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Aroma release and chewing activity during eating different model cheeses

A. Tarrega*, C. Yven, E. Sémon, C. Salles

UMR1129 Flaveur, Vision et Comportement du Consommateur, ENESAD, INRA, Université de Bourgogne, 17 Rue Sully BP86510, F-21000 Dijon, France

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Abstract

This study focused on the effect cheese properties had on chewing behaviour and aroma release as well as the relationship between them. Chewing activity and the kinetics of aroma release were simultaneously monitored during the consumption of eight model cheeses with the same flavour content. Differences in chewing behaviour explained most of the variability in aroma release among subjects. Aroma release increased with chewing work, bursts' number and amplitude. For cheese samples, the chewing behaviour varied according to texture. Interaction between cheese composition and the chewing behaviour effects affected aroma release: (i) decreasing fat content increased aroma release as a result of both higher release from the matrix and higher chewing work and (ii) decreasing melting point and mixing speed during cheese preparation resulted in softer cheese. In this case, the expected increase in aroma release due to greater mobility of the aroma compounds was counteracted by a low chewing activity.

Keywords: Aroma release; Cheese; Texture; APCI-MS; Electromyography

1. Introduction

In the development of new healthier products, knowledge of the mechanisms involved in the modification of aroma release when composition and texture change, may help to optimise formulations delivering the desired aroma profile.

Most studies on aroma release from food have been conducted in vitro, under static conditions showing significant and complex effects of food composition and structure on the retention of aroma compounds. However, in vivo, the aroma release also depends on how the food matrix is manipulated in-mouth before being swallowed. Mastication causes the disorganisation of the matrix and the mix of food particles with saliva, which modifies the transfer interface of volatile compounds (Harrison, 2000). Nowadays, the in-nose measurement techniques of atmospheric pressure ionisation-mass spectrometry (API-MS) and proton transfer reaction-mass spectrometry (PTR-MS) are available for evaluating the aroma release in the expired air of a subject during food consumption. Using these techniques, the impact of structure and texture on aroma release has been studied in different types of products but the results were not always in accordance. In gel model systems, different authors (Baek, Linforth, Blake, & Taylor, 1999; Guinard & Marty, 1995) observed that aroma release decreased when the rigidity of gels increased. Saint-Eve, Juteau, Atlan, Martin, and Souchon (2006) also observed a decrease in aroma release when increasing the viscosity of yoghurt. However, Weel et al. (2002) and Mestres, Moran, Jordan, and Buettner (2005) showed that the quantity of aroma released was not modified by the texture of whey protein gels and the same findings were observed by Lethuaut, Weel, Boelrijk, and Brossard (2004) in custard systems. Finally other authors observed an increase in the amount of aroma release with an increased hardness of gelatine and pectin gels (Boland, Delahunty, & van Ruth, 2006) and model cheeses (Gierczynski, Labouré, Sémon, & Guichard, 2007). The latter authors (Boland et al., 2006; Gierczynski et al., 2007) attributed the different findings to differences in chewing behaviour and in the

*Corresponding author. Tel.: +33 3 80 69 30 85; fax: +33 3 80 69 32 27.
E-mail address: atarrega@dijon.inra.fr (A. Tarrega).

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experimental protocol used. They pointed to the importance of studying chewing parameters in the aroma release studies even more when the texture of samples varies.

Chewing activity is usually evaluated by electromyography (EMG). The combination of API-MS and EMG records permit the chewing behaviour, especially muscle activity, and aroma release to be simultaneously followed during the consumption of food. Using both techniques, Pionnier, Chabanet, Mioche, Le Quéré, and Salles (2004) and Blissett, Hort, and Taylor (2006) demonstrated that the differences in chewing behaviour between subjects influenced aroma release. However, documentation of the effect that chewing behaviour has on aroma release when eating products with different textures is limited.

