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TEXTURE-AROMA INTERACTIONS IN DAIRY PRODUCTS: DO *IN-VIVO* AND *IN-VITRO* AROMA RELEASE EXPLAIN SENSORY PERCEPTION?

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Abstract

The influence of the texture on perceived aroma intensity and on *in-vivo* and *in-vitro* aroma release was investigated on three types of dairy products, prepared with different textures. Aroma release depends on in mouth breakdown of the product. The consequences of a textural modification on aroma perception were not the same for the different products. In the case of liquid to semi-liquid products (yogurt and custard dessert), *in-vivo* aroma release decreased when viscosity increased. For firm gels (model cheeses) *in-vivo* aroma release was found to increase when cheese hardness increased, but inverse results were obtained in *in-vitro* conditions. Thus, aroma release could explain perceived aroma intensity for yogurts but not for cheeses for which large inter-individual differences were observed. An adaptation of the chewing pattern was supposed *in-vivo* leading to high structural modifications.

Introduction

The molecules responsible for olfactive and gustative stimuli are released during food mastication and then reach the sensory receptors. Despite the new technical developments for measuring *in-vivo* release of molecules during food consumption, the origin of the differences observed in sensory perception between matrices with different structures are not well elucidated, suggesting a combined effect of physico-chemical and cognitive mechanisms. In the context of a French collaborative project (RARE-CANAL-ARLE), the Atmospheric Pressure Chemical Ionisation-Mass Spectrometry (APCI-MS) technique was used to follow *in-vivo* and *in-vitro* aroma release in different types of food matrices. For each type of dairy food, different textures were obtained in order to evaluate the influence of the texture on aroma release and to relate these data to sensory analyses of aroma and texture attributes.

Experimental.

Products. Two yogurts (22.5% dry matter, 4% fat, 5.4% protein) were prepared as already described (1) and only differed by their complex viscosity measured at a low shear stress of 0.1 Pa: thick yogurt (60 Pa·s) and liquid yogurt (25 Pa·s).

Dairy desserts (skim milk containing 3.2% protein, 7% sucrose, 3% starch and 0.2% κ-carrageenan) were prepared with different apparent viscosities (measured at 50 s⁻¹): viscous dessert (2.51 Pa·s) and soft dessert (1.02 Pa·s). For both yogurts and

dairy desserts, texture was modified at constant composition by applying an additional mechanical treatment.

Model cheeses (10% protein, 4% lactose, 1% NaCl, 0.2% yeast extract) were prepared as already described (2). They differed in their hardness by addition of chymosin: hard cheese with 1% chymosin ($F_{\max} = 2.11$ N) and soft cheese ($F_{\max} = 0.53$ N) with 0% chymosin.

In-vivo aroma release. On-line *in-vivo* aroma release measurements were performed using APCI-MS (2). The following compounds were analysed: ethyl butanoate (MH^+ : m/z 117) in yogurts and cheeses and benzaldehyde (MH^+ : m/z 107) in dairy dessert. The samples were taken into the oral cavity, chewed while keeping the mouth closed, then swallowed.

In-vitro aroma release (example of cheeses). Samples of 60g were placed in a mouth simulator (3) (30°C) then stirred for 6 min at a same shear rate of 110 s^{-1} . Headspace was continuously drawn at 30 ml/min and led to the APCI-MS.

Sensory analysis. Sensory properties of texture, taste and aroma were evaluated by a trained panel or a panel of naive consumers (in the case of dairy dessert).

Results

In-vivo aroma release. For all food products aroma release in the nasal cavity reached its maximum concentration (I_{\max}) after swallowing. For yogurts (Figure 1 left), I_{\max} was the highest for the liquid sample. In dairy desserts (Figure 1 right), I_{\max} was higher and the time to reach I_{\max} tend to be shorter in the soft product. Concerning model fresh cheeses (Figure 2), the reverse situation was observed, with a higher I_{\max} for the harder cheese.

