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Understanding the role of dynamic texture perception in consumers' expectations of satiety and satiation. A case study on barley bread

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ABSTRACT

Dynamic sensory perception has become of interest particularly related to consumers' affective response, however, better understanding the eating experience further than liking, taking into account how the dynamic sensory perception correlates to satiety perception becomes also very relevant. The objective of this work was to better understand satiety expectations in relation to the temporal aspects of texture perception during consumption. Eight barley bread samples were manufactured, with the same formulation, ingredients and caloric content but manipulating their texture by changing process parameters. A trained sensory panel evaluated the eight samples in triplicate, using a dynamic sensory method: Temporal Dominance of Sensations (TDS). Based on the results, four samples with well differentiated dynamic profiles were selected. These samples were also evaluated via classic descriptive analysis by the trained panel. A consumer test (n = 96) was run where consumers evaluated overall liking, expected satiety and expected satiation and answered to a check-all-that-apply (CATA) question that included 23 sensory and 15 non-sensory attributes. The results showed that the samples did not present mayor differences in liking but were significantly different in their expected satiety. Results showed that in solid foods like barley breads with the same ingredients, same composition and same caloric content, the oral processing, determined by textural changes, was the driver of different expectations of satiety and satiation. Dynamic textural changes responsible for driving satiety and satiation expectations were identified. Chewiness dominance mainly in the first stages of mastication and coarseness throughout the mastication were drivers of enhanced satiety perceptions, whereas a dominant perception of dryness and crumbliness at the beginning were linked to breads less expected to be satiating. A penalty lift analysis on the CATA results highlighted *compact*, *coarse* and *heavy* as the most important drivers of expectations of satiety and satiation for consumers, while *aery/fluffy* and *not coarse* were inhibitors of those perceptions.

1. Introduction

Overweight and obesity are major risk factors for various diseases, including diabetes, cardiovascular diseases and cancer. They are not only considered a problem in high-income countries, but also in middle- and low-income countries. From Global Health Observatory (GHO) data, in a global basis, around 39% of adults aged 18 and over were overweight in 2014; 13% were obese.

To control meal size and tackle overeating, there is a need to formulate healthy and satiating low-energy foods reaching consumers' acceptance. Satiety related perceptions include satiation and satiety; the former is process that leads to the termination of eating and therefore controls meal size, the latter is process that leads to inhibition of further eating, decline in hunger, and increase in fullness after a meal has finished. Compared with satiety, satiation is more strongly related to sensory attributes (Blundell et al., 2010; Lesdéma et al., 2016). The amount of intake of a particular food, however, is not solely governed by hedonic responses. It depends on the associations between sensory attributes and its metabolic consequences or expectations after consumption (Brunstrom & Rogers, 2009; Brunstrom, Shakeshaft, & Scott-Samuel, 2008). These expectations are thought to guide both portion size selection and actual food intake (Keri McCrickerd, Lensing, & Yeomans, 2015).

Recent studies (Brunstrom, 2014; McCrickerd & Forde, 2016; Wilkinson & Brunstrom, 2009) have highlighted that decisions about portion size are likely to be taken before a meal begins and that people are very good at estimating 'expected satiety' and 'expected satiation', that is, the experience of satiety is influenced more by what the person see and remembers eating, and less by what they actually ate. Brunstrom (2007, 2014) stated that the expectations of satiety and

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satiation are highly correlated with the actual number of calories that people consume, and are learned over time. Expectations are based on the complex interaction of various parameters like energy content, volume, weight, sensory properties, oral process or 'eating topography' determined by bite size, bite rate, swallow rate, etc. (de Graaf, 2011; Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013).

In human subjects, food is emptied into the duodenum for absorption at a rate of only about 10 kJ/min (Carbonnel, Lémann, Rambaud, Mundler, & Jian, 1994). This greatly constrains the opportunity for physiological adaptation and the detection of energy as a meal proceeds. To overcome this problem, people often use their prior experience to moderate intake as well as satiation. In other words, meal size is controlled by the decisions about portion size, before a meal begins. Thus, satiation might be determined by the volume of food that is consumed rather than its energy content (Brunstrom, 2011).

Texture and flavor are the important dimensions of sensory perception. Between these dimensions, texture rather than flavor, determines expected satiation (Hogenkamp, Stafleu, Mars, Brunstrom, & de Graaf, 2011). From a cognitive perspective, people may think solid foods are more satiating than liquid foods, i.e. solid foods will contain more energy than liquid foods, without reflecting about their actual calories (de Graaf, 2012). Besides, texture plays a critical role in satiation or satiety through its effect on oro-sensory exposure. Due to their fluid nature, liquid foods require less oral processing time than semi-solid and solid foods, leading to reduction in oro-sensory exposure, which is important for the development of satiety related perceptions (Keri McCrickerd, Chambers, Brunstrom, & Yeomans, 2012). It is therefore essential to gain a deep understanding of how texture impacts expected satiation and satiety.

