Food Hydrocolloids 52 (2016) 648–660

Contents lists available at ScienceDirect

Food Hydrocolloids

journal homepage: www.elsevier.com/locate/foodhyd

Dynamic texture perception, oral processing behaviour and bolus properties of emulsion-filled gels with and without contrasting mechanical properties

Marine Devezeaux de Lavergne [a, b], Carole Tournier [c], Dominique Bertrand [d], Christian Salles [c], Fred van de Velde [e], Markus Stieger [a, b, *]

[a] TI Food and Nutrition, P. O. Box 557, 6700 AN Wageningen, Netherlands
[b] Wageningen University, Agrotechnology and Food Sciences Group, P. O. Box 8129, 6700EV, Netherlands
[c] INRA, UMR1324 Centre des Sciences du Goût et de l'Alimentation, F-21000 Dijon, France
[d] DATA FRAME, 25 rue Stendhal, 44300 Nantes, France
[e] NIZO Food Research BV, P. O. Box 20, 6710 BA Ede, Netherlands

ARTICLE INFO

Article history:
Received 7 May 2015
Received in revised form
9 July 2015
Accepted 22 July 2015
Available online 8 August 2015

Keywords:
Dynamic texture perception
Mechanical contrast
Gelatine
Agar
Emulsion-filled gels
Food bolus
Oral processing

ABSTRACT

Many highly palatable foods are composed of multiple components which can have considerably different mechanical properties leading to contrasting texture sensations. The aim of this study was to better understand the impact of contrasting mechanical properties in semi-solid gels on oral processing behaviour and dynamic texture perception. Four reference emulsion-filled gels without mechanical contrast were prepared using agar (1 or 2 wt%) or gelatine (2.5 or 5.5% wt). Six emulsion-filled gels with contrasting mechanical properties were obtained by combining two different gel layers. Agar reference gels displaying low fracture strain produced boli with many small particles and were perceived as grainy. Gelatine reference gels displaying high fracture strain produced boli with few large particles which melted in mouth and were perceived as creamy. Reference gels with large fracture stress were masticated for long times with a high chewing muscle activity and perceived as firm and grainy. Bolus properties, oral processing behaviour and dynamic sensory perception of the 6 contrasting gels were compared to the 4 reference gels using Principal Component Analysis. The presence of an agar layer in contrasting gels dominated bolus properties which contained many small particles and did not mix readily in mouth. The temporal sensory profiles and sensory trajectories of contrasting gels fell between the temporal sensory profiles and sensory trajectories of the two gel layers which they were composed of. We conclude that distinct features of dynamic texture perception in emulsion-filled gels with mechanical contrast are perceived separately in mouth.

1. Introduction

Texture perception is complex and dynamic as it depends on food properties such as composition, structure and changes thereof during oral processing (Hutchings & Lillford, 1988). The structure of many composite foods is macroscopically inhomogeneous. Many foods that are highly palatable and highly liked are composed of multiple components with considerably different mechanical properties, for example in cookies often dry and crispy biscuits are combined with soft and creamy fillings. The mechanical contrast might lead to contrasting texture sensations which have been suggested to enhance palatability of foods (Hyde & Witherly, 1993). Texture perception has been shown to be an important factor contributing to consumer acceptance and food palatability. Texture contrast has been hypothesized to make generally well liked foods even more palatable. Texture contrasts are considered a desirable product property both within a meal and within a single bite (Szczesniak & Kahn, 1984). Such texture contrasts can be caused by inhomogeneity in food structure or changes of structure over eating time, the second being considered as dynamic contrasts (Hyde & Witherly, 1993). Dynamic texture contrast leads to continuous changes in intensity and quality of perceived texture as the food

* Corresponding author. TI Food and Nutrition, P. O. Box 557, 6700 AN Wageningen, Netherlands.
E-mail address: markus.stieger@wur.nl (M. Stieger).

http://dx.doi.org/10.1016/j.foodhyd.2015.07.022
0268-005X/

structure is broken down in the mouth. The combination of macroscopic components with contrasting mechanical properties in composite foods results in complex oral food breakdown behaviour in mouth and dynamic texture perception. Dynamic texture perception of foods with mechanical contrast depends on the mechanical properties of each compartment of the food as well as the oral processing of the compartments and their mixing behaviour in mouth. For example, bread, consisting of a crispy crust and soft crumb can be considered as a food product with different compartments which cause contrasting texture sensations. Methods of bolus analyses of breads have been proposed to determine the level of mixing between the different compartment (crust and crumb) in mouth during mastication (Tournier, Grass, Zope, Salles, & Bertrand, 2012). The bolus properties of another inhomogeneous food, peanuts embedded in different food matrices, have been investigated. It was observed that the oral breakdown behaviour of the peanuts depended on the matrix they were embedded in (Hutchings, Foster, Bronlund, & Morgenstern, 2011, 2012). However, eating behaviour, e.g. number of chews, was not significantly influenced by the properties of the matrices. It has not been investigated whether changes of matrices influence dynamic texture perception of the peanuts. Chewing behaviour which can be monitored by Electromyography (EMG) provides additional insights into texture perception of semi-solid and solid foods (Çakir et al. 2012). Texture perception can be monitored dynamically by sensory methods such as Temporal Dominance of Sensations (TDS). Albert, Salvador, Schlich, and Fiszman (2012) concluded that TDS can be used to analyse dynamic texture perception over time of complex inhomogeneous foods consisting of different structures.