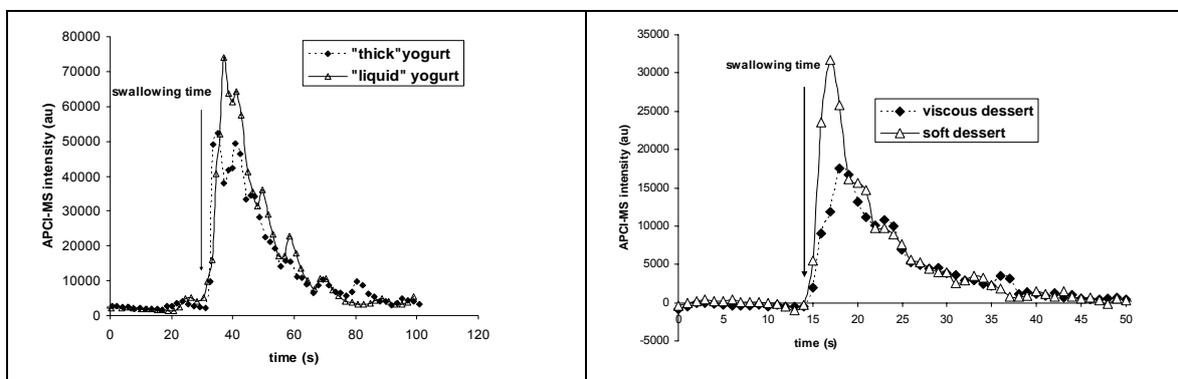


Figure 1. *In-vivo* APCI-MS release curves for ethyl butanoate from yogurt (left) with low mechanical treatment (thick yogurt) and with high mechanical treatment (liquid yogurt) and for benzaldehyde from dairy desserts (right) without mechanical treatment (viscous dessert) and with high mechanical treatment (soft dessert).

In the case of liquid or semi-liquid products (yogurt or dairy dessert), no or low release was observed before swallowing whereas for model cheeses two groups of subjects have been identified according to their *in-vivo* aroma release profiles: for group 1 aroma compounds are released in the nasal cavity before and after swallowing whereas for group 2 aroma compounds are detected mainly after swallowing. Moreover the shapes are similar for the 2 cheeses. These differences may be explained by physiological considerations (4, 5). During swallowing the velum

opens to allow the transfer of the bolus into the pharynx, thus allowing the aroma compounds to reach the nasal cavity. For subjects of group 1, the velum opens also during the chewing phase.

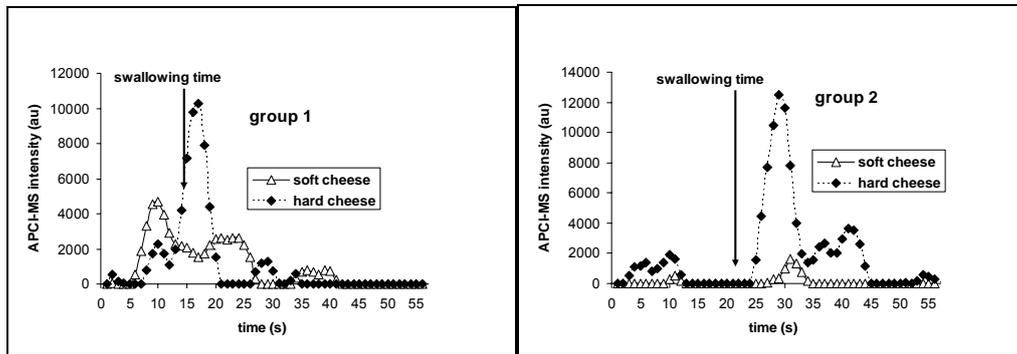


Figure 2. *In-vivo* APCI-MS release curves for ethyl butanoate from model cheeses varying in gel hardness, soft cheese without addition of chymosin (soft cheese), with addition of chymosin (hard cheese), example of 2 subjects with different behaviour (group1 and group 2).

