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# The impact of sugar and fat reduction on perception and liking of biscuits

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ABSTRACT

Reducing the fat and/or sugar content in biscuits can be a way to improve their nutritional composition. Seventy-nine consumers of biscuits were recruited to study the impact of these reductions on liking and perception. Four categories of products were selected from a wide range of biscuits available at the French market. Three to six variants of each type of biscuit were produced based on reduced content of sugar, fat or both. Consumers tested the samples under laboratory conditions (6 sessions), recording their liking during initial sessions and crispiness, sweetness and fat perception during latter sessions.

Sugar-reduced biscuits were perceived as less sweet than standard biscuits at low reduction levels, whereas fat-reduced biscuits were perceived as less fatty than standard biscuits at higher reduction levels (except for one biscuit among the three biscuits studied). A reduction in the sugar content had no effect on perception of fat, whereas a reduction in the fat content sometimes induced a reduced sweetness perception. For most of the biscuits studied, the least appreciated variants were those perceived as (1) less sweet, (2) less sweet and less fatty or (3) less sweet and less crispy than standard biscuits. Moreover, the variants only perceived as less fatty were not significantly disliked. These results suggest that from a sensory point of view, it is more acceptable to reduce the fat than the sugar content in biscuits, at least when products are not perceived as being less sweet.



## 1. Introduction

Sugar and fat are two major ingredients in biscuits. They have crucial structural and textural properties during biscuit dough preparation and baking, providing a typical shape and texture to the final product (Maache-Rezzoug, Bouvier, Allaf, & Patras, 1998; Pareyt & Delcour, 2008; Pareyt et al., 2009; Zoulias, Oreopoulou, & Tzia, 2002). They also play important sensory functions. Sugar is responsible for sweetness, while fat contributes to the texture, mouthfeel, flavour and aroma of food (Drewnowski & Almiron-Roig, 2010; Drewnowski, Shrager, Lipsky, Stellar, & Greenwood, 1989; Mela & Marshall, 1991).

Multiple factors are linked to consumer perceptions of sweetness and fat in biscuits. Sweetness is mainly due to the sugar content (Drewnowski, Nordensten, & Dwyer, 1998; Drewnowski et al., 1989), but it also depends on the fat content and moisture (Abdallah, Chabert, Le Roux, & Louis-Sylvestre, 1998). However, fat perception is more complex than sweetness. It depends on the fat content, the sugar content, texture, moisture, flavour, the nature of the food (liquid or solid) and mouthfeel (Abdallah et al., 1998; Drewnowski & Almiron-Roig, 2010; Drewnowski et al., 1989; Mela, 1990; Mela & Marshall, 1991; Monneuse, Bellisle, & Louis-Sylvestre, 1991).

Overconsumption of fat and sugar is associated with many diseases, such as obesity, high blood cholesterol and coronary heart diseases (Melanson, Astrup, & Donahoo, 2009; World Health Organisation, 2003). Thus, authorities encourage people to reduce fat and sugar consumption in public campaigns such as the National Nutritional Health Program in France (French Ministry of Health, 2006; Hercberg, Chat-Yung, & Chauliac, 2008). Industries are also encouraged to improve the nutritional composition of well-known commercial biscuits.

Reducing the sugar and fat content in biscuits results in structural, textural, sensory and hedonic consequences. Pareyt et al. (2009) described the structural and textural consequences of these reductions on sugar-snap cookies. They reported a modified microstructure, diameter, height and surface cracking pattern of the biscuit.

Sensory consequences of fat and sugar reductions depend on the product and the level of reduction. In biscuits, a 50% butter reduction was not distinguishable, whereas a 25% sugar reduction was perceived as significantly less sweet than a standard biscuit

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(Drewnowski et al., 1998). Nevertheless, Holt, Cobiac, Beaumont-Smith, Easton, and Best (2000) noticed that more consumers had difficulty discriminating different sucrose levels in a solid, high fat biscuit than in water, orange juice or custard.

Liking of biscuits is predicted by the overall flavour intensity, texture, sweetness and fat perception (Abdallah et al., 1998; Drewnowski et al., 1998). Preferences for high fat stimuli were observed even if they are not based on conscious perception of fat content (Abdallah et al., 1998; Drewnowski et al., 1989). Nevertheless, liking seems more related to sweetness than fat perception (Abdallah et al., 1998; Drewnowski et al., 1998). Drewnowski et al. (1998) showed that acceptability ratings for biscuits dropped after a 25% reduction in sugar content, while they were relatively unaffected after a 25% reduction in fat content.

