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Engineered Interfaces

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pEI-1

Influence of interfacial composition on the in vitro interfacial gastrointestinal digestion.

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The main reason to modulate the lipid digestion is because the high lipid absorption has been associated with an important number of health problems (obesity, etc.). Many processed foods consist in oil/water (O/W) emulsions, in which the lipids are embedded in form of droplets in an aqueous medium. Coated the droplet surface, the emulsifier forms an interfacial film that play an important role in the formation and stability of emulsions but also affects the behaviour of the emulsions during the digestion process. In the small intestine the pancreatic lipase catalyzes the hydrolysis of triglycerides into free fatty acids (FFA) and 2-monoglycerides. The lipolysis is facilitated trough the action of bile salts (BS) which allows the adsorption to the lipase at the O/W interface and remove the FFA release by solubilization in BS micelles.

In the present work the evolution of interfacial tension (γ) was used to investigate the effect of gastrointestinal fluids on O/W interfacial films: proteins (β-lactoglobulin (βlg) and soy protein isolate (SPI)) and polysaccharides (hydroxypropylmethylcelullose (HPMC)).

Clear differences were observed among the different emulsifiers. During the gastric phase, HPMC showed the lowest change in γ values as compared to protein films. The most important changes occurred during the intestinal stage where it was observed an important decrease of γ associated with the rapid penetration of BS, followed by a lower rate of decrease attributable to the accumulation of FFA at the interface. In the last stage the subphase was exchanged by buffer alone to remove the adsorbed FFA. The interface formed by SPI and HPMC could difficult the removal of FFA, producing an inhibitory effect in the lipase activity. The interfacial film modulates the BS adsorption and therefore the extension of lipolysis as reported in previouys study on the behavior of emulsions (Bellesi et al., 2016).

The results put in relevance the role of BS in the control of lipid digestion as a key factor of study to understand the lipolysis process.

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pEI-2

Interfacial and bulk rheological properties of sugar beet pectin – sodium caseinate stabilised emulsions

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The rheological properties of emulsion are determined by many design factors one of which is their interfacial properties. The overall aim of the research presented is to examine the relationship between the interfacial rheological properties of complex oil-water interfaces and the bulk rheological properties of emulsions at high volume fraction stabilised with sugar beet pectin and sodium caseinate. We hypothesise that the interfacial rheological properties can be tuned by way of complex formation, i.e., in bulk or in-situ at the interface, and that this has an impact on the bulk rheological properties of the emulsions

Experimental data acquired on emulsions stabilised with either sugar beet pectin, sodium caseinate, or complexes formed close to isoelectric point (IEP) of sodium caseinate will be presented. Complexes were also formed in-situ by emulsion preparation at neutral pH based on sodium caseinate followed by the addition of sugar beet pectin near the IEP of sodium caseinate. Emulsions in presence of both single surface active species were also prepared. Emulsion analysis included zeta potential, droplet size distribution, and rheological properties in steady shear and dynamic oscillatory shear. It was, e.g., found that the ratio of sugar beet pectin to sodium caseinate during complexation in bulk, i.e., before emulsification, had a significant impact on the viscoelastic moduli of the densely packed emulsion cream phase. The different types of interfaces were replicated in a pendant drop tensiometer for dilatational interfacial rheological property analysis. Correlations between interfacial and bulk rheological properties will be discussed on the poster.

pEI-3

Improved heat stability of whey protein isolate-stabilised emulsions by conjugation with Low Methoxyl Pectin through dry heat treatment

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Whey Protein Isolate (WPI) is known to have excellent emulsifying properties but exhibits a low stability towards heat. As heat processing is commonly encountered in industry for improving the safety and shelf life of foods, the limited heat stability becomes the limiting factor for the application of WPI on an industrial scale.

In this research project, we compared the effect of combining WPI with Low Methoxyl Pectin (LMP) on the stability of WPI stabilized emulsions towards gravitational force and heat. This was accomplished either by simple mixing or by conjugate formation by dry heat treatment. Protein and polysaccharide conjugates produced by this method has been mentioned as a promising replacement for synthetic surfactants in food applications [*Garti*, 1999], whereby it is suitable for the production of "clean-label" emulsions. WPI-LMP mixtures and conjugates were prepared at a WPI to LMP ratio of 2:1. Conjugates were prepared by means of dry heat treatment at a temperature of 60^{o}C and 74% relative humidity by incubation for 1,2,3, 4, 8, and 16 days.

0.5% of the mixture or conjugate of WPI-LMP was used to stabilize 10% oil in water emulsions. Heating the emulsions at 80^{o}C and pH 6.5 for 20 minutes revealed that emulsions stabilized by WPI-LMP conjugates did not undergo any change in the stability of the emulsions, expressed as their creaming velocity. Particle size measurements by laser diffraction also supported this finding by showing no noticeable change in the particle size distribution of emulsions stabilized by WPI-LMP conjugates upon heating at pH 6.5. Finally, rheological measurements indicated gel-like structure formation upon heating the WPI-stabilised emulsions, whereas replacement of WPI by WPI-LMP conjugates enabled to retain the original low viscosity during heating. Furthermore, electrophoretic mobility measurements indicated that conjugation shifted the protein's isoelectric point to a lower pH value which is beneficial for their application at low pH especially at pH around the isoelectric point of WPI.

Overall, our experiments indicated that conjugation of WPI and LM Pectin by dry heat treatment could largely improve the heat-sensitivity of WPI-stabilized emulsions. Additionally it also shifted the isoelectric point of proteins.

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pEI-4

Evolution of buriti oil-droplet sizes stabilized by soy protein/pectin during storage

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Buriti oil contains chemical compounds that provide special nutritive value due to its high content of β-carotene and tocopherols (Rodriguez-Amaya, 1996). These compounds are light, oxygen and temperature sensitive and susceptible to autoxidation. The emulsion technology represents an adequate method to encapsulate, protect and release the lipid bioactive compounds, avoiding their rapid degradation (McClements et al., 2007). The complexation between protein and polysaccharides oppositely charged is a colloidal phenomenon involved in the structure of biological systems (Dong et al., 2015). Polysaccharide addition may increase the physical stability of emulsions by electrostatic and/or steric effects, which modify rheological properties of interface and increase emulsion viscosity (Serfert et al., 2013). Based on these considerations, the objective of this work was to produce emulsions containing buriti oil stabilized by soy protein isolate (SPI) and high-methoxyl pectin (HMP) at different formulations and to investigate the evolution of oil-droplet sizes throughout a 7-day period. The assays were carried out using a central composite rotatable design (CCRD) with three variables: buriti oil ratio in the emulsion (from 10 to 30 %), percentage of SPI in the wall material (from 50 to 80 %), and pressure applied in the homogenizer (from 200 to 400 bar). The droplet size distribution was investigated by measuring the mean diameter of 300 particles in images obtained by optical microscopy. In the first day, the CCRD analysis showed that oil content and applied pressure were the parameters with statistical significance ($p < 0.1$) for particle size. Taking into account the results obtained in the last day, in addition to buriti oil content and applied pressure, the interaction between oil content and SPI, and the interaction between SPI and applied pressure were also statistically significant. Oil ratio presented a positive effect in the particle size, whereas applied pressure showed a negative contribution. Samples that exhibited higher stability presented particles with higher diameter, ranging from 4 to 7 μm. The mean diameter of particles from creamy phase of emulsion demonstrated a slight tendency to increase, although significant differences ($p < 0.05$) could not be noticed among most treatments over the period of analysis.

