



Development of a sensory tool to assess overall liking for the fatty, salty and sweet sensations



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ABSTRACT

Understanding the origin of the overconsumption of too high levels of sucrose, sodium chloride and lipids in foods raises the question of the influence of the hedonics for these sensations. To better understand this relationship, a sensory tool that enables measurement of liking towards sweet, salty or fatty sensations is required. This liking towards a sensation has to be understood as an overall attractiveness of the sensation. Instruments already existing were unsatisfactory as including a limited number of foods not representative of the overall sensation.

A set of hedonic tests, named PrefSens, was developed to measure an overall liking for fatty, salty or sweet sensations. Each test consisted in the rating on a 9-point hedonic scale of a food product at 5 different levels of lipids, sodium chloride or sucrose. To build the PrefSens test, a total of 144 food ranges were tested during the development step ($n = 341$ subjects) including various food categories, matrices and serving temperatures. Then, based on the technical feasibility and ability to discriminate, 32 food ranges were selected (10 for fatty, 10 for salty and 12 for sweet). The perceived intensity of fatty, salty or sweet "sensations" of these selected foods was evaluated by a trained panel ($n = 12$) using Spectrum[®] scales. During the application study, the hedonic evaluation of the selected foods was assessed in 6 tasting sessions by 567 subjects over 8 laboratories spread out in France. For each subject and each product, hedonic ratings (y) were fitted versus the level of fatty, sweet or salty (x) in a quadratic regression, from which the predicted optimal level (Lpref) was derived based on the x -coordinate of the parabola's maximum weighted by the correlation coefficient between observed and predicted data. The overall liking score for fatty, salty or sweet sensations was the average Lpref over the compounding food ranges.

The sensory profile showed that within each sensation the mean perceived intensity significantly increased in a linear manner with the nutrient level. An exception was for the two lowest levels of lipids which were not significantly perceived differently. Concomitantly, the overall liking scores followed an inverted U-shape centered on the middle level of lipids, sodium chloride or sucrose. The distribution was close to normality. Internal validity and consistency of the items compounding the sensations of fatty, salty or sweet were demonstrated. PrefSens is an internally valid and original tool that can be applied to a population sample in order to better understand the determinants of dietary behaviors.

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1. Introduction

The available nutritional guidelines that aim to prevent the health risk induced by overconsumption of too high levels of

sucrose, sodium chloride and lipids in foods (Herberg, Chat-Yung, & Chauliac, 2008) are not well followed by the population. Sucrose, sodium chloride and lipids are known to largely contribute to food palatability, as recently discussed (Cornwell & McAlister, 2011). Understanding the origin of this overconsumption raises the question of sensory preferences for the sensations brought by these nutrients (Blundell & Finlayson, 2004). To better understand this relationship, a sensory tool that

Abbreviations: Lpref, predicted optimal level.

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enables measurement of liking towards sweet, salty or fatty sensations is required. This liking towards a sensation has to be understood as an overall attractiveness of the sensation.

Even some authors (Hayes, Sullivan & Duffy, 2010) have used a diverse range of solid and liquid foods that varied in sodium to study liking for salty sensations, much of previous studies that assessed such liking have employed one or two simple food models presented with grading contents of sucrose, sodium chloride or lipids. Main food models were: soup, crackers, popcorn, tomato juice or hash browns for salty liking (Beauchamp, Bertino, Burke, & Engelman, 1990; Kanarek, Ryu, & Przypek, 1995; Kim & Lee, 2009; Bobowski, Rendahl, & Vickers, 2015; Lucas, Riddell, Liem, Whitelock, & Keast, 2011); water solutions, fruits flavored drinks or dairy products for sweet liking (Beauchamp et al., 1990; Hayes & Duffy, 2008; Monneuse, Bellisle, & Louis-Sylvestre, 1991); biscuits, popcorn or dairy products for fatty liking (Bowen et al., 2003; Engell, Bordi, Borja, Lambert, & Rolls, 1998; Hayes & Duffy, 2008; Kanarek et al., 1995). Results from these sensory tests based on a few simple foods are unlikely to represent liking for the sensation as experienced in various food models, including more complex food matrices. Such liking is thus unlikely to stand for the overall liking for the sensation of interest. A few studies have shown that the optimal concentrations of sucrose, sodium chloride or lipids differed with the food matrices, probably due to a different taste perception according to the food matrix (Dręwnowski & Schwartz, 1990; Dręwnowski, Shrager, Lipsky, Stellar, & Greenwood, 1989). In the study of Bertino, Beauchamp, and Jen (1983), the optimal sucrose content was different between a solid and a liquid stimuli with values being 15% in water vs. 24–30% in cookies, but it was related to a similar level of perceived sweetness (approximately 5 out of a 9-point scale). When Mela (1990) plotted the liking scores for 8 different food matrices (with different fat contents) against the perceived fat level, he observed the expected inverted U-shape (Pangborn, 1988; Stone & Pangborn, 1990) unlike that observed when plotted against the fat content. Similarly, Hayes and Duffy (2008) observed that, although all their studied groups of subjects liked highly sweet and creamy sensations (in liking by sensation models), the fat and sugar levels for hedonic optima varied (in liking by concentration models). This suggests that the overall liking for a sensation, as measured in different matrices, may be better determined according to the taste perception rather than directly according to the nutrient content.

