapsulate lipophilic compounds was investigated. We studied the influence of pH, protein/polysaccharide ratio as well as the effect of crosslinking with sodium tripolyphosphate (NaTPP) on the formation of complexes. The formation of complexes was evaluated by optical density and ζ-potential, and data showed that the optimal condition of complexation was at a pH 2.0 and 2.0 $g.g^{-1}$ protein/polysaccharide ratio, for all pairs analyzed. Four core/wall material ratios were analyzed (4:1; 2:1, and 1:1) and the ratio 1:1 presented the highest encapsulation efficiency for all proteins tested, with the best performance observed for the rice protein (63.97 ± 0.15%).Scanning electron microscopy analysis showed that NaTPP crosslinking provided a structure with smaller pores, although there were no significant differences in the encapsulation efficiency. The stability results showed that coacervates produced with plant proteins and CMC showed to be stable in acidic medium (pH 3.0), presenting swelling and dissociation at pH 7.0 after four hours of incubation. These results indicate that commercial plant proteins have potential to applied in coacervates together with CMC to delivery lipophilic compounds in alkaline conditions, such as the intestinal environment once they are resistant to acidic medium.

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PO98 - 25007 - EFFECT OF THE ORGANIZATION OF THE TRIACYLGLYCEROLS AND THE TYPE OF EMULSIFIER ON THE PHYSICAL STABILITY OF DAIRY BASE LIPID NANOPARTICLES

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Keywords: Dairy proteins, Milk fat, High oleic sunflower oil

Abstract

This study aimed to evaluate the potential of fully hydrogenated milk fat (FHMF) to produce solid lipid nanoparticles, as well as a blend containing FHMF and high oleic sunflower oil (HOSO) to produce nanostructured lipid carriers. Lipid nanoparticles were produced by high-pressure homogenization (800 bar / 3 cycles) and stored for 90 days at 25 °C for stability study. Whey protein isolate or sodium caseinate was used as stabilizers, and the FHMF:HOSO blends were prepared with mass ratios of 70:30 and 50:50. After 90 days of storage, all lipid nanoparticles were spherical in shape and uniformly distributed, with the smallest diameter (138 nm) observed for the solid lipid nanoparticles. The addition of high oleic sunflower oil to the fully hydrogenated milk fat promoted a significant increase in the size of the nanostructured lipid carriers due to the less organized and less compact conformation of the system. The increase in particle size resulted in lower kinetic stability of the 50:50 FHMF:HOSO system. The sodium caseinate-emulsified nanoparticles exhibited a lower mean diameter and higher physical stability when compared to the whey protein isolate-emulsified particles. The higher diameter of the whey protein isolate-emulsified nanoparticles may be related to the greater thickness of the water-oil interface layer due to the whey protein denaturation during the hot homogenization process. Therefore, both the solid lipid nanoparticles and nanostructured lipid carriers can be used to deliver different active compounds, once the organization of the crystalline structure and the type of emulsifier exerted some influence on the physical stability of the nanoparticles, suggesting a potential for release during the digestive process.

PO99 – 24764 - ANTIMICROBIAL AND MORPHOLOGICAL CHARACTERISATION OF CHITOSAN-GELLAN GUM NANOPARTICLES

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Keywords: Antimicrobial activity, Nanoparticles, Chitosan

Abstract

The development of antimicrobial nanoparticles has gained emphasis due to the intensification of properties provided by scale reduction. Chitosan has been widely used, owing to its cationic character, conferred by amino groups, and is an efficient inhibitor of bacteriological growth. This work aims to evaluate the effect of scale reduction on the antimicrobial capacity of chitosan. Nanoparticles were produced by electrostatic complexation of chitosan and gellan gum. Complexes were analysed in three ratios of chitosan (C):gellan (G), in order to study the effect of charge density in the nanoparticles functionality: 10C:90G (negative), 15C:85G (neutral) and 30C:70G (positive). All complexes were produced at the constant final concentration of 0.5% (m/v) at 25 °C and pH 4.5. Nanoparticles size and zeta potential were determined by Dynamic Light Scattering. The greater ratio of chitosan in the nanoparticles resulted in positive surface charge. Complexes with higher charge density present smaller size, due to the higher electrostatic repulsion between the particles. The positive particles showed hydrostatic diameter of 115 nm, that was confirmed by Transmission Electronic Microscopy. Micrographs also showed spherical particles. Infrared spectra of nanoparticles presented new bands as compared to pure compounds. These bands in 808 and 1,707 cm^{-1} were related to interactions between chitosan and gellan gum (CO-NH and NH_3^+). Neutral and negative charged particles did not inhibit *S. Aureus* growth. Inhibition was only observed for pure chitosan and positive complexes, the Minimum Inhibitory Concentration (MIC) were 0.0313 and 0.0646% (m/v), respectively. Despite the MIC of complexes were slight higher than pure chitosan, nanoparticles have 62% less chitosan than the pure solution. Thus it was possible to improve chitosan antimicrobial activity by nanoagregation. Size was also an important factor in the antimicrobial assays of positive complexes, since nanoparticles with smaller size had lower MIC.

Acknowledgements
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PO100 - 24699 - STARCH NANOPARTICLES AS NANOVEHICLES FOR BIOACTIVE MOLECULES. RELEASE KINETICS IN FOOD SIMULANT MEDIA

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Keywords: Starch nanoparticles, Banana starch, Bioactive molecules

Abstract

Starch nanoparticles are small materials (within the nanoscale) with high surface-to-volume ratio, which allows them to pass through biological barriers and encapsulate different types of bioactive molecules. Due to their biocompatibility, wide array of natural sources and ease to modification through physical, chemical and enzymatic methods, starch nanomaterials have generated a great interest in the food, agricultural, cosmetic and pharmaceutical industries. In recent year, research in nanoencapsulation of bioactive molecules in starch nanomaterials and their application in different agri-food fields have grown substantially, however, several aspects like their release kinetics and behavior in food media has not been systematically studied. In this work, we present the development of native and acetylated cassava starch nanoparticles as vehicles for three model bioactive molecules, curcumin, β-carotene and ferulic acid, evaluating aspects like particle size, encapsulation efficiency and their release kinetics into several food simulants, as well as simulated gastric conditions. Acetylated banana starch showed higher encapsulation efficiency for all three molecules, than their native counterpart, due to their lower polarity as many starch hydroxyl groups are replaced by acetyl molecules. Acetylated starch nanoparticles also provided a more controlled release of the studied molecules in food simulants indicating that polarity not only plays an important role in starch nanoparticles but also in the release into different food media.

Acknowledgements
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PO101 - 24916 - INCORPORATION OF CURCUMIN-LOADED LACTOFERRIN NANOHYDROGELS INTO A MODEL GELATINE: RELEASE KINETICS AND CHARACTERIZATION

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Keywords: Whey protein, Nanohydrogels, Nutraceuticals, Release kinetics, Gelatine

Abstract

The design and development of whey protein nanostructures as encapsulating agents for nutraceutical's controlled release has been intensively studied towards the production of functional foods. However, the interactions of these structures with food matrices are not well understood at the nanoscale and therefore they must be addressed. In this study, a curcumin-loaded lactoferrin (LF) nanohydrogel was developed aiming at its behaviour evaluation when incorporated into a model food matrix (gelatine). The release kinetics of curcumin from LF nanohydrogels added to food simulants (hydrophilic medium: ethanol 10%; and lipophilic medium: ethanol 50%) were performed at 25 °C (according to the Commission regulation EU No 10/2011). The resulting experimental data were fitted by the linear superimposition model (LSM) aiming at the evaluation of the release mechanisms of curcumin through LF nanohydrogels. This system was then incorporated into an unflavoured commercial gelatine and further characterized. For this purpose, the protein nanohydrogel isolated and loaded with curcumin was dehydrated by freeze-drying, resulting in a homogeneous LF-curcumin powder. Freeze-dried nanohydrogels were characterized by dynamic light scattering (DLS), circular dichroism (CD) and fluorometry. LF nanohydrogel showed higher release of curcumin in a lipophilic food simulant (ca. 16 µg) in comparison with a hydrophilic one (ca. 1.6 µg). Curcumin release kinetics through LF nanohydrogels have shown to be mainly driven by Case II transport, rather than Fickian diffusion, in both simulants. The behaviour of this system and curcumin release kinetics in food stimulants showed that LF nanohydrogel has a huge potential for the controlled release of lipophilic nutraceuticals in refrigerated food products of hydrophilic character. Finally, LF nanohydrogels were successfully incorporated in a gelatine matrix and showed no degradation in this process.

Acknowledgements

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PO103 - 24970 - MODULATION OF MICROGELS DIGESTIBILITY BY ADDING STARCH AND COATING LAYER

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Keywords: Gellan gum, Hydrolyzed Collagen, Starch

Abstract

The addition of coating layers and the use of fillers are interesting strategies to modulate beads properties and, consequently, increase retention of compounds. In this context, we produced an enteric delivery system based on electrostatic interactions between gellan gum and collagen peptides, without previous crosslinking with salts, to protect anthocyanin throughout the gastrointestinal tract. We also verified how starch addition and a gellan coating layer modulate microgels properties. The production of particles consisted in atomizing a gellan gum solution (G) (0.5% w/w) added with anthocyanin (0.05% w/w), containing or not containing starch (S) (0.5% w/w), into a hydrolyzed collagen (HC) solution (gelling bath) (2.5% (w/w)/10 °C/pH 2.5/10 min). A coating was carried out in part of samples with a gellan gum solution (0.2% w/w), followed by reticulation with $CaCl_2$ (150 mM). All samples were submitted to *in vitro* digestibility and they were analyzed regarding their particle size distribution, anthocyanin release, and optical microscopy. According to particle size data and microscopy images, the microparticles presented irregular shape and large polydispersity that were attributed to the slower diffusion of HC molecules as compared to salts, commonly used in ionic gelation. Considering the digestibility, although all formulations were quite stable to the oral and gastric conditions, microgels containing starch released more content of anthocyanins in the oral stage, probably due to the degradation of the starch by alpha-amylases and the change in the pH of the microgels into the oral condition. Only coated microgels were found without disintegration after 2 h in enteric phase, indicating that the bioactives could be delivered to the microbial flora present in the colon. This study has demonstrated the influence of coating layer and filler addition on the delivery of anthocyanins throughout the gastrointestinal tract.

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PO104 - 25000 - INFLUENCE OF DEPOSITION TECHNIQUE ON FUNCTIONALIZATION OF POLY (L-LACTIC ACID) FILMS WITH NANO LAYERS OF CHITOSAN AND NANOCELLULOSE CRYSTALS

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Keywords: Layer-by-layer, Nanocoatings, Nanotechnology

Abstract

Poly (lactic acid) (PLA) is a non-toxic, compostable bio-based material derived from starch and/or sugar and has high mechanical strength and plasticity. It is accepted as GRAS by the Food and Drug Administration and suitable for use in food and beverage packaging. One of the strategies to incorporate active compounds on these materials is the deposition of uniform (a crucial step in the final properties) layers with active compounds (e.g. antimicrobials). In this work, two different coating techniques - dip-coating and ultrasonic spray coating - were evaluated for the deposition of nanolayers on PLA films. Chitosan (Ch), a naturally occurring cationic polysaccharide, with antimicrobial properties and cellulose nanocrystals (CNC) with the ability to enhance the barrier properties were used to functionalize PLA films. During the production step, PLA films were modified by oxygen plasma during 15 min with high voltage, to improve the adhesion of hydrophilic molecules. Afterwards, the multilayer system was developed with six active layers of chitosan and cellulose nanocrystal (Ch-CNC-Ch-CNC-Ch-CNC). For dip-coating, PLA films were immersed alternatively in each polyelectrolyte solution (1% (w/w) of Ch and 1% (w/w) of CNC) during 15 min and dried with nitrogen between layers. For the deposition with the ultrasonic spray, layers were optimised using different flow rates (0.005-0.1 mL/min) and different speeds (50,000, 100,000 and 150,000 mm/s). The film surface resulting from each deposition step was analysed using ATR−FTIR spectroscopy and contact angle measurements. An XPS analysis was used to determine the effect of chemical changes during the formation of the multilayer system. Also, changes in structure and surface roughness were investigated using scanning electron microscopy (SEM). This work revealed that ultrasonic spray coating is the most efficient technique (faster and economic) allowing to obtain a homogeneous active layer.

Acknowledgements

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PO105 - 24968 - CHARACTERIZION AND BIOACCESSIBILITY OF β-CAROTENE ENCAPSULATED ON MICROCAPSULES PRODUCED WITH STARCH AND PROTEIN FROM AMARANTH GRAIN

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Keywords: Amaranthus, Spray-drying, Microencapsulation, Bioaccessibility

Abstract

β-carotene is a carotenoid that, due to its scavenging free radicals property, presents a wide spectrum of biological activities (e.g., anti-cancer, anti-hypertensive, and anti-inflammatory). However, they are quite unstable under certain intrinsic food physicochemical properties and processing conditions, which limit their food application. In this work, β-carotene was encapsulated to improve its stability and bioavailability. Starch and protein extracted from Amaranth seed were used as materials for β-carotene microencapsulation by atomization. The encapsulation efficiency, particle size, ATR-FTIR, β-carotene stability and bioaccessibility were assessed. The total amount of b-carotene encapsulated in starch and protein microcapsules was 10 mg/L. The encapsulation efficiency was 68.62 ± 0.22% for starch-based and 64.09 ± 0.31% for protein-based microcapsules. The average size of the microcapsule composed of Amaranth protein and starch was 2.22 ± 1.84 µm and 1.55 ± 1.12 µm, respectively. The absorption bands in β-carotene are observed, FTIR spectra of the microcapsules exhibited peaks corresponding to 3,005 cm^{-1}, confirming the presence of the -OH stretch bond, the microcapsule spectra manifested distinctive peculiar peaks at 1,455 cm^{-1}, and stretching CH at the aromatic ring. Starch and protein-based microcapsules with β-carotene were stored under different conditions for 90 d (37 °C in the dark; at room temperature in the dark; at room temperature under lighting conditions; and at 8 °C in the dark). The stability of β-carotene within the protein microcapsules was better, even at higher temperatures than within the starch microcapsules. This could be due to protein higher retention network that can act as a physical barrier that isolated and protected the compound from external factors. The β-carotene bioaccessibility was 4.5 ± 1.2% and 5.7 ± 0.8%, for starch and protein, respectively. Results obtained suggest that starch and protein from Amaranth can be considered as potential wall materials for β-carotene encapsulation.

Acknowledgements

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PO106 - 25006 - FULLY HYDROGENATED MILK FAT: AN ALTERNATIVE OF STRUCTURING LIPID MATERIAL

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Keywords: Dairy fats, Novel structure, Physical properties

Abstract

The oils and fats industry has faced the challenge of producing structured lipid bases with a technological potential to replace industrially-produced trans fats. Milk fat is an alternative to obtain structured lipid bases due to its unique chemical composition and physical properties, and its total hydrogenation has not yet been sufficiently explored. This study aimed to produce and characterize fully hydrogenated anhydrous milk fat. Full hydrogenation resulted in a lipid base with a heterogeneous fatty acids composition (C4 to C24), predominantly palmitic (C16:0) and stearic (C18:0) fatty acids, and higher melting point (46 °C) when compared to anhydrous milk fat (32 °C). The hydrogenated milk fat showed a lower induction time of crystallization, with a balance between liquid and crystallized fat over a wide temperature range (-40 to 50 °C). Although some changes were observed in the thermal behavior of the hydrogenated milk fat due to the increase in the concentration of trisaturated triacylglycerols, which are responsible for inducing crystallization, both the type of crystal (spherulite) and the crystalline form (β') were maintained. These characteristics give this lipid base the ability to structure the crystallization process and suggest a potential for technological applications that require thermal resistance and a balance between liquid and crystallized fat over a wide temperature range.

PO107 - 24875 - EMULSION-BASED NUTRIENT DELIVERY SYSTEMS FOR THE ELDERLY PEOPLE

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Keywords: Emulsion, Nutrient, Elderly, Food

Abstract

Emulsion-based delivery systems, such as nanoemulsions are particularly suitable for encapsulating, protecting and delivering both lipophilic and hydrophilic bioactive components in various products with emphasis in foods[1]. In particular, oil-in-water (O/W) nanoemulsions are considered as promising delivery systems of vitamins (A, D, E and K), omega-3 fatty acids, carotenoids, and plant sterols since they provide biocompatible, stable and clear formulations of lipophilic bioactive compounds[2]. Emulsion-based delivery systems can be applied to a variety of food and beverage products and they can be exposed to various temperature conditions during processing and storage[3]. In this study, we aimed to investigate the effects of PGPR substitution on vitamin D_3-loaded NLC (Nonostructured-Lipid Carrier) emulsions and to design the appropriate emulsions with different carrier oils on the stability of emulsion against environmental stresses. As results, modified NLC emulsions for encapsulation of vitamin D_3 were successfully fabricated using four different carrier oils. The effect of PGPR substitution and different carrier oils was examined by analyzing the particle size, zeta potential, encapsulation efficiency, and multiple light scattering properties, in which Soybean and chia oil showed the highest zeta potential values, followed by MCT oil (39.5 - 67.8 mV). The fabricated NLC emulsions exhibited high encapsulation efficiency of vitamin D_3 (85.2 - 90.4%). The improved stability of the emulsions exposed to environmental stress was highly related to the PGPR substitution effect rather than to the use of different carrier oils. In contrast to NLC control, all modified NLC emulsions displayed good storage stability. Particularly, soybean and MCT oil emulsions seemed to be superior to others. Based on our observations, we expect that PGPR-substituted vitamin D_3 emulsions could be widely and efficiently applied to various food and beverage products.

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PO108 - 24987 - BREWERY SPENT YEAST INSOLUBLE RESIDUE AS MICROCARRIERS FOR BIOACTIVE COMPOUNDS

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Keywords: Yeast cell wall, Incorporation of bioactive compounds, *Saccharomyces pastorianus*

Abstract

Brewery spent yeast (BSY), the second major by-product of beer industry, have been reported as a suitable source of immunostimulatory substances, such as glucans and mannoproteins. These cell wall compounds may be extracted by hot water followed by exhaustive alkali treatments, resulting in another by-product: an insoluble residue (BSYIR) with preserved spherical cell wall structure. Whereas yeasts and yeast cell wall particles have been reported as natural microcapsules, this study aims to evaluate the use of the *Saccharomyces pastorianus* BSYIR as a GRAS hollow microcarrier for incorporation of bioactive compounds. Alkali extractions increased the cell surface hydrophobicity, by shifting the water contact angle from 39° to 111°. On the other hand, the extractions did not cause a great impact on cell surface charge which ranged from 10.7 to -39.2 mV and from 6.2 to -32.1 mV for BSY and BSYIR, respectively, when ranging the pH from 2.3 to 8.9. Both materials showed neutral charge at pH 4 and higher net surface charge density near pH 8. Hydrophobic or electrostatic interactions between BSYIR and four model bioactive compounds (β-carotene, tryptophan, bovine serum albumin and lactoferrin) were evaluated. After preliminary tests, a Central Composite Rotatable Design was run for each compound except tryptophan which showed no detectable incorporation into BSYIR. Lactoferrin exhibited the highest incorporation efficiency (79.5%) and yield (29.8%) at optimized conditions (pH 6.0, 33 °C and 0.55 lactoferrin/BSYIR mass ratio (w/w)) suggesting the occurrence of electrostatic interaction once compounds were oppositely charged at this pH. β-carotene and albumin were suggested to have hydrophobic interactions with BSYIR, although the determination of incorporation efficiency and yield might be masked by some precipitation out of the matrix. These results may guide further studies of bioactive

compound immobilization onto or into BSYIR, system coating and stability, as well as bioactive release.

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PO110 - 24888 - DELIVERING CURCUMIN USING PICKERING OIL-IN-WATER EMULSIONS STABILIZED BY WHEY PROTEIN NANOGEL PARTICLES: ROLE OF PH AND IONIC STRENGTH ON CURCUMIN RETENTION

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Keywords: Curcumin, Pickering emulsion, Nanogel, Retention, Whey protein, Electrostatic interaction

Abstract

In this study, Pickering oil-in-water emulsions (20 wt% oil) stabilised by whey protein nanogel particles (WPN) (0.1-3.0 wt%), latter of hydrodynamic diameter 80 nm was proposed as a delivery vehicle for curcumin (CUR). Medium chain triglyceride was used as the oil phase to allow effective solubillization of CUR. The effect of pH (pH 2.0 -7.0) and ions (50 mM NaCl, 10 mM $CaCl_2$) of physiological relevance, on the retention stability of CUR encapsulated within the Pickering emulsions was assessed at 37 °C. The emulsions were characterized using static light scattering, microscopy across scales (confocal, scanning and transmission electron microscopy) and surface coverage was calculated. Results supported by theoretical calculations suggest that 1 wt% WPN was sufficient to completely cover the surface of the emulsion droplets (mean droplet size, d_{43} 12.34 ± 0.28 µm) and the Pickering emulsions were stable against coalescence for several months. CUR-loaded Pickering oil-in-water emulsions (500 µg/ mL CUR, 20 wt% oil, 1 wt% WPN) were then prepared and loading of CUR did not result in any change in the droplet size or ζ-potential ($p < 0.05$). UV-Vis spectrophotometric revealed that retention of CUR within the Pickering emulsions was statistically lower ($p < 0.05$) in acidic (pH < 7.0) emulsions (60.53 – 73.97%) compared to neutral pH (76.85%). Fluorescence measurements reveled that retention of CUR in acidic conditions can be possibly attributed to hydrophobic and electrostatic interactions between WPN at the interface and CUR in the dispersed phase as revealed by CUR-WPN binding constants calculations (K_a = 6.67×10^1 - 1.33×10^4 M^{-1}).

PO111 - 24903 - CELLULOSE AS CARRIER OF TART CHERRY PHENOLICS AND VOLATILES

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Keywords: Cellulose, Tart cherry, Phenolics, Volatiles, Structural changes

Abstract

Potential for use of cellulose as a tool for preparation of functional food additives was investigated in this study. For that purpose, adsorption of phenolics and volatiles of tart cherry juice on cellulose were tested out. For preparation, the used juice amount was constant and cellulose amounts varied (2.5, 5, 7.5 and 10%). Adsorption capacities of cellulose for phenolics, anthocyanins, and volatile compounds were determined. Adsorption capacity of cellulose for phenolics increased with increased cellulose amount from 2.5 to 5% but afterwards a sharp decrease of adsorption capacity occurred. Anthocyanin adsorption was the highest when the lowest amount of cellulose was used, and it decreased with the increase of cellulose amounts up to 7.5%; after which a constant adsorption capacity was reached. Cellulose amounts also had an important role in adsorption of volatiles. For comparison, several volatile compounds defined as key tart cherry volatiles (benzaldehyde, benzyl alcohol, phenyl ethyl alcohol, α-ionone and β-ionone) were chosen. The highest adsorption capacity for benzyl alcohol was achieved with 7.5% of cellulose and for all other compounds with 2.5% of cellulose. Overall adsorption capacity (for selected volatiles) was highest at 2.5% and lowest when 10% of cellulose was used. There was no difference in volatiles adsorption between 5 and 7.5% of cellulose contents. Comparison of structure of cellulose and loaded cellulose was also carried out. FTIR spectra of cellulose had one peak at 1,640 cm^{-1} while loaded cellulose was missing that peak but contained two other peaks, one at 1,714 cm^{-1} and another one a broad peak at 1,625-1,620 cm^{-1}. Another change in FTIR spectra of loaded cellulose was observed in the range of 820-775 cm^{-1}. Obtained formulations can be used in preparation of dairy, fruit and bakery product in order to improve their health benefits, antioxidant potential, color and/or flavor profiles.

PO113 - 25020 - ENHANCEMENT OF EICOSAPENTAENOIC ACID PRODUCTION BY NANNOCHLOROPSIS OCULATA USING STRESS MODULATION: TEMPERATURE AND LIGHT

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Keywords: Microalgae, *Nannochloropsis oculata*, Eicosapentaenoic acid, Stress modulation

Abstract

Microalgae are sources of health-promoting polyunsaturated fatty acids (PUFA), namely of eicosapentaenoic acid (EPA), and can be utilized to develop functional foods, either via biomass incorporation, or as an EPA-rich extract. EPA production can be modulated via manipulation of environmental stresses including temperature, light, ionic strength among others. However, such stresses are well controlled to prevent decreases in microalgal biomass productivity.
The aim of the present work was to enhance EPA production of *Nannochloropsis oculata* through its exposure to modulated stresses, namely, temperature and light.
To assess the impact of each stress on lipid production and biomass yields, culture was exposed for some days to optimal conditions, followed by some days to stress conditions (reduced temperature/light), repeating this cycle and finishing with some days of exposure to optimal growth conditions. Stress temperature applied was10 °C and light was 30 µmol s^{-1} m^{-2}. At the end of each temperature/light exposure period, biomass (OD, cell counts and ash-free dry-weight; AFDW) and EPA content (GC) were assessed.
The first stress application promoted a decrease in EPA *per* cell, but an increase of EPA *per* biomass. In comparison to controls, the difference observed was in temperature, where stress resulted in lower EPA *per* cell (52 vs 71 fg/cell). However, upon re-exposure to optimal conditions, the second stress application step, EPA content increased in all cases and biomass remained similar, in comparison to controls. At the end of the growth cycle, EPA content was 24 and 87% (*per* cell) and 50 and 76% (*per* biomass) higher in cultures under stress, when compared with cultures grown at optimal conditions throughout. Biomass yield was not negatively influenced by stresses.

Controlled reduction of temperature/light throughout growth cycle can enhance EPA production up to 115 and 140 (fg/cell), and 27 and 37 (µg/g AFDW), respectively, without decreasing biomass yields.

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PO114 - 24947 - FACTORS AFFECTING THE FORMATION OF HIGHLY CONCENTRATED EMULSIONS AND NANOEMULSIONS AS CURCUMIN DELIVERY SYSTEMS

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Keywords: High concentrated nanoemulsions, Curcumin

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Abstract

Curcumin consumption has been associated with numerous health benefits. However, it presents a poor adsorption in the gastrointestinal tract thus being excreted almost completely. Then, highly concentrated (HC) oil-in-water emulsions, which contain at least a 40% w/w of lipid phase, arise as an interesting strategy to carry this kind of lipophilic bioactive compounds. HC-emulsions can be loaded with higher concentrations of the bioactive compound than those used in regular emulsions, which can improve the formulation of nutraceuticals. The aim of this work was to assess the influence of the emulsification method and conditions (*i.e.* high-shear homogenization, ultrasonication and microfluidization), oil volume fraction (ϕ) and surfactant-to-oil ratio (SOR) on the formation of HC-emulsions and nanoemulsions as curcumin carriers. The higher the intensity of the homogenization treatment accomplished, the smaller the particle size, reaching values between 0.31 and 0.52 µm. However, HC-emulsions showed over-processing destabilization phenomena when ultrasonication over 200 s or microfluidization for 2 cycles were applied. Overall, as increasing the ϕ from 0.4 to 0.7, the droplets particle size decreased leading to a dramatic rise of HC-emulsions apparent viscosity (µ). Nonetheless, microfluidized HC-emulsions with ϕ ≥ 0.6, experimented coalescence and their consequent breaking. Furthermore, HC-emulsions with the highest SOR (0.2) and ϕ = 0.5, exhibited the smallest particle size reaching values below 0.41 µm after ultrasonication or microfluidization. This evidenced the feasibility to obtain nanosized HC-emulsions as long as the concentration of surfactant is high enough. The particle size reduction induced the µ increase due to the droplets packing. Indeed, those HC-nanoemulsions with the smallest particle sizes showed µ values around 8 times higher than the rest. The prepared HC-emulsions presented a high curcumin encapsulation efficiency (> 70%) and release (> 80% after 48 h). Results obtained in this study are relevant to elucidate the formation of HC-emulsions to be used as delivery systems of lipophilic bioactive compounds.

Acknowledgements

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PO115 - 24977 - PRODUCING POROUS POTATO STARCH BY COMBINING ALPHA-AMYLASE DIGESTION WITH ACID HYDROLYSIS OR SURFACE GELATINIZATION

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Keywords: Porous starch, Potato starch, Acid hydrolysis, Surface gelatinization

Abstract

Porous starch, successfully prepared by enzyme hydrolysis of A-type starches such as common corn starch has attracted much attention for its absorption and delivery properties. In contrast, no porous structure has been observed for B-type starches such as potato starch, which has been partly attributed to the absence of surface pores and the crystalline structure. We hypothesized that modification of starch granule surface would facilitate enzymes entrance into potato starch granules, thus producing a porous structure.