The aim of this study was to assess the impact of fat and sugar reduction on liking, sweetness and fat perception of biscuits. Few recent studies have focused on fat and sugar reduction in biscuits, but most of them dealt with fat- and sugar-reduced biscuits made in the laboratory (Drewnowski et al., 1998; Holt et al., 2000; Pareyt et al., 2009). There were interesting models but not directly comparable to commercial products. In fact, several points differ between laboratory and commercial biscuits. First, recipes of laboratory biscuits are often much more simple than those of commercial biscuits. Indeed, in these studies, biscuits were made with only five (Holt et al., 2000; Pareyt et al., 2009) to nine ingredients (Drewnowski et al., 1998). On the contrary, industrial biscuits contained more than ten ingredients. Second, for technical reasons, some emulsifiers, bulking agents and fibres are sometimes added to reduced variants of commercial products. Indeed, it would not be possible to knead the pastry without these ingredients. Third, subjects consumed laboratory biscuits one or two days after they were produced (Drewnowski et al., 1998; Holt et al., 2000), whereas commercial biscuits are usually consumed when they are in the marketplace, after at least 1 month. Thus, laboratory biscuits have sensory characteristics of homemade biscuits, contrary to commercial biscuits. For all these reasons, we wanted to study if fat and sugar reduction of commercial biscuits would give similar results to laboratory biscuits.

Based on the literature on laboratory biscuits, four hypotheses can be formulated regarding the impact of fat and sugar reduction on sweetness, fat perception and liking of commercial biscuits: (i) Sugar-reduced biscuits are expected to be perceived as less sweet than standard biscuits even at low reduction levels, whereas fat-reduced biscuits are perceived as less fatty than standard biscuits at higher reduction levels; (ii) for a similar level of reduction, sugar-reduced biscuits should be more disliked than fat-reduced biscuits; (iii) it can be assumed that fat- and/or sugar-reduced biscuits should be less liked than standard biscuits as soon as they are perceived as less sweet and to a lesser extent as less sweet and less fatty; (iv) these results should vary according to the categories of biscuits. Thus, several categories of biscuits were studied.

## 2. Material and methods

### 2.1. Subjects

French subjects were recruited through mail or circular advertisements. They had to report their level of frequency of their global biscuit consumption on a five-point scale, from "Never" to "More than three times a week". Eighty-six consumers of biscuits were recruited, who consumed biscuits at least once a week.

Finally, seventy-nine subjects took part in the whole study (92% of the initial panel), so we only kept the results for these subjects (64 women and 15 men). Exclusion criteria for participation included those with food allergies and individuals dieting to lose weight. Mean age was 42.5 years old (SD = 5) and mean body mass index (BMI = kg/m$^2$) was 25.4 (SD = 5.5). The procedure was approved by the local ethical Committee (Comité de Protection des Personnes Est I, Bourgogne). All participants signed an informed consent form and received an indemnity for their participation in the study.

### 2.2. Products

Four different French commercial dry biscuits were studied: a 'cat's tongue' biscuit (A Biscuit), a 'petit beurre' biscuit (B Biscuit), a chocolate and cereals breakfast biscuit (C Biscuit) and a shortbread biscuit (D Biscuit). A range of three to six variants of each type of biscuit were produced by a French biscuit manufacturer, based on reduced sugar, fat or both. Finally, eighteen variants were developed (Table 1). Differences between these variants were due to changes in fat and/or sugar proportions compared to the original recipe. (F-) and (F- -) were two variants with increasing level of fat reduction. (S-) and (S- -) were two variants with increasing level of sugar reduction. (FS) was a variant both reduced on fat and sugar content. For industrial reasons, the level of emulsifiers, bulking agents or fibres sometimes increased (Table 2). Two other ranges of products (nine variants) made with intense sweeteners were also tested in our experiment. Intense sweeteners were added for technical reasons, but they are known to increase sweetness (Zoulias, Piknis, & Oreopoulou, 2000). Results of these two other ranges of products are not presented in this article.

Biscuits were prepared more than 1 month before the beginning of the experiment in order to recreate the usual consumption conditions of commercial biscuits. For each biscuit, the range of different variants was manufactured on the same day in the same baking conditions to minimise differences in quality between the samples. Biscuits were wrapped in sealed plastic packages labelled with a code letter and sent to the sensory laboratory. Upon arrival, they were stocked at room temperature. Minutes before the beginning of the testing session, biscuits were removed from their packaging and served on identical plastic plates labelled with randomly generated three digit identification codes. New packages were used for each test session to ensure sensory quality consistency.

Pre-tests were conducted in the laboratory to verify that the number of samples chosen was appropriate. Furthermore, at the end of each session of the study, more than 80% of the subjects rated that the quantity consumed was 'just about right'.

### 2.3. Procedure

Subjects participated in one-hour testing sessions once a week during 6 weeks at 10:30 am, 3 pm or 5:30 pm. However, each subject came each week at the same hour of the day to avoid individual variability between weeks. Subjects were asked to avoid food consumption 2 h before the test to reduce variations between subject hunger levels. All tests were conducted in standardised individual white partitioned booths, lighted with artificial red light to hide possible appearance differences between samples.

For each subject, six testing sessions were necessary to test all the variants of the study, even the two ranges of products not presented in this article. During the first two sessions, biscuits were cut and samples of one or two mouthfuls were served to ensure that the total quantity consumed was not too much. Subjects tasted between twelve and fifteen samples per session and recorded their liking on a nine-point hedonic scale, from "I extremely dislike" to "I extremely like". During the last four sessions, biscuits were cut and samples of three or four mouthfuls were served. Subjects tasted between six and nine samples per session. They ate each sample in three mouthfuls and after each bite, to rate (a) crispiness, (b) sweetness and (c) fat perception on a five-point