Available online at www.sciencedirect.com
ScienceDirect
Food Research International 40 (2007) 480–492
FOOD RESEARCH INTERNATIONAL
www.elsevier.com/locate/foodres

Kinetic study of the release of aroma compounds in different model food systems

Anne-Marie Seuvre [a,b,*], Ellen Philippe [a], Sophie Rochard [c], Andrée Voilley [a]

[a] ENSBANA, Laboratoire d'Ingénierie Moléculaire et Sensorielle des Aliments et des Produits de Santé, Université de Bourgogne, 1 Esplanade Erasme, F21000 Dijon, France
[b] IUT, Département de Génie Biologique, Bd Dr Petitjean, BP 17867, F21078 Dijon Cedex, France
[c] Degussa Flavour and Fruit Systems, ZI du Plan, B.P. 82067, F06131 Grasse Cedex, France

Received 1 June 2006; accepted 6 September 2006

Abstract

Kinetics of release as a function of time from different model food matrices (mineral water, an oil-in-water emulsion, a carbohydrate matrix and a complex matrix containing lipids and carbohydrates) were measured at 37 °C for four flavour compounds. Carbohydrate matrix and complex matrix were elaborated to have a similar rheological behaviour. Flavour compounds belonging to the strawberry flavour note were chosen: a homologous series of ethyl esters (C_4, C_6 and C_8) and a ketone (C_5).

The influence of the nature of flavour compounds on the kinetics of release was studied. On the other hand, the influence of the composition of the matrix on the kinetics of release was pointed out. From the kinetics of flavour compounds release, the initial rate of release and the time to reach equilibrium were determined. The measurements of the rate of release during the first five minutes indicated a quickest rate of release during the first thirty seconds.

Keywords: Flavour compounds; Volatility; Kinetic; Release; Headspace gas chromatography; Triolein; Carbohydrates; Rheology

1. Introduction

Odour and aroma of foods result in an equilibrium between the concentrations of an important number of aroma compounds having different chemical nature in the vapour phase. A modification of the food composition may favour or hinder the release of some aroma compounds and consequently may conduct to a distortion of the initial aroma profile. Numerous sugar lightened or low fat foods have arisen and have required a new formulation. The interactions between aroma compounds and carbohydrates generally have a weak energy and are depending on numerous factors such as nature and concentrations in aroma compounds and carbohydrates (Solms, 1986). The modification of release can be attributed to interactions and to changes of diffusivity of the aroma compound in the matrix (Kinsella, 1989). The study of simple model media (water, aroma compounds, carbohydrates) allowed demonstrating (Nahon, Navarro y Koren, Roozen, & Posthymus, 1998; Perpète & Collin, 2000; Roberts, Elmore, Langley, & Bakker, 1996) that mono- and disaccharides can induce an increase of release for some aroma compounds, especially the more polar (ethyl acetate, ethyl butanoate, methyl anthranilate, acetone, ethanol, 1-heptanol, methyl butanoate, etc.) and an opposite effect for other aroma compounds, notably the apolar compounds (2-heptanone, ethyl hexanoate, 2-heptanal, octanal) (Nahon et al., 1998). Different behaviours were observed in

* Corresponding author. Address: ENSBANA, Laboratoire d'Ingénierie Moléculaire et Sensorielle des Aliments et des Produits de Santé, Université de Bourgogne, 1 Esplanade Erasme, F21000 Dijon, France. Tel.: +33 3 8039 6843; fax: +33 3 8039 6611.
E-mail address: amseuvre@u-bourgogne.fr (A.-M. Seuvre).

