FAT CRYSTALLIZATION IN COMPLEX FOOD EMULSIONS AS AFFECTED BY ADSORBED PROTEIN LAYERS : A DSC STUDY.

Perla Relkin[1], Stéphanie Sourdet[1], and Pierre-Yves Fosseux[2]
[1]Laboratoire de Biophysique des Matériaux Alimentaires
Ecole Nationale Supérieure des Industries Alimentaires
1, Avenue des Olympiades,F- 91 744 –Massy.
[2]Nestlé Product Technology Center Beauvais
Z.I.n°2, Rue Charles Tellier, F - 60000 Beauvais.
[1]relkin@ensia.inra.fr

ABSTRACT

In emulsions, the resistance to physical changes, such as flocculation/coalescence of fat globules is related to properties of the interfacial layer around the fat globules, different physico-chemical interactions or chemical bonds, and interdroplet medium (1). Besides these properties, fat crystallization has been demonstrated to play a role in emulsion stability. Numerous techniques such as dilatometry, ultrasonic velocity measurements, X-ray diffraction and differential scanning calorimetry which are used to study physical state transitions in bulk fat samples, are also used for monitoring crystallization behaviour in dispersed fat droplets (2, 3). Most of these studies focused mainly on the effects of fat droplet sizes as affected by the homogenisation step, but few attention was paid to effects of adsorbed proteins to the oil/solution interface.

We prepared emulsions consisting (all in weight proportions) of 3% milk proteins, 9% hydrogenated palm kernel oil, 5.3% lactose, 0.8% mineral ions from milk permeate ultrafiltrate, 14% sucrose, 3% glucose syrup (dextrose equivalent 40), and 0.5% stabilizer/emulsifier mixture composed of mono-and diglycerides, locust bean gum, guar gum and carrageenan (3). They were based on the same milk solid non-fat content, but they differed by the nature of the milk protein powder used in the formulation. We used a skimmed milk powder (SMP) and a whey protein isolate (WPI) to prepare emulsions, based on SMP, on WPI , and on a mixture of 50% weight ratio of SMP and WPI. Thermal behaviour of these three hydrogenated palm kernel oil-in-water emulsions, was studied in parallel with determination of other characteristic parameters such as aggregation/coalescence of fat droplets, and proportion of adsorbed proteins at the oil/water interface. Differential Scanning Calorimetry (DSC) was applied for monitoring crystallization and melting behaviour of non-emulsified and emulsified fat samples.

The supercooling temperature needed to initiate fat crystallisation in emulsified systems and the variation in growing rate of crystallinity, under cooling experiments, were affected by the homogenisation step, and they depedended by the amount and nature of adsorbed proteins (Fig1, 2, 3). A total replacement of milk proteins by whey proteins affected the fat crystallization behaviour of emulsified fat droplets, in parallel with changes in their protein surface coverage and in their physical stability against fat droplet agglomeration (Fig.4).

After the initial increase in fat crystallinity, the growing rate seemed to be reduced more significantly in emulsions containing caseins, and then more accelerated in a third temperature range, than in WPI emulsion. We observed a similar effect of protein type on the supercooling temperature for crystallization of other complex emulsions, where we replaced SMP by WPI, alone, or in mixture with micellar caseins (4, 5). The anticipated (or delayed) fat crystallization occurring in WPI-emulsion (or emulsions containing caseins), compared to bulk fat sample (Fig.3), could be explained by a catalytic (or non catalytic action) of adsorbed molecular species, as previously reported for small molecular weight emulsifiers in hydrocarbon and triglyceride oil-in-water emulsions (6).

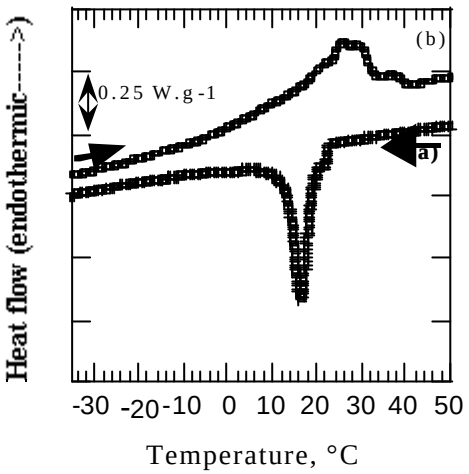

Fig 1: Cooling and heating DSC curves obtained from bulk fat

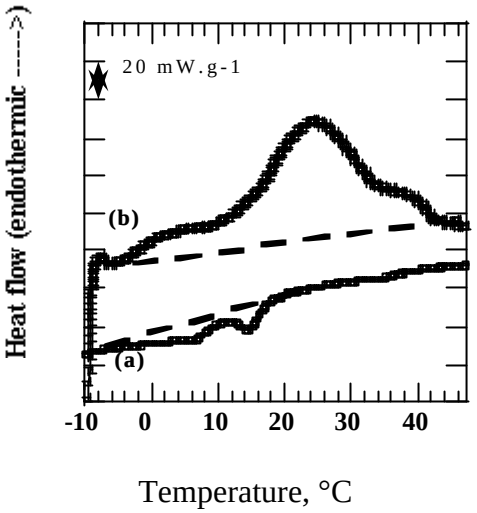

Fig 2: Cooling and heating DSC curves obtained emulsified fat sample

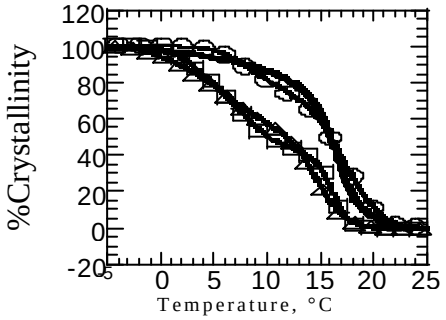

Fig. 3: Crystal growing rate in bulk sample (bold curve) and emulsions based on whey proteins (circles) and casein /whey protein mixtures (squares and triangles)

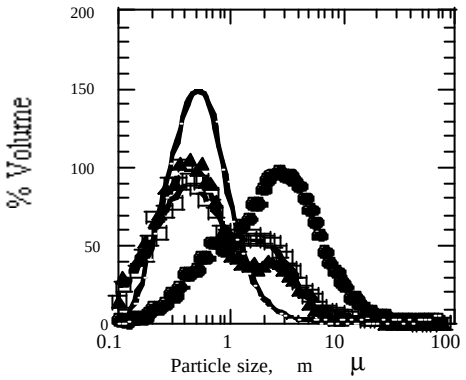

Fig.4. Globule fat distributions of corresponding emulsions.

(1) S. Sourdet , P. Relkin, P-Y Fosseux, V. Aubry, Lait 82 (2002) 567..
(2) P. Walstra and E.C. H. Beresteyn. Neth. Milk Dairy J., 29 (1975), 35.
(3) C. Lopez., P. Lesieur, G. Keller and M. Ollivon. *J. Colloid and Interface Sci.* 229(2000) 62.
(4) P. Relkin, S. Sourdet, P-Y.Fosseux, J.Thermal Anal. Calor., 71 (2003) 187.
(5) P. Relkin, A. Ait-Talleb, S. Sourdet, P-Y. Fosseux, JAOCS (2003), sous presse.
(6) W. Skoda and M. van den Tempel M., *J. Colloid Sci*. 18 (1963) 568.