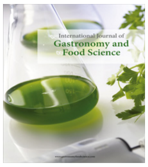

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Scientific Paper

Effect of highly aerated food on expected satiety

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Abstract

This work shows a practical way to design satiating new products by a real interaction of science and cooking. From the initial idea of the chef, a highly aerated product was designed to prove that the feeling of fullness starts before food is eaten, at the point when the food is just being viewed by the consumer. Mixtures of food-grade silica particles, methylcellulose (MC) and ovalbumin (OA) were used to get better distribution of air and to increase volume. Silica particles at a concentration of 0.3 wt% , mixed with MC (0.5 wt%) and OA (1 wt%) showed higher surface activity and viscoelasticity at the surface than the isolated ingredients. This mixture also showed the highest foam capacity and foam stability compared to the mixtures with none or 0.4 wt% of silica. Highly aerated structures were made by using the mentioned results. To verify the idea of having higher expected satiety with a highly aerated product, consumer study was performed. Subjects reduced their intake when a more-aerated sample was served compared to a less aerated sample.

Keywords: Proteins; Methylcellulose; Silica particles; Foaming properties; Satiety

Introduction

Food industry must have a strong focus on delivering innovation to meet market and consumer trends in health, texture, nutrition and targeted delivery solutions (Berry, 2008). Food developers must remember the following consumer demands: Is it good for me? Is it good for the world? Does it taste good? Does it consider gastronomic culture? Does it give me an extra-value? Chefs could play a key role by inspiring food industry with new developments and by manufacturing healthy and tasty food products. In fact, the creation of healthier, tastier and innovative food is one of the most important concerns of chefs nowadays. From a nutritional point of view, for example, science-based cooking can contribute to provide certain nutrients and other food components, which could confer healthy aspects to the dishes and menus (Navarro et al., 2012).

Common strategies for promoting healthy eating habits are controlling portion size and reducing the energy density of the meal (Hazen, 2007). The mechanisms controlling appetite and hunger are complicated but the study of these mechanisms could help get scientific evidence that could assist consumers in making healthier food choices. There are two different processes related to food intake. Firstly, satiation, that refers to the act of stopping food intake, an immediate reaction to the ingestion of food. During satiation, it seems clear that sensory (taste, volume, texture…) and cognitive factors will play an important role (De Graaf, 2012). Secondly, satiety, that refers to motivations to eat in between meals (Blundell et al., 2010), is body's response to the availability of nutrients from food that have been already digested and processed. From those close but different concepts, it has been reported that deficiencies in satiation seem to show more connections to obesity and binge eating than actual satiety (Kissileff, 1995; Spiegel et al., 1989).

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Therefore, enhancing satiation could restrict the daily food intake and the desire of overeating, contributing to body weight control (Hoad et al., 2004). Considering that satiation is partially governed by sensory factors (Blundell et al., 2010), it would be interesting to develop a product focused on the satiating effect of sensory perception, such as the visual factor. Consumer's sight influences the quantity of consumption, leading them to be less influenced by physiological signals of satiation. Wansink (2005) showed that manipulating visual signals of how much is eaten influences further intake: *people use their eyes to count calories and not their stomachs*.

There are many methods for the development of products related to this effect (satiation), which are based on lowering caloric density or modifying structure. For instance: the use of non-caloric ingredients, immobilizing high quantities of water and incorporating air as small dispersed bubbles (Zúñiga and Aguilera, 2008). Recent published research has highlighted the link between applied material characteristics like viscosity or gel performance of polysaccharides in food matrices and the effect of gastric emptying and satiety (Knarr et al., 2012). Methylcellulose (MC), for example, could be a good alternative, because it is a modified cellulose fiber that produces viscous solutions in the gastrointestinal tract. Furthermore, at the 244th National Meeting & Exposition of the American Chemical Society, a new product was presented based on modified methylcellulose that could present satiety properties (Huettermann, 2012).

Fixing air in food could be another alternative to design satiating products. In recent years, new aerated foods from the market are perceived as lighter in terms of calories, thus satisfying consumer needs. However, introducing a gas phase into a food matrix not only affects its texture and firmness making the product lighter, but also changes the appearance, color and mouth-feel (Campbell and Mougeot, 1999). So, it is essential to revise this aspect because these products are not only consumed for health purposes, but also for enjoyment. Aerated foods may provide a sense of fullness in comparison to the non-aerated food. There is some evidence that food intake is influenced by both the weight and volume of foods. It has been reported that increasing the air content may be an effective strategy to reduce energy intake from energy-dense products, like snacks (Osterholt et al., 2007). In this study, consumers ate 21% less weight and energy of the more-aerated snack than the less-aerated snack. This work presented the product with the same volume for both cases, so it is impossible to know whether consumers expected to be satiated before eating the product, just by sight signals. To the best of our knowledge, there is no literature at all describing the relation between expected satiety (from initially visual observation) and product volume.

The main objective of the present study was to design a significantly high-aerated product. This scientific study, together with chefs' gastronomic knowledge, would be used to fix the initially aerated structure, to get better distribution of air and increase volume, in order to check the perception of being full before eating. It was then hypothesized that the most-aerated product might give higher expected satiety than the less-aerated product.

Materials and methods

Materials

Methyl cellulose (Methocel Premium A15, mean molecular weight 14 kDa, methyl substitution between 27.5% and 31.5%) was obtained from The Dow Chemical Company (Midland, TX). Albumin from chicken egg white (A-5504) was purchased from Sigma-Aldrich (98%) and fumed synthetic amorphous silica AEROSIL® was purchased from Evonik Industries.

Two methodologies were used to get samples with different aeration. Two recipes were whipped at different speed to get structures of diverse volumes. The first one, the high aerated product (HA) was formed by pasteurized egg white, methyl cellulose (MC), amorphous silica and maltodextrin, which helped in the reinforcement of the foam structure. This dough was whipped in a Kitchen Aid Fagor® for 5 min at maximum speed. The second sample, the low aerated product (LA) was made just by pasteurized egg white, methyl cellulose and maltodextrin, and was whipped at the 4th speed for 20 min. After whipping, visually different samples were obtained with both methodologies. The final presentation of the dish ends with 15 g of each type of foam put in a Pirex® bowl.

Surface tension

Surface tensions at the air–water interface of protein solutions were measured by using an FTA200 pulsating drop tensiometer (First Ten Ångstroms, USA). The capillary drop was formed within an environmental chamber at room temperature, in which standing water increased the relative humidity to minimize drying effects. All measurements were made at room temperature ($\approx 20\ ^{\circ}\mathrm{C}$). Surface tension was monitored at room temperature for 30 min.

Surface rheology

Surface shear rheological measurements were carried out to study the mechanical and flow properties of adsorbed layers at fluid interfaces, which were sensitive to surface structure and composition (Ridout et al., 2004). Experiments at the air–water interface were made using a stress controlled rheometer, AR2000 Advanced Rheometer (TA Instruments) and an aluminum bicone (diameter 60 mm, angle cone 4:59:13) as measuring geometry. The surface rheological response in 50 mL solution was tested by oscillation mode within the range of linear viscoelastic region at a frequency and strain of 0.1 Hz and 0.014, respectively. Measurements were performed at room temperature for 30 min.

Foaming properties

Foam production was achieved by using a Foamscan TM apparatus (Teclis-ITConcept, Longessaigne, France), whose principle is to foam a 10 mL solution by gas sparging (N_2) through a porous glass frit (flow of gas: 45 mL min^{-1}; porosity 16–40 μm). The amount of liquid incorporated in the foam and the foam homogeneity are followed by