0963-9969/$ - see front matter
doi:10.1016/j.foodres.2006.09.005

presence of the sucrose molecule: Friel, Lindforth, and Taylor (2000) studying the influence of sucrose (65% w/v) on the volatility of 40 aroma compounds observed that some presented a ‘‘salting out’’ effect (linalool), some others a ‘‘salting in’’ effect (ethyl decanoate) whereas for some others no modification was noted (acetaldehyde). The release of the aroma compounds can also be influenced by polysaccharides such as starch based products (Arvisenet, Voilley, & Cayot, 2002; Boutboul, Giampaoli, Feigenbaum, & Ducruet, 2002; Cayot, Taisant, & Voilley, 1998; Escher, Nuessli, & Conde-Petit, 2000; Nuessli, Conde-Petit, & Escher, 1997), pectins (Hansson, Andersson, & Leufvén, 2001) or xanthans (Bylatte, Adler-Nissen, & Meyer, 2005). The availability of the aroma compounds decreases in presence of thickeners or gelling agents. Many studies have demonstrated that hydrocolloids not only modified viscosity and consistency, but often reduced intensities of odour, taste and flavour (Guichard, Issanchou, Descourvrieres, & Etievant, 1991; Lundgren et al., 1986; Morris, 1987). Several works have shown that the texture of gels can directly affect the release of the flavour compounds (Carr et al., 1996). The retention of the aroma compound in the matrix can be explained by a decrease of diffusion of the aroma compounds with the increase of viscosity and by the presence of interactions between polysaccharides and volatile compounds. Roberts et al. (1996) have observed that the diffusion of a solute is inversely proportional to viscosity. Lubbers and Guichard (2003), studying the effects of sugars and pectins on flavour release from a fruit pastille model system, have shown sensorily significant differences between the flavour intensities of gels produced with different sugar mixtures (sucrose + glucose, sucrose + glucose + corn syrups (DE40 or DE60)). Moreover the partition coefficients of the three studied aroma compounds in pectin gels were significantly lower than those obtained in the corresponding sugar solutions. Thus the addition of polysaccharides is often associated with a decrease of the intensity of the odour and the flavour. The study of a strawberry jam with different contents of high and low methylated pectins has shown that pectins were responsible of the variation of the retronasal perception of the different aromatic notes (Guichard, Tromelin, Juteau, Rega, & Roudnitzky, 2003). This effect was explained by a low diffusion of the aroma compounds induced by the structure of the gels; indeed no interaction between the studied aroma compounds and the pectin was found (Guichard et al., 2003). Lipids are the food ingredients that have been shown to have a great impact at the sensorial level because they are an excellent solvent for the aroma compounds: lipids decrease the vapour pressure of numerous volatile compounds and then influence the aromatic perceived profile (Guinard, Wee, McSunas, & Fritter, 2002; Widder & Fischer, 1996). Nevertheless the release of the aroma compounds depends also on their physicochemical characteristics such as polarity, hydrophobicity and solubility (Relkin, Fabre, & Guichard, 2004). Widder and Fischer (1996) observed that the description of the odour of an emulsion aromatised with a mixture of aroma compounds having different polarity is modified when the oil content increased from 1% to 20%: this modification was explained by the decrease of the release of the apolar compounds. The polar compounds presented more affinity for water: an increase of the oil content induced a migration of the compounds towards the aqueous phase and facilitate their perception. De Roos (1997) also observed that a decrease of the lipid content can induce a premature release of the lipophilic compounds.

The sensorial perception of the aroma compound at the level of the olfactory epithelium partly depends on its availability in the vapour phase. The retention by the constituents of the matrix and the rate of release modulate the release of the aroma compounds in the vapour phase in the mouth and therefore influence their sensorial perception. The behaviour of flavour compounds in models food systems was studied in a thermodynamic way (Philippe et al., 2003). The aim of the present study was to determine the impact of the different components of the matrices on flavour release. The studied matrices were mineral water taken as the reference medium, an oil-in-water emulsion, a carbohydrate matrix (containing mono- and polysaccharides) and a complex matrix containing lipids and carbohydrates. These two last matrices (carbohydrate and complex matrices) have been developed to have a similar rheological behaviour. The measurements of the quantity of released compounds from the matrices as a function of time were carried out on non-agitated matrices. The release of flavour compounds is thus simply due to the phenomenon of diffusion of these compounds within the matrix, then due to the transfer of the aromatised matrix towards the gas phase and to the diffusion within the gas phase. To mimic the dynamic processes occurring in the mouth further works on agitated systems are necessary.

2. Material and Methods

2.1. Material

2.1.1. Flavour compounds and media

Four flavour compounds, belonging to the strawberry flavour note and with different physicochemical properties, were chosen: a homologous series of ethyl esters (C_4, C_6 and C_8) and a ketone (C_5). Degussa Flavours and Fruit Systems (Maxens, Grasse, France) kindly supplied them. Their purities were higher than 98%. Their chemical formula, molecular weights, densities, boiling points and odour descriptors are given in Table 1.

Four media are selected: mineral water (Volvic, Danone, France) as the reference medium, an oil-in-water emulsion, a carbohydrate matrix and a complex matrix.

The physicochemical characteristics of these flavour compounds (saturated vapour pressure, *n*-octanol–water partition coefficients ($\log P$), water solubility), determined in the previous work (Philippe, 2003; Philippe et al., 2003), were presented in Table 2.