This study investigated the effect of acid hydrolysis and surface gelatinization on digestion of common corn (A-type) and potato (B-type) starches by alpha-amylase.

Starches were first treated with sulfuric acid to yield approximately 10.0% hydrolysis or subjected to surface gelatinization with lithium chloride to yield 8.0-9.0% surface gelatinized starches and then subjected to α-amylase digestion for 5, 10, and 24 hours. The resultant starches were characterized for hydrolysis degree by quantifying soluble sugars, morphology by scanning electron microscopy, and crystallinity by X-ray diffractometry.

The crystalline type of the starches did not change after modification by acid hydrolysis or surface gelatinization. Compared to their native counterparts, the extent of alpha-amylase digestion increased by 30.6 and 70.2% for potato and common corn starches, respectively, at the 10% acid hydrolysis level. The extent of alpha-amylase digestion of surface gelatinized starches increased by 12.3 and 11.3% for potato and common corn starches, respectively. A porous structure was observed in potato starch after the combined treatment.

The acid hydrolysis and surface gelatinization improved alpha-amylase digestion of potato starch, and subsequently the formation of porous potato starch. Because its limited digestibility and large granule size, native porous potato starch could present advantages over other starches as a delivery system for bioactive compounds.

PO116 - 25009 - ENCAPSULATION OF POLYPHENOLS BY PROTEIN BASED ENCAPSULANTS

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Keywords: Colloidal gas aphrons, Polyphenols, Blackcurrant pomace, Whey protein, Encapsulation, Spray drying

Abstract

Metabolic Syndrome (MetS), which is a combination of hyperglycemia, hypertension, obesity, which affect almost ten percent of the global adult population. More concerning is that drugs used to control MetS may be involved in the advancement of kidney failure and retinopathy. However, research has shown that bioactive molecules like polyphenols found in natural sources such as black currant have similar beneficial properties as drugs but without side effects[1]. Polyphenols are typically extracted, by solvent extraction. Alternatively, surfactant based extraction methods have shown to be able to recover a richer polyphenol fraction[2]. With this in mind the objective of this work is to develop a surfactant based extraction method for the extraction of polyphenols from blackcurrant pomace. First, a hydro-alcoholic extraction will be carried out and further processed by colloidal gas aphrons (CGAs), surfactant stabilized microbubbles (10-100 mm) to obtain a richer polyphenol fraction. CGAs are often made using synthetic surfactants like Tween 20; however, in this work whey protein will be used as a surfactant. Once the CGAs are obtained they will be subjected to spray drying process under temperature and flow controlled conditions to obtain microparticles. The yield of extraction, antioxidant capacity and phenolic compounds profile will be determined. The microparticles obtained after spray drying will be characterized by DLS for size and zeta potential. Finally, the integration of the recovery and formulation steps will be evaluated.

References

1. Naseri et al. 2018

2. Jauregi and Dermiki, 2013

Acknowledgements

This research was supported by the European project (H202-MSCA-RISE 778388) Food for Diabetes And Cognition (FODIAC).

PO117 - 25741 - EFFECT OF DIETARY FIBER AND PROCESSING THERMAL CONDITION ON RICE BRAN WAX BASED STRUCTURED EDIBLE OILS

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Keywords: Food Rheology, Bio-material Engineering, Alternative Oil Structuring

Abstract

Oleogelation is an innovative technique that enables the entrapment of liquid oils to obtain a thermo-reversible gel-like structure. Unlike chemical methods, the physical three-dimensional network can preserve the chemical characteristics and nutritional value of the high-unsaturated edible oil.
In this study, extra virgin olive oil (EVO) and sunflower oil (SFO) were structured with rice bran wax (RBW) at 10% wt/wt to develop oleogel. Bamboo fiber (BF) at 0.5% was added as structuring agent. The effect of fiber dimension (0, 40, 90 and 150 µm) and cooling temperature (0, 4 and 25 °C) on gel properties were evaluated.
Rheological, texture and differential scanning calorimetry tests were carried out to assess thermal and structural parameters of gels. Thermo-reversible capability was assessed evaluating the change of rheological parameters (stationary viscosity and storage and loss moduli) over temperature. Moreover, acidity and peroxide values were determined to evaluate the oxidative stress levels on lipid matrices.
For all samples, rheological properties and texture firmness were significantly affected by wax/oil compatibility and cooling condition. The storage modulus (G') value was higher than the loss modulus (G'') in all oleogels to confirms their solid-like characteristics. However, oil structured at 25 °C exhibit a stronger and more stable gel structure and higher hardness to penetration.
The effect of dietary fiber is more evident in sample cooled at 4 °C. Gels with the addition of finer fiber dimension (BF40) show rheological parameters similar to ones prepared at 25 °C. Wax/gel compatibility affects the thermo-reversibility of structured oils: SFO gels are less influenced by cooling condition and recover their solid-like form when thermo-mechanic stresses are simultaneously applied. On contrary, EVO samples prepared at 25 °C are more rigid. However, those possess lower reversibility than ones cooled at 0 and 4 °C. In addition, the effect of fiber improves the recovery of gel structure of those latter structures.

Acknowledgements

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PO119 - 25823 - INNOVATIVE MILK AND WHEY PROTEIN HYDROLYSATES

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Keywords: Protein hydrolysates, Milk proteins

Abstract

The generation of bioactive compounds from milk proteins is a possible way to obtain bioactive peptide ingredients having a health promoting activity in cardiovascular disease, inflammation and cancer. These peptide sequences are inactive in the native protein but can be released during digestion in the gut through the action of some microorganisms and can also be produced during *in vitro* enzymatic hydrolysis. Commercial products with milk bioactive peptides have begun to appear on the market. This is related to the industrial-scale production of bioactive compounds during food protein hydrolysis.

In this study three different milk protein substrates were used to generate enzymatic hydrolysates: milk protein concentrate, whey protein concentrate and sodium caseinate. These substrates were hydrolysed with two different enzyme preparations at 50 °C for 1 and 4 h at constant pH 7. The molecular mass distribution (determined by GPC), the particle size (determined by laser light scattering analysis), degree of hydrolysis, turbidity and viscosity profiles of the hydrolysates were evaluated.

The results show that both the used enzymes reached a hydrolysis degree up to 7% in all three substrates already after one h. The viscosity, as well as the particle size, decreased in all samples: after 1 h incubation, all hydrolysates have more than 25% of the particles with a molecular mass below 1 kDa.

Additional studies were carried out to evaluate the effect of freeze- and spray-drying on the viscosity and antioxidant properties of the hydrolysates. The final aim was to study their incorporation as functional ingredients in highly consumed products, such as biscuits.

Acknowledgements

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PO126 - 25912 - ANTIMICROBIAL PROPERTIES OF LACTOFERRIN -GELLAN GUM NANOPARTICLES

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Keywords: Biopolymers, Natural preservatives, Nanostructure

Abstract

Lactoferrin is a protein with antimicrobial activity that is capable to induce the rupture of some microorganisms membranes. The objective of this work was to enhance the antimicrobial action of lactoferrin trough it aggregation in nanoscale. The nanoparticles were formed by lactoferrin electrostatic complexation to gellan gum. Stock solutions 0.1% (w/v) of lactoferrin (L) and gellan (G) were mixed in different proportions of lactoferrin: gellan (L:G) 2L: 8G, 5L: 5G, 8L:2G, 1G:9L , 10G:0L and 0G:10L in a rotor stator at 10,000 rpm for 3 min at 25 °C, pH 4. The nanoparticles were evaluated for size and surface charge by DLS (Dynamic light scattering) and for antimicrobial activity (minimum inhibitory concentration assays - MIC) against *Staphylococcus aureus* in two different broths: TSB (Tryptic Soy Broth) and GYP (1% glucose, 0.025% yeast extract and 1% peptone).The nanoparticles of the 1G:9L ratio presented highest positive charge density (+21.20 $\pm$ 1.25 mV) and lowest hydrodynamic diameter (92.03 $\pm$ 13.61 nm). The minimum inhibitory concentration observed was 0.002 g/ml for pure lactoferrin and 0.000375 g/ml for the 1G:9L nanoparticle in GYP broth. In the TSB broth, the nanoparticles did not show antimicrobial activity due to the presence of large amounts of divalent cations such as Fe^{2+} (9.45 + 0.77 mg/kg), Mn^{2+} (1.10 + 0.02 mg/kg), Zn^{2+} (33.61 + 1.16 mg/kg) and Cu^{2+} (1.08 + 0.02 mg/kg). These salts probably compete for the anionic sites of the microbial membrane, impairing the ability of the lactoferrin to permeate the bacterial cell wall. In the GYP broth the capacity of nanoparticles to inhibit bacterial growth was higher than pure lactoferrin, proving that lactoferrin has its antimicrobial activity potentiated when aggregated at nanoscale.

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FAPESP and CNPQ

SESSION 2: SAFETY AND EFFICACY OF DELIVERY SYSTEMS


8th International Symposium on
"Delivery of Functionality in Complex Food Systems"
7 - 10 July, 2019 | Sheraton Porto Hotel Conference Centre

KEYNOTES

24952 - β-LACTOGLOBULIN DELIVERY SYSTEM ENHANCING THE BIOACCESSIBILITY, BIOAVAILABILITY AND BIOLOGICAL EFFICACY OF EGCG

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Keywords: EGCG, β-Lactoglobulin, Nutraceutical Delivery, Bioavailability, Health

Abstract

(-)-Epigallocatechin-3-gallate (EGCG), the major green tea polyphenol, is a highly potent antioxidant, attributed with numerous health benefits, e.g. combating cardiovascular diseases, obesity, diabetes and cancer. However, EGCG is bitter and astringent, highly susceptible to oxidation, and has low bioavailability. To maximize therapeutic utility of EGCG, a novel technology of β-lactoglobulin (β-Lg)-based delivery system had been previously developed by our group. These EGCG-β-Lg complexes protected EGCG during shelf life, and masked its bitterness and astringency.

Our objectives were to explore the effect of β-Lg complexation on EGCG stability, antioxidative activity during digestion, bioaccessibility, *in vivo* bioavailability, and on the efficacy of EGCG in preventing weight gain and improving glucose homeostasis in a high-fat-diet (HFD)-induced obesity mice-model.

EGCG antioxidant activity was evaluated by FRAP and ORAC assays. Bioaccessibility was studied by simulated digestion. *In vivo* bioavailability was evaluated in a rat model. Metabolic effects were evaluated in mice fed either HFD or normal diet (ND), which concomitantly consumed either milk (1% fat) fortified with EGCG-β-Lg complexes, or free EGCG, or water with EGCG or water only, for 12 weeks.

β-Lg–complexed EGCG showed significantly greater stability and antioxidant activity, in both FRAP and ORAC assays, during simulated digestion, than free EGCG. The digested EGCG-β-Lg system exhibited significantly higher EGCG bioaccessibility compared to EGCG alone. Compared to free EGCG, administration of β-Lg-complexed EGCG to rats doubled the bioavailability! HFD mice that received EGCG-β-Lg complexes in milk, had significantly lower liver-triglycerides compared to the control (*HFD-water*) group. Moreover, EGCG-β-Lg complexes in milk significantly reduced the glycemic response, in both diets compared to free EGCG in milk. A tendency toward improved insulin sensitivity was observed in mice fed with β-Lg-complexed EGCG compared to free EGCG in milk.

Thus, β-Lg delivery system has the potential to improve the efficacy of polyphenols like EGCG in preventing metabolic-syndrome effects.

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23661 - FOOD SYNERGY TO DELIVER ENHANCED FUNCTIONALITY: IMPLEMENTING DELIVERY SYSTEMS IN FOOD PRODUCTS

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Keywords: Food synergy, Bioactive peptides, Food chemistry

Abstract

Nutrition and functionality are commonly studied experimentally using food components in isolation or using simplified systems of a few components. This is called the “reductionist” approach because it simplifies the experiment by reducing complexity. In the real world, foods are generally prepared and consumed not as a single component, but as meals with a mixture of components and often several courses. Food synergy is the term used to describe how different components of food can interact as regulators, agonists or antagonists for the beneficial (or detrimental) effects of other food components. Food synergy takes into account the interactions between the food components within a food or food ingredient, in a single meal and even between meals that are close together. Food interactions can take place during meal preparation, in the mouth during chewing, in the stomach, in the small intestine and even in the colon. We will present a range of food interactions that can occur in the gastrointestinal tract and describe how foods can interact with different effects on functionality and its delivery. Examples will be presented with an emphasis on the effects of plant-origin proteolytic enzymes on functional foods.

25381 - STRUCTURES AND INTERACTIONS OF FOOD MATERIALS DURING GASTRIC DIGESTION: IMPLICATIONS FOR NUTRIENT DELIVERY AND ABSORPTION

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Abstract

With the growing crisis in diet-related diseases (e.g. type 2 diabetes, cardiovascular diseases, obesity), there is increasing recognition within research community the need for more detailed understanding of the behaviour of foods as they are processed within the human digestive system. The nutrients in individual foods are contained within complex structures/matrices, created through self-assembly and interactions of macromolecules. During the last decade, there is growing body of evidence to show that these food structures play a key role on the kinetics of transit, digestion and absorption of nutrients.

Gastric digestion is a crucial step; here the food material properties and structures are extensively modified, due to mixing with the digestive juices (containing various minerals, and enzymes) at a highly acidic pH. There is also mechanical agitation due to peristalsis in the stomach. These food breakdown processes and the resulting modified food structures play a key role in gastric emptying and consequently the delivery of nutrients in the duodenum. For instance, liquid milk can self-structure to form a curd inside the stomach, through the action of pepsin and acid on the casein micelles, thus influencing the stomach emptying rates of both protein and lipids. Emulsions systems that become unstable or remain stable or form gels in the stomach can be designed to exert specific biophysical behaviour in the stomach, modulating postprandial physiological responses. However, the fundamental mechanisms involved in gastric emptying, breakdown and mixing kinetics of different food materials in the stomach need to be better understood. As the food industry moves toward designing innovative foods with unique health benefits, the knowledge about digestive behaviour of food materials need to be embedded in new product development.

This presentation will provide an overview of the specific colloidal structures in selected dairy and plant foods and highlight recent studies on modification of these structures during digestion, focussing on gastric processing. Particular emphasis will be placed on exploring the structural changes in milk, almond and soya-based food systems during in-vitro and in-vivo digestion, and the consequent effects on rates of protein and lipid digestion.

ORAL COMMUNICATIONS

OC18 - 24986 - ROLE OF BACTERIAL CELLULOSE FIBRILS ON THE RETROGRADATION OF STARCHES WITH DIFFERENT AMYLOSE CONTENT

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Keywords: Starch, Bacterial cellulose, Retrogradation, Viscoelasticity

Abstract

Bacterial cellulose fibrils (BCF) have been described as biomaterial with wide applications in polymer science. However its use in food science and nutrition is not still well-explored. Based on hypothesis that BCF modify the crystalline configuration of starch during processing and storage, the goal of this work was to perform a preliminary analysis about the effect of BCF on the retrogradation of starches with different amylose concentration.

BCF were provided by Vuelo-Pharma (Brazil), which was blended with commercial wheat starch (~25% amylose) and waxy-maize starch (< 0.5% amylose). Starch-BCF based gels were obtained after complete gelatinisation of starch (90 °C, 30min) and then stored at 4 °C, 24 h. BCF was added at concentrations between 0.5-10% w/w. Gel strength was measured using a texture analyser measuring three times with five replications. Viscoelasticity of blends starch-BCF was evaluated by rheology in both temperature and frequency sweep considering at least five replications per condition.

Our results showed that addition of BCF conducted a significant decrease in gel strength in wheat starch but only slighltly increase in gel strength in waxy-maize at higher BCF levels, suggesting changes on the retrogradation of starch are amylose-dependent. These results are consistent with the viscoelastic behavior: BCF reduced significantly the G' in wheat starch, but only slighltly increased G' in waxy-starch. Interestingly, the contribution of BCF on the gel viscosity (G'') was higher in both starches which was well depicted by tan-d parameter, with starch-BCF gels showing values >1, suggesting a less crystalline system.

Therefore, addition of BCF does not promote higher association of starch polymer, which could be explained by an effect of phase separation previously reported on these starchy systems. Thus, BCF would not modify the crystalline configuration of starch but opening interesting perspective for using starch-BCF composites for designing novel foods oriented to customer with specifical requirements (e.g. dysphagia).

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OC19 - 24932 - ENZYMATIC PRE-TREATMENTS OF FRUIT BY-PRODUCTS TO MODIFY FIBRE COMPOSITION AND PHENOLICS RELEASE

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Keywords: Fruit pomace, Enzymes, Fibre, Phenolic compounds

Abstract

Grapes and other fruit crops generate huge amounts of solid residues (pomace) which are still rich in bioactive compounds including fibre and phenolic compounds with potential healthy properties. However, the fibres present in these by-products are mainly insoluble which is not the best composition from either a nutritional, or a technological point of view. Furthermore, some of the phenolic compounds are present in a form bound to the cell walls being, in this way, not much bioavailable. Tailored enzymatic hydrolytic processes to carry out on these by-products before drying, could help in modifying fibre composition and improving both nutritional and technological functionalities of "flours" obtained from these biomasses. The aim of this research is to develop a low-cost environmentally friendly process to improve the recovery of phenolic compounds and the rheological and nutritional properties of the hydrolysed fibre residue; producing innovative high-fibre low-sugar ingredients for incorporation into functional foods and diets.

Three different fruit pomaces were used: grape pomace (from wine-making process), apple and black-currant pomace (from fruit juice processing). Different commercial enzymatic preparations containing different carbohydrates hydrolytic activities were tested to treat the fresh pomaces before drying without any additional water addition, together with different time/temperature drying combinations. The effect of the enzymatic treatment on fibre composition (total, soluble and insoluble fractions) and total phenols extractability (with a conventional hydro-alcoholic extraction) was evaluated. The results, as expected, were different depending on both the type of pomace and used enzyme. For example, the use of a cellulase preparation on fresh apple pomace could increase up to 80% the total phenols release from the dried pomace, while the same treatment applied on black-currant pomace did not lead to any increased phenolics extraction. Enzymes already used in the wine-making process revealed to be the most efficient for the grape pomace pre-treatment.

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OC20 - 24878 - NOVEL SUSTAINABLE FUNCTIONAL INGREDIENTS FROM THE QUORN FERMENTATION CO-PRODUCT

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Keywords: Quorn, Co-product, Centrate, Rheology, Foam, Emulsion

Abstract

This study assessed the functional profile, composition and potential applications of a naturally foaming co-product (centrate) from the Quorn fermentation process.
A high molecular weight (HMW) fraction obtained via ultrafiltration of the centrate displayed good foaming stability, emulsifying properties and rheological properties (viscosity, gelation). Large mycelium aggregates reported in HMW possibly contributed to high viscosity and viscoelasticity and to foam and emulsion stabilisation. In parallel tensiometry measurements showed that interfacially-active molecules present in HMW formed a rigid film at the oil/water interface. A number of functional metabolites and proteins were identified in the centrate and could have also contributed to the properties reported, including a cerato-platanin protein, cell membrane and wall constituents and guanine-based nucleosides and nucleotides.
This study then assessed the potential of HMW as egg white replacer and the modulation of its functionality by sonication for fat reduction purpose. Results indicated that HMW could allow for 25% EW replacement as foaming agent and 25% to 50% EW replacement as gelifier. The large mycelium structures characteristic of HMW were reported in EW-HMW mixtures and possibly contributed to their functionality. Sonication of a HMW solution led to the breakdown of these structures into smaller fragments and to smaller emulsion oil droplets. Confocal micrographs suggested the possible contribution of these small fragments to oil droplet stabilisation. 50% oil-reduced HMW emulsions were prepared by mixing HMW emulsions with sonicated HMW solutions and displayed even smaller oil droplets.
This study highlighted the potential of extracts from the Quorn process as novel sustainable functional ingredients for the food industry with possible applications in egg white and emulsion oil reduction. This work also highlighted the complex and specific nature of the centrate's functionality, with possible contributions from a broad range of components, and the potential to modulate the structure and functionality of HMW by sonication.

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OC21 - 24918 - REDUCING THE GLYCAEMIC INDEX OF COOKIES BY USING APPLE POMACE AS A FUNCTIONAL INGREDIENT

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Keywords: Formulation, Short dough biscuits, By-product, Apple pomace, Type 2 diabetes

Abstract

The 30% of apples produced worldwide is annually transformed into juice. This process generates 10 million tons apple pomace, consisting of flesh, peels, seeds and stalks. This discard is generally disposed of or used to produce energy. However, apple pomace contains an impressive amount of high value-added compounds that can be recovered. To this purpose, several strategies have been proposed, including fermentation, biochemical processing or chemical extraction. Even if these approaches allow obtaining new products having a considerable market, they are costly and require an efficient management framework. To reduce these drawbacks, a promising approach is to reuse apple pomace, upon only negligible changes, to obtain high value-added food products. Since apple pomace contains considerable amounts of dietary fibre and phenolic compounds, the aim of the present research was to enrich cookies with this discard and to evaluate the effect on the glycaemic index of the product. Apple pomace was dehydrated and milled, to obtain a flour. The latter was characterized for soluble and insoluble dietary fibre, as well as for the phenolic content. The flour was used to partially substitute wheat flour (10 and 20%) to produce cookies, which were characterized for their sensory and nutritional properties. Cookies were submitted to *in vitro* digestion to monitor the release of glucose and predict the glycaemic index. Results indicated that the flour obtained from apple pomace contained nearly 40% of dietary fibre, mainly represented by insoluble fibre (more than 25%). Apple pomace flour led to a significant reduction in the expected glycaemic index of reformulated cookies. The conventional cookie presented a glycaemic index of 70 and was classified as high glycaemic index food. Substituting flour by 10 and 20% reduced cookie glycaemic index to 65 and 60 respectively, thus ranking the product within the intermediate glycaemic index foods.

OC22 - 25085 - ROLE OF CRYSTALLINE AND AMORPHOUS INGREDIENTS IN THE MOISTURE ABSORPTION OF CEREALS PRODUCTS

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Abstract

Food products are sensitive to moisture, especially cereals products that deliver crispy texture to consumers. Moisture uptake can induce defect in product quality, such as caking or loss of texture, and thus reduces product acceptance. Understanding the behaviour of food product towards moisture not only enables delivering good shelf-life properties, but also optimizing process such as drying during production. The sorption and desorption properties of a product can thus be studied through kinetics of moisture uptake and drying, and through sorption isotherms at equilibrium. The impact of sucrose reduction in cereal recipes and the addition of larger molecular weight polysaccharides are not well known on these properties.

This study focuses on cereals products, texturized by extrusion-cooking, where three ingredients (sucrose, maltodextrin and resistant dextrin) have been added at four levels (5, 10, 15 and 20% w/w). The expansion of the extrudates was characterized by their expansion index and internal structure, e.g. mean walls thickness. Characteristic time of diffusion (T0) was determined during sorption from 15 to 70% relative humidity.

From 5 to 20%, sucrose increase led to a decrease in extrudate's radial expansion, maltodextrin increase led to an increase in extrudate's radial expansion and porosity with thinner walls. Resistant dextrin increase led to a loss in radial expansion with decreased porosity and thicker walls. For the three ingredients added, a link between extrudate's walls thickness and T0 was observed. The thicker the walls, the greater T0. Each ingredient has an impact on the expansion, which may depend on: (i) their state (amorphous/crystalline), (ii) their impact on starch depolymerisation during extrusion, and (iii) their interaction with the flour components during extrusion. All these phenomena impact the cereals structure at different length-scales (walls structure and crystallinity, porous structure), and in turn, the moisture uptake when exposed to higher relative humidity.

OC24 - 24733 - CURCUMIN LOADED ORANGE OIL NANOEMULSIONS INCORPORATED INTO BANANA STARCH EDIBLE FILMS. SYNTHESIS, MECHANICAL CHARACTERIZATION, BARRIER PROPERTIES AND RELEASE KINETICS

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Keywords: Nanoemulsion, Banana starch, Edible film, Curcumin

Abstract

One of the most important trends in the last decades of food science is the development of biodegradable and edible coatings that can be use in the food protection while reducing the environmental impact of common plastic packaging. Besides, their edible nature, edible films can also be use as carriers of bioactive molecules, such as antimicrobials, antifungals and antioxidants that can have an active role in food preservation. Curcurmin, a polyphenol extracted from turmeric, has been recognized for its antioxidant, anti inflammatory and antioxidant activities, however, its application in the food industry has been limited due to its low water solubility. Nanoencapsulation has emerged as an effective way to improve curcumin´s water solubility and its inclusion into polymeric films. In this project, we present the development of curcumin loaded orange oil nanoemulsions incorporated into banana starch edible films, studying their mechanical properties (tensile strength and elongation at break), barrier properties (water vapor permeability), optical properties (transparency) and curcumin release into food simulant media and both gastric and intestinal simulations. We observed that nanoemulsion incorporation creates a plastizacing effect into the polymeric matrix, increasing elongation at break values, while reducing tensile strength, on the other hand, barrier properties where increasing as the hydrophobic nature of both curcumin and orange oil reduces water interaction whit the polymeric matrix, thus reducing water vapor permeability. Finally, banana starch film showed a controlled release in aqueous food simulants, while a burst release was observed in highly hydrophobic simulants, due to the hydrophobic nature of curcumin and orange oil.

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OC25 - 24951 - DESIGN OF MICROPARTICLES AS DELIVERY SYSTEMS FOR WALNUT OIL RICH IN OMEGA-3: IMPACT OF THE LOCATION OF OXYGEN SCAVENGERS ON THE LIPID OXIDATION

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Keywords: Microencapsulation, Oxygen scavenger, Walnut oil

Abstract

Among vegetable oils, those obtained from plant sources rich in omega-3, specifically a-linolenic acid (ALA, 18:3-w3) are gaining interest because of their health benefits in vascular protection neuro-protective and anti-inflammatory functions, among others. However, ALA-rich oils as walnut oil (WO) is highly susceptibility to oxidative deterioration when they are exposed to environment, food and gastrointestinal conditions; in this context microencapsulation allows to overcome these drawbacks. The incorporation of an oxygen scavenger at specific locations in the encapsulated WO could preserve the oil stability and the functionality. The aim of this work was to study the effect of the location of oxygen scavenger on the lipid oxidation of spray-dried WO-microparticles designed as intestinal delivery system. WOS (Walnut oil stripped by adsorption chromatography) emulsion and WOS-emulsion encapsulation were performed applying a Box-Behnken and Central composite with axial-point experimental design, respectively. Microparticles with Capsul (C), sodium alginate (SA) as layer, and ascorbic acid (AA) as oxygen scavenger (WOS-C/SA-AA) were performed by three-fluid nozzle spray drying. Ascorbic acid was incorporated in the emulsion at specific locations (layer (L), aqueous phase of the emulsion (E) and both locations together (L+E)). Four systems WOS-C/SA-AA(L), WOS-C/SA-AA(E), WOS-C/SA-AA(L+E) and WOS-C/AS (control) were studied. WOS-Emulsion optimal conditions were lecithin content (0.38 g), homogenization time (3 min) and homogenization rate (20,000 rpm). WOS-emulsion encapsulation optimal conditions were inlet air temperature (114 °C) and WOS/Capsul ratio (1:5.2). The formation of SA-layer was confirmed by confocal laser scanning microscopy. WOS-C/SA-AA microparticles with AA in

either L or E, showed the highest induction time (>5 h) respect to WOS-C/SA-AA(L+E) (1.6 h) and control (0.99 h). WOS-C/SA-AA microparticles were characterized physico-chemically and morphologically by scanning electron microscopy (SEM), Induction time by Rancimat, particle sizes and their distribution by laser light diffraction (LLD). Additionally, WOS-C/SA-AA microparticles were evaluated in simulated gastrointestinal digestion to determine the bioaccessibility.

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OC26 - 24895 - OIL STRUCTURING AS A WAY TO CONTROL GEL FUNCTIONALITY AND DIGESTIBILITY

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Abstract

Fats are an important ingredient in many food products, contributing to food sensory and textural properties, providing energy and needed for metabolic pathways. High intake of saturated and trans unsaturated fats was found to be related to negative health effects leading to search for healthier fat replacements. The multi-functionality of fat in food products raises a great challenge for the development of fat replacement or reduction. Oil structuring has been proposed as a promising strategy for fat replacement due to their solid texture and high unsaturation content.