Acknowledgments

The authors acknowledge Sao Paulo Research Foundation, FAPESP (Processes 2014/08520-6, and 2014/02910-7) and Coordination for the Improvement of Higher Level Personnel, CAPES.

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pEI-5

Characterization of a microemulsion system composed of food-grade surfactants, soybean oil and water.

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Microemulsions are isotropic and thermodynamically stable mixtures of two immiscible solvents composed of water, oil and surfactant, and sometimes a co-surfactant, such as an alcohol.
The construction of phase diagrams is a tool to determine the existence of microemulsions and rheological assays are helpful to elucidate the structural characteristics of the system. In addition, measurements of electrical conductivity are important means of determining the prevalence of aqueous or oily continuous domains in a microemulsion. This work aimed to study the formation of microemulsion using soybean oil (SO) and food-grade surfactants Span 80 (S) Tween 80 (T), co-surfactant propylene glycol (P), and water (W). The systems were prepared with different ratios of S:T:P:SO (mass basis) and titrated with distilled water under constant stirring at 25 °C. The phase diagram was constructed along dilution lines of 5 to 90 % water.
Visual evaluation of the prepared mixtures indicated formation of microemulsions at the ratios 8T:1S:1P:1SO and 8T:1S:1P:2SO, with water content ranging from 5 to 20 %. The type of microemulsion - W/O or O/W - was identified by a staining method, in which the hydrophilic dye methylene blue and the lipophilic pigment curcumin were added at equal amounts to blank microemulsions. The faster diffusion of methylene blue indicated the occurrence of O/W microemulsions. For the ratio 8T:1S:1P:1SO, conductivity values were 2.08, 1.61, and 1.75 µS/cm, respectively, for water contents of 5, 10, and 15%, whereas for the ratio 8T:1S:1P:2SO conductivity increased from 0.43 to 4.73 µS/cm for water contents of 5% and 20%, respectively.
As it was expected, the microemulsions were Newtonian and their viscosity increased with increasing water content. For the ratio 8T:1S:1P:1SO viscosity varied from 0.48 Pa·s for microemulsion containing 5 % water, to 0.58 cP for 15 % water. For the ratio 8T:1S:1P:2SO, the microemulsion viscosity varied from 0.49 cP, at water content of 5 %, to 0.89 cP, at water content of 20 %. The obtained microemulsions were translucent, stable over time, and presented some characteristics indicative of being O/W microemulsions, although additional investigation is still necessary to define completely the systems' structure.
The authors acknowledge of São Paulo research foundation FAPESP Process N° 2013/13471-0 and 2014/02910-7.

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pEI-6

Concentration effect of *Quillaja* saponin-Na-caseinate complexes on their emulsifying properties

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Quillaja saponins are a class of surfactants that have recently become very attractive for research and industry due to their good interfacial activity and emulsifying properties (Yang et al. 2013). In addition, the complexation of *Quillaja* saponins with proteins has gained interest (Kezwon & Wojciechowski, 2014). Thus, the present study investigated the emulsifying properties of *Quillaja* saponin-Na-caseinate complexes upon formation of 10% (w/w) oil-in-water emulsions (pH 7). The mixed surfactant systems were prepared at Na-caseinate concentrations of 0.1, 0.5, 1.0, 2.5, and 5.0% (w/w) with the addition of 0, 0.05, or 0.5% (w/w) *Quillaja* saponins. The prepared emulsions were analyzed for their mean droplet diameter (d_{43}). The results showed a decrease in droplet size of Na-caseinate-stabilized emulsions with increasing concentrations of Na-caseinate: At 0.1% Na-caseinate, the emulsions had a d_{43}–value of 1.17 ± 0.23 µm, whereas at a concentration of 5.0% Na-caseinate, the emulsions were nanosized (0.17 ± 0.02 µm). Addition of a small amount of *Quillaja* saponins (0.05%) into the Na-caseinate surfactant solution did not change the emulsion droplet diameter. In comparison, the addition of 0.5% *Quillaja* saponins to 0.1% Na-caseinate solution decreased the emulsion droplet diameter to 0.24 ± 0.10 µm. On the other hand, the mixtures of 0.5 - 5.0% Na-caseinate with 0.5% *Quillaja* saponins increased the emulsion droplet diameter gradually: The particle sizes were 0.24 ± 0.01 µm, 0.33 ± 0.26 µm, 0.31 ± 0.17 µm, and 1.33 ± 1.18 µm at 0.5, 1.0, 2.5, and 5.0% of Na-caseinate, respectively. The results indicate that complexation of *Quillaja* saponins with Na-caseinate does not improve the emulsifying properties compared to the single components, probably due to competitive adsorption of *Quillaja* saponin and Na-caseinate molecules or due to reduced interfacial activity of *Quillaja* saponin-Na-caseinate complexes.

pEI-7

Emulsifying capacity of whey proteins covalently modified with cabbage compund allyl isothiocyanate

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Whey protein isolate (WPI) is frequently used in foods as natural emulsifying agent; however at an acidic pH-value its emulsification capacity is strongly reduced. The covalent attachment of natural small hydrophobic molecules to WPI proteins is a promising approach to change the physicochemical properties of WPI in favour of a higher functionality at acidic pH-value.

Different concentrations of the cabbage compound allyl isothiocyanate (AITC) were covalently bound to WPI (rich in β-lactoglobulin), and the changed physicochemical properties (charge, aggregation, surface hydrophobicity, elasticity and secondary structure) were monitored over a wide pH range (pH 2 to 7). The results indicated that addition of AITC to WPI significantly increased the hydrophobicity of the WPI and significantly reduced the interfacial tension at acidic pH-value. These effects were less pronounced at pH 6 and 7.

Following this, emulsions of rapeseed oil in water (O/W) were prepared using either 1 % modified or unmodified WPI and the emulsifying properties (oil droplet size, creaming stability and information on the interfacial barrier) were monitored over a wide pH range (pH 2 to 7). The WPI-AITC conjugates showed a significantly smaller droplet size than native WPI at pH 2 and a higher creaming stability at pH 2, 4, 6 and 7.

The AITC modification of WPI could be a simple technique to increase the emulsifying capacity of WPI, especially at acidic pH.

pEI-8

Effects of fish gelatin-alginate interactions on interfacial and forming characteristics

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Food foams form a major category of food products due to their unique textural and mouthfeel properties. Protein-polysaccharide interactions are regarded to be able to effectively stabilize food foams. This study aimed to investigate the effects of fish gelain (FG)-alginate (AL) interactions on interfacial and foaming characteristics. The FG-AL interactions in aqueous mixtures were controlled by varying pH (3.5, 5.0, and 7.0), FG to AL ratios (FG:AL = 100:0, 80:20, 50:50, 20:80, and 0:100), and total biopolymer concentrations (T_C = 0.25, 0.50 and 1.00%, w/v) at 25 ^{o}C. Air-water interfacial properties were examined by measuring the air-water interfacial tension, electrophoretic mobility, viscosity, and complex size of FG-AL mixtures at 25 ^{o}C. Foaming characteristics were examined by measuring the volume ratio and bubble size of the foams generated by homogenization during the storage at 25 ^{o}C for 18 h. When pH = 3.5, FG:AL = 80:20, and T_C = 1.00%, the foam volume ratio of FG-AL mixtures showed the highest value (1.6), although the value was lower than that of pure FG (2.0) or whey protein concentrate (2.0). The bubble size (117 μm) at these conditions was similar to that of pure FG or whey protein concentrate, but much smaller than the values (173 - 648 μm) obtained for the other samples. At the same conditions, minimum values of air-water interfacial tension (42 mN/m), negative electrophoretic mobility (–0.85 $m^2/V{\cdot}s$), and viscosity (1.35 cP) were obtained with a maximum volume weighted mean diameter (3 μm), indicating that attractive interactions between FG and AL were the strongest at these conditions. The results demonstrated that the formation of foams in FG-AL aqueous mixtures was enhanced by the attractive interactions between the biopolymers. It was also found that the increase of AL fraction enhanced the stability of foams by increasing the viscosity and negative electrophoretic mobility, although it was not desirable for foam formation. These findings provide basic knowledge useful to design foam structures with specific functionalities and applications.

