Relating perceived temporal change of sensory attributes in semi-solids to oral physiology

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Background

In 1999 a multidisciplinary project was initiated aimed at uncovering the underlying mechanisms involved in the perception of oral texture attributes for semi-solids. In this project, physico-chemical food properties were related to perceived texture. First, these food properties were assessed in vitro by rheologists and food chemists. Next, the changing food properties in the mouth during mastication were assessed by physiologists. Finally, the resulting sensations were assessed by psycho-physicists with the use of panels of trained subjects. The present study related time-intensity measurements of vanilla custard desserts to in-mouth food properties measured physiologically. Time-intensity measurements were performed on a sub-set of attributes generated previously by a panel trained within the same project according to the principles of Quantitative Descriptive Analysis. The time-intensity panel consisted of 6 subjects who had been trained and tested extensively in time-intensity measurements on a variety of semi-solids foods using the FIZZ response acquisition system. The same subjects also participated in the physiological measurements. The rated time-intensity attributes included creaminess, plus a number of attributes that are presumably relevant for creaminess, namely coldness, fattiness, stickiness, and roughness. Each measurement started when a subject took a spoonful filled with approximately 10 grams of custard into the mouth. Five of the six custards were model custards ranging in milk fat from 0% to 15%. All five custards contained 4.5% VA85T starch, 6.5% sugar, and 0.1% vanillin. The sixth custard was a commercially available custard with 3% fat. Subjects continuously rated the intensity of mouthfeel for one attribute until the custard was swallowed (after 20 sec.). Over the next 40 seconds the intensity of afterfeel for the same attribute was rated.

During the mouthfeel and afterfeel phases of time-intensity measurements custards go through a range of changes as a result of processes such as heating, mixing and dilution by saliva, chemical break-down by amylase, and physical break-down by mechanical forces. Generally, oral processes may be divided into mixing processes and breakdown processes. In mixing processes, saliva is mixed into the custard as a result of food properties, such as viscosity, and tongue movements. In breakdown processes, the amylase of the mixed-in saliva converts starches into sugars resulting in a decreased viscosity. The changes in custards over time may not only depend on differences between custards (e.g., starch and fat content) but also on differences between subjects (e.g., tongue movements and production/composition of saliva). Presumably, changes in time-intensity ratings over time reflect these changes in food properties.

In this study we evaluated two methods of quantifying the amount of mixing that custards were subjected to prior to swallowing. In the first method, the *carbon method*, a 100 μl of an aqueous suspension of carbon particles was added to a spoonful of the custard which was then taken into the mouth by the subject. After a time interval of 5, 10, or 20 seconds, the custard was spat out by the subject and photographed. In the second method, the *water method*, the custard was simply spat out into a container of water after 5, 10, or 20 seconds and photographed. The images were subsequently analyzed by image processing software (**V**ideo **A**cquired **G**rey-scale **I**mage **N**umerical **A**nalysis) and mixing was described by image processing parameters. These parameters reflect food properties such as the degree of mixing and heterogeneity of the food sample. In the *turbidity method* subjects rinsed their mouth with 20 ml of water for 5 seconds, 1, 10, and 20 seconds post-swallow. The turbidity of the spat-out rinse water was subsequently measured (see Figure 1).