As a chewable product, cheese is an interesting model to study the influence of chewing behaviour on aroma release. Cheese analogues are useful systems for research studies as they allow for better uniformity between batches and over time than natural cheeses. In addition, its texture can easily be manipulated by altering the formulation and processing conditions. Increasing the water or fat content results in softer processed cheeses (Pereira, Bennett, Hemar, & Campanella, 2001). Both increasing the mixing speed during cheese-making and using fat with a high melting point result in an increase in cheese hardness (Jaros, Petrag, Rohm, & Ulberth, 2001; Lobato-Calleros, Vernon-Carter, & Hornelas-Uribe, 1998; Pereira et al., 2001).

The aim of this work was to study the effect of cheese characteristics on both chewing behaviour and aroma release and to establish the relationships between them following the release of four aroma compounds during the consumption of eight equally flavoured model cheeses.

2. Materials and methods

2.1. Model cheeses composition and preparation

The ingredients used for the cheese-making included deionised water (Milli-Q®, Bedford, MA, USA), rennet casein (Eurial Poitouraine, Nantes, France), commercial melting salts (Kasomel 2185, PRAYON; Europhos, Engis, Belgium), and milkfat (Cormans, Goe-Limbourg, Belgium). A solution containing the aroma compounds and a solution of acids and minerals were also used (Table 1).

Eight different cheese analogues were manufactured varying in lipid–protein ratio (L/P, 0.5 and 1), the type of fat (20 and 32 °C melting point) and the mixing speed during processing (700 and 2000 rpm). The moisture content was kept constant throughout the different model cheeses. The composition of each is described in details in Table 1.

Cheese manufacture was done in 500 g batches using a cutter mixer (R3VV, Robot Coupe, Montceau en Bourgogne, France). The mixer was heated to 65 °C prior to use and the ingredients were added in the following order: water, acid and mineral solution, aroma solution, rennet casein, melting salt and fat. A constant mixing speed was applied for 7.5 min, during this time the temperature was kept at 65 °C. The prepared model cheeses were immediately poured into plastic bags and stored at −20 °C for 25 min. They were then vacuum-sealed and preserved at 4 °C for 2 weeks before consumption. The absence of *Escherichia coli*, *Staphylococcus*, and *Salmonella* was checked for each cheese.

Table 1
Composition and characteristics of cheese model samples

	Cheese sample							
	1	2	3	4	5	6	7	8
Characteristics								
L/P ratio	0.5	0.5	0.5	0.5	1	1	1	1
Fat melting point (°C)	32	32	20	20	32	32	20	20
Mixing speed (rpm)	700	2000	700	2000	700	2000	700	2000
Hardness[a] (N)	37.85[b]	41.78[a]	28.02[d]	34.89[c]	19.52[f]	25.28[e]	17.25[g]	21.42[f]
Composition for 1 kg								
Milk fat (g)	159.8	159.8	159.8	159.8	239.7	239.7	239.7	239.7
Rennet casein (g)	319.6	319.6	319.6	319.6	239.7	239.7	239.7	239.7
Deionised water (g)	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Melting salts (g)	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2
Salt (NaCl) (g)	10	10	10	10	10	10	10	10
Solution of aromas[b] (g)	200	200	200	200	200	200	200	200
Solution of minerals and acids[c] (g)	200	200	200	200	200	200	200	200

[a]Values with different superscript letters (a–g) are significantly different ($p<0.05$).

[b]Composition: butyric acid (10 μL), diacetyl (3 μL), 2-heptanone (5 μL), 2-nonanone (5 μL), 3-octanone (5 μL), ethyl hexanoate (5 μL), ethyl butanoate (4 μL), dimethyl disulfide (10 μL), propylenglycol (953 μL) and deionised water up to 200 g.

[c]Composition: $CaCl_2$ (7.36 g), $MgCl_2$ (21.7 g), KCl (21.9 g), lactic acid (4 g), citric acid (4.4 g) and deionised water up to 200 g.