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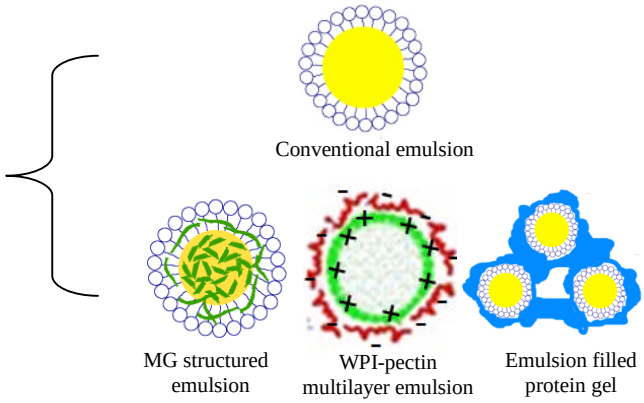
Novel Structured Emulsions for Delivery of Engineered Food Flavours



Key external stakeholders:

Dairy and beverage industry
Fat-reduced food manufacturers
Academic and research institute

Practical implications for stakeholders:

The outcome/technology or information/recommendation is……

The study provided important information about different structured emulsions as delivery systems for flavour compounds, and on how food structure can be designed to modulate flavour release. The findings suggested that it is possible to modulate flavor release (response to different triggers) by changing emulsion structure, which could be helpful in the development of functional foods with improved flavour profile. The emulsions studied in this research many also find applications to deliver non-volatile functional ingredients.

Main results:

1. Monoglyceride formed liquid crystalline structures in the oil phase of oil-in-water emulsions, and crystalline structure worked to reduce the amount of flavour released to the headspaces.
2. Headspace concentration of flavours was significantly lower in WPI-pectin multilayer emulsions than that in conventional emulsions and flavour release can be modulated by adjusting pH, salt concentration of the emulsion.
3. Flavours had lower release rates and headspace concentrations in emulsion filled protein gels, and the release was more inhibited when more protein was included. Reduced flavour release in oil-reduced gels can be achieved by increasing WPI content.
4. The involvement of matodextrins in the emulsions improved emulsion stability against freeze-thawing, and flavours had similar release profiles before and after freeze-thaw treatment.

Opportunity / Benefit:

This research provides profound knowledge about emulsion structures and flavor release, and the designing of flavor delivery systems. Different structured emulsions with structuring of the oil phase, water phase, and interface allow better delivery of food flavors and other functional ingredients. The findings obtained in this study provided important information on designing novel food products with specific health/function claims and improved flavor profile, e.g., fat reduced food, long-shelf-life foods.

Collaborating Institutions:

University College Cork

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Teagasc project team: Dr. Song Miao (PI/PL), Dr. Like Mao (Walsh Fellow)

External collaborators: Prof. Yrjö Roos (UCC)

1. Project background:

There is growing interest in functional foods with low fat, low sugar, low salt, or bioactives-enriched, to develop healthy diets for human wellbeing. In the meantime, consumers ask for food with desirable organoleptic properties, particularly flavour profile. It is a big challenge for academic and industrial researchers to design healthy food products without sacrificing food flavour, as flavour release is not only influenced by food ingredients but also food structures.

Food emulsions have long been used as delivery systems for functional food ingredients, and different types of emulsions facilitate their involvement in complex food systems. An important characteristic of an emulsion is that the structures in water phase, oil phase and interface can be designed to meet special requirements, and the release of the compounds incorporated can then be modified. Currently, there is limited knowledge on flavor delivery using structured food emulsions.

2. Questions addressed by the project:

The main questions were whether novel structured emulsions are suitable to deliver volatile food flavors, and how flavor release can be modulated by just adjusting emulsion structures. We tried to correlate environmental stresses (e.g., pH, salt concentration, saliva) with food structures and then flavor release. In addition, it is meaningful to see whether the structured emulsions can find applications in fat-reduced food with desirable flavor profiles.

3. The experimental studies:

The current research investigated four structured oil-in-water emulsions with structuring in the oil phase, oil-water interface, and water phase. Oil phase structuring was achieved by the formation of monoglyceride (MG) liquid crystals in the oil droplets (**MG structured emulsions**). Structured interface was created by the adsorption of a whey protein isolate (WPI)-pectin double layer at the interface (**multilayer emulsion**). Water phase structured emulsions referred to emulsion filled protein gels (**EFP gels**), where emulsion droplets were embedded in WPI gel network, and **emulsions with maltodextrins** (MDs) of different dextrose-equivalent (DE) values. Flavour compounds with different physicochemical properties were added into the emulsions, and flavour release (release rate, headspace concentration and air-emulsion partition coefficient) was described by GC headspace analysis.

