Food Research International 78 (2015) 141–147

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

How is an ideal satiating yogurt described? A case study with added-protein yogurts

P. Morell [a], B. Piqueras-Fiszman [b], I. Hernando [c], S. Fiszman [a,*]

[a] Instituto de Agroquímica y Tecnología de Alimentos (IATA-CSIC), Agustín Escardino 7, 46980, Paterna, Valencia, Spain
[b] Marketing and Consumer Behaviour group, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, the Netherlands
[c] Food Microstructure and Chemistry research group, Department of Food Technology, Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain

ARTICLE INFO

Article history:
Received 1 October 2015
Received in revised form 20 October 2015
Accepted 21 October 2015
Available online 22 October 2015

Keywords:
Yogurt
Protein
Expected satiating ability
CATA question
Ideal
Penalty analysis

ABSTRACT

Protein is recognized as the macronutrient with the highest satiating ability. Yogurt can be an excellent basis for designing satiating food as it is protein-based food product. Five different set-type yogurts were formulated by adding extra skim milk powder (MP), whey protein concentrate (WPC), calcium caseinate (CAS) or a blend of whey protein concentrate with calcium caseinate (CAS–WPC). A control yogurt without extra protein content was also prepared. Differences in sensory perceptions (through CATA questions) were related to the consumers' expected satiating ability and liking scores (of several modalities). In addition, an "Ideal satiating yogurt" was included in the CATA question to perform a penalty analysis to show potential directions for yogurt reformulation and to relate sensory and non-sensory yogurt characteristics to satiating capacity.

1. Introduction

Yogurt is one of the most popular dairy products because of its good nutritional value and its healthcare function (Han, Fu, & Zhao, 2015). This milk derivative contributes considerably to the intake of nutrients such as proteins, vitamins B2 and B12, and also certain minerals, mainly calcium, magnesium, and zinc. Knowledge of the beneficial effects of milk derivatives has led manufacturers to produce a wide range of yogurts with different flavors, textures, and consistencies in response to consumer preferences (Luis et al., 2015). Yogurt contains high levels of protein, which is recognized as the macronutrient with the highest satiating capacity (Blundell, Lawton, Cotton, & Macdiarmid, 1996; Benelam, 2009). Consequently, yogurt could be an excellent basis for designing a satiating product (Morell, Hernando, Llorca, & Fiszman, 2015a) that offers the pleasure and satisfaction associated with low-energy/healthier versions of foods without consumers feeling 'deprived' (Hetherington et al., 2013). However, it is difficult to reformulate since the new constituents can affect the energy density, palatability and texture, and a number of other factors that are involved in eating episodes (Varela & Fiszman, 2013).

In yogurt production, the solids content of milk is usually increased, as milk powder is traditionally used to enrich the yogurt milk before fermentation. However, new milk and whey fractionation technologies produce a wide range of dairy proteins of increased quality and availability, such as whey protein concentrates (WPCs) and Na- or Ca-caseinates, that may provide a cost-effective alternative to skim milk powder (Sodini, Montella, & Tong, 2005) and help to bring new products with added protein onto the market. These dairy proteins have different properties and can be used separately or blended. The effect of caseinates and WPCs has been compared (Damin, Alcântara, Nunes, & Oliveira, 2009; Guzmán-González, Morais, Ramos, & Amigo, 1999; Akalin, Unal, Dinkci, & Hayaloglu, 2012) but there are few references to the effect of blends of caseinates and WPCs on yogurt properties (Guzmán-González, Morais, & Amigo, 2000; Remeuf, Mohammed, Sodini, & Tissier, 2003).

The effect of the replacement of milk powder with WPC on the textural and physical properties of yogurts has been widely studied, and positive effects on yogurt firmness and viscosity have been reported (Salvador & Fiszman, 2004; Cheng, Augustin, & Clarke, 2000; Puvanenthiran, Williams, & Augustin, 2002). In general, yogurts with sodium caseinate added have also been found to be firmer and have less syneresis than yogurts that have the same protein level due to whey protein-based ingredients (Peng, Serra, Horne, & Lucey, 2009; Marafon et al., 2011; Isleten & Karagul-Yuceer, 2006). Comparison of

* Corresponding author.
E-mail address: sfiszman@iata.csic.es (S. Fiszman).

http://dx.doi.org/10.1016/j.foodres.2015.10.024
0963-9969/

the effects of caseinate and whey proteins on the sensory properties of yogurt has not been reported.

The firming effect of added proteins could be advantageous in the formulation of yogurts with enhanced expectations in satiating capacity, since it is recognized that textural characteristics play an important role in eliciting these sensations (Morell, Ramírez-López, Vélez-Ruiz, & Fiszman, 2015b). A number of techniques have been used to quantify 'expected satiating capacity' (Brunstrom & Rogers, 2009): rating fullness after showing food images (Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013; deGraaf, Stafleu, Staal, & Wijne, 1992), or after tasting a mouthful of food (Green & Blundell, 1996); a comparison method with images (constant stimuli) was also reported (Brunstrom, Shakeshaft, & Scott-Samuel, 2008) to estimate the expected satiety of a number of common foods. These measures are remarkably good predictors of the energy content individuals self-select and ultimately consume (Wilkinson et al., 2012).

