Neutrons & Food Sydney, Australia

Contribution ID : **24** Type : **Oral**

Interface structure of 70% fish oil-in-water emulsions stabilized with combinations of sodium caseinate and phosphatidylcholine: use of small angle neutron and X-ray scattering techniques

Thursday, 18 October 2018 09:40 (20)

Marine long chain (LC) omega-3 polyunsaturated fatty acids (PUFAs) have been reported to have numerous beneficial effects on health such as decreasing cardiovascular diseases, improving immune system and mental health. Oil-in-water emulsions have been used as delivery systems to enrich foods with LC omega-3 PUFAs, such as eicosapentaeonic (C20:5n−3, EPA) and docosahexaeonic (C22:6n−3, DHA) acids, in order to increase the intake of these bioactive compounds. However, LC omega-3 PUFAs are highly prone to oxidation, which results in formation of lipid oxidation products causing undesired sensory properties as well as loss in nutritional profile. As high fat omega-3 delivery emulsions are applicable to many food systems and lipid oxidation in emulsions have been claimed to be initiated at the oil-water interface, food researchers and industry are highly interested in understanding the inner dynamics of these systems.
This study focused on characterizing interfacial structure of high fat (70%) oil-in-water emulsions emulsified with sodium caseinate (CAS) and phosphatidylcholine (PC). Structure of emulsifiers which are adsorbed on water-oil interface could be best studied by Small Angle Neutron Scattering (SANS) together with Small Angle X-Ray Scattering (SAXS). Interfacial structure was aimed to be characterized by identifying thickness of the interfacial layer and distances between emulsifiers adsorbed at the oil-water interface as well as obtaining information on adsorption behavior of the combined use of emulsifiers in high fat delivery emulsions. In order to study these characteristics, simpler versions of this system was also studied; e.g. different concentrations of CAS in D2O, different concentrations of PC in D2O, 70% oil-in-water emulsions produced only with CAS or only with PC at different concentrations. Contrast matching between oil and water phase as well as contrast variation of water phase were applied. For this reason, scattering length densities and relative concentrations of employed compounds were calculated and hydrogen content was considered to be minimized. From these considerations, it was proposed to have a model system of deuterated water and various mixtures of deuterated and regular hexadecane or only deuterated hexadecane providing maximum contrast between liquids and emulsifiers. Fish oil was also included in some of the measurements in order to compare the results from model systems with the original system.
SAXS results have shown that CAS forms aggregates and PC forms multilayers both in water and high fat oil-in-water emulsion. It was found that CAS concentration affected the periodic repeat distance of the PC bilayers. When the mass concentration of CAS increased, the distance between PC bilayers become smaller, this was attributed to the decrease in water amount trapped between PC layers. When the concentration of CAS was fixed, the distance between PC bilayers was the same independently from PC concentration. Moreover, SANS results indicated that the aggregate size was bigger when CAS was in the emulsion interface together with PC compared to the CAS in D2O which might be an indication of the interaction between CAS and PC at the oil-water interface in high fat oil-in-water emulsions.

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Session Classification : Morning Session

Track Classification : Food gels and emulsions