4. Main results:

- In **MG structured emulsions**, MG self-assembled into liquid crystalline structures, which offered the emulsions viscoelastic properties. Flavour compounds in MG structured emulsions had lower initial headspace concentration and air-emulsion partition coefficients than those in unstructured emulsions. Flavour release can be modulated by changing MG content, oil content and oil type.
- **WPI-pectin multilayer emulsions** were stable at pH 5.0, 4.0, and 3.0. Increase of pH from 5.0 to 7.0 resulted in higher headspace concentration but unchanged release rate, and increase of NaCl concentration led to increased headspace concentration and release rate. The study also showed that salivas could trigger higher release of hydrophobic flavours and lower release of hydrophilic flavours.
- In **EFP gels**, increases in protein content and oil content contributed to gels with higher storage modulus and force at breaking. Flavour compounds had significantly reduced release rates and air-emulsion partition coefficients in the gels than the corresponding ungelled emulsions, and the reduction was in line with the increase of protein content. Gels with stronger gel network but lower oil content were prepared, and lower or unaffected release rates of the flavours were observed.
- In **emulsions containing maltodextrins**, water was frozen at a much lower temperature, and emulsion stability was greatly improved when subjected to freeze-thawing. Among different MDs, MD DE 6 offered the emulsion the highest stability. Flavours had lower air-emulsion partition coefficients in the emulsions with MDs than those in the emulsion without MD. Maltodextrins worked to maintain the volatile characteristics of emulsions after freeze-thawing.

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5. Opportunity/Benefit:

Teagasc can provide expertise for the designing of flavor delivery system (also works for some non-volatile lipophilic functional ingredients) in dairy products or beverages to meet special requirement for customers. The techniques obtained in this research allow to test food flavor profile in different environmental conditions.

6. Dissemination:

Main publications:

1. Mao, L.; O'Kennedy, B.T.; Roos, Y.H.; Hannon, J.A.; Miao, S*. Effect of monoglyceride self-assembled structure on emulsion properties and subsequent flavor release. *Food Research International*, 2012, 48, 233-240.
2. Mao, L.; Roos, Y.H.; O'Callaghan, D.J.; Miao, S*. Volatile release from whey protein isolate-pectin multilayer stabilized emulsions: effect of pH, salt and artificial salivas. *Journal of Agricultural and Food Chemistry*, 2013, 61, 6231-6239.
3. Mao, L.; Roos, Y.H.; Miao, S*. Volatile release from self-assembly structured emulsions: effect of monoglyceride contents, oil contents and oil types. *Journal of Agricultural and Food Chemistry*, 2013, 61, 1427-1434.
4. Mao, L.; Boiteux, L.; Roos, Y.H.; Miao, S*. Evaluation of volatile characteristics in whey protein isolate-pectin mixed layer emulsions under different environmental conditions. *Food Hydrocolloids*, 2014, 41, 79-85.
5. Mao, L.; Calligaris, S.; Barba, L.; Miao, S*. Monoglyceride self-assembled structure in O/W emulsion: formation, characterization and its effect on emulsion properties. *Food Research International*, 2014, 58, 81-88.
6. Mao, L.; Roos, Y.H.; Miao, S*. Study on the rheological properties and volatile release of cold-set emulsion filled protein gels. *Journal of Agricultural and Food Chemistry*, 2014, 62, 11420-11428.
7. Mao, L.; Miao, S*. Structuring food emulsions to improve nutrient delivery during digestion. *Food Engineering Reviews*, 2015, in press.
8. Song Miao*; Like Mao. 2014. DSC Usefulness to Measurement of Food Emulsion Stability, in Emma Chiavaro (Eds.) Differential Scanning Calorimetry: Applications in Fat and Oil Technology. CRC press.
9. Mao, L.; Roos, Y.H.; Miao, S*. Flavour release from monoglyceride structured oil-in-water emulsions through static headspace analysis. *Food Biophysics*, 2014, 9, 359-367.
10. Mao, L.; Roos, Y.H.; Miao, S*. Effect of Maltodextrins on the Stability and Release of Volatile Compounds of Oil-in-Water Emulsions Subjected to Freeze-Thaw Treatment. *Food Hydrocolloids. 2015.* 50,219-227.
11. Mao, Like; Roos, Yrjo; Biliaderis, Costa; Miao, Song*. Food Emulsions as Delivery Systems for Flavor Compounds - A Review. *Critical Reviews in Food Science and Nutrition*. 2015. In press.
12. Like MAO (2014). Novel Structured Emulsions for Delivering of Food Flavours. PhD thesis, School of Food and Nutritional Sciences, University College Cork.

Popular publications:

Mao, L.; Roos, Y.H.; O'Callaghan, D.J.; Miao, S*. Volatile release from whey protein isolate-pectin multilayer stabilized emulsions: effect of pH, salt and artificial salivas. *Journal of Agricultural and Food Chemistry*, 2013, 61, 6231-6239.

Mao, L.; O'Kennedy, B.T.; Roos, Y.H.; Hannon, J.A.; Miao, S*. Effect of monoglyceride self-assembled structure on emulsion properties and subsequent flavor release. *Food Research International*, 2012, 48, 233-240.

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