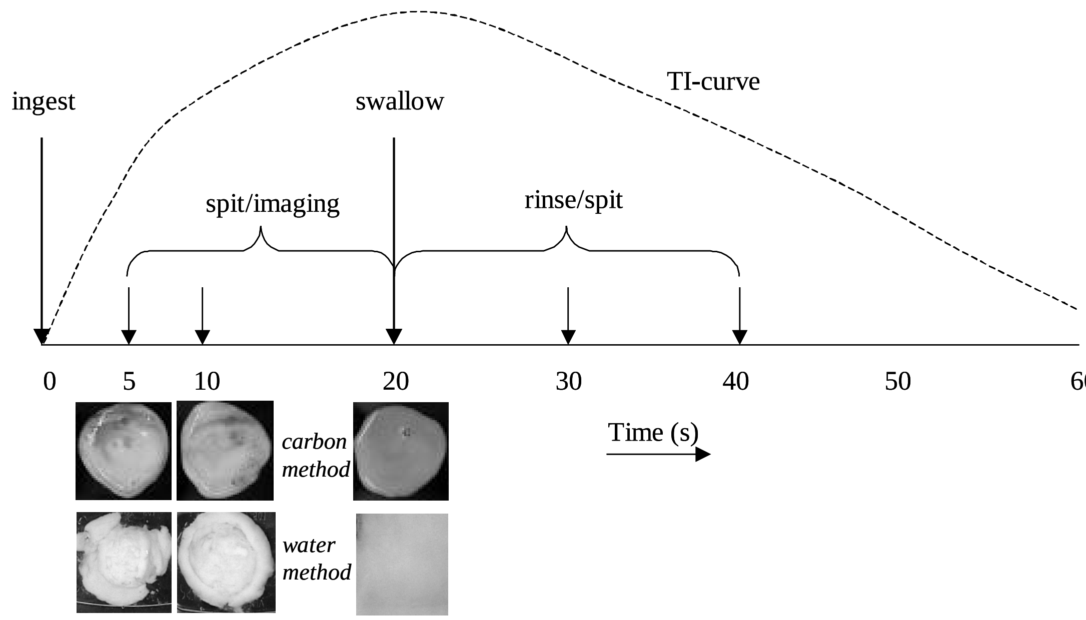


Figure 1. Design of the oral physiological part of the study, including examples of spat-out samples of the low fat vla after 5 (left), 10 (middle), and 20 seconds (right) residence time in the mouth for both the carbon (upper row) and the water (bottom row) method.

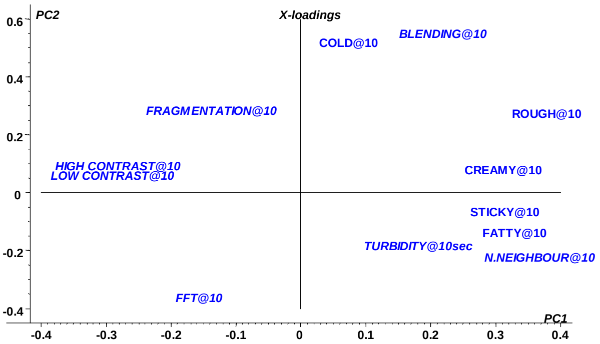
Results from T-I measurements

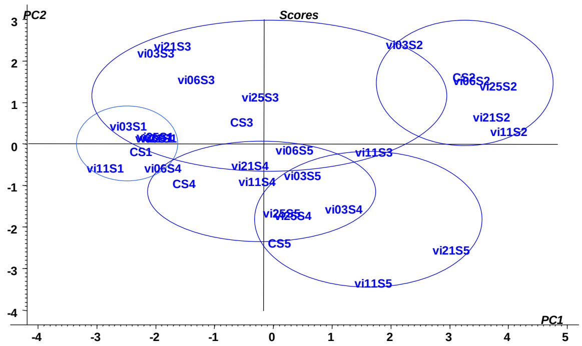
Results from uni-variate ANOVAs indicated significant product differences for all attributes except coldness. These differences were especially observed in the maximum intensities (Imax), parameters related to the ascending and descending slopes of the t-I curves, and in parameters related to areas under the curves. Maximum intensities for most custards increased with fat level.

Results from physiological measurements

ANOVAs revealed for both the water and carbon methods significant differences between products and between residence times in the mouth on parameters related to the color distribution across the spat-out food samples (parameters: blending, contrast, and fast Fourier transfomation (FFT)). Parameters related to fragmentation failed to differentiate between products and/or residence times (parameters: fragmentation and nearest neighbour). Most of the imaging parameters showed no apparent relationship with fat level, but showed a gradual change with residence time in the mouth. Turbidity of rinse water also showed significant effects of product and residence time. Turbidity increased with fat level, and decreased with time after swallow. The largest decrease was observed in the first 10 seconds after swallow.

Results from T-I and physiological measurements





Figures 2: Example PCAs depicting relations between physiological (*in italic*) and sensory attribute ratings after 10 sec residence time (left figure) and individual results (S1-5) for five model custards (VI) and one commercial custard (C). Circles indicate different custards for the same subject (right figure).

Initial results of combined Time-Intensity and physiological measurements indicate that:

- Both Time-Intensity and physiological color distribution parameters showed differences between the various food products and between the various residence times of the products in the mouth.
- Specific physiological measurements (e.g., contrast measurements) relate to specific sensory attributes (e.g., creamy/sticky) but not to others (e.g., cold) (Figure 2, left).
- Variations between judges exceeded variations between food products, especially in T-I measurements (Figure 2, right).