The current research aims to explore the relation between gelation mechanism, oleogel texture and oleogel digestibility. Three different oil structuring agents were examined with canola oil; ethyl cellulose (EC), E471, and β-sitosterol/γ-oryzanol mixture. Mechanical analysis exhibited gel hardness in the order of E471<EC<β-sitosterol/γ-oryzanol mixture. While simulated pH-stat lipolysis on the same samples demonstrated a significantly different lipolysis scheme for the different gels with total lipolysis percentage in the order of EC< β-sitosterol/γ-oryzanol mixture<E471 suggesting an indirect relation between mechanical properties and oleogel digestibility. The ability to control the oleogel texture and lipolysis was also examined using combination of E471 and EC. Harder gels were obtained in the E471: EC samples in comparison to simple addition of each component contribution suggesting a synergistic interaction between these two components. While combination of E471 and EC allude to new lipolysis profile with intermediate FFA release, up to 50%, in comparison to each structuring agent lipolysis. Moreover, combination of these two components improved the oleogel thixotropic behavior. Overall, this study demonstrated the ability to design new functional food materials with desired textural attributes and controllable lipid digestion based on the oleogelation mechanism used.

OC27 - 24938 - CLUSTERING OIL DROPLETS IN EMULSIONS AND GELS: IS IT A USEFUL STRATEGY TO INFLUENCE PERCEPTION?

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Keywords: Emulsions, Sensory, Tribology, Perception

Abstract

The microstructure of oil-containing foods has a large influence on the physical properties of emulsions and gels, but also on sensory perception. Changing the structure can therefore be used as a strategy to alter perception. In this study, we investigated how changes in the structure on a small lengthscale influence rheological and tribological properties, and how this influenced sensory perception.

The structure was varied by clustering the oil droplets in both emulsions and emulsion-filled gels. Oil droplet clusters were obtained by electrostatic attraction (hetero-aggregation) or protein-polyphenol interactions. For hetero-aggregation, emulsions with oppositely charged droplets were mixed in different ratios to obtain oil droplet clusters varying in size (1–50 µm). For clustering with polyphenols, whey protein-stabilised emulsions were treated with polyphenols at different concentrations to vary cluster size (up to 150 µm). The strength of the interactions lead to variation in the cluster morphology and cluster strength.

Large and open clusters increased the effective volume fraction of oil droplets by up to 5x compared to single droplets, and therewith the viscosity of the emulsion increased by a factor 100x. The friction coefficients of these clustered emulsions were lower than for the single droplet emulsions, demonstrating that clustered emulsions act as better lubricants than single droplet emulsions. This was highlighted by the fact that clustered emulsions were also perceived as creamy and thick, and therefore clustering positively contributes to mouthfeel. Also in gels, the clustering had a large effect on the gel modulus, and showed changes in the sensory perception with respect to multiple sensory attributes. With respect to friction measurements, we found that saliva provides large changes in structure during oral processing, which correlate well with perception of several attributes.

We conclude that the clustering of oil droplets improves fat-related sensory perception by improving lubrication properties and changing flow properties.

OC28 - 24690 - A GRITTY STORY: EXPLAINING VARIABILITY IN DETECTION THRESHOLDS OF MICROSCOPIC PARTICLES BY FOOD PROPERTIES AND CONSUMER CHARACTERISTICS

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Keywords: Grittiness, Texture sensitivity, Saliva, PROP status, Consumer familiarity, Fungiform papillae density

Abstract

This study aimed to unveil how consumer's product familiarity and physiological parameters affect detectability of microscopic heterogeneities in foods varying in consistency. Cellulose particles differing in size (50-780 µm) were added (1.5% w/w) to a spoonable (quark) and chewable matrix (processed cheese). Discrimination thresholds for perceived grittiness were determined by a group of Dutch (n=47) and Chinese (n=45) women using the method of Constant Stimulus. Participants were characterized for familiarity with products, stimulated saliva flow, PROP status and fungiform papillae density. These psychological and physiological parameters were related to individual particle size detection thresholds (BET) causing grittiness sensations. Particle size detection thresholds did not differ between Dutch and Chinese women, but differed significantly between the two matrices. Considering all consumers, particle size detection threshold for grittiness for quark was 51.5 µm and for processed cheese 85.8 µm. This shows that grittiness detection depends on matrix consistency, but not on consumer ethnicity. Consumer's product familiarity was significantly negatively correlated with particle size detection threshold only for quark ($r = -0.20$, $p = 0.047$). A positive significant correlation between stimulated saliva flow and particle size detection threshold was found only for processed cheese ($r = 0.21$, $p = 0.041$), suggesting that salivation induced by mastication of a chewable matrix might enhance sensitivity to perceive grittiness. Consumers PROP status and fungiform papillae density did not correlate with particle size

detection threshold for grittiness for both matrices. We conclude that matrix consistency contributes strongly to particle size detection thresholds of consumers causing gritty sensations. Product familiarity and stimulated saliva flow seem to contribute weakly to individual differences in particle size detection thresholds between consumers, whereas ethnicity, PROP status, and papillae density did not seem to contribute to individual differences in particle size detection threshold.

OC29 - 24924- THE EFFECTS OF CONSUMING WHOLE APPLES WITH A DAIRY-BASED HIGH FAT MEAL ON LIPID MICROSTRUCTURE, DIGESTIBILITY AND BIOACCESSIBILITY *IN VITRO* AND POSTPRANDIAL LIPEMIA *IN VIVO*

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Keywords: Whole apples, Postprandial lipemia, Lipid microstructure, *In vitro* digestion, Lipid bioaccessibility, *In vitro-in vivo* correlation

Abstract

Pectin and polyphenols can modulate lipid digestion and absorption *in vitro*. Therefore, apples containing both bioactives may reduce postprandial lipemia, a risk factor for atherosclerosis-related diseases. A randomized crossover trial with 26 healthy overweight and obese adults was undertaken to investigate the impacts of consuming 200 g whole apples (2.2 g pectin) with 500 mL dairy-based high fat emulsion (3 wt% protein; 14 – 31 wt% fat, depending on body weight) on postprandial lipemic response. To study the mechanisms by which the presence of apples affects lipid microstructure, digestibility and bioaccessibility, similar emulsions (3 wt% protein; 10, 15 and 20 wt% fat) were digested with and without apples using static (i.e. adapted from INFOGEST standardized protocol) and dynamic (TIM-1) *in vitro* methods. For static digestion, two gastric pH levels, i.e. 3.0 as per the INFOGEST protocol and 6.5 to reflect anticipated buffering capacity of dairy products, were applied. Correlations between the *in vitro* and *in vivo* data were made to explore the suitability of these *in vitro* tools for lipid research. In humans, apples did not change postprandial lipemia or gastric emptying, but fructose-induced hyperinsulinemia which can promote the secretion of triacylglycerol-rich lipoproteins may have counteracted any lipid-lowering effects of apple components. With *in vitro* digestion, the 10 wt% fat emulsion was influenced by gastric pH, but not apples. It was the opposite for the 15 wt% fat emulsion, potentially due to the lower protein-to-fat ratio. Similarly, the 20 wt% fat emulsion was destabilized by apples, but it did not lead to lower TIM-1 lipid bioaccessibility, agreeing with the no effect of apples seen in the human study, although limited bioaccessibility was observed. Overall, this work highlights the complexity of food matrix effects on lipid metabolism and the need to improve the physiological relevance of *in vitro* investigations.

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OC30 - 25014 - IN-VITRO BIOACCESSIBILITY OF BETA-CAROTENE IN LIPIDIC SYSTEMS

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Keywords: Lipophilic, Bioactive, Digestion, Bioaccessibility, Beta-carotene

Abstract

β-carotene's bioactivity is usually compromised by low and highly variable bioaccessibility. This can be dependent of the matrix structure that will be responsible for its delivery. Different systems have been developed and proposed as carriers of lipophilic bioactive compounds but their performance and behavior under gastrointestinal conditions has been scarcely studied. In the present study four different optimized lipidic systems were loaded with the same amount of β-carotene and its *in-vitro* bioaccessibility was studied using static model simulation. Two bio-based nanoemulsions, produced using high-energy homogenization followed by ultrasound-assisted emulsification, one was stabilized with 15 % (w/w) of tween-20 in a 15:85 (O/W) ratio and the other with 3 % (w/w) of whey protein isolate (WPI) dissolved in water in a 5:95 (O/W) ratio. One oleogel (OG) and one hibrid gel were also produced. The first was produced using 6% w/w beeswax as gelator for the sunflower oil and the second was developed under mechanical mixing, combining the OG and a hydrogel (2% w/w aqueous solution of sodium alginate) in a 20:80 ratio.
In-vitro digestion of lipidic systems was performed following the INFOGEST standard protocol. Visual inspection, confocal microscopy and free fatty acids quantification of the digested samples were performed. The amount of β-carotene in the micellar phase, after digestion, was quantified by HPLC, after solvent extraction. The bioaccessibility varied from high in the WPI nanoemulsion > tween nanoemulsion > hybrid gel > oleogel. The degree of lipolysis was higher for oleogel and hybrid gel and lower for the nanoemulsions, irrespective of the surfactant used. Digested samples were visualized under confocal microscopy showing β-carotene (auto-fluorescent) incorporated into mixed micelles (nilered stain). The type of lipidic system proved to be determinant regarding β-carotene bioaccessibility.

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OC31 – 24988 - EXTRACTION OF CAROTENOIDS SUPPORTED BY OHMIC HEATING AND CHARACTERIZATION OF BIOLOGICAL PROPERTIES AND STABILITY THROUGHOUT GASTROINTESTINAL TRACT

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Keywords: Ohmic heating, carotenoids, gastrointestinal tract, carotenoids-derived aroma compounds, prebiotic, tomato by-products, anti-inflammatory

Abstract

Carotenoids are lipophilic isoprenoid compounds with a polyene backbone that contains a variable number of conjugated double bounds, being precursors of aroma compounds. They are important in human nutrition since they are a source of vitamin A (β-carotene). Several studies have linked the regular consumption of carotenoids to prevent human diseases, such as cardiovascular, cholesterol, neurodegenerative diseases, antioxidant and anti-cancer. Very little is known about release of entrapped carotenoids from complex matrixes and their impact on the gut microbiota. Extractable carotenoids were obtained from tomato by-products through green efficient process using ohmic heating (OH). The extracts were submitted to simulated gastrointestinal tract and digested samples were subjected to fermentation using faecal matter from 5 different controlled donners (male and female alike). The total carotenoids were assessed by spectrophotometric method. Individual carotenoids and carotenoids-derived aroma compounds during each step of digestive tract and from the microbiota assay were also analysed by LC-MS and LC-HR-QTOF-MS, respectively. The short-chain fatty acids (SCFA) and lactic acid and sugars from microbiota assay were analysed by HPLC. The human faecal microbiota was assessed by real-time quantitative PCR. Prebiotic, anti-hypertensive activity, anti-inflammatory activities were also evaluated. In the OH extract, the major carotenoids identified were lycopene and b-carotene (corresponding to 92% of total carotenoids). After digestion process and fermentation only carotenoids-derived aroma compounds and other metabolites resulting the carotenoids were found, including camphenol, linalool acetate, (+)- sabinol, acetovanillone and hexadecanedioic acid. The results suggest that

fermentation of OH tomato by-product extract demonstrated a prebiotic effect through the increasing of the number of *Bifidobacterium animalis* and improving the production of SCFA, approving a potential modelatory effect upon the gut microbiota and consequently providing a prevention of numerous diseases. Complementary, the OH extract also proved anti-inflammatory activity and moderate anti-hypertensive activity.

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OC32 - 24971 - EFFECTS OF CHEWING ON THE GLYCAEMIC POTENCY OF KIBBLED GRAIN BREADS

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Keywords: Blood glucose response, Glycaemic index, Glycaemic potency, Kibbled grain breads

Abstract

The *in-vitro* glycaemic response of New Zealand breads is reduced by incorporating a high concentrations of kibbled grains into the bread matrix. Three breads were formulated (1) 100% white bread matrix (WB - reference), (2) 75% of hydrated kibbled purple wheat in 25% white bread matrix (PB) and (3) a 1:1 mixture of 37.5% kibbled soy beans and 37.5% of kibble purple wheat in 25% white bread matrix (SPB). The breads contained between 24% and 42% (wet wt basis) of potentially available carbohydrate and for each subject, bread containing 40g of potentially available carbohydrate was consumed at each meal.

The three breads were each consumed by 12 participants in three different forms — chewed, unchewed or homogenised. The postprandial blood glucose responses were measured over 120 min following ingestion. Based on a GI of 70 for the chewed WB (reference) the GI values (*in-vivo*) for the chewed, unchewed and homogenised breads were WB: 70.0 (reference), 70, 70, PB: 75, 42, 61, SPB: 57, 48, 55 (%) (Least significant difference = 17.43, $p < 0.05$, bold numbers do not differ significantly from WB). The glycaemic response for WB was the same regardless of the way in which it was ingested. Ingesting PB and SPB unchewed significantly reduced its glycaemic potency compared with WB and the homogenised and chewed form of breads showing that the moderating effect of grain structure was lost when the bread was chewed. However, when the glycaemic potency of the breads was expressed on an equal weight of bread consumed, the kibbled grain breads had a significantly lower GI than WB. It is clear that particle size alone is ineffective in reducing the glycaemic potency of breads. However, the properties of the bread matrix could be focussed to lower the glycaemic potency of breads.

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OC33 - 24990 - TIMING OF FRUIT INGESTION AND BLOOD GLUCOSE RESPONSE

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Keywords: Blood glucose, Temporal separation, Fruit

Abstract

Partial equal carbohydrate substitution of kiwifruit sugars for starch in foods co-ingested with whole kiwifruit (KF) leads to a substantial reduction in glycaemic response. The reduction in response appears to be due to both the exchange of fructose for glucose, and to the physical influence of undigested KF remnants on digestive processes in the foregut. As fructose consumption has been reported to promote blood glucose disposal, and KF remnants appear to retard processes that mediate absorption of starch-derived glucose from the foregut, it is possible that the ability of digestion-resistant remnants of kiwifruit to modulate the glycaemic response to starchy food depends on the temporal proximity of the ingestion of KF and starchy staple. To test this dependence of interaction on the closeness of intakes, KF (200 g = flesh of two KF) was ingested 10 h, 90 min, 30 min before, at the same time as, or 30 min after a starch-based wheaten biscuit (WB) containing the same amount of available carbohydrate, mainly starch, as the KF. Capillary blood glucose concentrations and satiety were measured after ingestion of the foods. Partial substitution of WB by KF caused a 20–30% reduction in total glycaemic response irrespective of the separation of KF and WB ingestion. However, ingesting KF 30 min before WB decapitated the blood glucose “spike”, whereas the reverse, WB ingested 30 min before KF, did not. The results suggest that both the temporal distribution of available carbohydrate (meal slowness) and differences in the composition of foods consumed at different stages in a meal may affect glycaemic response, perhaps by exerting different degrees of delay in the release of available carbohydrate from the stomach to small intestine during digestion.

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POSTERS

PO01 - 24966 - GELATIN FILMS ACTIVATED WITH PICKERING EMULSIONS ENCAPSULATING HESPERIDIN: EMULSIONS AND FILMS MICROSTRUCTURES

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Keywords: Active films, Chitosan, Nanoparticles, Stability, Laser scanning microscopy

Abstract

The intention in the development of active films has recently been steadily increasing due to the critical concerns about consumer demand for higher food quality. Active films have added functional activities, such as antioxidant and antimicrobial, further than their mechanical properties. However, a wide range of challenges arises during the development of such systems, due to the different characteristic of biopolymers, often hydrophilic, compared to numerous bioactive compounds with lipophilic character. Hesperidin is a flavonoid that exhibits low aqueous solubility found in citrus by-products, with great antioxidant and antimicrobial activities. In this study, we focus on the preparation and characterization of active gelatin-based films incorporated with oil-in-water (O/W) Pickering emulsions stabilized with chitosan nanoparticles (ChiNP) and encapsulating hesperidin. Results revealed Pickering emulsions with $d_{3,2}$ of 5.4 µm and *PDI* of 0.3. The emulsion characterizations, using confocal laser scanning microscopy (CLSM) micrographs, showed direct evidence that the ChiNP were adsorbed at the interface between the oil and water phases. Detailed microstructures of the emulsion droplets were visualized by scanning electron microscopy (SEM), corroborating the potential of ChiNP as wall material for the development of Pickering emulsions. Films were produced by the casting method incorporating different emulsion' levels (5, 10, 20, 30 and 50 g oil/100 g of gelatin). Microstructure analysis with confocal laser scanning microscopy (CLSM) images showed a similar droplets size and size distribution in the film matrix as compared with emulsions, endowing the films with homogeneous distributions of oil droplets over their 3D network architecture. SEM images suggested that this phenomenon might be related to Pickering stabilization effect of oil droplets incorporated into the film matrix. Interestingly, the incorporation of Pickering emulsions was effective to produce films with good compatibility between interface of oil droplets and gelatin matrix.

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PO03 - 25002 - EFFECT OF MOLECULAR WEIGHT AND K-CARRAGEENAN ON DELONIX REGIA GALACTOMANNAN-BASED FILMS PHYSICOCHEMICAL PROPERTIES

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Keywords: Polysaccharides, Films, Galactomannan

Abstract

Edible films play an important role in food industry. So, the research on new material sources to improve films properties is relevant. One of the possibilities is the use of galactomannan blended with other polysaccharides such as k-carragennan (k-Carr)[1,2]. It has been reported that a 60:40 film blend (galactomannan:k-Carr) presents improved water vapor permeability values (WVP) and mechanical properties when compared with both pure components[1]. In this work the effect of non-conventional *Delonix regia* galactomannan (DRGM) molecular weight (Mw)[3] and the k-Carr blends with the native DRGM and hydrolysates on film properties were studied. Nine different film formulations at 1% (w/v) of polysaccharide concentration were produced: a) native DRGM, high Mw (HMWH), medium (MMWH) and low Mw (LMWH) DRGM hydrolysates, b) k-Carr, and c) blends from Native:k-Carr, HMWH:k-Carr, MMWH:k-Carr and LMWH:k-Carr at a 60:40 ratio. From SEM micrographs the films surfaces showed to be homogenous, where insoluble material disappeared as galactomannan Mw decreased. Interactions between galactomannans and k-Carr were determined by FT-IR spectra from the bands shifts between 900 and 1200 cm^{-1}, corresponding to C-O-C and C-O-H respectively. Furthermore, DRGM Mw reduction increases film solubility from 69.1% to 76.08% while DRGM and hydrolysates blended with k-Carr attain 100% solubility. Films integrity after 24 h in water decreased as Mw decreases, native DRGM and HMWH became swollen meanwhile MMWH and LMWH disintegrated in small slices. All films had contact angles below 90º and the WVP of DRGM films increased with hydrolyzation from $7.55x10^{-11}$ g/(m*s*Pa) to $12.62x10^{-11}$ g/(m*s*Pa) for HMMH and MMWH films while for LMWH the values reach a $9.60x10^{-11}$ g/(m*s*Pa). On other hand, WVP values decrease for k-Carr films blended with DRGM

hydrolysates. Mechanical properties did not decrease significantly by DRGM Mw reduction showing tensile strength values around 60 MPa and values of elongation at break around 3.8%.

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PO05 - 24992 - INCORPORATION OF OLIVE POMACE INGREDIENTS IN YOGHURT AS SOURCE OF FIBRE AND HYDROXYTYROSOL: BIOACTIVITY AND STABILITY OF THROUGHOUT GASTROINTESTINAL DIGESTION

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Keywords: Olive pomace, Dietary Fibre, Hydroxytyrosol, Yoghurt fortification

Abstract

Yoghurt is highly appreciated for its nutritional/health benefits linked to its high calcium content, bioactive peptides and functional bacteria[3,4]. Nevertheless, yoghurt does not contain fibre nor polyphenols. Various food ingredients have been added to yoghurts to increase its phenolic content[4] and fibre content[2], including cereals, fruit and recently vegetable purees. The powdered ingredients developed from olive pomace (OP) could be a new attracting source of dietary fibre[5] and antioxidants[6]. OP is the most relevant byproduct from olive oil industry[7], but also a high source of dietary fibre[8] and polyphenols, mainly hydroxytyrosol[6].

The main goal of this study was to assess the feasibility of incorporation of OP powders [liquid-enriched powder (LOPP) and pulp-enriched powder (POPP)] into yoghurt as a source of fibre and polyphenols. The evaluation of the bioaccessibility and antioxidant activity during simulated gastrointestinal digestion were also assessed.

The incorporation of OP powders into yoghurts showed that fortification with 2% POPP would be allowed the claim of "source of fibre" in the final product. The addition of LOPP (1%) represents the presence of 5 mg of hydroxytyrosol and derivatives. Therefore, the consumption of one yoghurt/day in an equilibrated diet, it may allow a health claim of "protection of LDL from oxidative damage"[9]. Fortified yogurts exhibited higher total phenolic content (62-75%) and higher radical scavenging activity (78-87%) compared to control yogurt ($p<0.05$). Concerning the bioaccessibility of polyphenols, the Y-LOPP revealed a recovery index of 46% of LOPP phenolics. The Y-POPP exhibited an increasing in ABTS scavenging activity of 15% when compared to POPP. These results showed that yoghurt matrix allowed the release of OP polyphenols into the gut.

OP powders can be considered an important source of fibre and bioaccessible hydroxytyrosol and dairy products may be good carriers of olive pomace bioactives, conveying significant nutritional and health benefits to the consumers.

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PO07 – 24953 - EFFECT OF FARMING SYSTEMS ON THE QUANTITATIVE AND QUALITATIVE COMPOSITION OF PHENOLIC ACIDS IN POTATO TUBERS WITH DIFFERENT COLOURED FLESH

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Keywords: Biodynamic, Conventional, Organic, Chlorogenic acid, Phenolic acids, Potatoes

Abstract

Agricultural systems and cultivation technologies applied have an impact on the biochemical composition and quality of potato tubers. Therefore, the aim of the present study was to investigate the effects of different farming systems on the quantitative and qualitative composition of phenolic acids in potato tubers with coloured flesh.
Five potato cultivars with different coloured flesh (Laura, Tornado, Red Emmalie, Violetta, Salad Blue) were cultivated at a farm in the Širvintos district of Lithuania. Potatoes were grown following traditional potato production technology in conventional, organic and biodynamic farming systems. The concentrations of phenolic acids and their derivatives were determined with a method described by Hallmann (2012)[1] using the HPLC equipment.
The results show that biodynamic potato contained significantly higher concentrations of total phenolic acids and most of individual phenolic acids (chlorogenic and p-coumaric acids), in comparison with the organic and conventional. Hovewer, conventional potato contained significantly more gallic acid. The cultivar effect on the concentrations of total phenolic acids and individual phenolic acids was also identified. Tornado cultivar contained significantly more of total phenolic acids (141.43 mg 100 g^{-1} DM), chlorogenic acid (138.13 mg 100 g^{-1} DM), caffeic acid (1.17 mg 100 g^{-1} DM) and p-coumaric acid (0.74 mg 100 g^{-1} DM) in comparison to other studied cultivars. However, Laura cultivar contained significantly more of gallic acid (1.75 mg 100 g^{-1} DM).

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PO08 - 24956 - PEA PROTEIN MICROGEL PARTICLES-STABILIZED PICKERING EMULSIONS: INFLUENCE OF PH AND IONIC STRENGTH

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Abstract

There is burgeoning research and industrial interests for designing ultra-stable plant protein-based emulsions. In this study, we have designed a new class of Pickering stabilizer *i.e.* plant protein-based microgel particles (1 wt% protein) using a top-down approach to stabilize Pickering emulsions (20 wt% sunflower oil) and investigated the responsiveness of these emulsions to pH and ionic strength. The Pickering stabilizer *i.e.* pea protein microgel (PPM) particles of ~ 232 nm hydrodynamic diameter (D_h) with polydispersity index (PDI) ~ 0.2, was created using heat set gel formation followed by controlled shearing [1,2]. The pI of the PPM particles was around pH 5.0 with the net surface charge being close to zero. With increasing ionic concentration (1-250 mM NaCl), the zeta-potential of particles changed from -40 mV to -8 mV due to electrostatic screening effects. The PPM particles could successfully stabilize oil droplets with mean droplet size (d_{43}) ~ 23 µm at pH 7.0. When the pH of PPM stabilized Pickering emulsion (PPM-E) was adjusted from pH 7.0 to pH 5.0 (the pI of PPM particles), the oil droplets trended to aggregate each neighbour which leaded to cream phase separation. Interestingly, adjusting the pH of Pickering emulsion from pH 7.0 to pH 3.0 resulted in similar sized droplets with aggregation of PPM particles at the particle-laden interface providing a better surface coverage as compared to that at pH 7.0, supported by confocal images (Figure 1). With increasing ionic concentration (1-100 mM NaCl), although the zeta-potential of oil droplets changed from -40 mV to -20 mV, the mean droplets size of emulsions did not changd. In summary, these findings suggest that PPM can act as a suitable Pickering stabilizers and pH can be a suitable trigger to tune the surface properties of the droplets.

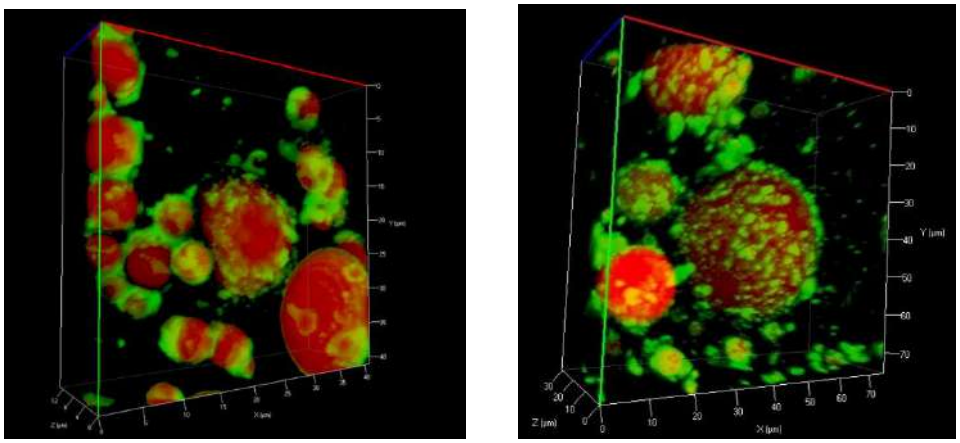

Figure 1. Confocal micrographs of PPM-stabilized Pickering emulsions at pH 7.0 (left) and after adjusting the pH to pH 3.0 (right). Spherical oil droplets were stained with Nile red which is presented in red, and protein microgel particles were stained with Nile blue which is presented in green.

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PO09 – 24880 - EFFECT OF PARTICLE SIZE ON OPTICAL PROPERTIES AND VISCOELASTICITY OF NANO-MICROSTRUCTURED CELLULOSE BASED SUSPENSIONS

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Keywords: Cellulose nanocrystals, Bacterial cellulose, Optical properties, Viscoelasticity

Abstract

Cellulose structured at nano and microscale are novel materials with wide and interesting applications in food science and technology (e.g. packaging, coatings, emulsions), however their use in commercial products are still limited. The goal of this work was to analyse the role of particle size on optical properties, viscosity and viscoelasticity of suspensions of cellulose nanocrystals (CNC) and bacterial cellulose microfibrils (BCMF). CNC (100 nm lenght) were purchased on Process Development Center UMaine (USA), whereas BCMF (300 microns length) were kindly provided by Vuelo-Pharma (Brazil). Suspensions of CNC and BCMF in distilled water were prepared at 0.16, 0.52 and 0.90%w/v. CNC-BCMF suspensions were analysed in terms of their optical properties (absorbance-transmittance between 400-700 nm, spectrophotometry), viscosity (Brokfield viscometer) and viscoelasticity (apparent viscosity by flow sweep; G', G'', tand by frequency sweep. Rheometer). All measurements were carried out considering at least five replications. BCMF showed absorbance higher than 0.75 in all tested range, whereas CNC showed values close to 0.15 or even lower in the same range. Transmittance was higher than 75% in CNC suspensions, but lower than 10% in BCMF. BCMF also showed higher viscosity than CNC suspensions, tested by both viscometry and flow sweep (e.g. 5-7 cP in CNC, >100 cP in BCMF). Both CNC-BCMF suspensions showed to be non-newtonian. The latter was consistent with the viscoelasticy, where BCMF showed values of both G' G'' 2-4 log magnitude higher than CNC suspensions, and with BCMF showing G' values independent of the frequency, suggesting formation of stiff gels, which was not observed in CNC suspensions. This behavior is coherent with the behavior of tand which was constant and <1 in all BCMF samples, but strongly dependent of angular frequency in CNC suspensions. Therefore, particle size would be one of the key factors which define the performance of cellulosic materials structured at nano and microscale.

