Anhydrous Milk Fat enrichment with ^{13}C-triacylglycerol tracers: effects on thermal and structural behavior.

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Introduction

The crystallization, melting behavior and polymorphic stability of fats are determined by the behavior of the triacylglycerols (TAGs) they contain. In clinical studies, there is a need to add some ^{13}C TAGs as tracers to the ingested fats in order to track their metabolic fate. This procedure could modify physicochemical properties of the fat. The present study was conducted in the framework of a clinical trial aiming at highlighting the effect of the physical structure of a fat (droplets in O/W emulsion or bulk) in a meal on the absorption, chylomicron transport and further metabolic handling of dietary fatty acids (1, 2). We therefore monitored the thermal and polymorphic behavior of anhydrous milk fat (AMF) enriched in tracers (mixture of PPP, OOO and CCC; 1.5 or 5.7 wt%) using DSC and XRD and further compared it to the native AMF.

Material & Methods

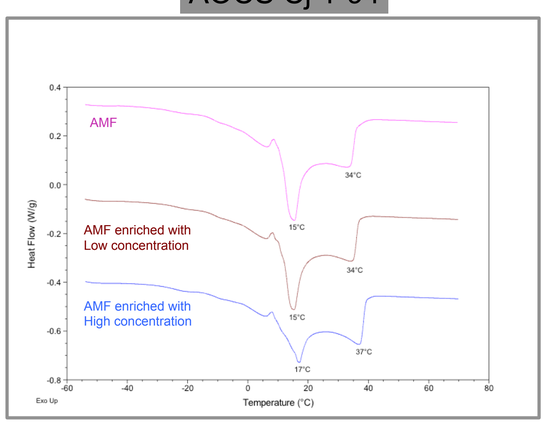
DSC melting profiles were recorded using a Q1000 DSC (TA Instruments, USA) according to different procedures:
1) according to AOCS Cj1-94 official method (cooling rate -10°C/min ; heating rate 5°C/min)
2) Using a tempering procedure in order to mimic the real conditions of the clinical trials:
- Tempering 1 : slow cooling (-1°C/min) to 4°C followed by 15 h tempering at 4°C and subsequent melting from 4 to 70°C (heating rate 15°C/min).
- Tempering 2 : slow cooling (-1°C/min) to 4°C followed by 15 h tempering at 4°C, heating from 4 to 37°C (heating rate 15°C/min), isothermal period of 4h at 37°C, melting from 37 to 70°C (heating rate 15°C/min).

Polymorphism by XRD using a Bruker D8-Advance Diffractometer (Bruker, Germany) and an Anton Paar TTK450 chamber: short and long spacings, after cooling and tempering just as for DSC experiments.

Results : effect of addition of ^{13}C TAGs to AMF

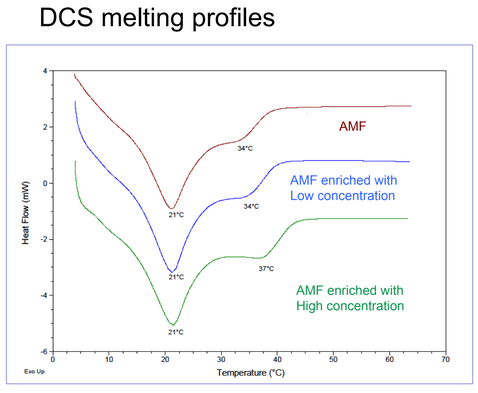
DSC Melting profiles and polymorphic stability of Bulk AMF

AOCS Cj 1-94

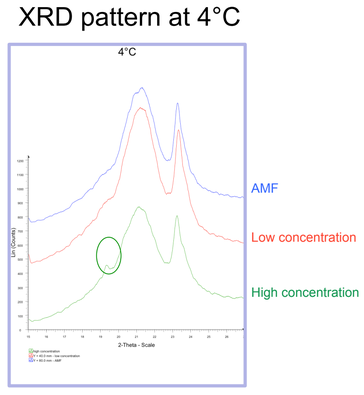


Tempering « 1 »

DCS melting profiles

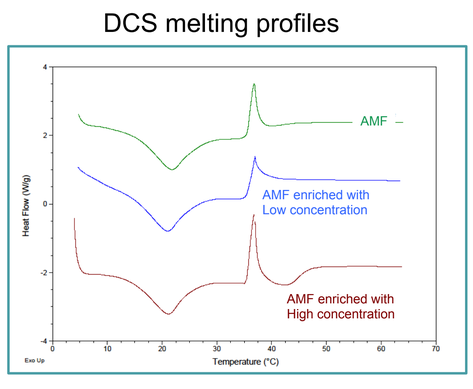


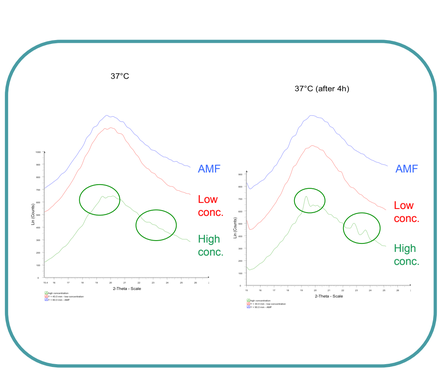
XRD pattern at 4°C



Tempering « 2 »