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pEI-9

Effect of intrinsic wheat lipid composition on interfacial and foaming properties of dough liquor.

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Breadmaking quality is determined by various factors of the wheat grain and the flour, which can be influenced by breeding, processing and formulation. These variables influence the physico-chemical properties of the dough and hence its ability to produce good quality bread in terms of texture, taste, loaf volume and shelf life. Wheat flour doughs possess cohesive and visco-elastic properties which depend on various properties including flour composition, gluten protein quality, formulation and the dough mixing process. The viscoelastic properties of the gluten-starch matrix allow the entrapment of gas cells formed during mixing, and which grow during proving, leading to the formation of a foam, which is fixed during baking to give a light, porous crumb structure.[1] However, the properties of gluten proteins cannot entirely predict breadmaking quality. Another important aspect of breadmaking quality is the stability of the gas cells. High levels of stability are required during proving and the early stages of baking in order to maintain the integrity of the loaf. It is known that wheat lipids influence the stability of gas cells and hence loaf volume,[2] but the mechanisms are not clear. Therefore this work aims to understand the relationship between the lipid composition of wheat flour and the foaming and interfacial properties of dough liquor. Doughs were made from a single variety breadmaking flour (Hereward), from three successive harvests. The surface properties of dough liquor were found to be different, and correlated with both the foaming properties and the lipid composition of the dough liquor. Compositional analysis of the foam showed that certain polar lipids were enriched in the foam, explaining the beneficial effects that these lipids have on foaming properties and potentially on breadmaking quality. Preliminary test baking trials showed similar improvements in breadmaking quality for the most foam active flour.

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pEI-10

Generation of Ultra-stable Microbubbles for Industrial Application

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Large numbers of everyday foods have their pleasant mouth feel and texture as a result of the presence of foams and air bubbles. Examples of food with foamy texture are beers, ice cream, breads, and cakes. Creating a gel network containing bubble aggregates instead of emulsion droplets has great advantages for designing food with lower caloric content and also lower cost of production [1]. Microbubbles are thermodynamically unstable. Stabilizing microbubbles for a sufficient duration of time remains a challenging problem. A microbubble with a radius equal to 1µm will typically have a life time that is very short, only about few milliseconds [2].

The aim of the current work is to stabilize very fine microbubbles in food and non-food systems via Pickering stabilization mechanism. We use the unique protein hydrophobin II in combination with sodium caseinate in order to stabilize microbubbles that are created by application of shear in low concentration protein solutions, in an aqueous phase. Hydrophobin II, acts as a very small nanoparticle as it is known not to unfold or denature at air-water interfaces. Thus the mechanism of stabilization of microbubble is in many ways closer to that seen from Pickering particles as opposed to that from other proteins (e.g. milk proteins). Preliminary results show that microbubbles stabilized by this protein are stable for a relatively long time and at least for a few days.

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pEI-11

Interfacial properties and emulsifying ability of crude and purified soybean oil bodies

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Introduction: Oil bodies, an organelle storing neutral lipids in soybean seed cells, have the triglyceride core surrounded by a phospholipids monolayer and oleosin proteins. The capability of oil bodies as a carrier of lipophilic substances has been intensively studied because of their high stability against coalescence and lipid oxidation. Recently, Maurer *et al.*[1)] indicated that oil bodies can be also used as an emulsifier, whereas detailed interfacial properties and emulsifying ability are still unclear.

Oil bodies inevitably involve other proteins such as glycinin and β-conglycinin on the surface during the homogenizing processes. Such proteins can be removed under alkaline conditions according to Chen and Ono.[2)] The aim of this study is to reveal interfacial properties and emulsifying ability of oil body-protein complexes (OBC) and purified oil bodies (OB).

Materials and Methods: OBC and OB were extracted by the methods of Chen & Ono.[2)] The protein contents and composition of OBC and OB were analyzed by BCA method and SDS-PAGE, respectively. Interfacial activity was measured by a pendant drop method. OBC and OB-stabilized emulsions (OBC-E/OB-E) were prepared by adding soybean oil to 1 wt% of OB and OBC suspensions and homogenizing the mixtures by a high-speed blender. Emulsion stability during storage was evaluated at room temperature. The particle size distribution and zeta-potential of the emulsions were measured using a laser-diffraction particle size analyzer and a laser-Doppler zeta-potential analyzer. Microstructure was observed via Cryo-SEM and CLSM. Determination and compositional analysis of proteins at the oil droplet surfaces were performed.

Results and Discussion: Interfacial tension measurements revealed that both OBC and OB adsorbed at the oil/water interface, suggesting that the proteins have emulsifying ability. Mean particle size of OBC-E more rapidly increased than that of OB-E during the stability test, while no oil-phase separation was observed for both the emulsions. OBC-E and OB-E have net negative charges, suggesting that electrostatic repulsion contributed to the stabilization of oil droplets. The amount of proteins adsorbed at the oil droplet surface in OBC-E was higher than that in OB-E.

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pEI-12

Effects of heat treatment and homogenization on milk fat globules and proteins in whipping cream

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Introduction

Commercial whipping creams are usually subjected to heat treatment and homogenization to improve their shelf-life, whereas such processings result in substantial changes in emulsion stability and foaming properties of the creams. In this work, samples prepared under large-scale and small-scale production were systematically analyzed to reveal effects of heat treatment and homogenization on milk fat globules and proteins in whipping cream.

Materials and Methods

Large-scale and small-scale samples were manufactured via UHT methods and high-pressure homogenization process. One set or two sets of sequential heating (HT)-homogenization (HG) processes were applied for large-scale samples, while HT, HT-HG, HT-HG-HT or HT-HG-HT-HG treatments were employed for small-scale samples. Particle size analysis, zeta-potential measurement, scanning electron microscopy, differential scanning calorimetry, and determination and compositional analysis of proteins at the oil droplet surfaces were carried out.

Results and Discussion

For large-scale samples, mean particle size of fat globules in once-treated samples (1-HTHG) was significantly smaller than that in twice-treated ones (2-HTHG), while amount of proteins adsorbed at the oil droplet surfaces in 1-HTHG was higher than that in 2-HTHG. On the other hand, little difference was observed for zeta-potential, protein compositions and thermal behaviors. For small-scale samples, the mean particle diameter and the amount of proteins adsorbed at the oil droplet surfaces decreased according to the increase of processing steps.

pEI-13

Kinetics, thermodynamics and dilational rheology of β-lactoglobulin adsorption at the water/tetradecane interface: effect of pH and ionic strength

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Proteins are amphiphilic and adsorb at liquid interfaces. Therefore, they are efficient stabilizers of foams and emulsions [1,2]. β-lactoglobulin (BLG) is one of the most widely studied proteins due to its major industrial applications, in particular in food technology. Drop profile analysis tensiometry in different experimental modes was applied to study adsorbed layers of BLG at various liquid interfaces, such as the water/oil interface [3, 4].