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PO11 - 24975 - DEVELOPMENT AND EVALUATION OF LIMITED WATER SOAKING CONDITION ON THE FORTIFICATION OF RICE BY PARBOILING

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Keywords: Parboiled rice, Fortification

Abstract

Micronutrient deficiency disorders are widespread in predominantly rice-consuming countries, particularly in South Asia. Accordingly, parboiled rice is an effective vehicle for micronutrient fortification without changing consumer eating habits. However, parboiling processes consume tremendous amounts of water during soaking generating about 1-1.2 kg waste water per kg of paddy. Disposal of untreated waste water results in nutrient overload in soil and therefore represents a serious environmental concern.

In this research, a limited water soaking method was developed and evaluated for the effectiveness of fortification and reduction of fortificant usage.

The limited-water soaking was achieved by using vacuum packaging and soaking one part of rice in 0.5 parts of soaking solution. In contrast, the conventional parboiling process (excess-water soaking) uses one part of rice and two parts of soaking water. Rice was fortified with calcium (50 g/L), iron (200 mg/L) and their combination (50 g/L Ca + 20 mg/L Fe) along with a control (no minerals). The amount of waste water and total solids in waste water, milling quality, and mineral content of the fortified rice were determined.

The limited-water soaking not only reduced the amount of effluent by 41.25% on average, but also the amount of total solids in waste water by up to 6.14%. Fortified rice by limited-water soaking showed a similar head rice yield and mineral uptake as the conventional soaking.

The limited-water soaking method has great potential to reduce the cost of fortification and waste water treatment without affecting milling quality and fortification efficiency.

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PO12 - 24946 - EFFECT OF FARMING SYSTEMS ON THE QUANTITATIVE AND QUALITATIVE COMPOSITION OF ANTHOCYANINS IN POTATO TUBERS WITH RED AND PURPLE FLESH

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Keywords: Anthocyanins, Biodynamic, Conventional, Organic, Petunidin-3,5-di-O-glucoside, Potatoes

Abstract

Potatoes are among the world's most widely cultivated crops, so the conditions under which they are grown, and the impact of these conditions on qualitative and quantitative parameters of potatoes, are very important. Therefore, the purpose of the present study was to estimate the effects of different farming systems on the quantitative and qualitative composition of anthocyanins in potato tubers with coloured flesh.

Three potato cultivars (Red Emmalie (red flesh), Violetta (dark purple flesh) and Salad Blue (light purple flesh)) were cultivated at a farm in the Širvintos district of Lithuania. Potatoes were grown following traditional potato production technology in conventional, organic and biodynamic farming systems. The concentrations of anthocyanins and their derivatives were determined with a method described by Hallmann (2012)[1] using the HPLC equipment.

The results show that the conventional potatoes contained higher concentrations of total anthocyanins, as well of individual anthocyanins such as petunidin-3,5-di-O-glucoside, peonidin-3,5-di-O-glucoside and pelargonidin-3,5-di-O-glucoside. The cultivar effect on the content of selected antocyanins in the samples was also observed. Vitelotte contained significantly more total anthocyanins (46.25 mg 100 g^{-1} DM), petunidin-3,5-di-O-glucoside (43.35 mg 100 g^{-1} DM), peonidin-3,5-di-O-glucoside (1.52 mg 100 g^{-1} DM) and pelargonidin-3,5-di-O-glucoside (1.39 mg 100 g^{-1} DM), in comparison to other studied cultivars.

This study confirms that the farming systems may have a significant impact on quality of potato tubers. The conventional potatoes appeared to be richer in anthocyanins.

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PO14 - 24883 - ASSESSMENT OF THE ANTIOXIDANT ACTIVITY OF BILBERRY LEAVES (VACCINIUM MYRTILLUS L.) DIETARY SUPPLEMENTS ON SHELF LIFE OF EGG

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Keywords: Bilberry leaves, Antioxidant, Oxidative stability, Eggs

Abstract

Lipid oxidation and the generation of secondary oxidation products have always been serious concerns of food quality and consumer health, storage time and storage temperature being important factors that contribute to oxidative stability of food.
The effect of dietary bilberry leaves on the oxidative stability of egg yolk over a 28-day storage has been evaluated. Sixty TETRA SL laying hens, 32 weeks old, distributed into 2 groups (2 hens/cage; 15 cages/group), were given a control diet or a diet supplemented with 0.5% bilberry leaves. Lipid oxidation was analysed by measuring the concentration of hydroperoxides (PV), conjugated dienes (CD), conjugated trienes (CT), para anisidine value (PA) and thiobarbituric acid-reactive substances (TBARS) in egg yolk samples. Following 4 weeks of feeding, eggs (18 eggs / group) were collected and the rate of lipid oxidation was determined in eggs stored 28 days, at 16 °C in the presence of light.
The primary oxidation products (PV, CD, CT) decreased with 25% in experimental group comparing to control. The secondary products (PA, TBARS) showed 36% lower values for experimental when compared to control group. Significant differences ($P<0.05$) between groups were noticed for all studied parameters. The results showed that dietary bilberry leaves supplement had an intense effect in delaying the oxidation process of yolk during storage.

PO15 - 24957 - MICROENCAPSULATION OF CAROTENOID RICH EXTRACT OBTAINED FROM INDUSTRIAL WASTE: POTENCIAL USE OF GUARANA PEEL (PAULLINIA CUPANA)

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Keywords: Spray chilling, Encapsulation, Stability

Abstract

Guarana is a species native from Amazon region of Brazil. The fruit is known for its stimulant and medicinal properties and widely used for the production of soft drinks, energy drinks and concentrated. Guarana peels are waste generated and have potential for exploitation because they are rich in carotenoids. In this context, the aim of the study was to encapsulate by spray chilling carotenoids-rich extract obtained from guarana peels, evaluating the efficiency of the process and the stability of the particles. The extraction of carotenoids from guarana peels was carried out at 50 °C for 4 hours, considering the ratio of 1:10 (w/v) peel: absolute ethanol. Using a temperature of 15±2 °C, three formulations were produced by varying the proportions extracts in hydrogenated soy oil (20, 30 and 40% w/w). The content of total carotenoids, moisture, and color parameters, L, a * and b *, were analyzed every 15 days during three months. The mean diameter and the size distributions of the microparticles were obtained at the beginning and at the end of storage. Total carotenoid content of the free extract was also analyzed in this period. The particles and the free extract were stored at 37 °C and 33% relative humidity. The microparticles of the 20% formulation showed no reduction in carotenoid content, while the carotenoid content reduced 10, 16 and 44% in the formulations 30%, 40% and the free extract, respectively. In general, the color parameters showed a reduction of microparticle color intensity during storage. All microparticles increased in size after 90 days. The results showed that spray chilling is an efficient encapsulation technique to guarantee stability during this period for carotenoids, reducing the degradation and increasing its applicability.

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PO16 - 24882 - TOMATO AND ROSEHIP BY-PRODUCTS AS VALUABLE SOURCE OF NUTRACEUTICALS FOR LAYING HEN NUTRITION

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Keywords: Tomato peels, Rosehip meal, Bioactive compounds, Egg

Abstract

The processing of fruits at industrial level generates large amounts of by-products, which can be reused in animal nutrition, being a rich source of valuable bioactive compounds. The present study was conducted to investigate the effects of tomato peels and rosehip meal included in the laying hens diets, on the transfer of vitamins A and E, lutein and zeaxanthin into egg yolks.
A total of ninety, 42-week-old TETRA SL hens were randomly assigned into 3 groups (C, E1, E2) and housed in metabolic cages (2 hens / cage, 30 hens / group). The hens were fed on a corn-soybean meal based diet enriched in PUFA by the inclusion of 6 % linseed meal. The experimental diets were supplemented with 2 % tomato peels (E1) and 2 % rosehip meal (E2), for 4 weeks. Feed intake was not influenced by the treatements. Diet E1 increased (P≤0.05) laying performance and egg weight. Vitamin A concentrations in eggs increased (P≤0.05) in E2 group with 23.6 % compared to C, while in E1 group no differences where observed. The highest vitamin E content (P≤0.05) in eggs was found when 2 % of tomato peels were included, and was with 9 % higher then C group. Determination of lutein and zeaxanthin concentrations in eggs showed no differences between groups.
This study provides information about the nutraceutical potential of tomato peels and rosehip meal and posible future application in the animal nutrition.

PO17 - 21364 - ROLE OF ANTIFOAMS ON HINDERING EFFICIENT OIL RECOVERY IN FERMENTATIVE PROCESSES

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Keywords: Process yield, Emulsions stability, Antifoaming agents, Biotechnology

Abstract

The interest in fermentation based on genetic engineering has boosted in the last years, being recognized as a process that results in high valuable products (e.g. flavors and chemicals). This technology involves the action of microorganisms, but during process other indispensable components are added to improve fermentation efficiency, such as antifoams. These agents are added in the fermentation broth to reduce bubbles formation during reaction; however, negative impacts can derive from their use. For instance, emulsions formation can be triggered by antifoams presence, containing either ionic or non-ionic amphiphilic molecules. The formation of these emulsions is a drawback since they entrap the desired product (oil), impacting not only on a higher energy applied to phases separation, but also on the use of demulsifiers to promote enhanced product recovery. The latter generates wastes impacting on the environment. Thus, this study aimed at understanding the mechanisms of emulsions stabilization provided by different antifoams combined with varied oils, to investigate the action promoted by these agents depending on the features of the medium. This knowledge would allow to increase oil recovery by either preventing or reducing droplets stabilization. Therefore, model emulsions were prepared in a mechanical stirrer using two antifoaming agents (antifoam C and poly(ethyleneglycol)-block-poly(propyleneglycol)-block-poly(ethyleneglycol)) combined with three oils (sunflower oil, hexadecane and a medium chain triacylglycerol). Creaming index, particle size, rheological properties, optical and confocal microscopy of emulsions were analyzed, as well as the interfacial tension between the phases. These results allowed the identification of parameters influencing droplets formation. Albeit all antifoams provided the production of emulsions, the pluronic promoted lower interfacial tension, besides the decrease of droplet size. Therefore, one can assume that antifoams addition along fermentation is an important factor hindering product recovery. Furthermore, the nature and concentration of antifoams are extremely relevant to define the properties of bio-based systems.

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PO18 - 25016 - HIGH HYDROSTATIC PRESSURE (HHP) AND PHAGE SALMONELLEXTM AS A SYNERGISTIC PROCESS FOR SALMONELLA INACTIVATION IN EGG WHITE

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Keywords: Salmonella, Bacteriophage, High-pressure processing, Egg white

Abstract

Salmonella spp. still represents a major concern among foodborne diarrheal illnesses, with a special emphasis for its main vehicle of transmission, eggs and egg-derived food products. *Salmonella* Enteritidis is the most common serotype associated with non-typhoidal salmonellosis, through the ingestion of raw and undercooked eggs. A revolution in consumers eating habits is taking place worldwide with a growing demand for healthy food products, with a notable increase in the consumption of egg white. Thermal pasteurization, commonly employed in egg white decontamination, seems to be ineffective in the complete elimination of *Salmonella.* In this sense, high hydrostatic pressure (HHP) represents one of the most promising technologies as a viable replacement to this traditional food processing. The aim of this study was to evaluate the effect of a synergistic process which combines mild HHP and phage Salmonellex^{TM} as a novel non-thermal technology for *Salmonella* reduction in egg white.

Samples of egg white were inoculated with Salmonellex^{TM} with a final MOI of 10 to 10^7 log (CFU/mL) of *Salmonella* cocktail composed by two *S.* Enteritidis and two *S.* Typhimurium. After twelve hours of storage at 4 °C, three samples were subjected to HHP (300 MPa, 5 min, 10 °C) and other three directly stored at atmospheric pressure (0.1 MPa) under refrigeration (4 °C, unprocessed). Stability of Salmonellex^{TM} inoculated in egg white and viability of *Salmonella* were assessed at pre-set time intervals (0, 0.5, 1, 4 and 7 days) in unprocessed and processed samples.

Pressure treated egg white samples with a final MOI of 10, exhibited a 5.1 logarithmic cycles of *Salmonella* reduction immediately after pressurization, whereas HHP alone resulted in a 2.9 log reduction. Phage particles were stable in egg white throughout storage and no significant differences were observed in the phage titers. The pressure-phage system is a promising minimal food processing option.

Acknowledgements

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PO45 - 24691 - DIRECTING ATTENTION: STRATEGIES TO MASK UNDESIRED PERCEPTION OF GRITTINESS IN FOODS

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Keywords: Liking delivery systems, Texture perception, Consumer expectations, Fat content

Abstract

This study investigated how the addition of particles or fat to common foods (quark) can be used to perceptually mask negative texture perceptions (grittiness). Cellulose beads were added as model particles (1.5% w/w; average size: 263 µm) to quark (0% fat) to induce grittiness. Two particle types were used: granola pieces and model peach gel pieces. Fat concentration of quark was also varied (4 and 8 % w/w). The results show that addition of cellulose beads to quark significantly increased grittiness and dryness, while creaminess and liking significantly decreased. When granola pieces were added to quark containing cellulose beads, the decrease in liking was prevented, although quarks were still perceived as gritty. Granola increased liking relative to both the homogeneous and cellulose beads containing quarks. We suggest that the presence of granola pieces might have focused attention of consumers to positive, more dominant sensations (i.e. crunchiness). Hence, product liking increased, although consumers could still perceive grittiness when they performed an analytical sensory evaluation. In contrast to the granola pieces, the addition of model peach gel pieces to quark containing cellulose beads did not prevent a decline in liking nor did it suppress grittiness. No differences in liking were found between the homogeneous low-fat quark without cellulose beads and the full-fat quark with cellulose beads probably due to fat lubrication properties. We conclude that addition of particles such as crunchy granola pieces or fat can be used as strategies to shift consumers attention towards positive sensations leading to an increase of liking while negative sensations (grittiness) caused by structural heterogeneities (cellulose beads) are still sensed. This approach could be used to mask undesired sensations in high protein foods.

PO46 - 24923 - DESIGN OF EMULSION-BASED DELIVERY SYSTEMS FOR PROBIOTIC BACTERIA

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Keywords: Probiotic bacteria, Delivery system, *In vitro* digestion, Structured emulsion, Monoglycerides

Abstract

Probiotics are increasingly gaining popularity in vast food applications due to their recognized health benefits to the host. However, several factors could significantly reduce their viability during food manufacturing and storage, as well as during their passage through the gastrointestinal tract (GIT). Thus, today there are intense research efforts to design probiotic delivery systems able to protect bacteria not only in food but also during human digestion. Unfortunately, the maintenance of microbial viability into food is not enough to guarantee that the ingested bacteria act as probiotics. In fact, the hostile gastrointestinal conditions may substantially reduce the number of transient or colonized probiotics. Therefore, new approaches to protect and deliver probiotics in foods as well as through the GIT are highly demanded. This research was addressed to study the potential use of monoglyceride (MG) structured systems as delivery systems for probiotic bacteria. To this propose, a *Lactobacillus rhamnosus* strain was inoculated in different binary or ternary MG-based structured systems. The viability of the bacteria as well as the structural changes were evaluated both during storage at 4 °C and upon *in vitro* digestion. Results highlighted the excellent capability of monoglyceride-structured emulsions to protect probiotic bacteria from environmental stresses suffered during sample storage and *in vitro* digestion. This ability was attributed to the peculiar structure formed by MG, even if the probiotic protection capacity resulted strictly related to the system composition. The best performing system was finally used in the production of a probiotic ice-cream. Interestingly, MG structures confirmed their probiotic protection ability, displaying at the same time a good structuring capability, resulting in ice-cream samples with acceptable quality characteristics. In the light of these findings, the proposed approach could be considered an innovative way to deliver probiotic bacteria into foods.

PO48 – 21359 - MAPPING THE SPATIOTEMPORAL DISINTEGRATION AND RELEASE OF NUTRIENT FROM EGG WHITE GEL MICROSTRUCTURE DURING IN VITRO GASTRIC DIGESTION

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Keywords: Gastric digestion, Egg white gels, Pepsin, Time-lapse confocal microscopy, TRITC-dextran

Abstract

Digestion of protein-based solid food begins in the stomach. It is well-known that the proteolysis of the food matrix by gastric pepsin leads to the release of peptides, but the effect of food microstructure on proteolysis kinetics is not yet well understood. The aim of this work was to investigate the impact of egg white gel (EWG) microstructure on pepsin activity, and its effects on gel disintegration, during gastric digestion. EWGs of the same protein concentration (10%) but different microstructures as modulated by two different pH conditions (pH 5 and pH 9) during heat gelation were used as product models. A methodology based on time-lapse confocal microscopy was developed to monitor the spatiotemporal microstructural changes of EWGs during static *in-vitro* gastric digestion. Tetramethylrhodamine isothiocyanate (TRITC)-dextran (4.4 kDa), chosen as a model fluorescent molecule of nutrients (i.e. peptide-like size), was incorporated into the EWGs. The gel breakdown and the release of TRITC-dextran were quantified by particle area fraction measurements and fluorescent intensity loss respectively, using image analysis. Microscopic observations showed that the loosest network of pH5 EWG disintegrates more quickly and to a greater extent, leading to a higher rate of TRITC-dextran release, than the most tightened network of pH 9 EWG. Pepsin activity being highly dependent on local pH, the high buffering capacity of EWGs may also affect the disintegration rate that is slower in the pH 9 EWG. Moreover, only the particle area fraction of the both gel surfaces in contact with gastric fluid is eroding over digestion, suggesting that surface erosion is probably the main mechanism of EWG disintegration in these experimental conditions. This methodology enabled a better understanding of how EWG microstructure modulates digestion

kinetics. However, improvements are still required to decouple the kinetics of acidification by the gastric fluid from the pepsin activity itself.

Acknowledgements

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PO49 - 24922 - COFFEE BREW FORMULATION AND PROCESSING AFFECT CHLOROGENIC ACID BIOACCESSIBILITY AND A-GLUCOSIDASE ACTIVITY

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Keywords: Coffee, Milk, HPH, Fat concentration, *In vitro* digestion, Type 2 diabetes

Abstract

Coffee was demonstrated to reduce type 2 diabetes risk. This effect was attributed to phenolic compounds, and in particular to chlorogenic acids (CGAs), which are able to inhibit *α*-glucosidase, the enzyme responsible for glucose release at intestinal level. However, most studies refer to model systems, such as phenolic compounds purified from coffee, not considering the whole coffee beverage. The latter can be obtained by different processes and may include other ingredients, among which the most common are dairy products and in particular milk. CGAs bioactivity can thus be affected by food matrix composition and by the interaction among different components. Moreover, the digestion process affects CGAs bioaccessibility and could thus boost or decrease their bioactivity. This study aimed at investigating the effect of coffee beverage formulation and processing on CGAs bioaccessibility and on their inhibitory effect against *α*-glucosidase upon *in vitro* digestion. Instant coffee brews were added with skimmed, semi-skimmed and whole (0.1, 3.6 and 7.1% fat, respectively) milk and homogenized at increasing pressure (0 to 150 MPa). CGAs bioaccessibility and *α*-glucosidase inhibition upon *in vitro* digestion were assessed. Milk addition and homogenization increased CGAs bioaccessibility from 20-25% to >50%, suggesting a protective effect of milk against CGAs degradation upon digestion. In particular, CGAs bioaccessibility was affected by fat content and HPH intensity. The presence of fat could reduce the susceptibility of CGA to degradation by promoting their micellarization. In addition, phenolic compounds may complex with milk proteins, resulting less prone to breakdown during digestion. The addition of milk and the use of higher pressures also improved *α*-glucosidase inhibitory capacity of coffee beverages. However, no relation was found between CGAs bioaccessibility and *α*-glucosidase inhibitory capacity, suggesting that other components may be involved in the antidiabetic properties of coffee beverage.

PO51 - 24873 - EFFECT OF HUMAN SALIVA ON STRUCTURE BREAKDOWN OF EMULSIONS THICKENED WITH DIFFERENT HYDROCOLLOIDS

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Keywords: Emulsions-based matrices, Thickening agent, Human saliva, Breakdown structure

Abstract

Nanoemulsions have been used in healthy food product development because improve the bioavailability of bioactive compounds. However, during its consumption different biological fluids can interact with compounds present into nanoemulsions, which it may alters their physical properties causing a great influence on sensory perception. Thus, the objective of this work was to evaluate human saliva effect on rheological properties of emulsions thickened with hydrocolloids. Two different emulsion types (N: nanoemulsion and C: conventional emulsion) were prepared using 6% w/w emulsifier mixture (5% soy lecithin and 1% tween 80) and 5 % w/w avocado oil as lipid phase. Resource® (xanthan gum) and Enterex ® (starch) were used as thickening agent. Four samples were studied: N+Resource, N+Enterex, C+Resource and C+Enterex. Emulsions were characterized by particle size and flow properties. Viscosity changes due to saliva addition were evaluated in a rotational rheometer equipped with a cylindrical cup, which was filled with 16 g of each emulsion and 3.5 mL of stimulated human saliva. Apparent viscosity at 50 s^{-1} was registered for 30 s at 37 °C. Results showed that all samples presented a pseudoplastic flow behavior and that particle size varied among 88-111 nm and 3,067-3,286 nm in nanoemulsions and conventional emulsions, respectively. The structure breakdown curves obtained showed a decay of apparent viscosity values with time; the kinetics of this decay was modeled using a second order equation reflecting the destruction of the internal structure of the systems caused by shearing and saliva activity. Differences due to thickener and emulsion type were found after structure breakdown. Nanoemulsions and starch-systems showed a rapid decrease in apparent viscosity by the saliva effect. In conclusion, the use of thickeners with different structural characteristics in the development of emulsion-based matrices affects the breakdown of their structure during oral processing, which may involve different sensory perceptions during their consumption.

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PO52 - 24874 - FOOD MATRICES BASED ON BIOACTIVE EMULSIONS: INFLUENCE OF PARTICLE SIZE AND THICKENER TYPE ON LIPID DIGESTION

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Keywords: Lipid digestion, Food emulsions, Thickening agent, Bioaccessibility

Abstract

In the recent years, there has been a growing interest in the development of nutrient delivery systems using nanoemulsions. Nanoemulsion-based food can have a complex structure due to the incorporation of different biopolymer as stabilizing agent in order to enhance its physical stability during storage; however, the addition of hydrocolloids can play an important role on nutrient release and bioavailability. In this context, the aim of this research was to study the impact of particle size and thickener type on free fatty acid release kinetic from emulsion-based matrices during *in vitro* digestion. Oil-in-water emulsions were prepared with 6% w/w emulsifier mixture (5% soy lecithin and 1% Tween 80) and 5% w/w avocado oil as lipid phase. Particle size (NE: nanoemulsions and CE: conventional emulsions) and thickener type (Enterex®: starch and Resource®: xanthan gum) were varied. Two control samples without thickener-added were also prepared (C-NE and C-CE). To characterize emulsions: particle size, physical stability and flow properties were determined. *In vitro* mechanical gastric system (IMGS) was used to study the kinetics of free fatty acid release. Physical characterization of different matrices showed that particle size increased slightly by adding of thickening agents (from 3,067 to 3,286 nm and 88 to 111 nm in CE and NE, respectively). C-CE and CE+Resource presented creaming formation after a centrifugation process. Control emulsions showed a Newtonian flow behavior, whilst all thickened systems had a pseudoplastic flow behavior. Emulsion-based matrices presented significant differences on the digestion rate due to thickener type and particle size. CE+Resource showed the lowest digestion rates and final extent of free fatty acids released. In conclusion, lipid bio-accessibility of food emulsions-based matrices is affected by both thickener type and particle size, which it is necessary taking account in the development of delivery nutrient emulsion-based systems.

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PO54 - 24993 - INFLUENCE OF DIETARY FIBERS ON THE BIOACCESSIBILITY OF GLUCOSE RELEASED FROM RICE DURING DYNAMIC IN VITRO GASTROINTESTINAL DIGESTION

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Keywords: Fibers, *In vitro* gastrointestinal digestion, Absorption, Bioaccessibility

Abstract

Dietary fibers, known for their health benefits, namely reducing the probability rates of heart diseases, type 2 diabetes, colon cancer, etc., influence how nutrients and chemicals are absorbed in the gastrointestinal tract. In this sense, an *in vitro* dynamic gastrointestinal model was used to evaluate the bioaccessibility of glucose released during the digestion of whole grain rice (WGR) and white rice (WR). This model allows the quantification of absorbed glucose by simulating the passive absorption of small molecules/water through a hollow fiber system.
Rice samples were cooked and grinded before being submitted to the *in vitro* digestion, which consisted in the simulation of the mouth, stomach, duodenum, jejunum and ileum. Samples were collected after the oral phase, from the stomach (60 and 90 min) and duodenum reactors (120 min), and from the filtrates (from jejunum and ileum) and non-filtrated (ileum delivery) portions.
Glucose released until 120 min was similar for both samples, with 5.90% of glucose from WGR and 5.53% from WR. Major differences were then observed when analysing the absorbed glucose, collected from the filtrates' portions. Glucose from the WR sample was absorbed in substantially higher quantities in the jejunum (6.73%) and ileum filtrates (7.29%) compared to the glucose absorbed from the WGR sample (1.80% in jejunum and 0.74% in ileum filtrates).
These absorption differences could be correlated to the lower quantity of glucose released during digestion of WGR sample (13.49% released from WGR and 46.98% from WR), and to WGR's higher fiber content (presence of germ and bran). Bioaccessibility of glucose from the WGR sample was inferior, since only 18.81% of available glucose was absorbed as opposed to 29.83% of the WR sample.
The use of a (more realistic) dynamic *in vitro* GI system allowed confirming the importance of the presence of fibers in the control of sugars absorption during digestion.

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PO55 - 24896 - IN VITRO BIOACCESSIBILITY OF PHENOLIC ACIDS IN SOFT AND HARD SOY PROTEIN GELS

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Keywords: Soy proteins, Soy gels, Digestion, Phenolic acids

Abstract

The bioavailability of phenolic bioactives in foods is typically very low, and this may be due to limited bioaccessibility. The aim of this study is to explore how protein matrix structure influences bioaccessibility in order to develop biofunctional soy protein gels that improve the bioavailability of phenolic compounds. Our hypothesis is that the soy protein network may regulate release of bioactives during digestion.

Soy protein (SP) gels with incorporated bioactive phenolic acids (protocatechuic acid and o-coumaric acid) were prepared using glucono-delta-lactone (GDL) as a coagulant. A low concentration of GDL resulted in soft gels with fine stranded network, whereas high concentrations of coagulant followed with a subsequent pressing step produced hard gels with a particulate network. We assessed the protein hydrolysis (via release profile of α-amino groups) and the bioaccessibility of the added phenolics using an *in vitro* gastrointestinal simulated digestion model. Both bioactives were released more rapidly from the soft gel matrix, at the initial phase of the gastric processing. On the contrary, the release of the phenolics from hard gels was gradual and it was increased at the intestinal phase. Moreover, the extent of protein hydrolysis was higher in the soft than the hard gels. The release profiles of protocatechuic and o-coumaric acids were different in both gels, suggesting different protein binding affinities.

The results demonstrate that hard SP gels could potentially be used for delivering phenolic acids in the small intestine.

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PO56 - 21360 - ROLE OF NATIVE EGG WHITE PROTEIN GEL MICROSTRUCTURE ON THE DIFFUSION OF GASTRIC PEPSIN

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Keywords: Pepsin, Diffusion coefficient, Egg white gel, FRAP, FITC-dextran, FITC-pepsin

Abstract

Fundamental knowledge of the diffusion of pepsin into food structures during gastric digestion is crucial to better control the disintegration and release of nutrients. This study aimed to investigate how protein based food microstructure, in the form of two different egg white gels (EWGs) with similar protein concentration (10%), impacts the pepsin diffusion. The two different EWG models were prepared by heating fresh egg white, previously adjusted to two different pH values (pH 5 and pH 9). Their microstructures were evaluated using a high-resolution confocal microscopic technique followed by image analysis. To better understand the ability of pepsin to diffuse within each EWG's structure, the effective diffusivity (D_e) of fluorescein isothiocyanate (FITC)-pepsin and FITC-dextran were measured in the native EWGs, using the fluorescence recovery after photobleaching (FRAP) technique. The neutral FITC-dextran (40 kDa) was used as a control to highlight the potential effects of electrostatic interactions between the egg white proteins and FITC-pepsin.

