Explaining fat sensitivity in cottage cheeses by aroma release and oral physiology parameters

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Abstract

Great inter-individual differences exist in fat perception. Forty subjects were grouped according their global fat perception in cottage cheeses. The more sensitive subjects were also more sensitive to fatty odorants, they had a higher respiratory flow and thus a higher rate of release of aroma compounds in the nasal cavity, which could explain the role of the olfactory modality in fat perception. Fat sensitive subjects had a lower saliva flow, less viscous saliva, and less amount of product remaining in the mouth after swallowing, which could explain, why they were more sensitive to taste and textural modalities of fat perception.

Introduction

In the aim to increase sensory acceptability of low fat content foods, a better understanding of the physiological mechanisms involved in fat perception is needed. Fat perception is considered as a multimodal sensation in itself involving smell, taste and texture perception [1, 2]. In a previous experiment conducted on 40 subjects and focusing on fat perception in cottage cheese, great inter-individual differences in fat sensitivity were observed in both absolute and difference detection thresholds [3]. An Ascending Hierarchical Classification evidenced three subsets of subjects with contrasted sensitivity profiles: high, medium and low absolute and difference thresholds. For each group of subjects, thresholds were always lower when the subjects did not wear nose clips, suggesting a strong impact of the olfactory modality in fat perception. The aim of the present paper was to determine, on the same well-characterized 40 subjects, the physiological parameters related to aroma release and/or aroma sensitivity that better explain the differences of fat perception in cottage cheeses.

Material & Methods

Odour detection and recognition thresholds were determined for 3 aroma compounds (pentane-2,3-dione; hexane-3,4-dione and 3-hydroxy-2-butanone) using the AS'SCENT International Olfactometer (St. Croix Sensory, Stillwater, MN). Detection thresholds were estimated using a 3-Alternative Forced Choice (AFC) procedure based on 14 dilution steps. Recognition threshold were estimated using a 4-AFC method in which subjects has to choose among 4 odour labels at each detection trial. Thresholds were expressed as the absolute value of the logarithm of threshold dilution level; the threshold could range from 0 for the less sensitive to 5 for the most sensitive.

General olfactory capabilities were estimated using the European Test of Olfactory Capabilities [4]. The overall score to the test is usually expressed as a percentage, here as a value between 0 and 1.

In vivo release of 2 aroma compounds imparting fatty notes (pentane-2,3-dione and hexane-3,4-dione) was followed by a Proton Transfer Reaction-Mass Spectrometer

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equipped with a Time-of-flight analyser (PTR-ToF 8000, Ionicon Analytik, Innsbruck, Austria), while consuming 1% fat content cottage cheese. Sampling was performed at a total flow rate of 60 mL/min with the transfer line maintained at 80°C. All the release data were calculated from the breath concentration ncps data, using Microsoft Excel 2010. Ten parameters were extracted from the smoothed release curves as described in Figure 1.

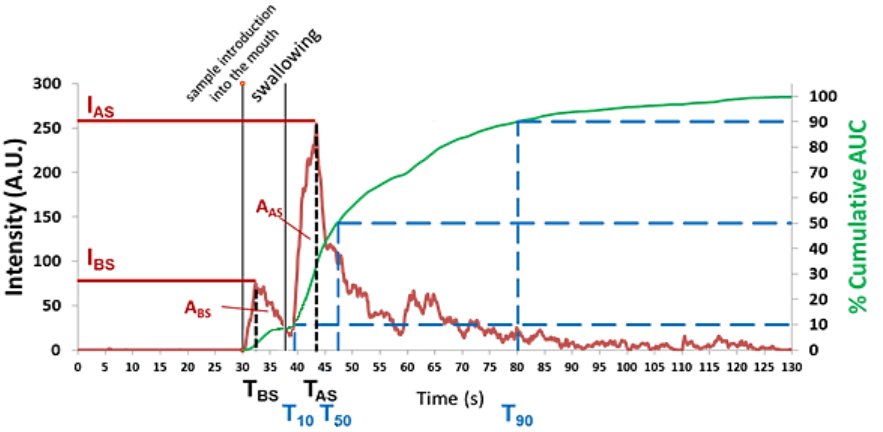

Figure 1: Parameters extracted from in vivo release curves**.** Maximal intensity before swallowing (**I_{BS}**) and after swallowing (**I_{AS}**), Time to reach maximal intensity before swallowing (**T_{BS}**) and after swallowing (**T_{AS}**), area under the curve before swallowing (**A_{BS}**) and after swallowing (**A_{AS}**), and time to reach 10% (**T_{10}**), 50% (**T_{50}**) and 90% (**T_{90}**) of the total area (**AUC**).