In the present work, the influence of different pH and ionic strength on the equilibrium and dynamic tensions of BLG layers at the water/tetradecane interface has been investigated. Dynamic interfacial tension and interfacial dilational elastic modulus (E') of BLG solutions at three different pH values of 3, 5 and 7 and at three different ionic strengths are measured by Profile Analysis Tensiometer (PAT-1, SINTERFACE Technologies, Berlin). The presented results of the adsorption isotherm are compared with existing theoretical models, taking into consideration the interaction with the oil molecules.

The dilational visco-elasticity of the BLG interfacial layers is determined from measured dynamic interfacial tensions during sinusoidal drop area variations. The interfacial tension response to these harmonic drop oscillations is interpreted with the same theoretical model. A quantitative data analysis requires additional consideration of depletion due to BLG adsorption at the interface at low protein bulk concentrations. This fact makes experiments more efficient what oil drops are studied in the aqueous protein solutions rather than solution drops formed in oil.

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pEI-14

Adsorption of β-Lactoglobulin at the Water/Air Surface: Effect of the pH and Ionic Strength of the aqueous solutions

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The dynamic surface pressure Π of air bubbles aging in buffered β-lactoglobulin (BLG) solutions containing various protein concentrations C_{BLG} (10^{-9} – 10^{-4} M), pH (3 – 7) and buffer concentrations C_{buff} (1, 10 and 100 mM) was measured as a function of time t by bubble profile analysis tensiometry. Adsorption kinetics was studied by recording Π(t) data for 80 000 s and the final Π-values were used to construct the surface pressure isotherm Π(C_{BLG}) for the pH values of 3, 5, 7 (C_{buff} = 10 mM) and 6.3 (in pure water). On the basis of these results and the values of the induction time τ_{ind} determined from the Π(t) data, the effect of pH on the protein surface activity was qualitatively analysed.

At constant C_{buff} = 10 mM and relatively low protein concentrations ($C_{BLG} < 10^{-8}$ M), BLG exhibits shortest τ_{ind} and highest Π-values at pH 7 (negative net charge), in comparison to pH 5 and 3, whereas at sufficiently high protein concentrations (ca. $C_{BLG} > 10^{-6}$ M) BLG is most surface active at pH 5 (negligible net charge in the vicinity of the isoelectric point, p*I* ≈ 5.1). At constant C_{buff}, BLG solutions with pH 3 show the lowest surface activity.

The influence of the ionic strength (buffer concentration) of the solution on the dynamic Π was studied at a selected protein concentration of $C_{BLG} = 10^{-5}$ M. The kinetics of adsorption is weakly affected by C_{buff} for solutions with pH 5 and significantly enhanced by increasing C_{buff} for solutions with pH ≠ p*I*. Supportive information about the effect of the type of the electrolyte was obtained for non-buffered aqueous BLG solutions (natural pH ~6.3), containing different concentrations of monovalent NaCl or bivalent $CaCl_2$.

It is demonstrated that the adsorption kinetics and the surface pressure isotherm of BLG at the water/air surface depend strongly on the protein net charge, which is dictated by the solution pH and is screened by increasing ionic strength of the solution.

pEI-15

The impact of interfacial ingredients on the colloidal interactions in a model cheese

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This study seeks to determine the role of the interfacial layer on the colloidal interactions, structure and material properties of oil-in-viscous protein emulsions as applied to a model cheese composition. Lab scale model cheese (25 g) of 23 % fat and 20 % protein was prepared by combining oil-in-water emulsions and non-fat cheese curd under controlled temperature, shear speed and residence time using a rapid visco analyser (RVA). 3 % Sodium caseinate solution and 2 % Tween 20 solution were used to stabilise the oil-in-water emulsions of 45 % fat used in the preparation of the model cheeses.

Fat droplets stabilised with sodium caseinate were hypothesised as binding with protein matrix of model cheese, thereby behaving as 'active fillers'. Confocal laser scanning microscopy supported this hypothesis showing homogeneously dispersed fat droplets within the protein network. This emulsion system did not show fat-protein phase separation in baking (170 °C 10 min) as droplets were prevented from coalescing as a consequence of entrapment within the protein phase.

Fat globules covered with Tween 20 were hypothesised as behaving as 'inactive fillers' with the adsorbed layer not expected to form bonds with the surrounding protein network. Confocal microscopy instead showed localised domains of fat within the protein structure. Cheeses comprising Tween stabilised droplets exhibited phase separation on baking and visible oiling-off on the surface of cheese arising from extensive coalescence taking place within the localised regions of fat.

Additional rheological analysis of model cheeses was made in relation to a non-fat control cheese to determine the contribution of emulsion interactions on cheese material properties. Findings showed that, at temperatures below fat crystallization (< 30 °C), both inactive and active fillers had a higher relative modulus to the non-fat sample (seen to be greater for inactive fillers). However, at elevated temperature without fat crystals, inactive fillers resulted in a relative reduction in storage modulus when compared to the non-fat cheese, while active fillers increased relative storage modulus.

Model cheeses were then compared to these prepared from natural cream. Texture and material characterisation indicated emulsion droplets stabilized with native milk fat globule membrane where consistent to behaviours observed for the Tween stabilised cheese emulsions, indicating the presence of inactive emulsion droplets.

pEI-16

Spinach lipid extract as an alternative flow aid for fat suspensions

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Chocolate is a material composite with a high fraction of solid particles dispersed in a fat phase largely composed of cocoa butter. Viscosity properties of chocolate can be manipulated by the amount of fat - increased levels of fat lead to lower viscosity. However, a high content of cocoa butter can increase the cost of the chocolate and instead surfactants are used to manipulate viscosity behaviour. Most commonly lecithin and polyglycerol polyricinoleate (PGPR) are used. Lecithin is a natural lipid emulsifier which is based on phospholipids while PGPR is a chemically produced emulsifier which based on the long continuous chain of ricinoleic acid. Lecithin and PGPR act to lower the viscosity and yield stress, respectively. Recently, natural lipid emulsifiers based on galactolipid as the functional ingredient have become of interest. Spinach lipid is found to have a high amount of galactolipid, specifically MGDG and DGDG. The aim of this research is to explore the influence of spinach lipid in comparison with PGPR and lecithin on the rheological properties of sugar/oil suspensions which serve as chocolate model system. For that purpose, icing sugar was dispersed from 40%, 45% and 50% (w/w) in oil which has spinach lipid at concentrations from 0.1 – 0.7% (w/w). Based on viscosity at 40 s^{-1} and yield value reported as shear stress measured at 5 s^{-1}, it was found that spinach lipid shows viscosity reducing and yield stress lowering effects comparable to lecithin and PGPR, respectively. This characteristic of spinach lipid demonstrates great potential for it to act as single natural lipid emulsifier in chocolate.

pEI-17

Stability of whey protein emulsions to heat treatments is mainly governed by the stability of the proteins in the aqueous phase

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Native milk proteins are natural surfactants used to emulsify and to stabilize dairy emulsions. However, at high protein concentrations, they do not sufficiently stabilize emulsions against flocculation, coalescence, aggregation or gelation during processing such as heat treatments and manufacturers used to add non-dairy additives to prevent above mentioned detrimental instabilities. Identification of alternative ways to protect dairy emulsions against instabilities without using non-dairy additives is an active research area in order to match with new market trends (clean label tendency). Alternatives using whey protein aggregates were suggested to be more efficient than native whey proteins to stabilize emulsions at high protein concentration (Çakir-Fuller, 2015) but the exact mechanism is not completely clarified especially in an industrial context where whey protein ingredients contain variable amounts of caseins, peptides, etc.