The diffusion of FITC-dextran and FITC-pepsin were explained by microstructural parameters of EWGs. The microstructure of pH 5-EWG was characterized by a more porous and interconnected void network than that compact and homogeneous structure of pH 9-EWG. As a result, the diffusivity of FITC-pepsin was significantly higher ($p<0.05$) for the pH 5 EWG than the pH 9 EWG (D_e = 52.5±5.3 $\mu m^2.s^{-1}$ vs D_e = 44.2±6.1 $\mu m^2.s^{-1}$). Comparison of FITC-dextran and FITC-pepsin diffusivities confirmed the existence of electrostatic interactions between the egg white proteins and FITC-pepsin in the pH 5-EWG, but not in pH 9-EWG.

In conclusion, the diffusion of pepsin within the EWG appeared to be not only modulated by the initial gel microstructure, but also by environmental conditions such as pH. Further

research is therefore still needed to understand the limiting factors for pepsin activity and particle disintegration of semi-solid and solid foods in the stomach.

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PO57 - 25005 - ROLE OF INULIN AS AN ENCAPSULATING AGENT FOR COLONIC RELEASE ON OLEUROPEIN UNDER SIMULATED GASTROINTESTINAL DIGESTION

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Keywords: Oleuropein, Microparticles, Olive leaf extract, *In vitro* digestion

Abstract

Olive leaves are waste from olive oil processing. However, they have an extensive phenolic compound profile, being oleuropein (OE) the main compound. Although, several beneficial effects of OE on health, such as anticarcinogenic and anti-inflammatory have been reported, OE is susceptible to degradation due to environmental and gastrointestinal conditions. In this context, the encapsulation would allow addressing these drawbacks and target the OE release to the colon, where its localized effect and/or absorption is desired. This aim of this work was to study the evolution of encapsulated OE with inulin (IN) by spray-drying under *in vitro* gastrointestinal digestion, its bioaccessibility, and potential bioavailability. Olive leaves extract (OLE) was elaborated and characterized according to polyphenols profile by HPLC-DAD-TOF-MS (24-compounds). OLE encapsulation was performed applying a Central composite with axial-point experimental design. The optimal conditions of OLE-IN microparticles were OLE/IN ratio and inlet air temperature of 1:2 and 166 °C, respectively. The encapsulation efficiency of OE reached a value of 82% in OLE-IN microparticles obtained under optimal conditions. OLE-IN microparticles were characterized by physicochemical and morphologically. OE was released under gastric conditions (42%) and partially degraded under intestinal conditions. The OE content was higher at the end of intestinal and colonic digestion (15 and 7.8 mg, respectively)

respect to non-encapsulated OLE (1.5 and 0.7 mg, respectively), suggesting a protective role of IN on OE degradation by the formation of non-covalent inulin-OE complexes. In this context, OE bioaccessibility was higher in OLE-IN microparticles (12%) than in non-encapsulated OLE (1.5%). However, OE potential bioavailability evaluated by passive diffusion was not detected. Therefore, encapsulation of OLE with IN allowed the protection of OE until reaching the colon.

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PO58 -25008 - NANOEMULSION DELIVERY SYSTEMS: IMPACT OF EMULSIFIER TYPE ON CURCUMIN'S BIOACCESSIBILITY DURING IN VITRO DIGESTION

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Keywords: Nanoemulsions, Static *in vitro* digestion, Lecithin, Tween 80

Abstract

Nanoemulsions (NE) are a colloidal delivery system with increased interest in food science due to properties such as high encapsulation efficiency, high surface area and control release capacity, improving the bioavailability and stability of lipophilic compounds. Curcumin is a lipophilic compound already used as spice or colorant in food products. Besides, it exhibits a wide range of health benefits such as anti-oxidant, anti-tumoral and anti-inflammatory activities. However, this compound has poor solubility in aqueous solutions and low bioavailability. Therefore, the development of novel delivery systems to improve curcumin's bioavailability is of utmost importance, as well as understanding their behavior in gastrointestinal tract and assessing their safety.

The main objective of this research was to evaluate the influence of two emulsifiers, lecithin (LEC) (bio-based emulsifier) and Tween 80 (TWE) (GRAS emulsifier), in a curcumin-enriched-NE formulation when submitted to *in vitro* digestion and to assess their cytotoxicity. NE were characterized in each step of digestion through size, ζ-potential and morphology. At the end of digestion, free fatty acids (FFA) released and curcumin's bioaccessibility was determined. Cytotoxicity of both NE was evaluated on Caco-2 cell line through the MTT assay.

NE-LEC showed some instability at gastric phase, showing an increase in the particle size. NE-TWE showed to be stable until intestinal phase, where an increase in their particle size occurred. NE-TWE presented a higher concentration of FFA released when compared with NE-LEC, showing that TWE enhanced the lipid digestibility. Despite of difference in FFA released, NE-LEC and NE-TWE presented similar curcumin's bioaccessibility. Both formulations presented high cell viability at all concentrations tested, indicative of low cytotoxicity.

This work contributed to the development of NE with improved curcumin bioaccessibility using only ingredients with GRAS status and to their application in food sector by combining essential data on *in vitro* digestion and safety of different formulations.

Acknowledgements

This study was supported by the Portuguese Foundation for Science and Technology (FCT) under the scope of the Project PTDC/AGR-TEC/5215/2014, the strategic funding of UID/BIO/04469/2019 unit and BioTecNorte operation (NORTE-01-0145-FEDER-000004) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte.

PO59 - 25013 - ENHANCING THE BIOACCESSIBILITY OF CROCINS FROM CROCUS SATIVUS L. BY USING EXCIPIENT EMULSIONS

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Keywords: Crocins, Saffron, Bioaccessibility, Excipient emulsions

Abstract

Crocins are a group of water-soluble apocarotenoids made of various molecules originating from zeaxanthin by enzymatic cleavage; it is the main compounds responsible for the spice colour (ca. 6-16% of the total dry matter). From a chemical point of view, they are glycosides of a C_{20}-dicarboxylic acid, of saffron where glucose, gentibiose and triglucose esterify the end of crocetin. Crocins exert a potent antioxidant ability with antiapoptotic action; moreover, they show therapeutic efficacy on many organs, including the nervous, gastrointestinal, cardiovascular, genital, endocrine and immune systems[1]. Carotenoids in saffron are present in a rigid cell and it is known that the drying influences the release of the compounds by physical damage of the plant tissue.

This study aimed to evaluate the bioaccessibility of crocins from *Crocus sativus* L. stigmas, obtained by different drying treatments (oven, microwave and toasting) and the effect of excipient emulsions upon the *in-vitro* digestion test[2]. The bioaccessibility was thus studied on saffron aqueous extracts in either absence or presence of an excipient oil-in-water emulsions (sunflower oil, WPI: 6 wt%). Crocins fate upon digestion was evaluated by UV-Vis and HPLC-DAD analysis.

Results highlighted that bioaccessibility of crocins in aqueous spice extracts is general very low (ca. 10-12 %) slightly affected by the drying process conditions of saffron. However, presence of the excipient emulsion resulted in a significantly enhanced bioaccessibility in extracts obtained from saffron dried under intense and innovative (microwave) drying conditions, while, on the contrary, reducing it for those obtained under mild drying conditions. Protective effects of the dispersed oil droplets and adsorption phenomena could have limited crocins degradation.

Results of this study could contribute in the design and development of formulated functional and nutraceutical food products.

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PO60 - 25004 - LIPID-BASED NANOSTRUCTURES AS STRATEGIES TO ENHANCE CURCUMIN'S BIOAVAILABILITY: EFFECT OF CARRIER OIL PHYSICAL STATE

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Keywords: Solid Lipid Nanoparticles, Nanoemulsions, Nanostructured Lipid Carriers, Static *in vitro* digestion

Abstract

Curcumin, a lipophilic compound derived from turmeric, is attacking considerable attention in food science due to its wide range of health-promoting functions, such as anti-inflammatory, anticarcinogenic and antioxidant activities. However, its health benefits are limited by its poor solubility in aqueous media, low bioavailability and quick degradation in aqueous solutions. Nano-based delivery systems can be a strategy to overcome some of these issues, increasing curcumin's stability and solubility in aqueous solutions and enhancing curcumin's permeability in the human body.

In this context, three formulations of lipid-based nanostructures (i.e. nanoemulsions (NE), solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC)) with the carrier oil at different physical states (i.e. liquid, solid and liquid/solid mixture, respectively) have been tested as strategies to enhance the bioavailability of curcumin. These lipid-based nanostructures have been submitted to the *in vitro* harmonized static digestion and their cytotoxicity and cellular uptake were evaluated using the Caco-2 cell line.

All nanostructures presented some instability at gastric phase, however NE presented the highest increase of particle size while SLN and NLC exhibited similar values. NE showed the highest values of curcumin's bioaccessibility and stability, while SLN presented the lowest values. SLN and NLC presented similar values of FFA released while NE presented the highest values. All nanostructures presented no cytotoxic effects at all concentrations tested, and SLN showed to cross the cellular layer more easily. Therefore, it can be concluded that the physical state of the carrier oil exhibited a high influence on the behavior of particles during digestion process and on cellular permeability.

This work contributes to the development of nanostructures with improved bioavailability and on their application in food sector by gathering fundamental data on digestion, absorption and safety of different nanostructures.

Acknowledgements

This study was supported by the Portuguese Foundation for Science and Technology (FCT) under the scope of the Project PTDC/AGR-TEC/5215/2014, the strategic funding of UID/BIO/04469/2019 unit and BioTecNorte operation (NORTE-01-0145-FEDER-000004) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte.

PO120 - 25863 - WATER ACTIVITY AND GLASS TRANSITION OF FOOD PROTEIN STUDIED BY INELASTIC NEUTRON SCATTERING AND MOLECULAR DYNAMICS SIMULATION

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Keywords: Water activity, Glass transition, Water mobility, Inelastic neutron scattering, Molecular dynamics simulation

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Abstract

Water activity (Aw) and glass transition are important parameters to predict the physical property and quality of food. These thermal and mechanical properties in macroscale are related to the water mobility and hydration structure in food in nano-scale. Thus, it is essential to elucidate the interaction of water with food ingredients in food design.
We studied the water mobility and hydrogen-bond network structure of hydration water in food protein as a function of water activity and temperature by Inelastic Neutron Scattering (INS) and Molecular Dynamics (MD) simulation, and then elucidated how the water states (mobility and structure) are changed with increasing water activity or across the glass transition temperature.
INS was used to examine water mobility and glass transition of amorphous in nano-scale, such as diffusion and relaxation processes[1]. It is also advantageous when examining water mobility because the food ingredients and water can be selectively observed by the isotope effect[2]. MD simulation was used to examine molecular structure and its dynamics with atomic resolution[2].
Water sorption isotherm of freeze dried protein was obtained using the static saturated salt solution method. The glass transition was observed above Aw = 0.8. It was found that water mobility was slowed down and spatially restricted by the interaction with the protein in glassy state, while translational diffusion of water was activated in rubber state. Hydration water network via hydrogen bond are formed with increasing water activity, and the percolation transition of the network was observed at Aw = 0.8.
Water mobility and hydration structure are coupled with each other, and these are correlated with water activity and glass transition.

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Acknowledgements

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PO124 -25888 - IN VITRO DIGESTION OF GRAPE POMACE EXTRACT: BIOACCESSIBILITY OF PHENOLIC COMPOUNDS AND IMPACT ON HUMAN GUT MICROBIOTA

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Keywords: Grape pomace, *In vitro* digestion, Bioaccessibility, Phenolic compounds, Metabolic activity, Microbiota

Abstract

Alicante Bouschet (*Vitis vinifera* L.) is a grape cultivar that has been used for the production of wines in the Brazilian semi-arid region. This activity generates many residues, still rich in phenolic compounds. In this work, a concentrated liquid extract was obtained from Alicante Bouschet grape pomace and the phenolic compounds bioaccessibility was determined. An *in vitro* static model was used to evaluate the influence of the extract on the metabolic activity of the intestinal microbiota. Phenolic compounds were analyzed by high performance liquid chromatography with diode array detection (HPLC-DAD) in the crude extract and after oral, gastric and intestinal digestion and colonic fermentation. Effects of the extract upon major microorganisms of the human microbiota (*Lactobacillus* spp., *Bifidobacterium* spp., *Clostridium* spp. and total coliforms) were monitored over 24 h using plate count techniques. The fermentative activity was evaluated by short chain fatty acids production using gas chromatography with flame ionization detection (GC-FID), and by proteolytic activity according to ammonium ion production. Results showed a low bioaccessibility of anthocyanins and flavanols (23% and 25%, respectively), after *in vitro* digestion; and high bioaccessibility of phenolic acids (> 100%) after *in vitro* intestinal digestion and colonic fermentation. Although 24 h of in vitro colonic fermentation were not enough to stimulate the microbiota growth, acetic (16.7 mmol.L^{-1}), propionic (0.87 mmol.L^{-1}) and butyric (traces) acids were detected in the fermented extract. Propionic and butyric acids were only detected after the extract fermentation. Ammonium production was low (10.05 mg NH_4^+. L^{-1}) after 24 h and there were no significant difference (p > 0.05) in relation to the initial time (12.60 mg NH_4^+. L^{-1}). This suggests that the grape pomace extract favored the metabolic activity of the intestinal microorganisms and therefore, has a potential prebiotic effect for the long-term modulation of the microbiota.

Acknowledgements

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PO127 - 25909 - COLLOIDAL STABILITY AND LIPID OXIDATION OF OIL-IN-WATER EMULSIONS CONTAINING AVOCADO PEEL AND SEED EXTRACTS

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Keywords : Phenolic compounds, Antioxidants, Food emulsions

Abstract

The peel and seed from avocado fruit are important sources of phenolic compounds (PC), usually discarded during its processing. PC have hydrophilic hydroxyl groups and hydrophobic aromatic rings, thus conferring them surface active properties. Therefore, they may affect the formation and stability of emulsions and act as interfacial antioxidants against lipid oxidation. Thus, the aim of this study was to evaluate the effect of PC extracts from avocado peel (AP) and seed (AS) on the colloidal (particle size and distribution) and lipid oxidative (peroxide value and TBARS) stability of oil-in-water (O/W) emulsions stabilized with Tween 80 (T80) or low methoxyl pectin (LMP) during storage. On the one hand, emulsions with T80 had a lower particle size (around 0.5 µm) and narrower particle size distribution (between 0.2 and 0.8 µm) compared to emulsions with LMP (around 4 µm and a distribution between 1 and 10 µm). Nonetheless, O/W emulsions stabilized with LMP together with AP or AS extracts had a smaller droplet size (1.45±0.10 and 1.12±0.03 µm, respectively) and narrower distribution (between 1 and 5 µm), and remained stable during at least 50 days of storage. Conversely, emulsions with T80 in presence of AP or AS extracts showed poor stability over time, with a 7-fold particle size increase after 15 days. On the other hand, the presence of AP and AS extracts reduced lipid oxidation in emulsions, especially in those stabilized with LMP, which showed lower hydroperoxide values in comparison with T80-stabilized emulsions. However, no differences in TBARS formation were observed in emulsions using T80 or LMP when AP and AS extracts were added. Hence, phenolic-rich extracts from avocado residues present interfacial activity influencing the stability of O/W emulsions and reducing their lipid oxidation, thus showing potential to be used as additives in emulsion-based foods.

Acknowledgements

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SESSION 3: HEALTHY FOOD DESIGN: IS MULTI-FUNCTIONALITY THE RIGHT WAY FORWARD?


8th International Symposium on
"Delivery of Functionality in Complex Food Systems"
7 - 10 July, 2019 | Sheraton Porto Hotel Conference Centre

KEYNOTES

21373 - THE MODULATION OF SERUM TAG LEVELS IN HUMANS USING ETHYLCELLULOSE OLEOGELS

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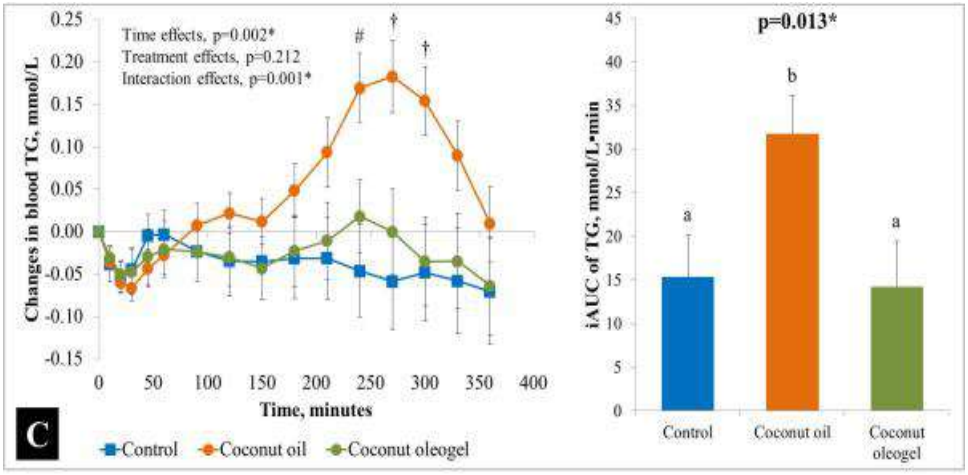
Keywords: Oleogels, Bioaccessibility, Beta carotene, Fat digestibility, Triglyceride lowering, Lipolysis

Abstract

Ethylcellulose oleogels of vegetable oils were used to restrict the ability of pancreatic lipase to digest the gelled oils. A reduction in triglyceride hydrolysis was demonstrated in vitro and was correlated to the molecular weight of the ethylcellulose used rather than concentration. Various oils where then gelled and fed to humans subjects in a feeding trial. The gelling of coconut oil did not affect cholesterol levels or inflammatory response upon ingestion. However, post-prandial serum TAG levels were strongly affected by the gelling of the oil. The characteristic peak in serum TAG concentration was almost completely absent when the coconut oil was gelled in 45cP ethylcellulose. These results suggest that judicious design of the physical matrix that contains a macronutrient such as fat could be used to control the lipidemic index of a particular food. Elevated TAG levels are associated with and increased risk of coronary heart disease. Here we present a simple but effective strategy to mitigate high serum TAG levels after consumption of a fatty meal. One could envision the possibility of designing foods with specified rates of macronutrient release to optimize nutrition but minimize any deleterious effects to health.



Acknowledgements

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25024 - TUNING CARBOHYDRATES FOR FOOD FUNCTIONALITY: CONSUMER APPEAL, HEALTH AND SUSTAINABILITY

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Keywords: Carbohydrate, Process, Sensory, DSC, X-ray diffraction, Pasta analogues, Rheology, Glycemic index

Abstract

Whereas diets high in protein have attracted wide attention and a major focus in food science and technology is on the development of plant-based high protein foods, such as meat analogues, the reputation of carbohydrates as healthy nutrients has suffered. The consumption of excess carbohydrates, in particular sugar, has been implied in obesity and in a range of chronic diet-related illnesses. Notwithstanding, carbohydrates are an integral part of our diet. In particular complex carbohydrates fulfill important roles in supplying energy to the body while minimizing the glycemic index of foods.

In this lecture, I will first briefly review the nutritional status of carbohydrates as part of the human diet and then discuss the emerging appeal of several classes of novel carbohydrate-based foods. I will then show how carbohydrate functionality can be optimized to create these novel types of foods that fit in a healthy and sustainable lifestyle and that will still meet the high demands for consumer appeal. Specifically, I will discuss the following cases:

1. Impact of the physical state of sugar on sweetness perception in baked goods: minimal sugar for maximum sweetness[1].
2. Starch functionality in sustainable high-protein foods: the case of pasta analogues.
3. Carbohydrate rheology close to the glass transition temperature: texturization of foods[2].
4. Delivery of micronutrients in carbohydrate-based delivery systems[3].

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25933 - HOW TO DESIGN HEALTHY AND SUSTAINABLE FOOD SYSTEMS?

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Abstract

How to change the current unhealthy, environmentally unsustainable consumption patterns? With respect to food losses, how can e.g. profit or discount measures be utilized for food discarded in retail shops? In what way can legislation, taxes, incentives and (welfare) services be changed to reduce huge nutrition-related costs? How could we move to real product prices including environmental burdens? Which alternative scenarios could be imagined like giving discarded, but safe and healthy, food to homeless people? …
The overall question that we pose is how to move from a cost-driven to a multi-quality-driven food system approach based on circularity including health and socio-economics. We will try to answer by identifying the research gaps which could be addressed and what research is the most needed to cope these gaps.

ORAL COMMUNICATIONS

OC34 - 24906 - DESIGNING EMULSIONS WITH ENCAPSULATED BIOACTIVE SUBSTANCES FOR THE FORMULATIONS FOR DYSPHAGIA DIETS OF ELDERLY

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Keywords: Chokeberry, Emulsion, Dysphagia, Encapsulation, Elderly

Abstract

Dysphagia is a disorder of the swallowing mechanism that is most common for elderly. Providing food products for the people with this disorder the appropriate rheological properties, nutritional value as well as acceptable sensory characteristics is of great importance. The main goal of this study was to obtain water in oil in water (W/O/W) emulsion, which could be used for the delivery of bioactive substances in the formulations for dysphagia diets.

W/O/W emulsion was formulated with black chokeberry extract, zinc, selenium and vitamins C, B_9 and B_{12}, in the inner aqueous phase of emulsion. Hydrophobic vitamins A and D_3 were added into the oil phase of emulsion. W/O/W emulsion exhibited typical non-Newtonian behaviour (n value – 0.167) and attributed to the "honey-thick" category (351 – 1750 cP) according to National Dysphagia Diet guideline classification. It showed high creaming and thermal stability for two weeks of storage at 8 ^{o}C and high encapsulation efficiency of vitamis and black chokeberry extract (85 – 97 %).

Emulsion was subjected to a static in vitro digestion (Minekus et al., 2014) consisting on a gastric and small intestinal phase. The intensive release of vitamins (95.8 -100 %) was observed after the intestinal phase of digestion. Whilst the major part (50.2 – 70.1%) of vitamins A, D and C were released during the gastric stage of digestion. The release kinetics of bioactives contained in the black chokeberry extract was monitored by release of anthocyanins. Only 15.7% of cianidin-3-galaktoside and 16.8% of cianidin-3-arabinoside were found after the intestinal stage of digestion.

The study demonstrated that W/O/W emulsion with encapsulated bioactive substances could be successfully used for the formulations for elderly people diet. Such encapsulation system facilitates dosing of the required components and ensure better intestinal intake of necessary minerals, vitamins and bioactive ingredients.

Acknowledgements

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OC35 – 24867 - THE BEHAVIOUR OF SUNFLOWER OLEOSOMES AT THE INTERFACES

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Keywords: oleosomes, emulsions, natural emulsions, biomimetic, oil bodies

Abstract

The safe storage of oil and its arduous mixing with hydrophilic systems has been resolved by nature with organelles called oleosomes (or oil bodies). Oleosomes are natural particles equipped with a sophisticated membrane, comprising a continuous monolayer of phospholipids and hydrophobic proteins, which cover the triglyceride core and grant them extreme physical and chemical stability. The noteworthy qualities of oleosomes have attracted strong interest for their incorporation in emulsion formulations, however, little is known about their emulsifying properties and their behaviour on interfaces. For these reasons, oleosomes were isolated from sunflower seeds (96.2 wt% oil, 3.1 wt% protein) and used as an emulsifier for the stabilization of O/W and W/O interfaces. In both cases, oleosomes showed high interfacial and emulsifying activity. Individual oleosome particles had a broad size distribution from 0.4 to 10.0 µm and it was observed that the membrane of the larger oil bodies (>1-5µm) was disrupted and its fractions participated in the in newly formed interface. Oleosomes with a smaller diameter (< 1µm) were resilient during the mild emulsification as a great number of them was present in the emulsions especially on the interface of the emulsion droplets. This phenomenon was more pronounced for the W/O interface where oleosomes were absorbed intact in a manner similar to Pickering mechanism. However, when the triglycerides were removed from the core of oil bodies in order to focus more on the effect of the membrane, the remaining material formed sub-micron spherical particles, which clearly acted as Pickering stabilisers. These findings showcase the intriguing behaviour of oleosomes upon emulsification, especially the crucial role of their membrane. The study demonstrates relevance for future applications where immiscible liquid phases are present.

OC36 - 24908 - WHAT WE CAN LEARN ABOUT THE STRUCTURE OF CASEIN MICELLES BY USING THEM AS NANOCARRIERS

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Keywords: Casein micelle, Lysozyme, Linoleic acid

Abstract

Casein micelles are natural transport vehicles in milk enabling the nutrition of newborns. Though they are widely known as nanocarriers for bioactive substances, their precise structure is still under scientific debate. Therefore, the aim of our studies is to use loading experiments not just for developing of new nanocarrier strategies, but also to obtain insights into the micellar structure.

Hence, we studied the influence of pH and temperature on the casein micelle structure as well as on the efficiency of loading. Especially β-casein depletion as a result of cooling was expected as a potential option for high loading efficiency with hydrophobic substances. For this, lysozyme and linoleic acid were used as guest molecules binding predominantly via electrostatic or hydrophobic interactions. Micelle size and surface appearance were analyzed via dynamic light scattering and scanning electron microscopy. Loading efficiency was evaluated by quantifying lysozyme (RP-HPLC-UV, in-vivo and in-vitro activity test) and linoleic acid (GC-FID). Concentrations of individual caseins within casein micelles gave additional information about the incorporation process and were analyzed via RP-HPLC-UV.

Our results showed that increasing pH induces a swelling of casein micelles, which offers a novel loading strategy for positively charged substances like lysozyme[1]. The alkali-swollen micelles were able to incorporate more lysozyme than at natural pH, while bactericidal activity remained. Cooling to 5 °C induced a pronounced depletion of β-casein, but did not improve the loading capacity for linoleic acid. Incubation of casein micelles with linoleic acid also displaced micellar β-casein whereas micelle structure remained intact.

In conclusion, our studies offered a novel strategy to load positively charged substances into casein micelles by varying pH value. Additionally, the loading experiments gave information about casein micelle structure which let us speculate about a new structure model.

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Acknowledgements

We thank Prof. Dr. Michael Mertig, Chair of Physical Chemistry, Measurement and Sensor Technology, TU Dresden, for permission to utilize their ultracentrifuge, the Institute of Inorganic Chemistry I, TU Dresden, for performing the supercritical point drying and the Institute of Inorganic Chemistry II, TU Dresden, for organizing scanning electron microscopy.

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OC37 - 24714 - MORPHOLOGICAL AND RHEOLOGICAL CHARACTERIZATION OF EMULSION-FILLED COMPOSITE GELS OF WHEY PROTEIN ISOLATE AND SOY PROTEIN ISOLATE

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Keywords: Soy protein isolate, Whey protein isolate, Gelation, Composite gels

Abstract

Animal proteins, such as milk proteins, are the most commonly used proteins in food. However, due to their increasing cost and to changes in the consumers´ preferences and needs, the interest in using plant proteins as partial replacers of animal proteins has been increased. However, replacing one protein by another leads to protein matrices with different structural characteristics, such as rheology, compared to the original formulations composed of only one type of protein. Gels combining animal and plant proteins can be named *composite gels*. This study aimed to investigate the influence of the combining whey protein isolate (WPI) with soy protein isolate (SPI) to produce an emulsion-filled composite gel. The emulsions were produced with palm stearin as lipid phase (5% w/w) and WPI (5% w/w) as surfactant by high shear homogenization. The gels were produced with different ratios SPI:WPI (0:1, 1:3, 1:1, 3:1 and 1:0), both as non-filled (without emulsions) and filled-gels (aqueous phase replaced by emulsion). The total protein concentration was 15% (w/w), and the gels were prepared at pH 7.0 and using NaCl 0.1 M. The protein mixtures were heated at 95 °C for 30 min. The resulting gels were characterized by water holding capacity, confocal laser scanning microscopy, mechanical uniaxial compression and small deformation rheology. Water holding capacity was higher in the filled gels when compared to non-filled gels. The uniaxial compression data indicated the droplets act as active fillers in the structure, reinforcing them significantly in comparison to non-filled gels. The temperature sweep measurements indicated the formation of the protein network of the composite gels is driven by the formation of the WPI network. The SPI network is, actually, formed by “entlaged” agglomerates of the soy proteins, due to their higher insolubility, a fact confirmed by the confocal laser scanning microscopy results.

