"The effect of olive oil and fenugreek gum content on the stability and oxidation of o/w macro- and submicron-nano emulsions"

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Introduction

Within the last few years numerous polysaccharide extracts have been proposed as emulsion stabilizing agents.This increased interest arises from the fact that commonly used food polysaccharides like guar gum are used in non-food applications, mainly in petroleum refining and pharmaceuticals (Vaughna et al). Along with the lower global production this has resulted in price fluctuations, consequently severe price increase and supply shortage (Bahamdan et al, Barati et al, Anon et al). From a dietary point of view, the viscous property of fenugreek gum (Trigonella foenum graecum L.) has been proved to reduce in vitro the absorption of glucose and the plasma levels of triglycerides and cholesterol in vivo and could be used when designing low-at emulsified products. Ultrasonic emulsification is a cost effective technique and the interest for scale-up is increasing, as it is considered a **"Green Processing"** technology for the manufacture of nanoemulsions.

Aim

The objective of this study was to investigate the effect of droplet size reduction within the nano-submicron range on the physical and oxidative stability of olive oil emulsions containing different concentrations of olive oil, in order to design low fat products.

Experimental

Primary coarse emulsions prepared with a high shear device contained 10 wt% whey protein isolate (WPI, 92%wt in protein, Arla Foods) and 5, 10 or 20% olive oil. Ultrasonication (20 kHz, 12 min, 40 % amplitude) was used to reduce the particle size of coarse emulsions within the submicron-nano range. Emulsions coarse and/or submicron were further diluted with debitterized fenugreek gum solution (Fenulife, Frutarom, Belgium) to yield emulsions of 1% wt gum concentration. The final concentration of oil in final emulsions (Coarse or Ultra-sonicated, US) was 2.5, 5 or 10%. The pH of final emulsions was adjusted to 3.8.

Effect of FG concentration, olive oil content and emulsification method on emulsion stability

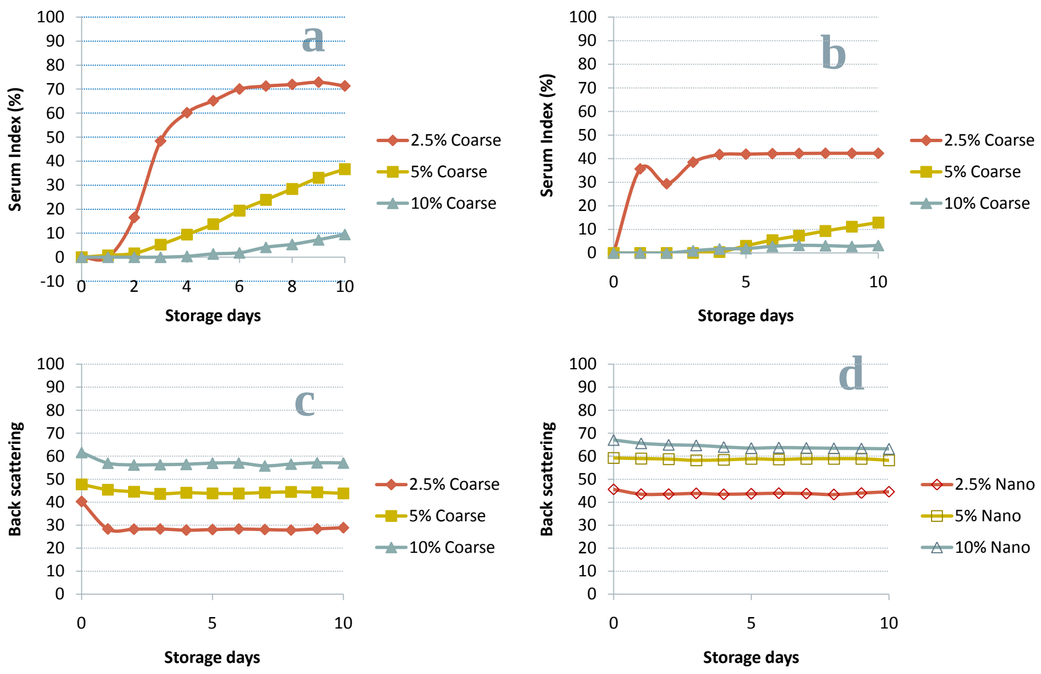


Figure 1. Stability of emulsions during cold storage (5° C) containing a) 0.5%, b) 0.75%, c) 1% FG Coarse and d) 1% FG Nano

- Emulsions containing 0.5 and 0.75 % were unstable regarding creaming (a,b).
- At 1% concentration FG, stable emulsions were prepared regardless of the olive oil content (c).
- Ultrasonication strongly improved emulsion stability. Higher values of Back scattering (BS) and minor changes of BS during storage (<4%), (d) indicative for highly stable emulsions.