Sensory perception, however, is not a single event but a dynamic process with a series of events (Labbe, Schlich, Pineau, Gilbert, & Martin, 2009). The relation between sensations and elicited satiation is not necessarily static during consumption. For example, using milkshakes thickened with several hydrocolloids, a recent study by Morell, Fiszman, Varela, and Hernando (2014) showed that satiety expectations were closely related to consistency and creaminess at the start of the consumption in products of similar consistency but different dynamic perception in mouth. Thus, the effect of texture on satiety expectations is not a straightforward function of hard/soft or viscous/not viscous, but rather related to a number of factors: viscosity, food particles, the complexity of the food items, their interaction, and their influence on the temporality of the in-mouth perception (Marcano, Morales, Vélez-Ruiz, & Fiszman, 2015; Morell, Ramírez-López, Vélez-Ruiz, & Fiszman, 2015; Tarrega, Marcano, & Fiszman, 2016). To further understand the relationship between sensory perception and expected satiating effects, it is required to take into account the dynamics of perception; attributes should be assessed during the length of oro-sensory exposure time. Temporal Dominance of Sensation (TDS) is a relatively new methodology in the sensory field for describing temporal perception, first presented at the Pangborn Symposium by Pineau, Cordelle, and Schlich (2003). Likewise, TDS has proven to be useful for evaluation of the dynamics of texture perceptions during food consumption (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009; Saint-Eve et al., 2011). Traditionally, TDS results have been presented as average dominance curves, showing the proportion of attributes dominance against time (Pineau et al., 2009). TDS scores can be also calculated in order to compare with sensory profiling results (Labbe et al., 2009). For each sample, TDS scores are applied for different time intervals during the mastication to obtain a sample trajectory which shows the evolution of sensory perceptions when the sample is consumed (Lenfant et al., 2009). The number and duration of time intervals are fixed, and chosen based on TDS curves (Dinnella, Masi, Naes, & Monteleone, 2013).

This study aimed at exploring the role of texture of solid foods in consumers' perception and expectations of satiation and satiety, in particular the role of dynamic perception during oral processing, with barley bread as a case study.

Table 1
Bread recipes.

Ingredient	With sourdough (g)	Without sourdough (g)
Wheat flour	1300	1400
Barley	600	600
Salt	30	30
Active yeast	20	20
Water for soaking or scalding	1000	1000
Water	400	500
Sourdough	200	–

2. Materials and methods

2.1. Samples

Eight barley bread samples were manufactured at Nofima's pilot bakery, using the same formulation and ingredients but manipulating the texture of the final products by changing process parameters. Samples were equi-caloric breads, prepared from standard recipes; texture was manipulated by scalding or soaking the barley, and through fermentation, as sourdough was added to some of the batches (Table 1).

In order to investigate different texture profiles, eight breads were made, based on four factors: barley type (flour or flakes), size (fine/thin or coarse/thick), treatment (soaking or scalding) and fermentation (yes or no) (Table 2). For each type of bread, six loaves were made.

For the fermented samples, 100 g of water and 100 g of wheat flour were removed from the standard recipe, and 200 g sourdough was added (see recipes in Table 1). The sourdough, 0.15 g Florapan L73, 500 g wheat flour and 500 ml water, was fermented at 25 °C (60% RH) overnight. Depending on soaking or scalding, the barley flour or flakes were soaked in 1000 ml of water (12 °C) for one hour, or 1000 ml of water (100 °C) was added, and cooled down overnight at room temperature, respectively. During both soaking and scalding the mixture was covered with a plastic film to prevent drying. Doughs were mixed and breads baked in an industrial oven. The loaves were cooled down on a tray, and stood overnight uncovered. The loaves were sliced in a bread slicer, the ends of the loaves were discarded, and the slices from the middle part of the loaves (1.1 cm thick) were used for testing. The sliced breads were frozen, then thawed for each of the tests. Thawing was done in the same conditions for all tests.

2.2. Temporal Dominance of Sensations (TDS)

Ten assessors with previous experience in quantitative analysis and TDS took part in this study. The evaluation was conducted following the TDS approach presented in (Agudelo, Varela, & Fiszman, 2015). The assessors were firstly reminded the concept of dominant sensation at a given time during the food consumption, then tasted eight samples and listed all the dominant attributes they perceived. After that, the most frequently cited attributes were selected upon agreement among the panelists. The sensory lexicon generated for breads included eight texture attributes (Table 3) and definitions from ISO 5492:2008.

Table 2
Experimental design for baking process.

Sample	Type	Size	Treatment	Fermentation
Bread1	Flour	Fine/thin	Soaking	No
Bread2	Flakes	Fine/thin	Scalding	No
Bread3	Flour	Fine/thin	Scalding	Yes
Bread4	Flakes	Coarse/thick	Scalding	Yes
Bread5	Flour	Coarse/thick	Scalding	No
Bread6	Flakes	Fine/thin	Soaking	Yes
Bread7	Flour	Coarse/thick	Soaking	No
Bread8	Flakes	Coarse/thick	Soaking	Yes