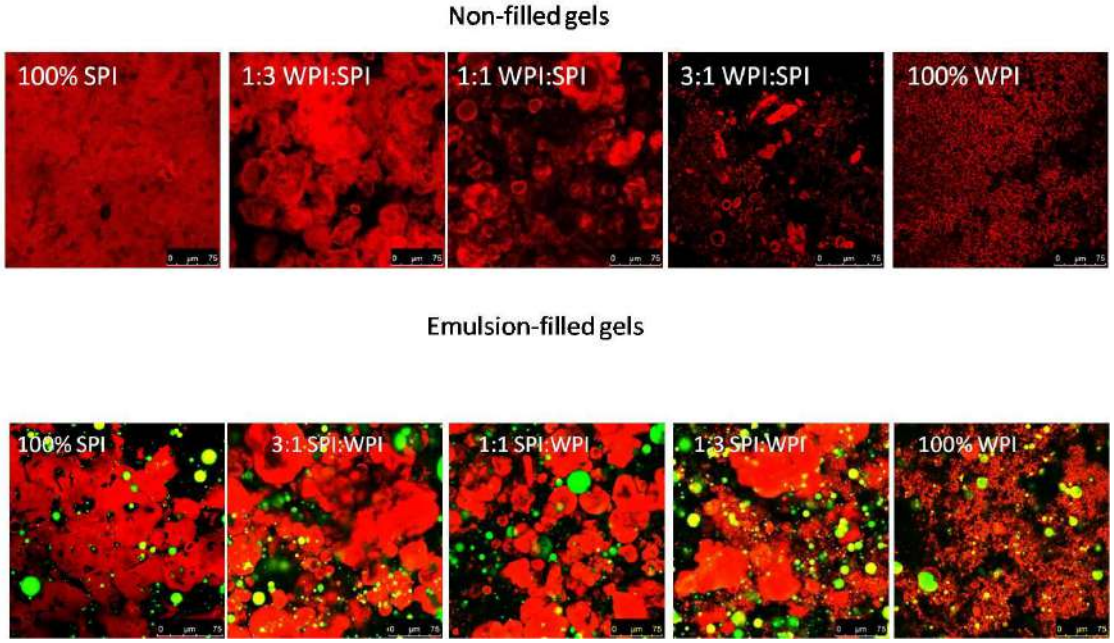
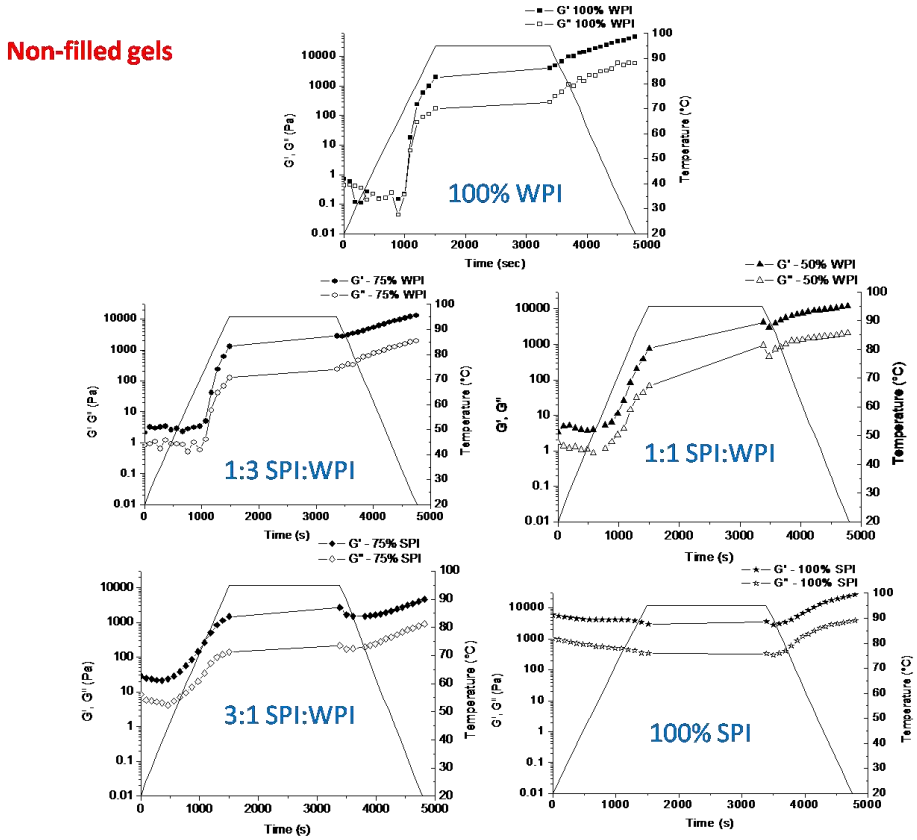


Figure 1. Micrographs obtained by confocal laser scanning microscopy of non-filled and emulsion-filled composite gels of WPI and SPI.



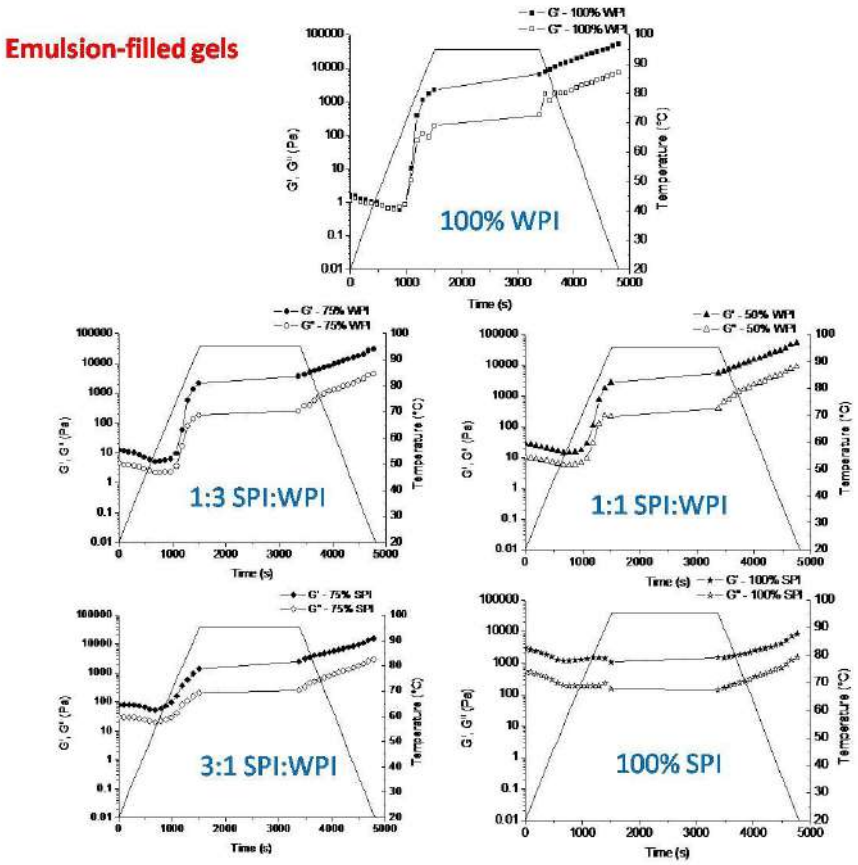


Figure 2. Temperature sweep tests for non-filled and emulsion-filled composite gels of WPI and SPI.

Acknowledgements

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OC38 - 24890 - CHAMBER DESIGN FOR TIME-LAPSE OPTICAL MICROSCOPY OF GELATINISATION AND DIGESTION OF STARCH INSIDE PLANT CELLS

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Keywords: Cotyledon cells, Time-lapse microscopy, Starch digestion, Gelatinisation, Flow chamber

Abstract

A cooking and digestion chamber was developed as an instrument for time-lapse optical microscopy of individual food particles. The instrument observed the same food particles through each stage of simulated hydrothermal processing, followed by *in vitro* gastrointestinal digestion. Instrument capabilities quantified the cooking and digestion dynamics of starch trapped inside isolated cotyledon cells from navy beans. The cells, contained within the chamber, were heated in water to 90°C at a rate of ~ 6.2 °C/min and held at 90 °C for a total cooking time of ~ 20 min. The cooked cells were subsequently subjected to pepsin, pH 1.2, 37 °C, 30 min (to simulate gastric digestion) and pancreatin, pH 6.8, 37 °C, 120 min (to simulate small intestine digestion). Little or no cell expansion was observed, and the cells remained intact, i.e., the cell walls showed no signs of rupture, throughout the entire process. In contrast, intracellular starch granules partially swelled and gelatinised, and the relative granule area increased by approximately 2.4 times at the end of cooking. No apparent changes were observed in starch during the gastric digestion. During the small intestinal digestion, cellular contents were observed to apparently "shrink" radially inwards towards the centre of the cells, implying that starch hydrolysis by pancreatic α-amylase had occurred inside the cells. Quantitative image analysis showed that the cells underwent amylolysis of cellular contents at different rates. We hypothesized that the different rates of amylolysis could be attributed to microstructural and compositional differences between individual cells. This finding demonstrates that our new technique allows quantitative characterisation of the gelatinisation and digestion properties of starch inside plant cells at the single-cell level and may be used to test mechanistic hypotheses.

Acknowledgements

This work is a result of a collaboration between Riddet Institute at Massey University (Palmerston North, New Zealand) and Faculty of Land and Food Systems at University of British Columbia (Vancouver, BC, Canada). The authors would like to acknowledge the Riddet Institute Overseas Placement Award for providing research funding.

OC39 – 24913 - FROM PLANT TISSUE MICROSTRUCTURE TO NEW FOODS WITH NOVEL SENSORY PERCEPTIONS. AN EXAMPLE OF BIOMIMETICS OF FOOD MEDIATED BY 3D PRINTING

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Keywords: 3D printing, Microstructure, Xray microtomography, Novel texture perception

Abstract

Food mimicking means the creation of a completely new type of foods with improved and/or desired/customized sensory and functional properties being inspired by their originals in nature. This invokes new knowledge at fundamental level of the structure-functionality relationships of food at different spatial dimensions, from the nano- to the macroscale, and will allow to produce foods with completely new properties, including personalized foods. We have dedicated a series of experiments to underpin the huge number of potential applications of food biomimetics. Our work aims to create novel sensory perceptions, mainly texture, by mimicking the 3D architecture of edible plant tissues. The workflow includes X-ray microtomography of some fruit and vegetables (apple, pear, etc.) as input data for the new products. Each image slice, along the *z*-direction, exhibits a unique microstructure according to their internal architecture. From the stack of X-ray CT image slices some selected image slices are used to obtain a 3D model easy to be used in 3D printing process. The 3D model is rescaled from mm to mm to keep the morphology of pores and solid elements intact. Finally, by using a commercial 3D printer, printing variables (layer height, nozzle size, print speed, etc.) have been adapted to print thin cereal-based 3D structures inspired by microstructure of the plant tissues. Finally, after cooking in an ordinary oven, these new 3D food structures have been stacked in different number and order by combining the diversity in microstructure and thickness with the main goal to create multi-layered food with innovative sensory properties.

OC40 – 24935 - INTERFACIAL PROPERTIES OF POTATO PEPTIDES IDENTIFIED BY BIOINFORMATICS: APPLICATION IN OMEGA-3 DELIVERY EMULSIONS

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Keywords: Fish oil-in-water emulsions, Synthetic peptides, Interfacial tension, Synchrotron Radiation Circular Dichroism, Physical stability, Oxidative stability

Abstract

Bioinformatics was used to identify emulsifying peptides embedded within the structure of potato protein. This reduced time and cost of extensive screening hydrolysis processes. Up to 40 synthetic peptides having between 10 and 29 amino acids, different net charge and potential different conformation at the interface (e.g. a-helix, b-sheet and unordered) were tested in this study. First, interfacial tension measurements and evaluation of the physical stability of 5wt.% fish oil-in-water emulsions (e.g. zeta potential, droplet size during storage) were carried out in order to select the best performing peptides. Secondly, Synchrotron Radiation Circular Dichroism (SRCD) was used to study the conformation at the oil/water interface of the selected peptides. Finally, the oxidative stability of fish oil-in-water emulsions stabilized with the selected peptides was evaluated by using Electron Spin Resonance (ESR) and determination of hydroperoxides and secondary volatile oxidation products.
The results indicated that up to five peptides showed similar or superior emulsifying activity when compared to sodium caseinate (e.g. based on interfacial tension measurements and droplet size of the emulsions). Thus, this work shows the feasibility of using bioinformatics to identify plant-based emulsifiers embedded in potato protein, which could be employed to stabilize omega-3 delivery emulsions.

Acknowledgements
This work was supported by Innovation Fund Denmark (PROVIDE project: Protein valorization through informatics, hydrolysis, and separation).

OC41 – 24944 - PRODUCTION OF WHEY PROTEIN NANOPARTICLES BY HEAT INDUCED AGGREGATION AND THEIR POTENTIAL FOR THE ENCAPSULATION OF FOOD BIOACTIVES

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Keywords: b-lactoglobulin, nanoparticles, heat induced aggregation, caffeine, resveratrol, encapsulation

Abstract

Food protein-based nanoparticles are of great interest for their application to food bioactives because they are Generally Recognised as Safe (GRAS). In particular, b-lactoglubulin (β-Lg) is able to aggregate forming nanoparticles which have been applied to the encapsulation of a range of bioactives. However, the complexity of some of the methods hinders their industrial application. The aim of the present work is to present an overview of our last work on the heat induced aggregation of whey proteins for the production of nanoparticles and their application to the encapsulation of a range of bioactives. Nanoparticles of β-Lg (average diameter 200-300) were obtained at high yield of aggregation (>93%) and with colloidal stability at optimum conditions (pH 6; heating at 75 ^{o}C for 45 mins). Nanoparticles characterisation by a range of techniques including fluorescence, DLS and microscopy in combination with the measurement of their stability to buffers led to an improved insight of their formation and their microstructure[1]. The investigation of their application to caffeine revealed that caffeine complexation with denatured protein followed a Langmuir isotherm. Nanoparticles fully degraded at simulated gastric conditions however, only 36% of the caffeine was released at these conditions while full release occurred at intestinal conditions. Furthermore, their application to encapsulation of resveratrol showed that b-Lg both, in native and nanoparticle form, had a protective effect against heat induced loss of antioxidant activity of resveratrol[2]. These findings are very relevant for the optimum processing and formulation of resveratrol.

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OC42 – 24898 - ULTRAFINE WHEY PROTEIN PARTICLES AS NOVEL DELIVERY SYSTEMS FOR OPTICALLY CLEAR FOODS AND BEVERAGES: PREPARATION, CHARACTERIZATION AND POTENTIAL FOR ENCAPSULATION OF BIOACTIVES

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Keywords: Whey protein isolate nanoparticles, Optically transparent delivery systems, Liquid antisolvent precipitation

Abstract

Whey protein (WP)-based nanoparticles have already been used in a variety of food-related applications, ranging from encapsulation of bioactives[1] to stabilization of foams and emulsions[2]. To date, however, their applicability in optically clear water-based food products is limited, since specific particle properties in terms of size and stability against disintegration are required. An efficient and economically viable approach to produce ultrafine and colloidally stable WP particles without compromising their functional attributes is therefore needed.

In this study, WP nanoparticles were produced using liquid antisolvent precipitation (LAS) prior to being treated with food-grade aldehydes or being exposed to elevated temperatures. These novel structures were characterized in terms of their size (distribution), surface charge and stability under conditions relevant for food processing and storage. In addition, their encapsulation potential for anthocyanins and resveratrol was studied.

The optimized particle production method allowed to very quickly and reproducibly form ultrafine ($d < 60$ nm) and electrostatically stable (z-potential > 30 mV) WP nanostructures. Furthermore, when subjected to a specific thermal (60 °C / 30 min) or food-grade aldehyde (7.5 mM vanillin) treatment, the particles' stability against (thermal) disintegration in aqueous and, to a lesser extent, acidified media was increased. The treated particles showed promising encapsulation potential for bioactive polyphenols, although the retention of water-soluble molecules such as anthocyanins was found to be less efficient in aqueous media.

LAS followed by a temperature or vanillin treatment proved to be a simple yet effective method to produce ultrafine and colloidally stable WP particles. These novel structures are promising encapsulation vehicles for bioactives, which makes them suitable for commercial application as functional ingredients in a range of optically clear food products.

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Acknowledgements

J. Boeve gratefully acknowledges the financial support from the Research Foundation – Flanders (FWO, Brussels, Belgium, project 151595).

OC43 - 24866 - ANALYTICAL INVESTIGATION OF THE THREE INTERFACIAL STABILIZATION STAGES OF β-LACTOGLOBULIN

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Keywords: Interfacial stabilization process, Pendant drop, Interfacial shear and dilatational rheology, β-lactoglobulin

Abstract

The stability and properties of protein-stabilized emulsions depend on the three stages of the interfacial stabilization; migration of proteins to the oil/water-interface (I), adsorption process (II), and interfacial film formation (III). Current research often focuses only on one stage and therefore does not provide a complete characterization of the interfacial stabilization process. The aim of this study was the characterization of all three stages of the interfacial stabilization process of the model protein β-lactoglobulin in respect to molecular properties such as conformational state and charge. For this purpose, we determined the migration through bulk phase (I) and adsorption rate (II) by pendant drop analysis as well as the protein film formation (III) by interfacial rheology of 0.1 wt% β-lactoglobulin at varying pH and ionic strength (pH 7, pH 9 and pH 7_{NaCl} containing 0.1 M NaCl). Additionally, the preoccupation level of the oil/water-interface with protein was varied for stage (I) and (II). Our results indicated that electrostatic and steric interactions determine the interfacial stabilization process as follows: β-lactoglobulin absorbed slower at pH 7 due to dense, electrostatic shielded molecules at pH 7_{NaCl} and due to electrostatic repulsion and increased hydrophobicity at pH 9. The higher the preoccupation level, the slower was the interfacial stabilization process. Interfacial shear and dilatational rheology of β-lactoglobulin at pH 7 showed similar trends for the film formation and viscoelastic properties at pH 9. The linear viscoelastic region appeared to be shorter and Lissajou-Plots showed a higher included area indicating a more viscous behavior at pH 9 and pH 7_{NaCl} than at pH 7. Our results contribute to a better mechanistic understanding of the interfacial stabilization process of proteins at oil/water-interfaces and enable the evaluation of emulsions regarding stable products with tailored properties.

Acknowledgements
This work is supported by the German Research Foundation Priority Program 1934 „DispBiotech“.

OC44 – 24893 - IMPROVING COLLOIDAL STABILITY OF HEMP GLOBULINS BY MAKING HEMP-CASEIN PROTEIN NANOPARTICLES WITH A PH CYCLING METHOD

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Keywords: Hemp protein, Caseins, Solubility, Colloidal stability, Protein-Protein interactions

Abstract

Hemp (Cannabis sativa L.) seed contains high-quality storage proteins (mainly globulins) that are easily digested. However, hemp globulins are extremely insoluble in water and are only soluble in salt solutions, which limits the use of hemp protein in many food systems. The aim of this study is to improve the solubility in water by making colloidally stable protein complexes between hemp protein and sodium caseinate (a mixture of four milk casein proteins) formed by globulin-caseins interactions through a pH cycling method. The dispersions of hemp globulin (1%) and sodium caseinate (0 – 2 %) were adjusted to pH 12 and reacted for 1 h. The dispersion was then neutralised to pH 7; the final ionic strength was adjusted to 35 mM. Monodisperse protein complexes with z-average diameter of approximately 100 nm were formed after this pH cycling treatment. The proportion of hemp globulins that were colloidally stable (measured after centrifugation, 10,000×g, 10min) increased dramatically from 3% to above 85% when there was more than 1% sodium caseinate. These complexes had zeta-potentials of approximately -18 mV, which was not enough to solely stabilise the colloidal complexes, so other interactions such as steric effects of caseins may also contribute to the colloidal stability. Globulin and caseins seem to be interacted via hydrogen bonds because the size of complexes decreased with temperature (from 25 to 70 °C) or after adding urea. The heat stability of the complexes was determined after heating at 90 °C for 30 min. The results showed the particle diameter increased from 110 nm to 220 nm, suggesting aggregation via disulphide linkages. No precipitation occurred after the heat treatment, while hemp globulins precipitated when heated alone. These protein complexes had high colloidal stability and may be used to increase the protein content of other non-soluble seed globulin proteins in beverages.

OC45 – 24885 - UNDERSTANDING THE AIR-WATER INTERFACIAL CHARACTERISTICS OF WHEAT GLIADIN BASED NANOPARTICLES

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Keywords: Foam, Gliadin nanoparticles, Air-water interface

Abstract

Plant proteins mostly have foaming properties inferior to those of animal proteins which is often due to the low water solubility of the former. A prime example of such water-insoluble proteins are gliadins, the prolamins of wheat and a major constituent of commercially available wheat gluten. Plant protein production is generally cheaper and has a lower environmental impact than that of animal protein. Novel strategies to improve the functionality of plant proteins are thus required. It has long been known that inorganic, solid particles can stabilize air-water and oil-water interfaces via a Pickering-type stabilization. However, it largely remains to be investigated to what extent protein based nano-sized aggregates exert a similar effect. Indeed, the mechanism of air-water interfacial stabilization of such particles has not yet been investigated. Here, gliadin based nanoparticles (GNP) were produced by means of anti-solvent precipitation and their air-water interfacial characteristics were thoroughly investigated. At pH 6.0, which is close to the point-of-zero-charge of gliadins, a GNP suspension displayed excellent foam stability, as assessed by a standardized stirring test. In contrast, the same GNPs at pH 4.5 had very low foam stability. Interfacial dilatational rheological rheology measurements showed that at pH 6.0 adsorbed protein films with very high surface dilatational moduli (E) were obtained, while at pH 4.5 adsorbed films had very low E. Moreover, intermolecular disulfide cross-links were formed upon adsorption of GNP at the air-water interface at pH 6.0, but to a much lesser extent at pH 4.5. Furthermore, cryo-SEM imaging of GNP-stabilized foams suggested that adsorbed GNPs at pH 4.5 retain their particulate nature, while at pH 6.0, a more smooth film is observed at the interface. It thus seems that to efficiently stabilize air-water interfaces, GNP need to spread out, mutually interact (covalently) and form an adsorbed protein film with high E values.

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W.K. Kellogg Chair in Cereal Science and Nutrition at KU Leuven. This work is part of the Methusalem program “Food for the Future” at KU Leuven.

OC46 - 24899 - FOOD PEPTIDE GELS AS DELIVERY VEHICLES PART 2: THE CASE OF A-CASEIN

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Keywords: Self-assembling peptide, Bioactive peptide, Peptide gel, Oral delivery

Abstract

Self-assembling peptides represent a fruitful source for biotechnology innovation, especially in the area of drug delivery. Bioactive peptides extracted from proteins able to form a gel used as a delivery vehicle are economically attractive. In our previous work, b-casein was investigated for its potential to contain a peptide that is both antioxidant and theoretically able to self-assemble into a gel structure.
The aim of our study was to assess the potential of a-casein as a source of novel nanostructures for oral delivery.
1. Evaluating gelling properties - Peptide Cutter[1] and Gel Predictor[2] predictive tools were used to evaluating peptide sequences from the milk protein a-casein to discover peptides with a high probability of anticancer properties and the potential to self-assemble into a self-supporting gel. These gelling properties were tested using a synthetic peptide.
2. Extracting the target peptide - a-casein was subjected to tryptic digestion for 28h. Then, the tryptic digest was subjected to anion exchange chromatography to isolate the target peptide.
3. Assessing gel potential for oral delivery - The potential of the gel for oral delivery was assessed with a simulated *in vitro* gastric/intestinal digestion of the peptide gel obtained from the tryptic digest. Samples were collected at regular intervals and examined by mass spectrometry for identification of the digest and by TEM analysis to evaluate the changes in the gel nanostructure.
The gelling properties of the target peptide were confirmed with a synthetic peptide. The target peptide was successfully isolated from the pure protein with tryptic digestion and fractionated with anion exchange chromatography. We will further present results from the simulated *in vitro* digestions and from detailed analysis based on TEM and mass spectrometry.
Peptides derived from a-casein show significant potential for bioactivity and the ability to self-assemble into gel structures that can be used in oral delivery. Detailed characterisations based

on simulated *in vitro* gastric/intestinal digestion and other methods provide further insight into the potential.

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OC47 - 24905 - THE EFFECT OF PURIFICATION PROCESSES ON THE COMPOSITION AND FUNCTIONALITY OF MILD TO HIGHLY PURIFIED YELLOW PEA FRACTIONS

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Keywords: Plant proteins, Mild processing, Yellow pea, Composition, Functionality

Abstract

Due to an increasing world population and global welfare, there is a growing demand for food and food ingredients produced in a sustainable manner. One of the developments in sustainable food production is the use of mild processing techniques without compromising and possibly even improving ingredient functionality. These developments entail challenges related to fraction complexity, physico-chemical stability and interactions.
This study focuses on the effect of mild aqueous purification processes on the composition and functional behaviour of the resulting fractions. To better understand our starting material yellow pea, its morphology before and after milling was studied using CryoSEM. This technique revealed the distribution of starch granules and protein bodies present in yellow pea. Furthermore, the effect of each processing step after milling of the seed on the composition was determined. The protein content of the mild to highly purified fractions varied from 40 – 85 %. The main impurity in these fractions were carbohydrates The protein and carbohydrate composition was further characterized by electrophoresis and chromatography-based separation techniques.
Solubility of the different fractions was determined, since this property is at the basis of different functional properties. It was found that extended purification resulted in slightly reduced solubility. More pronounced differences were seen after studying the viscosity differences between the highly to mildly purified fractions. Extended purification resulted in a pea protein isolate that showed strong viscosity increase with increasing concentration and shear-thinning behaviour upon increased shear. It was hypothesized that this resulted from protein complex formation. To further explain the differences between mild and extended purification on the viscosity, the effective volume fractions were calculated. Ultimately, a link

was established between purification processes that are typical in aqueous fractionation processes and composition and thickening capacity of the resulting fractions.

OC48 - 24927 - IMPACT OF DEFATTING PROCESS ON THE FOAMING PROPERTIES OF RAPESEED (BRASSICA NAPUS L.) MEAL PROTEINS

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Keywords: Rapeseed meal proteins, Foaming properties, Defatting methods, Protein-lipid interactions

Abstract

After extraction of oil from rapeseed, an important oilseed crop, a protein rich (30 to 50%) meal is obtained. Although rapeseed meal is mostly used as animal feed or fertilizer, its proteins can have potential in the human diet as alternatives for soybean derivatives and other plant and animal protein products. However, the de-oiling process may well affect the structure, composition and techno-functional properties of the rapeseed meal proteins and the remaining lipid population.

In this work, the impact of different defatting processes on the foaming properties of rapeseed proteins was investigated. The defatting methods were hexane partial defatting (HpD), hexane full defatting (HfD), cold-press defatting (CPD) and a combination of cold-press and hexane defatting (CPHD). In a next step, the proteins were extracted from the different defatted meals with water. The protein and lipid composition and yield of each extract were analyzed. The extracts were then diluted to a protein concentration of 0.5% and foaming capacity and stability were evaluated with a standardized whipping method.

The yield of protein extracted with water decreased in the order HfD (39%), CPHD (34%), CPD (28%) and HpD (25%) meals. The extract of the CPD meal showed very poor foaming capacity but high foam stability when compared to the extracts obtained after hexane defatting steps (HpD, HfD and CPHD). The CPD meal had a higher fat content than HfD and CPHD meal which explained its poor foaming capacity. However, while the HpD meal had a higher lipid content and lower foam stability than the CPD meal, it had better foaming capacity. The de-oiling method thus determines the techno-functionality of rapeseed meal. This work provides insights useful in rapeseed meal valorization tracks.

OC49 - 24943 - OPTIMIZATION OF EMULSION GELS AND ITS APPLICATION IN MEAT EMULSION AS FAT REPLACERS

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Keywords: Structured emulsion, Inulin, Healthier meat products, Experimental design

Abstract

Although meat products are important source of proteins, minerals and vitamin B, they have high-fat content (20-30 g/100g of product). Thus, reformulation is necessary and emulsion gel systems offer an innovative strategy in lipid modification of meat products. The aim of the present study was to optimize the formulation of emulsion gels in order to obtain a successful functional ingredient to be used as animal fat replacer in meat products. Soybean oil was used as a lipid phase in emulsion gels (EG). A Plackett-Burman 12 (PB) was applied to 7 independent variables for the elaboration of EG (soy protein isolate (SPI), sodium caseinate (SC), carrageenan (CAR), inulin (INUL), pectin (PEC), sodium tripolyphosphate (ST), and soy lecithin (SL)). Then, three selected factors (%, w/w); SPI, CAR, and INUL were optimized using a central composite rotatable design (CCRD). The responses evaluated in the emulsion gels were: pH, color, water holding capacity (WHC), and rheological properties. pH, color, and emulsion stability in meat emulsion also were measured. In PB design, pH values were influenced by the concentration of CAS, CAR, SL, PEC, and ST. Color parameters were affected by SPI, CAR, and SL concentration, and rheological properties of the EG were mainly affected by SPI, CAR, and ST concentration. CCRD showed that pH values in EG were mainly influenced by CAR and SPI addition. G' values increased in high concentration of SPI, CAR, and INUL. EG with 94% of WHC were obtained. The variation of the pH and color parameters of the gels did not show great influence on the properties of the meat emulsion. This is an important result for the continuation of the study since changes produced after adding the gel to the industrial formulations must be investigating to result in safe, stable and acceptable meat products.