To address this question we investigated the protein interfacial composition and the stability of dairy emulsions reconstituted with 30% milk fat and 3 to 6% whey protein (model whey protein ingredient) solutions unheated or heated prior to homogenization. Heating whey protein solutions at pH 7.0 prior to homogenization allowed the production of 70 nm-sized protein aggregates. Emulsions stability was determined by visual observation, granulometry and confocal laser scanning microscopy (CLSM) after heating the samples at 120°C up to 30 min. Emulsions prepared with unheated whey proteins did not show any sign of macroscopic instabilities up to 30 min of heating at 120°C at low protein concentration (3%) but a gradual decrease of heat stability when protein concentration increased. Instability at high protein concentration is due to protein aggregation or gelation in the aqueous phase with the participation of protein-coated fat globules. In the opposite, emulsions formed with whey protein aggregates are destabilized as soon as 10 min of heating at 120°C for low protein concentration (3%) but are more stable at higher concentration. The destabilization at low protein concentration is governed by the aggregation of interfacial whey protein aggregates leading to fat globule flocculation and emulsion thickening. The stability of the emulsions at protein concentration higher than 4% is correlated to the stability of the aggregates in the aqueous phase and the decrease of the proportion of whey protein aggregates at the oil/water interface due to increasing competition with peptides and caseins naturally present in the model whey protein powder.

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pEI-18

Investigation of Emulsion Formation in Couette Flow

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The mixture of two immiscible liquids, where one of them is dispersed (dispersed phase) in the other (continuous phase) is called emulsion (Umbanhowar et al. 2000). Emulsions play a key role in many processes including food, pharmaceutical, polymer and chemical industries. Droplet formation and its interfacial phenomena, which determine the droplet size distribution, are essential issues in liquid-liquid systems (Paul et al. 2003). Emulsion formation was studied, for example, by Grace (Grace 1982), where he studied the droplet breakup in a laminar Taylor-Couette flow. His data shows that in simple shear flow droplet break up is not possible for viscosity ratios (dispersed over continuous) larger than 4. However, there is considerable lack of sufficient data about droplet size distribution in both laminar and turbulent regimes in couette flows.

Thus, the main objective of this work is to find the drop size distribution versus the variation of Reynolds number (of the continuous phase). The experimental setup consists of an ordinary concentric Taylor-Couette flow device and a high-speed camera. Emulsion systems are created by mixing several oils with distilled water. A surfactant is not present in this work, in order to study the pure effect of the continuous phase inertia force in the turbulent regime as well as of the viscous force in laminar regime. Finally, the captured images are analysed by using a freeware image analysis software (ImageJ). The results show that the drop size distribution becomes wider as the Reynolds number increases. Furthermore, the data suggests that the Sauter mean diameter shows an asymptotic behaviour for Reynolds numbers higher than 1200 for the pumpkin seed oil. However, increasing the Reynolds number yields an increased number of droplets. Finally, we show that the interfacial tension is an additional key parameter characterising the difference between the droplet size distributions of the different oils at the same Reynolds number.

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pEI-19

Emulsifying and emulsion-stabilizing properties of gradually demineralized casein aggregates

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Casein micelles are highly aggregated colloidal particles of 150 to 200 nm diameter constituted of 4 casein molecules (αs_1, αs_2, β, κ) and minerals (mainly calcium phosphate). Physico-chemical changes alter the casein-mineral interactions and consequently modify their organization compared to the native casein micelles. These modifications provide possibilities for the development of new casein aggregates with original structures that deliver novel functionalities.

The objective of our work was to investigate the emulsifying and emulsion-stabilizing properties of gradually demineralized casein aggregates in model dairy emulsions. Sodium citrate, a calcium chelating salt, was used to remove calcium and inorganic phosphate from the casein micelle. 4 suspensions of different demineralized casein aggregates were produced and physico-chemically characterized. 2 types of milkfat-in-suspension (30:70) emulsions were then prepared to separately study the emulsifying and emulsion-stabilizing properties of these casein aggregates.

Results of asymmetrical flow field flow fractionation and atomic absorption spectrometry showed progressive dissociation and demineralization of casein micelles with the increase in sodium citrate concentration from 0 to 40 $mmolkg^{-1}$. The largest (from 70 to 296 nm) and the smallest (from 22 to 30 nm diameter) aggregates have respective calcium-demineralization rates of 6 % and 75 %.

The emulsions formed with the 4 different casein suspensions at a concentration of 1.20 gL^{-1} became thinner in size with the increase in demineralization rate. This result showed an increase in emulsifying properties for the small aggregates that are able to stabilize larger amounts of suspension/milkfat interface compared to the large ones.

Increasing the concentration of our casein suspensions to 20 gL^{-1} enabled us to produce 4 emulsions with identical droplet size whatever the type of casein aggregates used. These emulsions were less stable against flocculation when the aggregate demineralization rate increased, but still resist to coalescence under our storage conditions (21 days at 50°C).

Our study demonstrates that modulating the mineral content of the casein micelles revealed to be an interesting tool to understand its role in the formation and the stabilization of emulsion. This strategy could be extended to the study of other techno-functionalities.

pEI-20

Shear and osmotic sensitivity of W/O/W-type double emulsions with a gelled internal water phase

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Using W/O/W-type double emulsions, it is possible to produce functionalized and light O/W-type food emulsions. It has already been hypothesized and in some cases proven that gelation of the internal water droplets might allow the application of a higher shear in the second emulsification step while maintaining a high internal water content. As such, this technique could enable the production of double emulsion droplets with a small average diameter and narrow particle size distribution.
First of all, the internal water phase of the primary W/O-emulsion was gelled by thermal denaturation and subsequent aggregation of a concentrated WPI solution. Low-resolution NMR T_2-relaxometry was used to investigate whether the internal water phase was gelled.
In a next step, we investigated whether gelation of the internal water phase did lead to a higher retention of internal water during the production of the double emulsions.
As osmotic imbalances between the internal and external water phase are important to control the rheology and morphology as well as the release of encapsulated ingredients by droplet-globule coalescence, we also examined the osmotic behavior of the produced W/O/W-emulsions. To that end, the droplet size distribution of the W/O/W-double emulsions was measured over time by static laser light diffraction upon dilution in hypo- and hypertonic solution.
As the longitudinal, as well as the transversal relaxation time of the internal water phase in NMR-measurements decreased upon thermal treatment, it is clear that gelation indeed occurred. As a further consequence, a correction was necessary in order to obtain an accurate estimation of the amount of encapsulated water by PFG-NMR.
Upon gelation of the internal water phase, it was possible to produce double emulsions with an average diameter (D_{43}) of about 5 µm and a narrow particle size distribution, while maintaining a higher yield as compared to the samples with non-gelled internal water.
Finally, gelation of the internal water phase reduced swelling of the double emulsion droplets in hypotonic solution. On the other hand, gelation could not prevent shrinking of the double emulsion droplets in hypertonic solutions.

pEI-21

Improving the shelf-life of low-fat cheese through edible coatings based on antimicrobial nanoemulsions enriched with mandarin fibre