Mouth coating, defined as the residual food that sticks to the oral surface after food ingestion, was quantified by the "mouth rinse" method [5]. Dry matter of residual food (DM) was measured after lyophilisation. The lipids of residual food were quantified in the lyophilisate after extraction with chloroform/methanol (2:1) [6].

Resting saliva was collected as previously described [7] by instructing the subjects to spit out the saliva whenever they felt like into a pre-weighed cup over a period of 10 minutes. The cups were weighed and the salivary flow rates were expressed in mL/min. Saliva viscosity at rest (mPa.s) was measured with a Vibro – viscosimeter type SV-A (A&D Compagny Limited Japan).

An Eccovision® acoustic pharyngometer (Hood Laboratories, USA) was used to measure the oral volumes [8].

Respiratory flow was measured at rest using a spirometer (Pulmo System II, MSR, Rungis, France). Subjects were asked to breathe normally by the nose for three minutes. Respiratory frequency represents the number of respiratory cycles per minute and current volume, the volume of air used during each respiratory cycle.

Analyses of variance (ANOVA) were performed using XLSTAT® Software (Excel 97, version 8.0, Paris, France).

Results and discussion

The 40 subjects included in the panel pertained to 3 groups of sensitivity for fat perception in cottage cheese: 7 high sensitive subjects (S+), 24 medium sensitive (S0) and 9 low sensitive (S-) [3]. Among the different physiological parameters measured in

the study, only those presenting significant differences between the three groups of sensitivity are reported (Figure 2).

Subjects less sensitive to fat (S-) had lower overall olfactory capabilities reflected by lower scores to the ETOC (Figure 2a). They were less sensitive to aroma compounds imparting fatty notes (Figure 2a). They had especially a higher recognition threshold for 2,3-hexanedione and a higher detection threshold for acetoin. These results confirmed our previous hypothesis that olfaction is important for global fat perception.