Effect of olive oil content and emulsification method on emulsion droplet size & polydispersity

Table 1. Droplet size (median diameter, D_{50} and Z-average diameter) as affected by olive oil concentration and emulsification method applied

	Olive oil concentration		
	2.5%	5%	10%
Coarse emulsions			
D_{50} (μm)	5.93 (±0.93)	6.65 (±1.05)	15.17 (±1.96)
Span (-)	3.21 (±0.23)	1.35 (±0.25)	1.23 (±0.16)
Submicron/nano-emulsions			
Z-average (nm)	207.3 (± 1)	288.7 (±17.6)	685 (±69)
PDI (-)	0.219 (±0.006)	0.381 (±0.021)	1.083 (±0.149)

- Ultrasonication reduced the droplet size within the submicron/nano range.
- Oil concentration affected both droplet size and poly-dispersity.
- Samples containing 2.5% olive oil exhibited the smallest oil droplet diameter (~ 200 nm) and lowest poly-dispersity (PDI ~ 0.2).

Effect of olive oil content and emulsification method on emulsion rheological properties

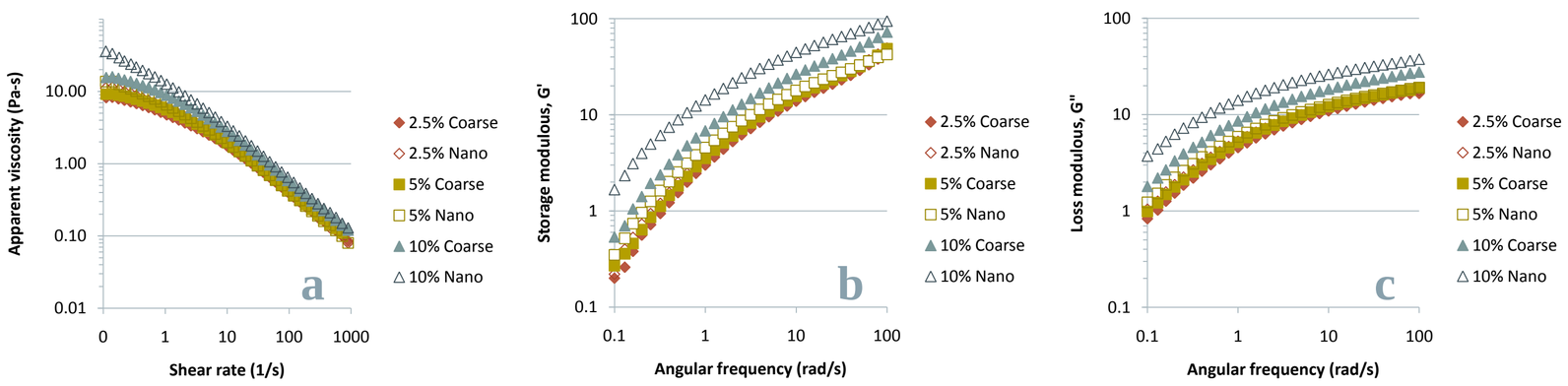
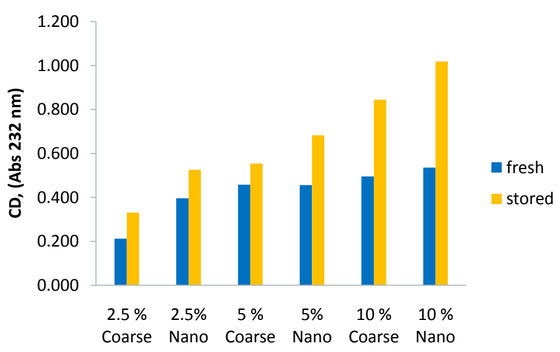


Figure 2. Viscosity (a), Storage (b)and Loss (c) moduli of coarse and nano emulsions

- Visco-elastic properties: viscosity and G",G' moduli were affected by sonication, due to droplet size reduction.
- Submicron /nanoemulsions exhibited higher viscosity and G",G' moduli values compared to their coarse counterparts
- This phenomenon was more evident in the case of emulsions containing 10% olive oil whereas for 2.5 and 5% differences were minor.

Effect of olive oil content and emulsification method on emulsion oxidation



- Submicron/nano-emulsions where characterized by increased oxidation in comparison to their coarse counterparts. This could be due to increase of particle surface and/or metal ions' migration from the acoustic probe.

Conclusions

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Oxidation rate was more pronounced for **nano-emulsions**

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Ultrasonication decreased droplet size within the nano range and **improved** the **physical stability** of emulsions.

FG could be considered an **alternative stabilizer** to create healthier low-fat salad dressing products.

Acknowledgements : This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund.
Olga Kaltsa acknowledges Frutarom SA for kindly donating Fenulife samples.