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The use of edible coatings based on nanoemulsions is a suitable strategy to encapsulate, transport and release functional lipid compounds like antimicrobials to highly perishable foods surfaces in order to increase their shelf-life. Therefore, the aim of this work was to enhance the nutritional and physicochemical quality and safety of a low-fat cut cheese using coatings from nanoemulsions containing oregano essential oil as antimicrobial agent and enriched with mandarin fibre. Nanoemulsions were formed by an aqueous phase consisting of alginate and mandarin fibre, a lipid phase of oregano oil and finally, Tween 80 as surfactant to provide stability to the blends. Three different percentages of oil -1.5%, 2.0% and 2.5%(w/w)- were tested not only to study the physicochemical parameters of nanoemulsions such as their particle size, viscosity and colour, but also the properties of the coated cheese by analysing their texture, colour, water vapour resistance and headspace gases. Afterwards, the efficiency of oregano oil as antimicrobial agent against total psychrophiles and moulds and yeasts counts was evaluated. All nanoemulsions were stable with ζ-potentials below -30 mV regardless the percentage of oil used (-39.78mV, -46.52mV and -41.70mV for 1.5%, 2.0% and 2.5% respectively). Besides, average droplet diameters were between 130 and 385nm in the three cases. Although the presence of edible coating controlled oxygen consumption and diminished water loss, oregano oil reduced cheese hardness. However, neither the colour nor the rest of the textural properties as cohesiveness, elasticity or adhesiveness of the cut cheese samples were altered. As expected, the higher the concentration of oil, the higher the antimicrobial activity of the coatings. Thus, it was possible to avoid the appearance of moulds and yeasts during more than 24 days and slow down the growth of psychrophiles due to the release of antimicrobial in both cases by using an edible coating with 2.5%(w/w) of oregano oil, representing an increase of at least 10 days concerning the normal shelf-life of cut cheese. In conclusion, nanoemulsion-based edible coatings enriched with mandarin fibre were effective in controlling the microbial growth, being able to increase the shelf-life of low-fat cheese without causing significant quality changes.

pEI-22

Protein-phenol complexes for interfacial stabilization

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New protein sources with low environmental impact and widespread availability were always among the primary interests of food industry. A decisive way to combine these aspects is valorisation of sunflower press cake. Sunflower press cake is a by-product originating from sunflower oil extraction and is currently underutilized although it contains essential and valuable ingredients, such as proteins, polyphenols and others [1]. Valorisation of this material was and still is a big challenge due to the interactions between proteins and polyphenols leading to discoloration and reduction of functionality and nutritional value of the proteins [1]. Deeper understanding of the nature of these interactions could result in more efficient fractionation techniques and higher functionality.

The aim of this project is to study the interactions of sunflower proteins and phenols in model dispersion systems. Previous studies have shown that chlorogenic acid (CGA), the major phenolic acid in sunflower seeds, can be associated with sunflower proteins through ionic, hydrogen and covalent interactions [2].Sunflower protein isolate (SFPI) of high purity (95 wt%) was isolated from seeds and characterised. Subsequently, SFPI was complexed with different concentrations of pure CGA. The interfacial properties of the resulting complexes were studied with static and dynamic interfacial tensiometry. In addition, advanced analytical techniques were employed in order to gain insights about the interfacial stabilization mechanism and the impact of the CGA. We have observed that the SFPI-CGA complexes showed different properties on the oil-water interfaces than SFPI alone. As we expected, the presence of the polar CGA had a great impact in the emulsifying capacity of the SFPI hence the qualitative attributes of the interface.

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pEI-23

Solid foams of whey proteins and its mixtures with polysaccharides

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The aim of producing foams in the food industry is to reduce product density, modify its texture and rheological properties, and improve its digestibility and sensory properties [1]. Proteins by themselves produce unstable foams and are generally accompanied by stabilizing agents such as polysaccharides. In this study, solid foams were obtained from liquid foams of whey protein isolate (WPI) and its mixtures with xanthan, guar or λ-carrageenan and glycerol or sorbitol as plasticizers. Concentrations were: 10% WPI, 0.15% xanthan, 0.15% guar, 0.20% λ-carrageenan and 12, 7% sorbitol and glycerol, respectively. WPI, polysaccharide and plasticizer solutions, at neutral pH, were stirred to generate liquid foams that were subsequently dried in two steps in microwave and convection ovens. The rheological behavior of the precursory liquid foams was studied using small amplitude oscillatory shear and steady shear measurements. Mechanical measurements and microscopy observations allowed determining the resistance to traction and pore size distribution, respectively, of solid foams. All liquid WPI foams and its mixtures exhibited viscoelastic behavior. Addition of a polysaccharide resulted in liquid foams of higher G' and G" while the presence of a plasticizer resulted in liquid foams of lower moduli. All showed shear-thinning behavior between 100 and 0.10 Pa.s. WPI, polysaccharide and plasticizer liquid foams exhibited similar viscoelastic behavior as WPI foams without additives. The resistance to traction of solid foams was in the range of 45 to 141 kPa, with 10% WPI, guar and glycerol being the most resistant. All sorbitol-containing solid foams had similar Young´s modulus; *ca.* 2200 kPa, while glycerol modified the mechanical behavior of the solid foams depending on the added polysaccharide. Likewise, all sorbitol-containing solid foams had lower pore sizes, 200 to 360 μm, with a mono-modal size distribution. In contrast, all glycerol-containing solid foams had higher pore sizes, 260 to 530 μm, and bimodal size distribution suggesting a relationship between this parameter and their mechanical properties. SEM observations and IR characterization are ongoing.

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pEI-24

Stability evaluation of soy protein/pectin dispersions containing buriti oil through the creaming index

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Nutritional value of buriti (*Mauritia flexuosa*) oil is atributted to the high content of carotenoids and tocopherols, providing pro-vitamin A and antioxidant properties (Rodriguez-Amaya, 1996). Nevertheless, these compounds can be lost due to the oil exposure to light, oxygen and high temperatures. Emulsion technology comes from the need of pharmaceutical and food industry, since it presents an adequate technique to encapsulate, protect and release lipid bioactive compounds (McClements et al., 2007). In order to stabilize emulsion systems, the use of synergistic effects from protein and polysaccharide interactions has been highlighted (Serfert et al., 2013). In this way, the objective of this work was to elaborate emulsions of buriti oil stabilized by soy protein isolate (SPI) and high-methoxyl pectin (HMP) under different formulations and study their stabilities over a period of 7 days. The assays were carried out according to a central composite rotatable design (CCRD) with three variables: oil ratio in the emulsion (from 10 to 30 %), percentage of SPI in the wall material (from 50 to 80 %) and pressure applied in the homogenizer (from 200 to 400 bar). The creaming index (CI), an indicative of emulsion stability, was determined as the reason between the lower phase height after storage and the initial height of the emulsion, throughout the 7 days. The analysis of CCRD for the first day showed that buriti oil ratio, SPI percentage, and their interaction were statistically significant ($p < 0.1$) parameters for creaming index. When analyzing the results obtained at the seventh day, the significant parameters were buriti oil ratio, SPI percentage, homogenization pressure, the interaction between oil and SPI contents, and the interaction between SPI content and applied pressure. Whereas the oil ratio and homogenization pressure had negative effects in the creaming index, the SPI percentage showed a positive contribution. The creaming index increased significantly ($p < 0.05$) throughout the 7 days, reaching 35 % in samples containing low oil ratio and high SPI percentage. On the other hand, samples with higher oil ratio and lower SPI percentage were stable (with no creaming) over the studied time.

Acknowledgments
The authors acknowledge São Paulo Research Foundation, FAPESP (Processes 2014/08520-6 and 2014/02910-7) for financial support.