Acknowledgements

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OC50 - 24715 - COMPARING THE METHODS TO PRODUCE FIBROUS MATERIAL FROM ZEIN

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Keywords: Zein, Texture Profile Analysis, Scanning Electron Microscopy

Abstract

Fibrous structures can be desirable in different food products, including meat analogues. One of the barriers to widespread acceptance of increasingly plant-based diets is that many people still desire the sensory qualities of meat. There has been limited success in accurately mimicking meat's characteristic oriented, fibrillar structure, restricting meat analogue products to primarily ground meat applications. To create meat analogues that more closely mimic a steak, fibrous material from plant-based proteins is critical. This work investigates different techniques to form fibrous material from zein, the major storage protein from corn.

Three techniques have been developed to produce fibrous material from zein, either as fibrous masses or individual protein fibres. These techniques are antisolvent precipitation of zein from ethanol using water, mechanical elongation of self assembled zein networks, and electrospinning zein polymer solutions. Comparison of the fibres was carried out using scanning electron microscopy, texture profile analysis of the fibres within tofu-style soy gels, and rheological analysis. It was determined that different advantages exist for each method. Electrospinning produces individual fibres that are of the smallest scale (1-2 µm in diameter). Antisolvent precipitation is the most rapid method, producing a web-like, fibrous network. Finally, mechanical elongation facilitates formation of an oriented fibrous network. Regardless of the method, zein ultimately demonstrates brittle deformation in stress vs. strain plots. When incorporated into soy gels, fibre size appears to be the most determinant factor in gel texture. Method choice will ultimately depend on processing requirements and formulation of the eventual end product.

OC51 - 24911 - ENHANCED FUNCTIONALITY OF BREAD ENRICHED WITH NATURAL PLANT EXTRACTS: DELIVERY OF BIOACTIVE POLYPHENOLS MODULATING POSTPRANDIAL GLYCEMIC RESPONSE

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Keywords: Bread, Polyphenols, Antioxidants, Blood glucose, Glycemic response, Diabetes risk

Abstract

Wheat bread is one of the major staple foods supplying energy and nutrients for human subsistence. However, consumption of starchy foods like bread results in postprandial hyperglycemia and hyperinsulinemia bringing to insulin resistance, beta-cells disfunction, oxidative stress and inflammation. Excessive bread consumption may play a role in development of type-2 diabetes, obesity and cardiovascular disorders. Polyphenols of plant origin possess anti-inflammatory activity reducing the risks of chronic diseases. Enrichment of foods with natural polyphenols can enhance their wholesomeness. In the present study we investigated antioxidant capacity, organoleptic and physicochemical properties and functional effects of wheat breads prepared with addition of polyphenol-rich plant extracts.

The additives included dry extracts of green tea, green coffee, blueberry leaves, rhododendron leaves, stevia leaves, red grape skins, grape rachis, mandarin peels and red wine. Our previous study revealed high antioxidant activity and high content of phenolic compounds in these plant extracts, most of them of local Georgian origin. Experimental bread samples were prepared at the laboratory of bioactive compounds at Tbilisi State Medical University and the industrial samples at commercial Tbilisi Bakery №4.

The addition of plant extracts resulted in 20- to 120-fold increase in the antioxidant capacity of bread samples. Typically, antioxidant capacity of the bread samples was correlated with their content of phenolic compounds. The consumption of antioxidant-enriched breads resulted in a significantly lower postprandial increase and smaller fluctuation of blood glucose content as compared with regular bread. The mechanisms of this modulation, as well as the effects of plant extract supplementation on bread microstructure will be addressed in the presentation.

Good organoleptic properties were observed in the samples enriched with the extracts from green tea (up to 0.5% content), mandarin peel, grape rachis and rhododendron leaves. Breads supplemented with natural polyphenol-rich extracts may be a new type of wholesome functional foods.


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POSTERS

PO19 - 24737 - MALT MODIFIED BY THE COMBINATION ULTRASOUND-STEARIC ACID AND IT USE AS STABILIZER INTO EMULSION (O/W)

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Keywords: Emulsifier, Starch, Barley, Sonication

Abstract

Malt is rich in important phenolic compounds for human nutrition; however, due to its low emulsifier property, it presents limitation for stabilizing emulsions. Therefore, the aim of this research was the modification of malt to increase its application in oil-in-water emulsions. Malt modification occurred by use of the stearic acid (2% m/m) as the catalyst in combination with at power sonication of 45, 81, 97 and 144W (which represent 25%, 50%, 75% and 100% of power amplitude in relation to the nominal power of the ultrasound probe) resulting in four distinct wall materials. These materials have been characterized for thermal properties, crystallinity by Diffraction-X, and scanning electronic microscopy (SEM). After, they were used to produce emulsions containing 15% of total solids (25% canola oil as an active model and 75% wall material), in a rotor-stator at 5000 rpm for 10 min. The emulsions were characterized through droplet diameter and size distribution, optical microscopy, stability Index and rheological behavior. The results showed that the sonication process increased the gelatinization temperature in relation to native malt, modifying the crystallinity of starch to the amorphous region, and hydrolyzing the starch molecules as observed by SEM. All emulsions presented a destabilization index lower than 5% after 24 h of storage at 25 °C, and bimodal size distribution, smaller droplet size (from 12.96±0.65 µm to 13.83±0.058 µm), spherical morphology, and lower viscosity in relation to the emulsion obtained by native malt. In conclusion, the stearic acid combined with ultrasound process was an effective method to improve the emulsifier properties of malt, which can be used as encapsulating material of hydrophobic compounds.

Acknowledgements

Authors would like to thank FAPESP-Fundação de Amparo à Pesquisa do Estado de São Paulo for scholarship conceded to Ana Gabriela da S. Anthero (Process number: 2018/02132-5). and Talita A. Comunian (Process 2018/01710-5).

PO20 - 24915 - PHYSICOCHEMICAL PROPERTIES OF DIFFERENT FRACTIONS OF WHEY PROTEIN BETA-LACTOGLOBULIN AMYLOID AGGEGATES

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Keywords: Amyloid aggregates, Beta-lactoglobulin, Different morphologies, Separation

Abstract

It is well known that amyloid aggregates of beta-lactoglobulin (BLG) offer a wide variety of functional properties for innovative applications in food and biotechnology (e.g. biosensors, nano-composites). At low pH-values and low ion concentrations, BLG associates to these stacked beta-sheet aggregates of different morphologies (e.g. long “fibrils” at pH <3 and “worm-like” aggregates at pH 3.5). Depending on the pH-value and incubation time (5 to 72 h), the building blocks of these aggregates are peptides or non-hydrolyzed BLG. At the same time, a large proteinogenic part is not incorporated into the amyloid aggregates. In order to further understand the functionality of these materials, it was of interest to compare the physicochemical properties of different amyloid morphologies as well as their fractionated amyloid and non-amyloid material, which was separated by centrifugal ultrafiltration.
When comparing pH 2 and pH 3.5 aggregates, the “worm-like” structures were more hydrophobic (Nile-red-assay), but also less stable during freeze-drying and filtration processes than the pH 2 fibrils. As expected, the physicochemical properties of both amyloid and non-amyloid fractions differed strongly after 5 h incubation, with respect to secondary structure (ATR-FTIR), zeta-potential (Zeta-sizer), size (SEC) and surface hydrophobicity (Nile-red assay). Furthermore, aromatic amino acids seemed to be rather integrated into the amyloid fractions (Tryptophan fluorescence and UV-VIS). The experiments also confirm a significantly different surface activity (A/W and O/W) of whole fibril samples and their respective fractions.
The results give further evidence for the versatile properties of amyloid aggregates, which could mediate different functionalities in dependence of the pH-value, the incubation time, the concentration of the amyloid fraction, the processing (drying, shearing, high-pressure) and storage. The separation of the amyloid and non-amyloid fractions could provide further evidence to the respective functionality they deliver and possible synergisms of their mixture.

Acknowledgements

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PO21 - 24997 - A NEW DAIRY MATRIX INCORPORATING OSMUNDEA PINNATIFIDA EXTRACT WITH POTENTIAL BIOLOGICAL PROPERTIES

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Keywords: Enzymatic extracts, *Osmundea pinnatifida*, Biological properties, Functional food, Probiotic bacteria

Abstract

Consumer interest and concern about diet and its influence on health and well-being has been increasing in the last decade. As a consequence, society dietary habits have been changing as consumers seek more natural solutions giving preference to food products that promote health rather than the use of capsules or tablets[1].

Dairy matrices are an excellent source of nutrients and a very versatile vector for proven bioactives, justifying constant innovation associated therewith. Hence, the main objective of this work is to develop and characterize a new potential dairy functional food that may act as a harbouring vector for the enzymatic extract from *Osmundea pinnatifida* seaweed obtained with Viscozyme L with reported biological properties[2,3]. The new dairy product combined "*requeijão*" whey cheese and plain Greek yoghurt in a smooth spreadable cream incorporating the *O. pinnatifida* extract (3%) and achieving a shelf-life of 21 days. Different bioactive properties were tested for the samples at 0, 7, 14 and 21 days.

The *O. pinnatifida* extract spreadable cream exhibited a higher antioxidant capacity than that of the plain counterpart at 0 and 7 days (with maximum inhibition percentage of 74.7% for the hydroxyl radical) and an interesting and stable antihypertensive activity: 30 mg spreadable cream inhibited angiotensin convertase-I between 57.4 and 49.5% over 21 days shelf-life. Higher prebiotic potential was also observed in *O. pinnatifida* extract spreadable cream mainly at 0 days; *Lactobacillus acidophilus* La-5 and *Bifidobacterium animalis* subsp *lactis* BB12 reached viable cell numbers of 8.82 log CFU/$g_{\text{spreadable cream}}$ and 7.71 log CFU/$g_{\text{spreadable cream}}$, respectively, numbers above minimum required threshold.

This new developed spreadable dairy cream has an advantage in being a multifunctional food offering a high-quality nutritional and organoleptic profiles and multi biological activities that may contribute to the health and well-being of citizens.

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PO22 - 25019 - DEVELOPMENT OF A NOVEL FERMENTED MILK WITH BACTERIOCINOGENIC POTENTIAL TO COUNTERACT LISTERIA MONOCYTOGENES INFECTION

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Keywords: Bacteriocin, Functional fermented milk, Listeriosis, Prophylaxis

Abstract

In situ bacteriocin production is regarded as a notable probiotic trait. These promising peptides could offer an alternative to antibiotic prophylaxis/treatment concerning infectious diseases, namely listeriosis. In this work, we intended to develop a novel functional probiotic-based fermented milk with potential of *in situ* antilisterial bacteriocin delivery, which holds a promising approach for this rare but deadly disease, when prophylactic chemotherapy or vaccination is not an option.

Bacteriocinogenic strains, *Pediococcus acidilactici* MK952 and *Lactobacillus alimentarius* MK426, were isolated and used as starter cultures for milk fermentation. The novel product was further evaluated regarding its probiotic and antilisterial potential through a simulated gastrointestinal (GI) digestion model, assessment of adhesion of both probiotics to human intestinal Caco-2 epithelial cells, and further ability to prevent two *L. monocytogenes* strains (Scott A and Lm 2542, from a pasteurized milk and cheese associated outbreaks, respectively) to infect Caco-2 cells.

A remarkable antilisterial activity of the fermented milk provided by the *in situ* bacteriocin production by both probiotics was observed. Both strains presented a high survival rate to the harsh GI conditions and a significantly higher ability to adhere to Caco-2 than that observed for the commercial probiotics used as a control. Throughout the simulated digestion, the *in situ* bacteriocin secretion by *Pediococcus* and *Lactobacillus* was effective in reducing *Listeria* to values below the detection limit. Furthermore, the capability to impair the *Listeria* invasiveness in the GI epithelium was demonstrated: *Lactobacillus* completely suppressed (100%) the pathogen infection, whereas *Pediococcus* reduced invasion to 10%. To the best of our knowledge, this is the first study proving the promising potential of a functional fermented milk as a suitable delivery vehicle of bacteriocinogenic probiotics for *Listeria* prophylaxis. This

would be of particular relevance for the elderly given the extraordinary rate at which the global population is aging.

Acknowledgements

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PO23 - 24920 - INNOVATIVE CONFECTIONERY PRODUCTS BASED ON HAZELNUT PASTE AND PROBIOTICS

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Keywords: Confectionery products, Hazelnut paste, Probiotics, Freeze drying, Accelerated storage test

Abstract

Health and hedonic benefits are key factors for the success of innovative foods. The purpose of this study was to develop new confectionery products, sensorially pleasant and intense, with high nutritional value, stable at high environmental temperatures, also with regard to the texture. Different recipes with hazelnut paste, maltitol, bitter cocoa powder, maltodextrin DE12, and tragacanth gum were prepared with the eventual inclusion of Bifidobacterium (BB-12®). The formulations were added with water, emulsified, and dehydrated by freeze-drying. Lyophilized samples were covered with dark or milk chocolate and, finally, kept for 24 weeks at 40 °C simulating 2 year storage at 20 °C. Samples were characterized (for moisture, fat, protein, reducing sugar, ash, and mineral contents) and monitored in terms of oxidative stability (moisture, acidity and pH, peroxide number, conjugated dienes and trienes, color, total phenols, tocopherols, organic acids, hexanal and hexanol compounds), microbial count (microorganisms at 30 °C, *Escherichia coli*, *Salmonella* spp., Staphylococci, yeasts and moulds, viable probiotic cells) and sensory characteristics (texture analysis, QDA test). All the different formulations were sensorially highly appreciated. Data from accelerated storage test did not highlighted the onset of relevant degradation phenomena. However, in the medium term (8-16 weeks) most of the examined parameters underwent significant variations, even though below the threshold of unacceptability; differences were perceptible also with regard to rheology and sensory (mainly as for brittleness and rancidity), even though these attributes went diminishing towards the end of the storage. After 16 weeks, the probiotic viability declined below 10^9 CFU/g.

PO24 - 24937 - IMPACT OF LIPID TYPE AND LIPID DROPLETS COATED WITH PROTEIN-SURFACTANT MIXTURE ON THE GASTROINTESTINAL FATE OF EMULSIONS

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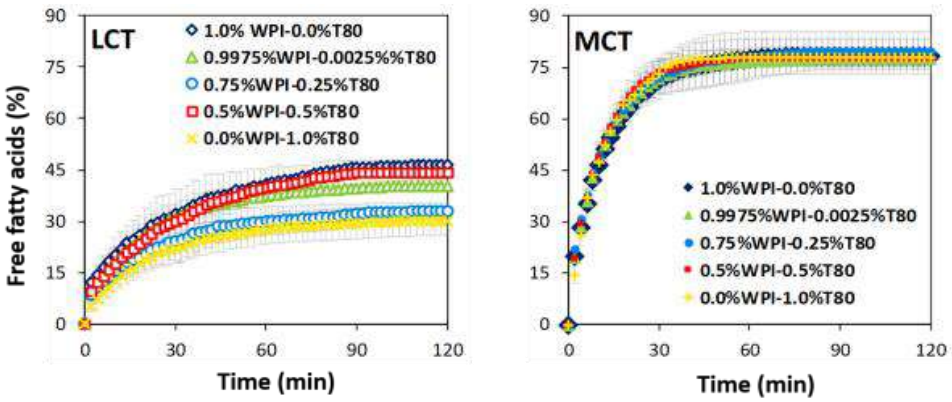
Keywords: WPI-Tween 80 blend, Sunflower oil, MCT oil, Lipolysis, Ingredient engineering

Abstract

The engineering of ingredients appears as a strategy to design emulsified products aiming to control the lipid hydrolysis. In order to evaluate the impact of ingredients choice on lipolysis, oil-in-water (O/W) emulsions were stabilized by WPI-Tween 80 (T80) mixtures in different ratios producing distinct oily phases (Sunflower oil - LCT or NEOBEE® 1053 - MCT). Emulsions were submitted to simulated gastrointestinal conditions and evaluated from optical microscopy, mean droplet size (D_{43}), zeta potential and release rate of FFAs. Emulsions with higher WPI-concentration showed flocculation and coalescence of droplets in the stomach step (low pH and pepsin action), resulting in droplets with lower interfacial area for lipase action in the intestine. These destabilization phenomena were not observed in 0.5% WPI/0.5% T80 systems, showing the strong T80 influence on the interfacial layer. These results show that the replacement of Tween 80 by WPI up to 0.5% (w/w) was efficient to avoid aggregation of droplets under gastric conditions and produce emulsions with similar characteristics to those stabilized only with Tween 80. T80 is not sensitive to pH change and pepsin, besides presenting some bile salts-lipase resistance. The interfacial composition did not affect the FFAs release, but lipid hydrolysis of MCT-emulsions was influenced by the chain size of FFAs. However, LCT-emulsions with higher WPI concentration showed higher release rate of FFAs. Differently, the LCT-system with 0.5% WPI/0.5% T80 presented similar release of the FFAs than 1% WPI/0% T80. In this protein-surfactant ratio, WPI and Tween 80 worked together and achieved an improved performance, which affected the behavior of this system during the gastric and enteric phases. Thus, results aforementioned reinforce the importance of rational selection of ingredients to design systems aiming to promote enhanced bioactive bioaccessibility and controlled lipid release.



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PO25 - 24998 - INFLUENCE OF OIL AND PROTEIN TYPE ON THE PARTICLE PROPERTIES OF MODEL INFANT FORMULA

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Keywords: Model infant formulas, Spray drying

Abstract

Considering the frequent need to develop new formulations that contain functional appeal to meet the scientific and technological demands, the objective of this study was to evaluate drying performance and physicochemical properties of model infant formulas composed of different types of oils and proteins. Formulations containing 20, 30, 30 and 40 g L^{-1} protein, oil, lactose and maltodextrin, respectively, were prepared using either whey protein isolate (WPI), whey protein hydrolysate (WPH), WPI+Lactoferrin (LF) or WPH+LF. The oil phase was composed of high oleic sunflower oil (HOSO), or a mixture of HOSO with medium-chain triacylglycerols (MCT) or coconut oil (CO). Emulsions were prepared in a double stage high-pressure homogenizer (30/5 MPa, 2 cycles). Powders were produced by spray-drying emulsions (inlet temperature of 170 °C) to an average final moisture content of approximately 1.5% and average water activity of 0.13. The extent of powder build-up on the dryer wall decreased for formulations containing LF and these powders showed higher encapsulation efficiency (above 70%). In addition, these formulations presented a slightly orange appearance due to the presence of LF, which was evidenced by the slightly higher b* values of the color analysis. Addition of MCT or CO oil also yielded a higher encapsulation efficiency. Additionally, differences in wettability, microstructure and particle size were linked to the emulsifier system and oil type used. The inclusion of LF and MCT in the formulation showed to be promising ingredients for the development of functional infant formulas.

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PO26 - 24868 - APPLICATION AND FUNCTIONALITIES OF GAMMA-AMINOBUTYRIC ACID ENHANCED WHEAT AS FOOD MATERIALS

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Keywords: Gamma-aminobutyric acid, Germinated wheat, PC-12 cell, Antioxidant capacity, Reducing anxiety

Abstract

Stress and anxiety have become an inevitable part of the modern life, and if anxiety is accumulated, it can cause mental or physical disability or disease. The gamma-aminobutyric acid (GABA), one of amino acids, is known to inhibit adrenocorticotropic hormone (ACTH), which is secreted from the pituitary gland of the human brain by stress or anxiety. The intake of GABA enhanced foods might help to reduce anxiety and depression. The germination is an effective way to increase GABA contents in wheat or cereals. The objective of this study was to investigate application and functionalities of GABA enhanced wheat by germination as food materials. The response surface methodology was used to enhance GABA contents of wheat, and the optimized conditions was germination for 46.18 h at 17.6 ℃. The GABA contents (1.20 mg/g) and antioxidant capacity (Oxygen radical absorbance capacity: 47.93 μM trolox equivalent (TE)/g) of germinated wheat at optimized condition were 20 and 10 times higher than those of the non-germinated wheat, respectively. In addition, the neuroprotective effects of GABA enhanced wheat extracts were determined by neuronal PC12 cell viability assay. Extracts of GABA enhanced wheat induced protective effects on oxidative stress in PC12 cells compared with non-germinated wheat. Therefore, utilization of GABA enhanced wheat by optimized germination condition might be effective in reducing anxiety and depression in the modern life.

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PO30 - 20332 - INTERACTIONS BETWEEN MAILLARD-REACTED BEEF BONE HYDROLYSATE AND PLANT PROTEINS ON EXTRUDED MEAT ALTERNATIVES

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Keywords: Maillard reaction products, High-moisture extrusion cooking, Meat alternatives, Degree of texturisation, Fibrous microstructure, Sensory evaluation

Abstract

Meat analogues are designed to have the same sensory properties to meat but are made from plant proteins. However, meat analogues exhibited very weak aroma and almost tasteless which resulted in low market success. Therefore, the addition of Maillard-reacted beef bone hydrolysate to the mixture before extrusion can produce meat alternatives with high aroma and taste quality, yet fibrous texture is still observed. To date, there are no studies shown to investigate the interactions between meat and plant proteins to form meat alternatives using a twin-screw extruder. Therefore, in this study, the objective was to understand the interactions between Maillard reaction product (MRP) of beef bone hydrolysate at different levels (0, 10, 20, 30 and 40% wet weight basis) with plant proteins (soy protein concentrate and wheat gluten) on the physicochemical properties of extruded meat alternatives. Meat alternatives (~48% moisture content) were extruded at maximum barrel temperature of 170°C, at a dry and water feed rate of 2.8 kg/h and 3.6 kg/h, respectively. The textural and structural properties of meat alternatives were studied, where meat alternatives containing 40%MRP showed the lowest degree of texturisation (1.24±0.11), but highest hardness (42.66±2.60 N) and chewiness (30.66±2.44 N) when compared with meat alternatives incorporated with MRP. Fibrous microstructure was observed for meat alternatives containing 0% MRP to 20% MRP, while multiple segmented layers accompanied with some fibrous microstructure were observed for meat alternatives containing 30% MRP and 40% MRP. Chemical bonding results suggested that a large amount of aggregated proteins were linked with hydrogen bonds. Disulphide bonds were the key force in the formation of fibrous structure of meat alternatives. Meat alternatives containing 20% MRP obtained highest sensory scores for all attributes and overall acceptability. Results showed that although the addition of MRP changed the textural and structural properties, it improved the sensory attributes of meat alternatives greatly.

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and Imaging Centre, Massey University for her assistance in SEM analysis. This research was carried out as part of the FIET program funded by the New Zealand Ministry of Business, Innovation and Employment (MBIE). The authors declare that they have no conflict of interest.

PO31 -24834 - MODELLING FOOD PROTEIN GELS AS PARTICLE-FILLED SOFT SOLIDS FOR TAILORED FUNCTIONALITY

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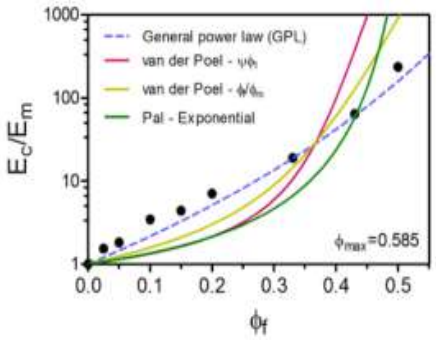
Keywords: Particle reinforcement, Particle filled gel, Composite gel, Whey protein isolate

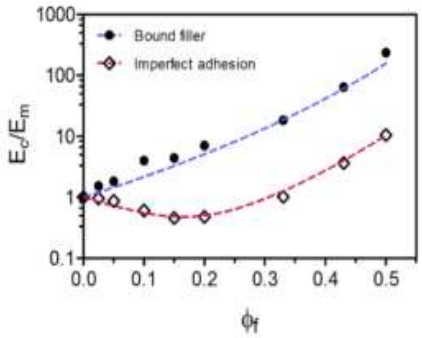
Abstract

The development of tunable biopolymer particles as delivery vehicles for bioactives and the controlled release of lipids has become a highly active area of research. These structures are often incorporated into food systems as emulsion gels or microgel particles. In such systems, these discrete particles may also serve a dual purpose of contributing to the structural, rheological, and functional properties of the food material. Well established theoretical models are often used to describe the rheological and mechanical behavior of particle-filled soft solids. However, it is generally recognized that existing models provide an incomplete physical description of food systems, causing discrepancies between theory and experimental data. In this work, we propose an empirically-derived model which accurately describes the impact of incorporating model fillers on the elastic modulus of a particle-filled food protein gel; heat-set whey protein isolate (WPI) gels filled with glass microspheres of distinct size ranges. The proposed model provided excellent fits of experimental data ($R^2 \geq 0.97$), and more accurately followed the observed trends in reinforcement than established theories. Increasing filler size and associated polydispersity decreased the observed reinforcement. This effect was attributed to an improved filler packing efficiency, which was explicitly expressed in the model through a maximum packing fraction term. Increasing the ionic strength of the WPI gels via addition of NaCl caused a decrease in the extent of filler-matrix interactions. We further demonstrate the empirical model could be adapted to incorporate imperfect interfacial adhesion by incorporating contributions of bound and unbound fillers using a weighted average approach. We are presently exploring methods of deriving the proposed model through a more rigorous mathematical approach to explicitly incorporate the relative contribution of both matrix and filler. This approach would serve to better predict how the discrete phase modulates the rheological properties of materials such as emulsion gels.

Comparison of theoretical fits to experimental data using established particle reinforcement models adapted to account for filler crowding with the proposed general power law (GPL) model.



Adaptation of the proposed general power law model to account for imperfect filler/matrix adhesion observed in experimental data



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PO32 - 24973 - OIL-IN-WATER EMULSION STABILIZED WITH LENTIL PROTEIN ISOLATED OBTAIN BY TWO EXTRACTION METHODS

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Keywords: Plant-protein, Functional properties, Protein extraction, Ultrasound-assisted extraction

Abstract

The interest for vegetable protein increased due their high nutrition value and functions properties. The traditional processes of extracting proteins are associated to long time and low yield. The use of the auxiliary processes, as ultrasound, is a strategy to increase the yield and purity of the extract. The objective this work was to evaluate the stability of oil-in-water emulsion stabilized by lentil protein (LP), obtained from two different extraction methods. Lentil protein (LP) were obtained by alkaline extraction at pH 9 (AL) and ultrasound-assisted extraction at 450 W (UL). 0.5% (w/w) solutions were prepared by the extracted proteins obtained by both methods. The oil-in-water emulsion was prepared by mixing 10% (w/w) of sunflower oil and 90% (w/w) of aqueous solution, using a rotor-strator at 20,000 rpm for 4 min. The emulsions were evaluated regarding their stability, microscopy and particle size for seven days. The lentil flour used for extraction contained 25% protein and extraction processes resulted in yield of 64.81% for the alkaline extraction and 67.3% for the alkaline ultrasound-assisted extraction, with no significant differences ($p>0.05$). The emulsion stabilized with LP obtained with ultrasound assisted methodology was stable for seven days, while the LP obtained solely by alkaline showed 4-day stability. The size distribution showed droplets with size between 0.5 and 30 µm for AL-stabilized emulsions while UL emulsions presented size between 0.5 and 10 µm, which was confirmed by microscopy images. Even though no significant difference was observed for process for yield, the ultrasound process imparted modifications on protein, resulting in more stable emulsions, with smaller droplets.