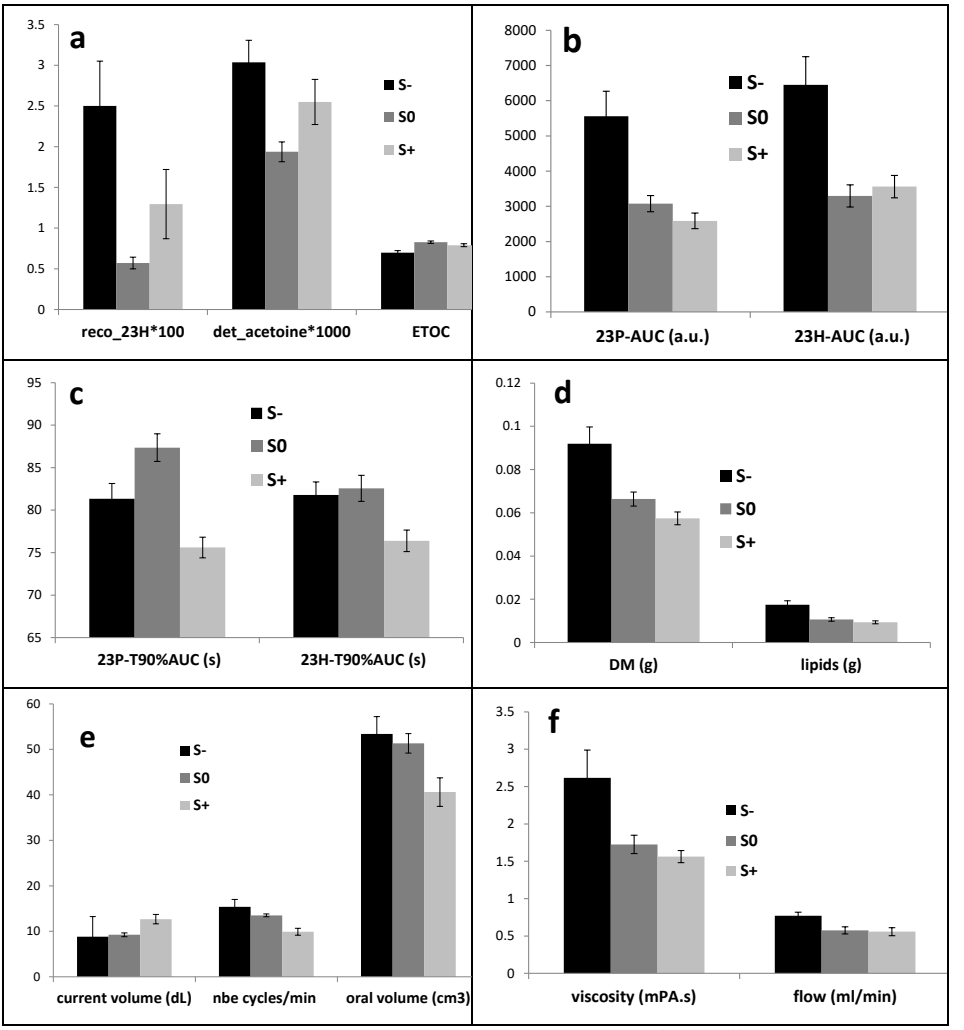

Figure 2: Physiological parameters (mean and standard error) showing significant differences between groups of fat sensitivity threshold (S+: high sensitive, S0: medium sensitive, S-: low sensitive) a) recognition threshold for 2,3-hexanedione, detection thresholds for acetoin, ETOC test; b) area under the curve (AUC) for 2,3-pentanedione (23P) and 2,3-hexandione (23H); c) time to reach 90% AUC for 23P and 23H; d) amount of dry matter (DM) and lipids remaining in the mouth after swallowing; e) respiratory parameters: current volume, number of cycles and oral volume; f) saliva viscosity and saliva flow.

Subjects less sensitive (S-) to fat significantly released a higher total amount of aroma than medium (S0) and high (S+) sensitive (AUC, Figure 2b), which cannot explain

their greater sensitivity. They needed a longer time to reach 90% AUC (Figure 2c), which means that their rate of release was slower. It has previously been suggested that the rate of release impacts more aroma perception than the total amount of aroma compounds release [9]. Moreover, subjects S- had a higher amount of product remaining in the mouth (DM and lipids, Figure 2d), which explains their higher amount of total aroma in the nasal cavity [8].

Subjects less (S-) and medium (S0) sensitive to fat had a higher respiratory frequency (nbe cycles/min) and a higher oral volume than high sensitive (S+) and subject's medium (S0) sensitive to fat had a significant lower respiratory flow (current volume) than high sensitive (S+) (Figure 2e). All these parameters could explain that the S- subjects had a higher rate of aroma release and thus aroma compounds will reach their olfactory receptors in a longer time.

Subjects less sensitive to fat (S-) also presented a higher salivary flow and saliva viscosity than medium (S0) and high sensitive (S+) (Figure 2f). These parameters, in addition to a higher mouth coating, could decrease the accessibility to taste and chemesthesic receptors and thus decrease textural and taste modalities of fat perception [3]. A high amount of lipid remaining in the mouth will form a fat barrier, which could limit the access to the receptors. A high viscous saliva will limit the diffusion of stimuli.

Conclusion

Fat perception in cottage cheese is multimodal and involves smell, taste and texture perception, with great interindividual differences. Subjects more sensitive to fat have higher olfactory capabilities, a lower respiratory frequency and a higher rate of aroma release in the nasal cavity; all these physiological features converge to increase aroma perception. Subjects less sensitive to fat have a higher saliva viscosity, a higher amount of product remaining in the mouth after swallowing, which could limit the access of the fat stimulus to the taste and chemesthesic receptors in the mouth.

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