Formulating yogurts with the addition of different proteins could lead to distinctive structural arrangements of the casein or whey protein in the yogurt protein network which would be closely related to its texture sensory sensations and elicitation of different expectations of satiating capacity. Check-all-that-apply (CATA) is a sensory technique that has been used to obtain rapid product profile (Meyners & Castura, 2014) where checked terms are considered by the consumers to be perceived as appropriate for describing the sample. An "ideal" product could be included in CATA questions to be evaluated after all the real samples have been presented; this way a penalty analysis is possible based on the gaps between the real products and the ideal and the impact on liking scores.

The aim of the present work was to relate the sensory (especially texture) characteristics of yogurts with added extra milk powder, whey protein concentrate, and calcium caseinate to their expected satiating capacity. A CATA question including a hypothetical "ideal satiating yogurt" was used for understanding the sensory features related to yogurts' satiating capacity and the potential cues for reformulation according to consumers.

2. Materials and methods

2.1. Ingredients

The ingredients used in the preparation of the yogurts were skim milk powder (kindly supplied by Central Lechera Asturiana, Siero, Spain), whey protein concentrate (AVONLAC 482, Glanbia Nutritionals Ltd., Kilkenny, Ireland), calcium caseinate (Fonterra Co-operative Group Ltd., Reference 385, Palmerston North, New Zealand), freeze-dried lactic culture (Natural Occidental Yogurt N11091 *Streptococcus thermophilus*, *Lactobacillus bulgaricus* and *Lactobacillus lactis*, Genesis Laboratories Ltd., Sofia, Bulgaria), sucralose (EPSA Aditivos Alimentarios, Valencia, Spain) and distilled water.

2.2. Sample preparation

Five different set-type yogurts were formulated: control (C), double skim milk powder (MP), added whey protein concentrate (WPC), added calcium caseinate (CAS), and a blend (50:50 protein basis) of added whey protein concentrate and calcium caseinate (CAS–WPC). The milk for sample C was prepared with 500 mL of distilled water and 50 g of skim milk powder; whereas 100 g of skim milk powder (instead of 50 g) was used to prepare 500 mL of milk for sample MP; sample WPC was prepared by adding 22.08 g of whey protein concentrate to the control milk; sample CAS was prepared by adding 18.28 g of caseinate to the control milk; and sample CAS–WPC was prepared by adding 11.09 g of whey protein concentrate and 9.14 g of calcium caseinate to the control milk. These additions were equivalent to doubling the protein content of sample C.

The skim milk powder, distilled water and whey protein concentrate or calcium caseinate as applicable were placed in glass beakers (1 L) and heated in a batch (Precisterm, JP Selecta S.A, Abrera, Spain) at 82–85 °C for 30 min (Morell et al., 2015b). The samples were cooled to the incubation temperature recommended for the culture used (42–43 °C) (digital thermometer, VWR International, Radnor, PA, USA) and inoculated with the lactic culture at 0.5 g/100 g of milk. Sucralose was added after cooling, to a total concentration of 0.0072 g/100 g of milk. The samples were placed in glass yogurt jars (125 mL) and placed in a yogurt-maker (YG523, Jata Electro, Abadiano, Spain). After a period of 6 h, the samples reached pH values of 4.5–4.6 (PH BASIC 20, Crison Instruments, S.A., Alella, Spain). The jars were individually covered and stored at 4–5 °C for 48 h.

2.3. Physicochemical properties

2.3.1. Instrumental firmness

The firmness of the yogurt samples was measured using a TA.XT-Plus texture analyzer (Stable Microsystems, Godalming, UK) equipped with a 5 kg load cell and a 12 mm diameter flat-ended cylindrical probe. Triplicate yogurt samples in glass containers were used. The samples were kept at 4–5 °C in a refrigerator until they were measured. The crosshead speed was set at 10 mm s^{-1} and the penetration distance at 10 mm. The firmness of the yogurt was defined as the maximum force measured during sample penetration (Salvador & Fiszman, 2004) expressed in N.

2.3.2. Syneresis

The level of whey that separated from the collapsed gels as a result of centrifugal force was measured. After 48 h of storage, approximately 20 g of yogurt was transferred into a 50 mL Falcon® conical polypropylene centrifuge tube. The sample was then centrifuged (Sorvall Super T 21) at 3300× g for 15 min at 4 °C. The separated whey was decanted and weighed. The syneresis was expressed as the percentage weight of the whey separated from the yogurt over the initial weight of the yogurt (Amatayakul, Sherkat, & Shah, 2006).

2.4. Sensory analysis

2.4.1. Consumers

A total of 116 consumers participated in the test (untrained, 59 women and 57 men, aged 18–65 years, mean age 22.9 years). All were recruited among the staff and student population of the Polytechnic University of Valencia and the students and employees of the Institute of Agrochemistry and Food Technology (IATA-CSIC). All were consumers of dairy products and declared no food allergies or lactose intolerance. All the experiments were performed in compliance with the national legislation, and according to the institutional framework and practices established by CSIC Ethics Committee.

2.4.2. Samples

The 5 samples were coded with random three-digit numbers and presented to the consumers in a balanced rotation order, following Williams' design (MacFie & Thomson, 1988). Consumers were provided with 80 ml white plastic cups filled in with 30 g of each sample and plastic spoons. The consumers were instructed to rinse their mouths with water between samples. The yogurts were served at eating temperature (8 to 10 °C).

2.4.3. Generation and selection of terms for the CATA (check-all-that-apply) question

A panel of ten assessors, skilled in quantitative descriptive analysis, evaluated the five samples to select the attributes that would be included in the CATA questionnaire. They were first given a number of samples, a brief outline of the procedure and a list of potential attributes taken from the literature (FIL, 1997). They were then asked to choose