Our purpose was to evaluate the liking of fatty, salty and sweet sensations, through a large number of foods being representative of each overall sensation. Instruments already existing were unsatisfactory for this purpose, as they did not assess an overall liking score for the sensation of sweet, salty or fatty. Thus, the present study aimed at developing such a tool that we called PrefSens. Firstly, a development study was conducted over a large series of food models sought to be representative of the usual food repertoire of the targeted population and of the various food contexts. The food models and the grading contents of sodium chloride, sucrose or lipids were selected according to their feasibility and their discriminating ability. The perception associated with each level of nutrients within each food product was assessed by a trained panel. Secondly, an application study was conducted over different laboratory tests spread out in the country. The internal validity and consistency of the overall score were explored using the statistical approach of exploratory factor analysis and by calculating the Cronbach's alpha coefficients. The distribution of the overall liking scores was examined.

PrefSens was developed in the framework of a larger project, called EpiPref, aimed at developing tools for measuring exposure to and liking for fatty, salty and sweet sensations in foods in both

consumer panels (several hundreds of subjects) and large human cohorts (several thousands of subjects).

2. Methods and participants

2.1. Development study

2.1.1. Food products and range levels

Pretests were conducted over a period of one and half years, over the course of six pre-testing campaigns with groups of 43–63 participants.

Food products were selected to represent the usual foods consumed by the French population, based on different matrix types and different consumption temperatures. Each product had to be “homemade” (not commercially prepared) and easily reproducible. There was no cross-variation, e.g. no concomitant variation of fat and sodium chloride in one product, to avoid as much as possible the interactions between the sensations. For fat, we selected fatty-salty and fatty-sweet products. The ingredients for the fatty “sensation” were sunflower oil, pork fat or whipping cream; for the salty one, it was NaCl (sodium chloride) and for the sweet one it was sucrose, intensified in some samples by a non-nutritive sweetener (aspartame).

It was assumed that for most individuals, the hedonic ratings for a food product plotted against the level of salty, fatty or sweet sensations should follow an inverted U-shape curve (Pangborn, 1970; Pangborn, 1988; Stone & Pangborn, 1990). Thus, the optimal level of sweet, salty or fatty sensations, which can be estimated as the curve maximum, can be assessed for most individuals and for each food product if the tested levels cover the U-curve abscissa.

For each food product, we tested several ranges of 5 levels of salty, sweet or fatty sensations. We hypothesized that the distribution of the maximally optimal level of sweet, salty or fatty over our population sample would approximate a normal distribution. Based on this, we determined the different levels of lipids, sodium chloride or sucrose. Firstly, the medium level (level 0, L0), which was initially based on the content usually met in the basic commercial products or common recipes, was adjusted to conform to the preferences of approximately 50% of subjects. From this L0 level was derived the four other levels, by decreasing it (levels L–1 and L–2) or increasing it (levels L+1 and L+2). We checked that over the population sample, the distribution of liking for a food product at different levels of lipids, sodium chloride or sucrose contents approximated a normal distribution.

2.1.2. Hedonic evaluation

The products were blind tasted under red light. For each food product, the participants received 5 samples at the same time, each sample corresponding to one level of the food range. The participants had to taste and swallow each sample following a balanced order based on a William Latin square and to rate their subsequent hedonic feeling on a 9-point scale, with anchors “I dislike very much” on the left (coded as 1) and “I like very much” on the right (coded as 9). The subjects were required to eat each sample entirely. We conducted pre-tests in order to derive the right portion sizes allowing product discrimination and small enough to be eaten entirely. For salty, a sufficient portion size to permit a discrimination of liking among the different levels was found to be about 10 g (one or two bites). For fatty and for sweet, the sufficient portion size had to be larger (25–30 g).

In order to construct a representative set of tests for each “sensation”, products were served cold (e.g. soft white cheese and milkshake served at about 4 °C), warm (e.g. mashed potatoes and vegetable soup, served at about 45 °C), or at room temperature (e.g. fish terrine

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