Model foods allow to control the structure and mechanical properties of the foods and to vary specific parameters individually. Therefore, model foods are often used to gain fundamental understanding of the factors contributing to texture perception (Stieger & van de Velde, 2013). Emulsion-filled gels are frequently used as models for semi-solid foods. Mechanical properties of model gels such as fracture stress and fracture strain have been related to specific perceived textural properties such as hardness and brittleness (Foegeding et al. 2011). Agar and gelatine are commonly used gelling agents in many food preparations and have often been used as the main ingredient to prepare model foods. Gels made with agar or gelatine are well characterised. An emulsion can be added to the gel matrix to engineer the fracture behaviour and to investigate sensory perception of fat related attributes (Sala, Van Aken, Stuart & Van de Velde, 2007; Sala, Van de Velde, Stuart, & Van Aken, 2007). Both agar and gelatine emulsion-filled gels are often used as model foods. The use of agar or gelatine provides different structural properties to gels resulting in different behaviours during oral processing leading to different textural sensations. Model gels made from gelatine are characterised by a high fracture strain which increases together with fracture stress with increasing gelatine concentration. Gelatine gels are perceived as elastic compared to other gels and perceived firmness increases with increasing fracture stress (Muñoz, Pangborn, & Noble, 1986a, 1986b). Upon mastication gelatine gels break down into a small number of large particles (Muñoz et al. 1986b). When semi-solid gelatine gels are masticated in mouth longer, the gelatine matrix melts and a liquid bolus is formed before swallowing (Inoue, Sasai, Shiga, & Moritaka, 2009). Gelatine gels are therefore perceived as melting in mouth (Hayakawa et al. 2014) which is thought to be a desirable property to deliver flavours and provide a pleasant mouth-feel (Koliandris, Lee, Ferry, Hill, & Mitchell, 2008). Emulsion-filled gelatine gels are perceived as creamy compared to other non-melting emulsion-filled gels suggesting that melting positively influence creaminess perception (Sala, de Wijk, van de Velde, & van Aken, 2008). Agar gels are often used as model foods due to their low complexity. With increasing agar concentration, fracture stress increases accompanied by an increase in perceived firmness. With increasing agar concentration fracture strain decreases slightly (Barrangou, Drake, Daubert, & Foegeding, 2006). Agar gels display considerably lower fracture strains than gelatine gels (Ikeda, Sangu, & Nishinari, 2003). Agar gels display strain hardening behaviour and brittle fracture (Sharma & Bhattacharya, 2014). Contrary to gelatine gels, agar gels do not melt in mouth but brake down into several small particles. At the end of oral processing, agar gels are swallowed as a bolus of small, broken down particles which are adhering to each other by saliva (Inoue et al. 2009). The breakdown of agar gels during oral processing is perceived in mouth and can be characterized by a rate of breakdown (Barrangou et al. 2006). The fracture properties of model gels can correlate with perceived chew down texture attributes (Barrangou et al. 2006; Melito, Daubert, & Foegeding, 2013). The model gels described above have homogenous structures without mechanical contrast. In comparison to the several studies of gels without mechanical contrast, little is known about the oral break down behaviour, in mouth mixing behaviour and dynamic sensory perception of multicomponent foods displaying mechanical contrast.

In this study, the impact of contrasting mechanical properties in foods on oral processing behaviour and dynamic texture perception of semi-solid model gels are investigated. We hypothesize that the composition of the emulsion-filled gel layers influences oral processing behaviour, breakdown behaviour in mouth and dynamic texture perception. We hypothesize that gel layers with high fracture stress dominate the oral processing behaviour and dynamic texture perception in emulsion-filled gel with contrasting mechanical properties when layers with high fracture stress are combined with layers with low fracture stress. The presence of an agar emulsion-filled gel layer is hypothesized to dominate the oral processing behaviour and dynamic texture perception in emulsion-filled gels with contrasting mechanical properties when agar layers are combined with gelatine layers. Indeed, agar gels do not melt in mouth and are expected to represent the bulk of the bolus once gelatine is molten into a liquid during oral processing.

The aim of this study was to better understand the oral processing and dynamic texture perception of composite foods by using emulsion filled gels with mechanical contrast. This would enable to identify which compartment of the food dominates the dynamic texture profile. First, the mechanical properties of the layers are measured. Then, the oral processing behaviour of the emulsion-filled gels without mechanical contrast is determined and their dynamic sensory perception is quantified. Knowing the mechanical properties, oral breakdown and texture perception of the gels without mechanical contrast will enable to understand the perception of gels with mechanical contrast. Therefore, the oral processing behaviour, bolus properties and dynamic sensory perception of the emulsion filled gels with contrasting mechanical properties are finally compared to the emulsion filled gels without mechanical contrast using Principal Component Analysis (PCA).

2. Materials and methods

As reference stimuli, four emulsion-filled gels containing two layers and displaying no mechanical contrast were prepared using 1 and 2% wt agar (denoted as LA + LA and HA + HA) or 2.5 and 5.5% wt gelatine (denoted as LG + LG and HG + HG). Two layers of emulsion-filled gels varying in mechanical properties were combined to yield six emulsion-filled gels with contrasting mechanical properties (LA + HA, LA + LG, LA + HG, HA + LG, HA + HG, LG + HG).