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Mechanistic approach to explain in-mouth aroma release and perception: case of dairy gels

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Abstract
The influence of flavoured yogurt texture, induced by protein composition and mechanical treatment, on temporal olfactory perception, and on *in vivo* and *in vitro* aroma release was investigated. The main results revealed that for the same matrix composition, the yogurt complex viscosity influenced in-nose release and olfactory perception. The study of thermodynamic and kinetic parameters leads to conclude that the exchange area between yogurt and oral cavity was the main physical mechanism responsible for in-nose release and perception.
Key words: yogurt, aroma release, olfactory perception, diffusion, shear rate

The influence of texture perception on aroma perception has been observed in numerous studies, but often, the sensory or physical origins of this influence are not well argued.
The aim of the present work was to identify and quantify physical mechanisms responsible for in-mouth aroma release in order to better understand the perception of flavoured yogurt. The influence of flavoured yogurt texture on temporal overall aroma perception during food consumption was investigated. In parallel, in-nose aroma release was measured by Atmospheric Pressure Chemical Ionization – Mass Spectrometer (APCI-MS) real time analysis on 6 yogurts with different textures. Two factors of texture variation were studied, the proteins composition (yogurts enriched with caseinate CAS, with milk powder MPO or with whey protein WP) and the mechanical treatment (MT- for low level and MT+ for high level).

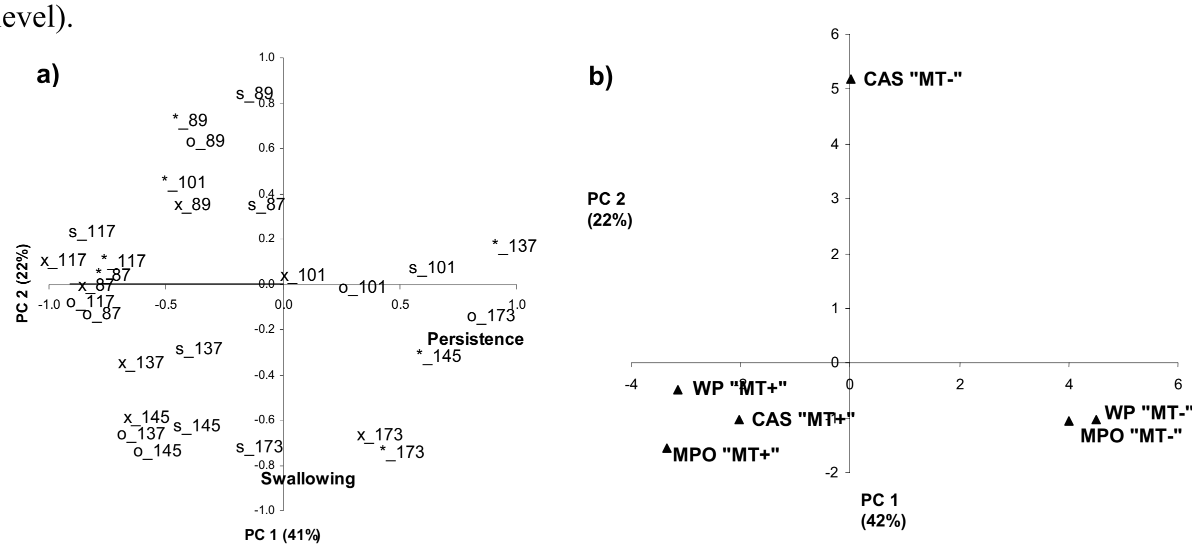

Figure 1: Principal Component Analysis plots (a): variables plot, b): individuals plot) on the sensory perception (at swallowing time and at persistence time) and APCI-MS scores of the six yogurts (ions m/z=87, 89, 101, 117, 137, 145 and 173). Symbol shapes differ with APCI-MS parameters (*: AUC1, o: AUC2, X: Imax2 and S: S_{50-60}). Imax2: maximum intensity of Phase 2 of the release profile, AUC1: area under the curve of Phase 1 of the release profile, AUC2: area under the curve of Phase 2 of the release profile, S_{50-60}: area under the 10 last seconds of the curve.

As main results, for yogurts with a same composition but with variable rheological properties, we observed that olfactory perception at swallowing was higher in yogurts with low complex viscosity (MT+ yogurts) than in yogurts with high complex viscosity (MT- yogurts).

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Moreover, the quantity of aroma compounds released in the nasal cavity (5 compounds over 7 followed by APCI-MS) was higher in low viscous yogurts than in high viscous yogurts (Figure 1). Thus, this result, associated with the sensory one, showed that the released quantity in the nasal cavity at swallowing time could explain the perceived olfactory intensity evaluated by the subjects at the same time.
Physical mechanisms which could explain these differences between "thick" and "liquid" yogurts in aroma transfer were investigated.
First, the interactions between the aroma compounds and the matrices were studied by headspace measurements in static conditions. But only few aroma compounds (1 to 3 on the 17 of the strawberry aroma used in this study) could contribute to explain the differences in in-nose aroma release. Secondly, the diffusivities of some key aroma compounds of the strawberry flavour in yogurts were determined. Even if higher diffusion coefficients were obtained in "liquid" yogurts than in "thick" yogurts, variations between yogurts were quite low and could not completely explain the in-nose aroma release.
The influence of the shear rate during yogurt consumption was studied on a specific equipment simulating the in-mouth conditions (Decourcelle *et al*., 2004). No difference in aroma release under shear rate measured by APCI-MS was observed between the yogurts of different complex viscosities.
Finally, the heat transfer mechanism modified by the level of the applied mechanical treatment, investigated by Paci Kora *et al.* (2004) on low fat yogurts, showed no differences in aroma release between yogurts with different structures. We hypothesized that this mechanism could not be at the origin of the difference in-nose aroma release.
Thus, we supposed that, during yogurt consumption, the low viscous yogurts (MT+) can cover more extensively the mucous membranes of the mouth and the throat. Consequently, these yogurts could develop a greater exchange surface area for the mass transfer of aroma compounds from the product to the air flow of breath. Since the quantity of flavour compounds transferred from the product to the air phase is directly proportional to the exchange area, the higher the surface exchange, the higher the release after swallowing.
The hypothesis of the role of the exchange area was also confirmed with the study of yogurts with different proteins composition. Protein composition modifications induce less significant effects, whatever the mechanical treatment is, suggesting that complex viscosity variation seems to prevail over physicochemical interaction in the in-nose aroma release and subsequent perception.
In conclusion, the integration of all the results seems to highlight the preponderant impact of the air/product interface generated in mouth for mass transfer. The interest to integrate *in vivo* and *in vitro* measurements was demonstrated in order to identify the limiting steps of mass transfer and the mechanisms in mouth responsible for the olfactory perception. Modelling in mouth of flavour release and simulations in progress would confirm this assumption (Atlan *et al.*, 2006).

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