

Dynamic aspects of oral processing of curcumin-loaded solid lipid nanoparticles yoghurts by rheology and soft tribology assessment

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Mouthfeel and consistency originating from the consumption of yoghurts represent decisive factors for the consumers' acceptability [1]. The present work aims to identify potential differences in the sensory perceptions of yoghurts with curcumin-loaded solid lipid nanoparticles (SLN) incorporation. Thus, rheology coupled with tribology were considered to simulate the dynamic aspects of oral processing. Similar values for the elastic (G') and viscous (G'') parameters were obtained for both control yoghurt and yoghurt with curcumin-loaded SLN, as well as flow index (n) and consistency index (k) around 0.56 and 1.50 Pa.sⁿ, respectively. However, the friction behaviour was characterised by significant differences in all tribological regimes, suggesting that the incorporation of nanoparticles in yoghurts could potentially affect the after-feel upon swallowing, whilst not directly impacting on yoghurt's structure.

Introduction

The ever-growing awareness from consumers regarding the link between food and wellness/health has led to an increasing interest in the development of new functional food products. The bright yellow chemical curcumin present in the flowering plant turmeric is a polyphenol with many benefits, such as antioxidant, anti-inflammatory, anti-microbial and anti-tumoral properties. Despite such beneficial attributes, curcumin exhibits low solubility in aqueous solutions, sensitivity to light and low bioavailability, therefore limiting its usage in functional foods [2]. A possible strategy to overcome some of the shortcomings consists in encapsulating curcumin particles. That said, several properties in the functional food development have impact on the consumer's acceptance. The relationship between rheological and tribological properties has been increasingly studied and constitute a valuable tool to achieve indicatives of in-mouth sensory perceptions.

Experimental Techniques

The rheological properties of plain yoghurts and curcumin-loaded SLN samples were assessed from flow curves acquired with an up-down-up step program and subsequently fitted with Herschel-Bulkley's equation. The oscillatory measurements were carried out within the linear viscoelastic domain. The tribological behaviour of the functional foods was studied using a ball-on-disc contact configuration. Polydimethylsiloxane (PDMS) polymeric hemispheres and discs, sliding with relative velocities up to 105 mm/s under constant applied load (1 N), were used to mimic oral soft tissues and confine the food samples during tribotesting.

Results and Discussion

Experimental results regarding the effects of incorporating curcumin-loaded SLN on the rheological properties of yoghurts are showed in Tab. 1 and Fig. 1. As can be seen, curcumin incorporation did not noticeably alter the apparent and complex viscosity, pseudoplasticity and viscoelasticity of the original yoghurt matrix. Therefore, the newly established molecular bonds between the matrix and SLN particles did not change the

consistency, firmness, smooth texture and microstructure of the functional foods. Nevertheless, as the particles' size of the yoghurt systematically decreases due to sliding, the tribological nature of the interactions starts to dominate and noticeable differences can be observed between the friction behaviour of normal and functionalized yoghurts (fig. 2).

Table I – Rheological properties (k , n and $\eta^*_{50 \text{ rad/s}}$) of control yoghurt and yoghurt with curcumin-loaded SLN.

Sample	k (Pa.s ^{n})	n	$\eta^*_{50 \text{ rad/s}}$ (Pa.s)
Yoghurt	1.51 ± 0.02	0.567 ± 0.005	1.89 ± 0.26
Yoghurt-curcumin SLN	1.50 ± 0.10	0.568 ± 0.005	1.85 ± 0.30

Curcumin incorporation potentially increased the creaminess, fattiness and slipperiness of yoghurts, which reflected itself in a significant increase of yoghurts' lubricating capacity.

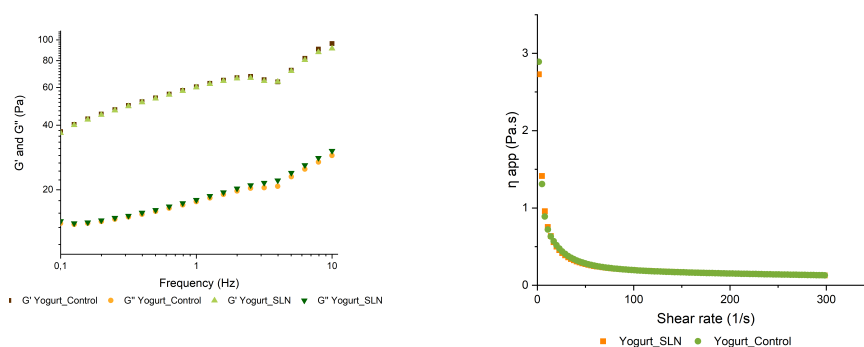


Figure 1 – Storage modulus (G') and loss modulus (G'') as a function of frequency (left); Apparent viscosity profile of control yoghurt and yoghurt with curcumin-loaded SLN (right).

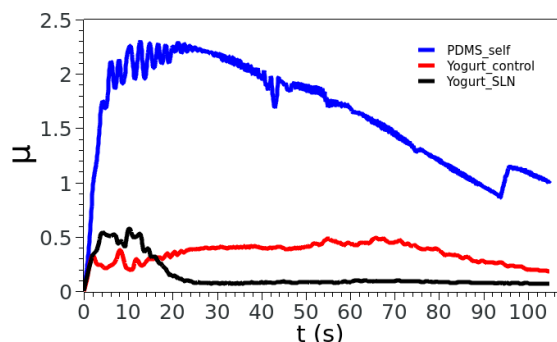


Figure 2 – Representative friction coefficient curves as a function of sliding time for control yoghurt, yoghurt with curcumin-loaded SLN and self-mated PDMS.

Conclusions

The lubricating properties of functionalized yoghurts cannot be entirely related to their viscosity, since the friction coefficient observed for yoghurts incorporating curcumin-loaded SLN is significantly lower than yoghurts, despite having similar rheological parameters.

References

- [1] Stokes, J.R. et al., "Oral processing, texture and mouthfeel: From rheology to tribology and beyond" *Curr Opin Colloid Interface Sci*, 18, 4, 2013, 349-359.
- [2] Chang, C., Meikle, T. G., Su, Y., Wang, X., Dekiwadia, C. et al., "Encapsulation in egg white protein nanoparticles protects anti-oxidant activity of curcumin" *Food Chemistry*, 280, 2019, 65–72.