In-vitro aroma release. In addition, *in-vitro* experiments were performed in order to avoid the impact of inter-individual differences and physiological parameters on aroma release. By applying the same stirring rate for the 2 cheeses differing in texture, no difference in the intensity of aroma release was observed, but a higher rate of release in the soft cheese (Figure 3 left). During the *in-vitro* experiments the soft cheese should be better mixed and the surface layers are renewed more rapidly which explains the higher rate of release. During *in-vivo* experiments, panelists may adapt their chewing pattern to the hardness and thus more structural modifications may occur for the hard gel. This result tends to confirm that *in-vivo* aroma release differences were due to an adaptation of the masticatory behaviour of the panelists to food texture rather than to a direct impact of the modification of the structure (2).

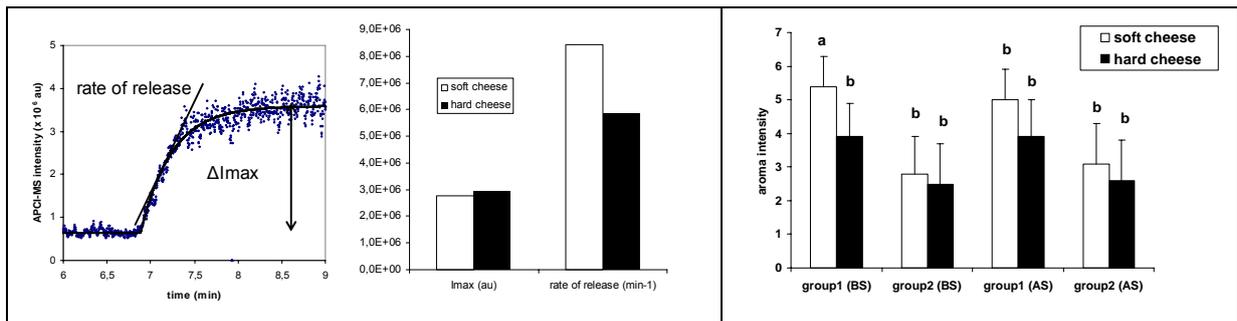


Figure 3. Left: *In-vitro* aroma release curve of ethyl butanoate from model cheeses by applying the same rate of stirring and values of rate of release and maximum intensity obtained for soft and hard cheeses. Right: Aroma perception for the 3 model cheeses before (BS) and after swallowing (AS): mean of aroma intensity for each group of subjects.

Sensory analysis: Texture and aroma. For all products the different textures were significantly discriminated by the panellists. However the consequences of a textural modification on aroma perception were dependant of the type of dairy products. For

yogurts, the liquid sample was perceived significantly higher in aroma intensity at persistence (6). For these products, *in-vivo* aroma release could explain sensory perception. For dairy dessert, no significant effect was observed (7). In the case of model cheeses, the soft cheese was perceived with slightly higher aroma intensity (8) whereas aroma release was less intense. These differences between aroma release and aroma perception could be explained by the fact that panellists paid more attention to texture attributes than to aroma attributes, or by taking taste - aroma interactions into account as the hardest cheese was also perceived with the lowest saltiness. By looking at the sensory results within each group of subjects (Figure 3 right), we noticed that the intensity of aroma perception was differently perceived: aroma intensity was perceived more intense for group 1 which presented a release before and after swallowing and a significant difference in aroma intensity between the 2 different cheeses was found only for group 1. These different behaviours could be explained by differences in physiology.

Conclusion

This paper points out the influence of in mouth food breakdown on aroma release and aroma perception. During food consumption liquid products can cover more extensively the mucus membranes of the mouth and the throat and consequently develop a greater exchange area for the mass transfer of aroma compounds from the product to the air flow of the breath leading to a higher aroma perception. In the case of liquid to semi-liquid products (yogurts), this effect was perceived by trained panelists. In the case of solid products panelists adapt their mastication with a more intense chewing for the harder product, which will induce a higher aroma release due to a higher exchange area between the broken product and the air flow. Perceptual interactions were also observed between texture and aroma for the solid products.

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