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pEI-25

Role of the interface on the crystallisation of water-in-cocoa butter emulsions

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Water-in-cocoa butter (CB) emulsions have been recently proposed to reduce fat content in chocolate[1]. In these emulsions CB crystals form a continuous solid network and a sintered crystalline layer around the water droplets, which implies a process of interfacial crystallisation at the water-oil interface. While the crystallisation behaviour of bulk CB has been well characterised[2,3], its solidification in oil continuous emulsions has not been investigated. The aim of this study was to characterise the static isothermal crystallisation of water-in-CB emulsions. It was hypothesised that water droplets act as seeds promoting CB crystallisation *via interfacial heterogeneous nucleation*.

Emulsions containing 20% and 40% water, in both cases containing 1% (weight/weight) polyglycerol polyricinoleate (PGPR) were processed to obtain the same droplet size. To evaluate the combined effect of microstructure and degree of supercooling, samples were melted to erase crystal memory and re-crystallised at four temperatures (T=5, 10, 15, 20°C); bulk CB was used as reference. No increase in droplet size was observed on multiple melting-crystallisation cycles confirming emulsions stability. Crystallisation kinetic parameters were calculated from NMR solid fat content (SFC) curves over time using the Avrami model. To obtain quantitative information on the polymorphs, DSC endotherms recorded for different time-temperature combinations were processed by Gaussian deconvolution.

At intermediate levels of supercooling (T≥15°C), emulsified CB evolved faster toward the equilibrium SFC (higher Avrami kinetic constant) than bulk CB. The similarity in the values of Avrami exponent among systems at all temperatures suggests that the mechanisms of crystallisation are not affected by microstructural changes.

With respect to polymorphism, melting peak temperature and deconvolution analysis revealed that in all samples CB crystallised in the metastable α-form (Form II) at the beginning of the annealing process. Emulsified CB always evolved faster toward more stable forms and a significant fraction of Form V was detected. It was hypothesised that faster transition between forms results from the interaction at the interface between α-form CB crystals (characterised by high freedom of movement) and PGPR: the presence of liquid-like moieties at the droplet interfaces promotes polymorphic transformation by increasing molecular mobility and re-arrangement of triglycerides into more stable forms.

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pEI-26

Fungal proteins from the Quorn fermentation co-product as novel foaming, emulsifying and gelling agents

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The food industry is looking for sustainable alternatives to functional proteins of animal origin (including egg, milk and whey) due to their high costs, market volatility and high environmental footprint. In this context the production of fungal proteins by Marlow Foods for use in their meat-replacer product Quorn offers a potential sustainable, environmentally-friendly and cost-effective option. This study assessed the functional profile (foaming, emulsifying and rheological properties) and composition of a naturally foaming and currently unexploited liquid co-product (centrate) from the Quorn fermentation process. A range of protein fractions were generated from the centrate via successive ultrafiltration steps and their functional and proteomic profiles were characterised in comparison with a commercial whey protein concentrate product. The high-molecular weight (HMW) fraction obtained displayed outstanding foaming stability, emulsifying and rheological properties. Foams prepared from HMW solutions proved more stable than ones prepared with a whey protein concentrate (WPC) control. Oil emulsions prepared with the HMW fraction showed a smaller oil droplet size distribution than with WPC and proved more stable, while HMW proteins displayed interfacial properties at the oil/water interface and formed a rigid protein film at the interface. HMW solutions and oil emulsions showed high viscosity in comparison with those prepared with WPC. HMW solutions gelled at a 5% protein concentration, and HMW solutions and hydrogels displayed a higher viscoelasticity than the WPC ones. Large protein aggregates and fungal cell debris were observed in the HMW extract by confocal microscopy. A protein from the surface-active cerato-platanin family was reported in higher proportions in HMW than in the other fractions and could have contributed to its higher functionality. The higher foaming and emulsifying stability of the HMW fraction could result from the presence of stabilising fungal cell debris and/or from the release of surface-active proteins from large fungal cell debris. This study highlighted the potential of functional fungal proteins from the Quorn fermentation process as novel sustainable ingredients for the food industry.

pEI-27

Characterization and functionalities of isolate proteins from *Tenebrio molitor* and *Tenebrio molitor* meal produced by thermo-mechanical process

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Insects are considered to be future source alternative proteins. To use them as a food ingredient, it is necessary to preserve the characteristics of the native protein and to maintain their techno-functional properties. This research deals with the extraction process and physico-chemical and functional properties of proteins from *Tenebrio molitor* larvae.

To do that, the protein fraction was isolated using a combination of thermo-mechanical treatment and alkaline extraction. After solubilization, the proteins were recovered and, analysed for molecular weights, solubility, surface charge, surface tension, and, their foaming properties were evaluated and compared to those of some commercial proteins.

The molecular weights were ranged below 14 and 100 kDa above and the amino acid profile presented all the essential amino acids and sufficient responding to requirements for animals and for humans. The solubility of proteins as a function of pH in range of 2 to 11, of the ionic strength in range of 0 to 1 M at two temperatures, 25 and 45°C was studied. The results showed a maximum of solubility at high pH, 0M and 45 °C with an isoelectric pH around 5. The study of surface charge by zetameter showed the surface charge decrease from 21 mV at pH 2 to -34 mV at pH 10 with a surface charge of zero around the isoelectric pH. That confirmed the isoelectric pH determined by the solubility. The results showed also the absolute value of surface charge decreased (from 18 to 9 mV) when the ionic strength increased from 0 to 1 M. The investigation by a drop tensiometer of surface tension has permitted to show that the surface tension of soluble proteins was 32 mN/m and was lower than other proteins (42-57 mN/m, Foegeding et al, 2006; Bos & Vliet, 2001). The soluble proteins had the foam capacity which increased remarkably with the concentration of proteins and the foam stability to a concentration of 6 % was comparable to whey protein or bovine serum albumin to a concentration of 10 %.

pEI-28

Foaming and air-water interfacial properties of wheat gluten hydrolyzates and the influence of sucrose and ethanol thereupon

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In food products such as meringues, beer or chocolate mousses, protein foams play important structural and textural roles. Mostly, animal protein, such as egg white, is used for these applications, despite their relatively high cost and environmental impact. Plant proteins could be a viable alternative but often lack functionality, which is partly due to their low solubility in aqueous media.

Controlled enzymatic hydrolysis of gluten, a co-product of the industrial wheat starch isolation process, increases its solubility in aqueous media and can enhance its foaming properties. Here, commercial wheat gluten was treated to degrees of hydrolysis (DH) DH = 2% and DH = 6% (determined with pH-stat) using trypsin or pepsin. Foam formation and stability of the resulting hydrolyzates in water were evaluated by a standardized whipping procedure and related to adsorption kinetics and protein film properties at the air-water interface. The substantial increase of foam formation with protein concentration for all samples was related to a faster adsorption at the interface at increasing protein concentrations, measured by a faster decrease in dynamic surface tension. Hydrolyzates with low DH resulted in higher foam stability than those with high DH, and this at different protein concentrations. This could be related to differences in surface pressure – area (π-A) isotherms upon compression which reflect protein film properties. Finally, the influence of sucrose (20% w/v) or ethanol (5% v/v) solutions as bulk liquids on foaming and air-liquid interfacial properties of the different hydrolyzates was investigated.