Acknowledgements
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PO33 - 24983 - SUBSTITUTION OF MEAT BY POTATO, PEA, SUNFLOWER AND PUMPKIN PIT POWDER, TVP OR HME PROTEIN TO OBTAIN A HEALTHY AND QUALITATIVE SAUSAGE

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Keywords: Hybrid cooked sausage, Protein network, Texturized vegetable protein, High moisture extrusion of vegetable protein, Plant proteins in different forms

Abstract

Frequent consumption of meat and meat products in larger portions is associated with higher risks on prevalence of cardiovascular, coronary and cerebrovascular diseases, stroke, diabetes type 2 and colorectal cancer[1,2,3,4]. It is believed that these implications are mainly caused by the presence of (saturated) fats, salt and nitrite, while specific essential amino acids present in animal protein are able to increase plasma cholesterol and induce diabetes type 2[5,6,7]. In addition to these health issues, the meat production chain has a considerable impact on the environment through the use of land and nitrogen and greenhouse emissions, resulting in loss of biodiversity and enhancing climate change[8,9,10]. Meat and meat products are also associated with severe animal welfare issues, such as the recent mistreatments of pigs in a slaughterhouse in Tielt (Belgium)[11]. To lower general meat consumption, the European project MeatHybrid was established, whereby cooked sausages were made in which the meat is partially replaced by plant protein. To obtain a (sensorial) qualitative and appealing hybrid sausage, the effect of adding sunflower, pumpkin pit, potato and/or pea protein as powder, high moisture extrudate (HME) or texturized vegetable protein (TVP) on the structure of the cooked sausage was studied. This was analysed by performing texture and colour measurements, rheology analysis, light microscopy, emulsion stability and sensorial tests with expert panel to examine the quality of the established protein network. Momentarily, several cooked sausages were already successfully produced whereby 10 to 50% of the meat protein was replaced with a combination of plant proteins in powder form. Cooked sausages with TVP and HME are currently being produced and analysed. Hereby the first results are looking promising and show potential to successfully partially replace meat proteins in cooked sausages.

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PO34 - 24945 - IS INULIN-BASED EMULSION GEL A GOOD FAT REPLACER IN BOLOGNA SAUSAGE?

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Keywords: Structured emulsion, Inulin, Healthier meat products, Fat reduction, Sensorial properties

Abstract

The association of meat products consumption and some chronic diseases has made consumers demand healthier meat products mainly focused on fat saturated. Structured emulsions offer a novel option to lipid reformulation besides increasing the nutritional value by adding functional ingredients in meat products. The aim of this study was to investigate emulsion gels (EG) formulated with soy protein isolate, carrageenan and/or inulin, and soybean oil as partial or total animal fat replacer in Bologna sausages along 60 days. Fat reformulation allowed the samples to be labeled as reduced total fat, reduced in saturated fat and good source of fiber. EG added sausages presented the higher hardness, the lipid oxidation was more intense as the storage time and the amount of EG increased and the EG in the meat emulsions made the network more dense and compact comparing to control. Bologna sausages were very stable microbiologically during chilled storage and the levels of all the microorganisms studied were very low (<3 log CFU/g). The Time Domain NMR relaxation curves for the Bologna sausages exhibited a multiple-exponential distribution with clearly two distinct water populations, one referring to entrapped/immobilized water associated within the highly organized protein or fiber bundles structures (relaxation time between 10 and 100 ms) and the second population referring to intermyofibrillar water located between fiber bundles interacting weakly with charged group (relaxation time of between 100 and 1,000 ms). Relaxation time was not affected by EG addition. Consumers test shown that all samples were judged acceptable during 60 days and CATA questions linked reformulated bolognas to rubbery, little spicy, dry and opaque appearance, firm, and aftertaste. This study shows that emulsion gel may be interesting sources of nutritional and healthy components in emulsified meat product that produce no detrimental changes in their sensory and technological properties.

Acknowledgements

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PO36 - 25103 - EFFECT OF FUNCTIONAL INGREDIENTS IN PLANT-BASED MILK ANALOGUES ON SENSORY PROPERTIES

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Keywords: Complex ingredient interactions, Plant-based milk analogues, Functional properties, Sensory properties

Abstract

Protein transition is one of the major global trends in the food industry. The demand for sustainable protein sources drives food developers into replacing animal-derived proteins with plant proteins. The growing interest in plant proteins is not only thought to be a more sustainable approach to ensure enough food for the growing world population but also fits in a more personalized nutrition approach.
This brings new challenges in food design, especially on the sensory performance, technical functionality and overall nutritional benefits. The understanding of the complex interactions in food and their processing, and the ability to understand consumers wishes, enables the development of the ideal healthy product. In this presentation, the impact of functional properties of plant proteins in milk analogues will be discussed with a focus on the sensory performance.
The quality of (plant-based) food products relies on the sensory performance of the product. This concerns the effect of the packaging materials, its convenience during preparing the food but largely also on the sensations that consumers experience during the eating. Taste, aroma, texture, trigeminal (pain), astringency, cooling effects, all these factors determine the sensory properties of foods and thereby affect the final quality judgment of the consumer. In many cases, all sensory attributes need to be in harmony to prove to the consumer that a product has a high quality.
Plant proteins are known for their off-flavours and astringent mouth feel, not appreciated in particular by the Western culture. The presence of volatiles, non-volatiles and tactile stimuli all play a role here. In this study we show the impact of different plant sources on the sensory perception of milk analogues. The beany off-taste and the astringent mouth feel will be further elucidated. We will discuss how masking technologies can be successful in optimizing the sensory performance. In addition, we will discuss how ingredients can be utilized to affect mouthfeel by their interaction with the oral surfaces. Unique *in-vitro* analytical techniques will

be introduced with which screening of potential masking molecules and of potential mouthfeel modulators has become feasible.

PO38 - 24696 - EFFECTS OF INCORPORATING DIFFERENT GALACTOMANNANS ON THE RHEOLOGICAL AND MICROSTRUCTURAL PROPERTIES OF COLD-SET GELS OF SOY PROTEIN ISOLATE

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Keywords: Soy protein isolate, Cold set gels, Mixed gels

Abstract

Soy protein isolate (SPI) is a plant-based ingredient, interesting to the food industry due to it functional properties, including the ability to form cold-set gels. However, commercial SPIs generally present challenging characteristics, such as the low solubility at acid/neutral pHs, which reduces its gelling capacity. This drawback can be overcome by incorporating polysaccharides in the gelled protein structures, such as galactomannans. In this context, this study aimed to investigate the effects of incorporating locust bean gum (LBG) or guar gum (GG) to NaCl-induced gels of SPI. For this purpose, SPI dispersions (14%, w/v, pH 7) with different LBG or GG concentration (0-0.3 %, w/v) were preheated (80 °C/30 min), cooled to room temperature and added with NaCl (300 mM). Gels were evaluated by frequency sweep tests (2% strain, 0.016 to 1.6 Hz), creep/recovery tests (creep: 5 Pa/15 min., recovery: 15 min.), confocal laser scanning microscopy and scanning electron microscopy. Frequency sweep results revealed that both galactomannans incorporations resulted in G'and G" reductions. Variations of GG concentration did not alter G' and G"; however, for gels produced with LBG, those with 0.1 and 0.3% polysaccharide had higher G' and G" than those with 0.2%. G' and G" reductions were possibly related to incomplete demixing of the systems. In addition, systems with LBG presented higher G' and G" than the gels produced with GG, which was related to LBG's higher M/G ratio. Creep/recovery results revealed that, whereas the incorporation of 0.1% GG resulted in reductions of compliance, higher concentrations of this polysaccharide increased this parameter. On the other hand, all LBG incorporations resulted in compliance decrease. Besides, every formulation presented similar recovery percentages. Micrographs revealed the different degrees of phase separation of the different formulations, which led to distinct rheological properties, and confirmed the occurrence of incomplete demixing in the gelled structures.

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PO40 - 24884 - RHEOLOGICAL PROPERTIES OF ACID HYDROLYZED INSOLUBLE PROTEINS FROM CHLORELLA PROTOTHECOIDES AT THE OIL-WATER INTERFACE

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Keywords: Microalgae, Insoluble proteins, Acid fragmentation, Interfacial properties, pH

Abstract

Microalgae are promising protein sources due to their overall high protein content. The low aqueous-solubility of the microalgae proteins, however, limits their application in food system, unless solubility is enhanced by hydrolysis. In the present study, we examined the interfacial rheological properties at the oil-water interface of the untreated insoluble microalgae protein (IMP) from *Chlorella prototheco*ides and their hydrolysates prepared by thermal-acid hydrolysis in hydrochloric acid at 65 °C (Hydrolysates 65) and 85 °C (Hydrolysates 85). The results revealed that the interfacial activity of IMP was improved after acid hydrolysis: Hydrolysates 65 and Hydrolysates 85 have higher interfacial storage G_i' and loss moduli G_i'' compared to the untreated IMP. The different ratios of the soluble protein fragments and insoluble protein particles in untreated IMP and both hydrolysates stabilized the interfacial layers. The influence of pH on the interfacial behavior of differently treated proteins was also determined and revealed that G_i' and G_i'' of the three differently treated protein decreased as pH increases from 3 to 9. The high viscoelasticity of the acid-hydrolysed IMP at oil-water interface indicates a high potential of them to be useful in stabilizing emulsion-based food products. The results provide foundation for studies on food functionality of microalgae proteins to expand their application.

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PO41 - 24697 - TECHNOLOGICAL FEASIBILITY OF INCORPORATING VITAMINS D_3 AND B_{12} IN EMULSION-FILLED PECTIN GELS

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Keywords: Pectin, Vitamin D_3, Vitamin B_{12}

Abstract

The demand for plant-based food has strongly increased due to the growing number vegetarian and vegans worldwide. However, it is common that these individuals develop deficiencies of vitamins B_{12} and/or D_3. Therefore, plant-based food matrices enriched with these micronutrients must be developed. The present study aimed to develop emulsion-filled pectin gels (EFG) for simultaneous incorporation of vitamins D_3 and B_{12}. The vitamin D_3 was encapsulated in the oil droplets and the vitamin B_{12} was incorporated in the aqueous phase of the gels. The emulsions were produced using flaxseed oil as dispersed phase and inulin associated with gum arabic as stabilisers. In order to produce the EFG, the aqueous phase was replaced by different amounts of emulsion (0 to 60% w/w). According to the results obtained in the mechanical and frequency sweep tests, the EFG with a replacement of 40% of aqueous phase by emulsion were the strongest, and they were chosen to incorporate the vitamins. Four gels were prepared: NFGB12 (non-filled gel with vitamin B_{12}), EFGB12 (emulsion-filled gel with vitamin B_{12}), EFGD3 (emulsion-filled gel with vitamin D_3) and EFGB12D3 (emulsion-filled gel with vitamins B_{12} and D_3). The stability of both vitamins in the gels was monitored by spectrophotometric methods, after their extraction. The gels were characterized by instrumental colorimetry (as vitamin B_{12} is red), water activity and moisture content. Vitamin B_{12} seemed to be stable (no significant statistical difference, $p<0.05$) after 30 days of storage period for EFGB12D3 and NFGB12 gels. In the EFGB12 gel, the vitamin B_{12} concentration decreased to about 90% of the initial amount at the end of the period. The stability of colorimetric parameters corroborated the stability of vitamin B_{12}. The vitamin D_3 concentration was not significantly changed along the storage period. The gels were, therefore, capable of protecting both vitamins incorporated in their structure.

Figure 1. Visual aspects of non-filled gel with vitamin B_{12} (A) and emulsion-filled gels with vitamin B_{12} (B), with vitamin D_3 (C), and with vitamins B_{12} and D_3.

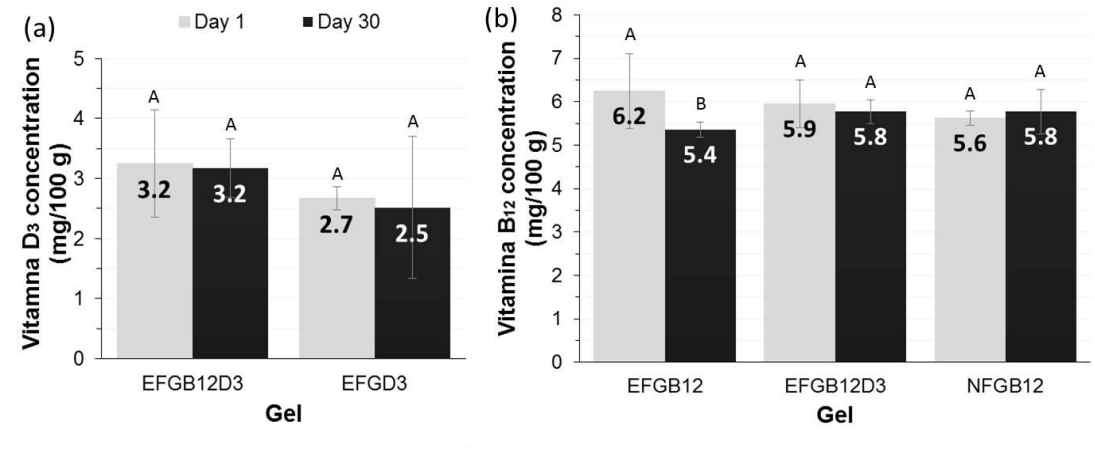

Figure 2. Temporal profiles: (a) vitamin D_3 concentration in the emulsion-filled gels (EFGD3 and EFGB12D3); (b) vitamin B_{12} concentration in the non-filled gels (NFGB12) and emulsion-filled gels (EFGB12 and EFGB12D3). Means followed by the same letter do not differ statistically from each other ($p<0.05$) by the Tukey test for the same sample over the storage period.

Acknowledgements

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PO42 - 24870 - STRUCTURE-FUNCTION RELATIONSHIP OF NATURALLY-DERIVED SURFACTANT GLYCYRRHIZIN

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Keywords: Glycyrrhizin, Saponin, Natural surfactant, Interfacial activity, Emulsion

Abstract

Plant-derived saponins are an especially promising category of biosurfactants. An example of such natural surfactant is glycyrrhizin extracted from licorice root (*Glycyrrhiza glabra* L.), and it is used as a natural sweetener (E958). Glycyrrhizin is a glycoside comprising a hydrophobic triterpenoid aglycone to which one hydrophilic sugar chain is attached. Little is known about the structure-function relationship of glycyrrhizin. Therefore, the purpose of this study was to investigate the interfacial and emulsifying properties of the saponin glycyrrhizin and its aglycone 18-glycyrrhetinic acid.

First, the interfacial activity of the saponin and its sapogenin was assessed by measuring the dynamic and static surface tension at an air-water interface as well as interfacial tension at an oil-water interface. Furthermore, the interfacial shear rheology was applied to gain insights into the interfacial properties. Second, the emulsifying properties were evaluated by generating oil-in-water emulsions by high-pressure homogenization. Third, a computer modeling was performed to gain insights into the molecular characteristics of the compounds.

The results showed that glycyrrhizin and its aglycone showed very little surface and interfacial activity. Moreover, the interfacial shear rheology experiments revealed that neither glycyrrhizin nor its aglycone formed viscoelastic interfaces. Nevertheless, both compounds formed stable nanosized emulsion droplets at a very low surfactant-to-oil ratio. These results revealed that the functionality as a surfactant does not necessarily relate to the interfacial activity, which is in contrast to other highly surface active saponins. Molecular modeling showed that hydrophobic surfaces dominate over the polar surfaces, indicating that hydrophobic interactions are important for interfacial stabilization. Surprisingly, the saponin and its aglycone did not show major differences in their interfacial and emulsifying properties. In conclusion, both glycyrrhizin and its aglycone are highly effective naturally-derived surfactants for a variety of emulsion-based products in food, cosmetic, and pharmaceutical industries.

PO43 - 24972 - CARIOCA BEAN PROTEIN (*PHASEOLUS VULGARIS* L.): EXTRACTION AND FUNCTIONAL PROPERTIES

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Keywords: Emulsifying properties, Plant-protein, Extraction-method, Functionality, Pulse-protein

Abstract

Proteins are amphiphilic macromolecules widely used as foaming, emulsifying, thickening and gelling agents. Diets containing more plant protein are increasing due to negative environmental impacts of animal protein production and increasing vegetarianism trends. In that sense, several sources of plant proteins can be identified and explored according to their functionalities. Beans are rich and cheap sources of plant proteins. The centesimal composition of these pulses indicates a protein concentration ranging from 17% to 35%. However, the application of these proteins as an emulsifying agent is still little explored. The objectives of this study were to extract proteins from carioca beans using chemical and physical methods and to evaluate and compare the emulsifying capacity of these proteins. The bean was characterized presenting in its composition 20% of proteins. They were extracted by the alkaline method, using different pH, and by applying ultrasound at varying sonication power. The best condition of alkaline extraction was obtained at pH 10.5, with a yield of 61%. Using the ultrasound, the best results were obtained at 450W, with the yield of 56%. Even though, ultrasound resulted in lower yield, the purity of the extract obtained was higher (73%) than the one obtained by alkaline extraction (60%). The proteins obtained by both extraction methods were used to produce oil-in-water emulsions at concentrations of 0.5 and 1% (w/w). The characterization of emulsions indicated the formation of droplets between 1 and 10 µm and 10 and 100 µm, for both concentrations and extraction method employed. Microscopy confirmed the formation of droplets with a wide range of sizes. Although the results indicate that further studies are needed to increase the emulsifying stability, the proteins were able to present activity as emulsifier, indicating the potential of this protein source for application in encapsulation systems.

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PO44 - 25030 - INGREDIENTS DERIVED FROM ALMOND PROCESSING: APPLICATION IN THE FORMULATION OF FUNCTIONAL BEVERAGES

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Keywords: Almond processing co-products, Biological properties, Probiotic almond milk, Functional beverages

Abstract

The consumption of plant food products as a substitute for dairy products has been increasing, both for medical reasons (lactose intolerance and allergies to milk proteins) or adoption of alternative or vegetarian/vegan lifestyles (health and sustainability issues). The main objective of this study was the formulation, production and characterization (microbiological, chemical and biological) of fermented beverages based on almond serum and almond milk with *Bifidobacterium animalis* subsp. *lactis* BB-12 and *Streptococcus thermophilus* inoculated in a 1:1 ratio (cell density). Two beverages were prepared: fermented almond serum (FBAS) and fermented mixture of almond milk with serum 1:1 (FBM). Almond serum and mixture "almond milk with serum" were used as controls. Beverages were incubated at 37 °C under 120 rpm until a final pH of 4.5 was reached and subsequently stored for 21 d at 4 °C.

The fermentation of the beverages FBAS and FBM with *B. animalis* subsp. *lactis* BB-12 and *S. thermophilus* occurred during 3.5 and 4.5 h, respectively; *S. thermophilus* reached maximum viable cell numbers of 7 log CFU/mL at a faster rate than *B. animalis* subsp. *lactis* BB-12. Nevertheless, *B. animalis* subsp. *lactis* BB-12 was more stable throughout storage, particularly in FBM, whereas *S. thermophilus* reduces viability by one log cycle after 14 d of storage both in FBAS and FBM. The fermentation potentiated an increase (9-17 times) in the total protein concentration in comparison to the control raw materials, without affecting the capturing capacity of the $ABTS^{\bullet+}$ radical; however, fermentation led to a loss of capturing capacity of the DPPH radical relative to what was observed in the raw materials (2-3 fold lower). Regarding the anti-diabetic activity, the fermentative process and the respective storage led to some decrease of this potential.

Almond milk and co-product almond serum demonstrated suitability for a probiotic alternative fermented beverage delivering multifunctionality.

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PO64 - 24702 - TUNING PHYTOSTEROLS-BASED OLEOGELS PROPERTIES BY SOYBEAN LECITHIN ADDITION IN DIFFERENT ORGANIC PHASES

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Keywords: Oil structuring, Fat replacer, Solvent quality, Organogel

Abstract

In this study the effect of soybean lecithin (L) addition and solvent quality in a hybrid oleogel system – formed by β-sitosterol and γ-oryzanol (BG) – was investigated. Medium chain triglycerides (MCT) and sunflower oil (SFO) were used as triglycerides with different chain length and degree of unsaturation, and hexadecane (HEX) as a model of linear hydrocarbon. The motivations in using lecithin are related to its natural/versatile properties, showing different functionalities such as emulsifier and co-oleogelator, and to the self-assemble ability of its molecules via non-covalent interactions. Hierarchical organization of structured oil was investigated applying techniques for bulk, meso and nanoscale. Self-sustained systems could no longer be observed after 40 wt% of BG replacement by lecithin. Small-angle X-ray scattering showed that building blocks were dependent on solvent type and BG:L ratio in the mixture of oleogelators. Differential scanning calorimetry showed that stability against temperature was improved decreasing the polarity of the solvent. In addition, thermal and rheological measurements showed a time-dependent self-assembly of molecules in hybrid systems. Microscopy images depicted changes on typical fibril aggregation of BG as lecithin was added, which promoted to a certain extent the suppression of phytosterols ribbons formation. Oscillatory shear and uniaxial compression measurements were influenced by BG:L ratio and solvent type mainly at higher lecithin amount. The combination of BG and MCT appeared to be the most affected by lecithin incorporation whereas SFO rendered harder oleogels. These results could contribute to understand the role of both lecithin addition and solvent type influencing the host oleogelator structure. It was hypothesized that intermolecular BG complex formation is hindered by lecithin, besides this phospholipid also might coexist as a different phase, causing structural changes in the gel network. Addressing the role of co-oleogelator can provide the opportunity to tune soft materials with desired properties.

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PO118 - 25785- EFFECT OF SALTS AND pH ON THE FUNCTIONAL PROPERTIES OF AFRICAN ORPHAN CROPS FINGER MILLET AND AMARANTH

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Keywords: Proteins, Amaranth, Finger millet, Functional properties

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Abstract

Nowadays, there is a growing demand of food products that are easy to consume, healthy, and with a good nutritional balance. Amaranth and Finger millet are African orphan crops, that grow easily even in adverse conditions. Amaranth grains are highly nutritious, with a protein content of 14 to 19%, where the main protein fractions present are albumins, globulins, and glutelin. Finger millet contains 5 to 8% of proteins, including albumins, globulins, prolamins and glutelin. The goal of this study is to experimentally quantify the effects of adding monovalent (NaCl) or divalent ($CaCl_2$) salts, and the effect of pH changes, in the gelation capacity, surface activity and microstructure of amaranth and finger millet protein suspensions/gels. The amaranth protein isolate (API) and finger millet protein isolate (FMPI) were dispersed in distilled water, in NaCl and $CaCl_2$ water solutions with different concentrations (0.02, 0.05, 0.1 and 0.5 M). Additionally, API and FMPI were also dispersed in buffer solutions with pH values ranging from 2 to 10. Dynamic light scattering and zeta potential experiments reveal that the addition of salt promotes aggregation of proteins and that API forms larger aggregates than FMPI. Aggregates are larger for both protein isolates at lower pH values. Furthermore, rheological experiments show that API is able to form gels. Surface activity experiments show that both API and FMPI stabilise the water-air/oil interface and that the addition of salts aids the decrease of surface tension.
The identification of the functional properties of amaranth and finger millet grain proteins and the effect of salts and varying pH on said properties is crucial for the designing of new food products using those grains, and their incorporation in existing processed food products.

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PO121 - 25865 – EFFECT OF GELATINISATION ON TEXTURAL PROPERTIES OF COMPLEX STARCH GELS: COMBINING MICROSCOPY AND WATER DISTRIBUTION TO QUANTIFY GELATINISATION DEGREE

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Keywords: Gelatinization degree, Water distribution, Textural properties, Starch gel, Microstructure

Abstract

Numerous foods contain starch as thickener or gelling agent, providing specific textural properties that vary based on type of starch (botanical source and chemical modifications) and different processing parameters (amount of water, heating temperature and heating time). A specific amount of water is required to fully gelatinize the starch granules at temperatures that are starch type dependent. Other water-binding ingredients will affect the gelatinisation degree of the starch, affecting the final structure of the system. The water distribution is therefore an important parameter that should be quantified in order to interpret the contribution of starch to the properties of the end product. In the present work, we studied the gelatinisation degree of two types of starch by observing the evolution of granule morphology by microscopy, that of size distribution by dynamic light scattering and by quantifying changes in the distribution of water (bound vs free) in time by centrifugation techniques. This made possible to estimate the gelatinisation degree of starch granules and the microstructure of starch gels. At low gelatinisation degree, the starch swelled a few times the original size and formed a compact particle gel, while at high gelatinisation degree, the starch granules totally collapsed, leaching amylose into the continuous aqueous phase and forming a polymer gel. The final gel type influenced the properties of the starch gel. The characterization of textural properties showed that the particle gels in which the starch granules were still recognizable were quite hard and brittle, while gels of the polymer type were soft and elastic. The possibility of linking gelatinisation degree, microstructure and textural properties of starch gels allows us to study the role of this ingredient in the functional and sensory properties of more complex systems and, ultimately, to modulate these properties for several types of foods.

PO123 - 25875 - GASTROINTESTINAL BEHAVIOUR AND FLAVONOID RELEASE FROM A RUTIN-FORTIFIED YOGHURT USING HUMAN GASTRIC SIMULATOR, A SEMI-DYNAMIC *IN VITRO* DIGESTION MODEL

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Keywords: Rutin, Dairy products, *In vitro* digestions, Food fortification

Abstract

Rutin is a dietary flavonoid and a potent antioxidant with clinically-relevant functions, such as diabetes prevention. Hence, rutin-enriched food products are promising candidates for preventing metabolic diseases. However, the main disadvantage of rutin is its poor bioavailability, which is attributed mainly to the low water solubility, poor stability and limited membrane permeability. Formulating rutin into products has many technical challenges linked to solubility issues and bitter taste. We developed a new technology (FlavoPlus ingredient) that allows fortification of foods with rutin without having negative effects on food quality. This work investigated the gastrointestinal bioaccessibility of microencapsulated rutin in a yoghurt matrix. A low-fat yoghurt fortified with 500 mg of FlavoPlus ingredient per serve (190 g) (RuYO) and an unfortified low-fat yoghurt combined with a gelatin capsule containing 500 mg powdered rutin (CtYO) were submitted to *in vitro* semi-dynamic digestions; where the gastric phase was simulated in a human gastric simulator (HGS). The physical properties and rutin content of digested samples were determined at different digestion times. The solids content of RuYO and CtYO in the gastric phase decreased with increasing digestion time, suggesting gastric emptying occurred at a constant rate. Confocal microscope images indicated that the protein network was increasingly hydrolysed in the stomach as digestion progresses.
Rutin solubility and stability during digestion of the RuYO was dramatically different from CtYO. Most of the rutin was insoluble in the gastric and intestinal phases. However, rutin was more stable in RuYO (total cumulative recovery 98%) than in CtYO (total cumulative recovery 61%). Similarly, rutin degradation was lower in RuYO in the intestinal phase (total cumulative recovery RuYO: 26%; CtYO: 17%). In conclusion, the enrichment of dairy products with FlavoPlus seems to be a feasible strategy to develop flavonoid-fortified foods.

PO125 - 25914 - EMULSIFYING PROPERTIES OF INTERFACIAL COMPONENTS OF COCONUT OIL BODIES

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Keywords: Oleosomes, Oil bodies, Encapsulation, Structural stability, Coconut

Abstract

The oil bodies from plant systems are emerging as novel ingredients for encapsulation of bioactives, and have potential applications in food, pharmaceutical and cosmetic formulations. They have high structural stability under stress conditions and possess unique properties resulting from the distribution of the biomaterials in the interfacial layer. This study investigated the emulsifying properties of interfacial biomaterials obtained from coconut oil bodies and those present in aqueous phase in a coconut oil body suspension.

Oil bodies from coconut milk were separated and the resulting serum phase freeze-dried to obtain serum extract (SE). The oil bodies were destabilized by freeze-thaw treatment and the interfacial extract was freeze dried (IE). The extracts were characterized by sodium dodecyl sulphate polyacrylamide (SDS-PAGE) and phosphorous assay. Soybean oil nanoemulsions (20%, w/v) were prepared using the extracts (0.4 and 0.8% w/v total protein) in the final emulsion. The emulsion characteristics were investigated as a function of pH (2-8) and ionic strength (0-500 mM NaCl) by static and dynamic light scattering and confocal laser scanning microscopy (CLSM). The structure of the emulsion droplets was investigated by probing using enzymes (pepsin, trypsin and phospholipase A_2).

The IE emulsions had a smaller size than SE emulsions and the particle size of emulsions decreased with an increasing extract concentration. Decreasing the pH or increasing the salt concentration, resulted in flocculation of the IE emulsion. The SE emulsion followed similar trend but the droplets were stable to flocculation even at high ionic strengths (500 mM NaCl). Both IE and SE emulsions were destabilized by pepsin and phospholipase A_2 but remained stable in the presence of trypsin. Our results offer insights into the mechanisms stabilizing the emulsions from IE and SE that could be used for encapsulation and the delivery of bioactives.

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