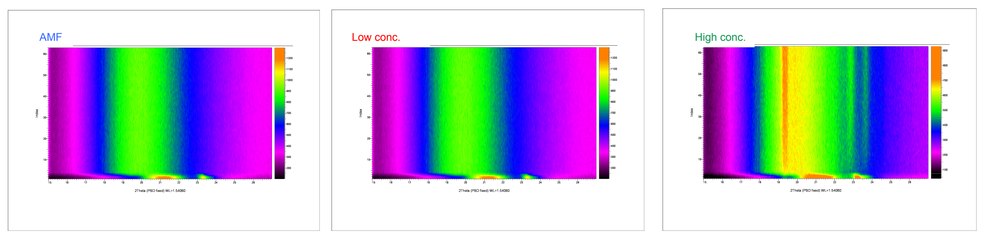
DCS melting profiles





Native AMF as well as AMF enriched in the low ^{13}C TAGs concentration are completely melted at around 37°C, i.e. close to the body temperature.
However, the AMF enriched in high ^{13}C TAGs concentration remains crystallized at 37°C.
Regarding polymorphic stability, at 4°C, after slow cooling only β' form is observed in the native AMF
Besides β', the β-form is also detected in the AMF containing high ^{13}C TAGs concentration.
The β-form even increases during the 4h at 37°C in the AMF sample enriched with high ^{13}C TAGs concentration.

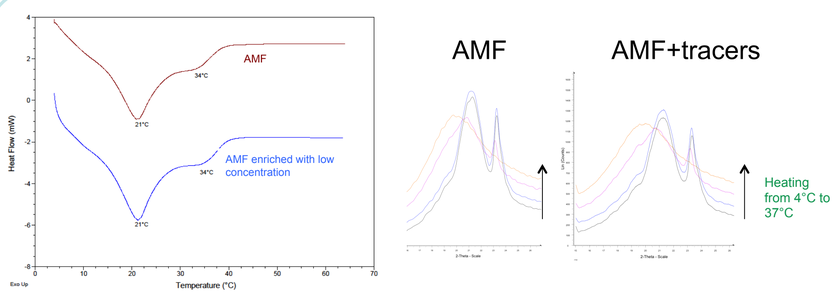
XRD pattern from 4°C to 37°C, followed by the isothermal period of 4hours at 37°C.



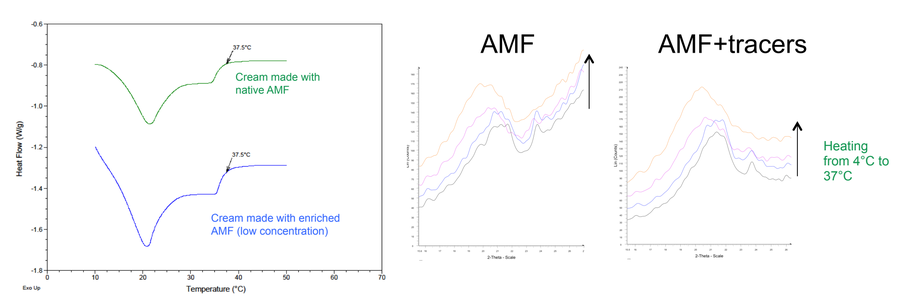
DSC Melting profiles and polymorphic stability of AMF in bulk and emulsified states (low ^{13}C TAGs concentration)

Tempering « 1 »

Bulk



Emulsified



Similar trends were observed in both bulk fat and creams, using the low concentration.

Conclusions

Addition of ^{13}C TAGs modified AMF melting profile, especially at high concentration. The enriched AMF was completely melted at around 37°C, i.e. close to body temperature. However, under some conditions, AMF enriched in high ^{13}C TAGs concentration remained crystallized at 37°C. Similar trends were observed in both systems (bulk *vs* emulsified). Moreover, AMF polymorphic behavior was also modified upon tracers addition. While only β' form was observed in native AMF, β form was detected in AMF containing high ^{13}C TAGs concentration.
Low concentration of tracers should not have any high impact on human digestive physiology.
However more attention should be paid to physicochemical structure when high concentrations are added.

(1)Vors et al. 2013. Modulating absorption and postprandial handling of dietary fatty acids by structuring fat in the meal: a randomized cross-over clinical trial. *Am J Clin Nutr, 97(1): 23-36.*
(2)Gabert et al. 2011. ^{13}C tracer recovery in human stools after digestion of a fat-rich meal labelled with [1,1,1-^{13}C3] tripalmitin and [1,1,1-^{13}C3] triolein. *Rapid Commun. Mass Spectrom*, 25(19):2697-703

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