pEI-29

Structure-affecting enzymes to engineer food dispersions

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In general, bio-inspired approaches are powerful tools to specifically engineer food dispersions. Enzyme technology has therefore been employed to modify physically assembled food structures. Of particular significance for texture, structure, colour, and sensorial modifications are enzymes that use food-grade proteins and/or polysaccharides as potential substrates. As such, it was shown that structure-forming enzymes can be used to network biopolymers in diluted or concentrated dispersions leading to new functionalities in terms of stability, release kinetics, rheology, appearance, digestibility, and texture. In particular, the oxidoreductase laccase (EC 1.10.3.2) induced crosslinking of interfacially adsorbed pectin in multilayered emulsions which improved its pH-, salt-, and temperature stability. Moreover, laccase promoted colour changes of lutein-loaded emulsions regardless of emulsifier type. In addition, the enzyme transglutaminase (EC 2.3.2.13), an acyltransferase, enhanced the formation of protein-stabilized emulsion gels rather than intra-membrane crosslinks at sufficiently high oil droplet concentrations (c_{oil} > 0.6). More recent studies have demonstrated that structure-degrading enzymes altered the native conformation of proteins leading to self-assembly of hierarchically ordered colloidal particles. In particular, an endopeptidase (EC 3.4.21-24) was used to hydrolyze sodium caseinate to various degrees of hydrolysis (DH). It was shown that a network formation was induced at low DH, whereas spherical micellar-like particles were obtained at higher DH. However, it was suggested that the accessibility of enzymes to their substrates might play a key role in modifying biopolymers. Potentially, the structural arrangement of biopolymers at the interface was thought to be a steric hindrance lowering the effectiveness of enzymes, particularly in tightly packed systems. Results of these studies thus show that rational use of structure-affecting enzymes may enable food manufacturer to produce food dispersions with improved physical, functional, textural, optical, and rheological properties.

pEI-30

Harnessing proteins to control crystal size and morphology, for improved delivery performance of hydrophobic bioactives, using genistein as a model

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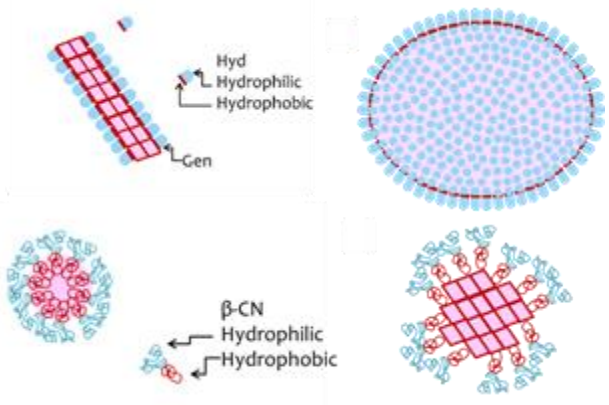
Protein-surface and protein-crystal interactions are important in many areas of technology including drug and nutraceutical delivery, as many bioactives are highly hydrophobic and tend to crystallize, resulting in poor bioavailability. The improved ability to control lipophilic bioactive nanocrystal formation and dispersibility can increase colloidal stability, and open new ways to control the release of incorporated bioactives and their bioavailability.

Herein we compared three model proteins: β-Casein, hydrophobin, and β-lactoglobulin, representing different structural groups of proteins, and assessed their functionality in preventing crystal growth, using genistein (Gen) as a model hydrophobic crystallizing bioactive.

Dynamic light scattering, polarized light microscopy and cryo-TEM showed that β-lactoglobulin, hydrophobin and β-casein, respectively inhibit genistein crystal growth in aqueous solution in increasing order of efficacy. Protein structure determines the mechanism and the efficacy by which it affects crystal growth and morphology: β-lactoglobulin, a rigid globular protein with an inward facing hydrophobic domain, indirectly suppresses crystallization by binding and reducing concentration of free hydrophobic compound molecules. Hydrophobin (Hyd), a rigid globular protein with a flat external hydrophobic domain, adheres to the surface of certain crystal faces limiting growth in the perpendicular directions. β-Casein, (β -CN) a rheomorphic protein with an external hydrophobic domain, adheres to different crystal faces non-specifically, thereby blocking growth in all directions. Consequently, an inverse correlation was observed between nanocrystal size and *in vitro* bioavailability. Based on this study, amphiphilic proteins can be more effectively selected and applied to control crystal growth and morphology of hydrophobic bioactives to improve their delivery and bioavailability in food and drug systems.



pEI-31

Towards a quantitative description of the formation of protein-stabilized emulsions and foams

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A tremendous amount of research focussed on studying the behaviour of proteins in foams and emulsions. Studies investigated the effect of system conditions such as pH and ionic strength on the foam and emulsion properties. Other studies focussed on the influence of system conditions on the interfacial properties. Despite these studies, it still proves difficult to predict the behaviour for a protein under different conditions or in a different system (foam/emulsion). For the future development of this field it is, however, important to come to a quantification of the effect of these parameters. We present results of the first attempts to develop a generic model to describe and predict the interfacial behaviour of proteins and to translate these to their effects on foam and emulsion properties. These attempts initially focussed on the fundaments of protein-stabilized foams and emulsions, i.e. adsorption of proteins to the interface. It is often described that a completely covered interface is required (i.e. certain amount of adsorbed protein (Γ)) within the time of formation of a bubble or droplet (i.e. t) to arrest coalescence. For emulsion formation, this view resulted in the development of a basic model and the introduction of the terms protein-poor and protein-rich regime[1]. The concentration which demarcates the transition from the protein-poor and protein-rich regime is dependent on the adsorption rate (dΓ/dt). The adsorption rate was found to be influenced by the molecular properties of a protein, mainly exposed hydrophobicity and surface charge. Incorporating these molecular properties into the basic model resulted in a more generic model describing emulsion formation, i.e. surface coverage model[2] (figure 1A). This model was also able to describe foam formation (figure 1B). This demonstrates the strength of this approach to provide a quantitative link between the molecular, interfacial and foam or emulsion properties of proteins.

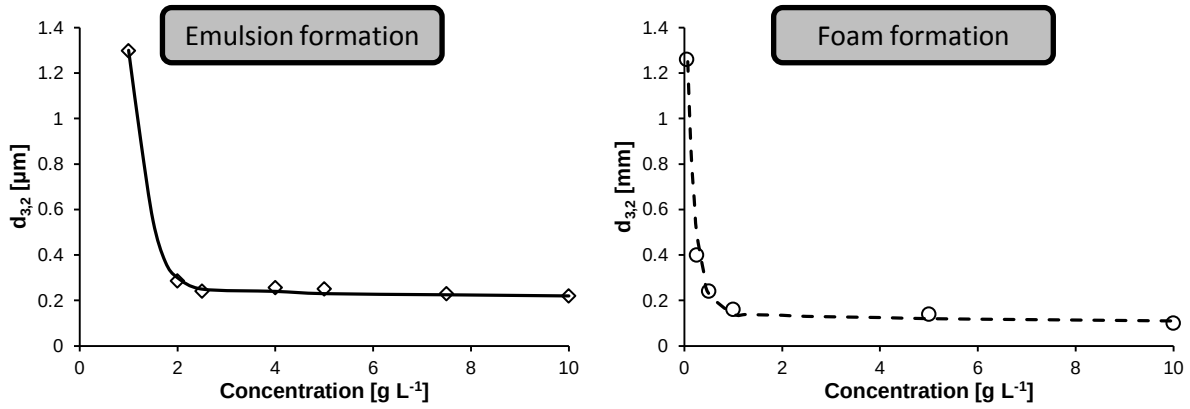

Figure 1. Effect of protein concentration on the formation of a β-lactoglobulin-stabilized emulsion (A) and foam (B).

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