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Sensory profile and preference mapping of orange cakes with addition of prebiotics inulin and oligofructose

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ABSTRACT

Orange cakes with addition of inulin and oligofructose to justify a prebiotic claim (minimum of 3 g of fructans in a 60 g serving of cake) were investigated regarding sensory aspects. The sensory profile of cakes with inulin, with inulin/oligofructose and without prebiotics (standard cake) was evaluated using descriptive quantitative analysis. Preference mapping was assessed using multidimensional scaling on data obtained through an acceptability test with a nine-point hedonic scale. The cakes with prebiotics presented greater crust brownness, dough beigeness, hardness and stickiness than the standard cake and lower crumbliness. Principal Component Analysis (69.5 and 10.7% of explanation to the first and second principal components, respectively) showed that crust brownness, dough beigeness, hardness and stickiness contributed to distinguish the cakes with prebiotics from standard cakes. The sensory acceptability was similar for the three cakes and higher when compared to three commercial cakes, but the preference mapping showed that cakes with prebiotics were preferred to commercial cakes. Addition of prebiotics in orange cakes is feasible, based on the sensory results, which may facilitate marketing of this functional food with sensorial qualities equivalent to conventional products.

1. Introduction

Prebiotics are food compounds that cannot be digested by the enzymes of the human gastrointestinal tract and behave like fibres. They act as specific substrates for beneficial bacteria, thereby selectively stimulating proliferation or activity of desirable bacterial populations in the colon, such as bifidobacteria and lactobacilli (probiotics) (Gibson & Roberfroid, 1995; Mattila-Sandholm et al., 2002). Because prebiotics present functional characteristics similar to soluble fibres, they are fermented in the large intestine by colonic bacteria, producing lactic acid, short chain fatty acids (acetic, propionic and butyric) and gases, thus reducing the intestinal pH and inhibiting proliferation of harmful microorganisms (Wang, 2009).

Inulin and oligofructose are types of prebiotics belonging to a class of carbohydrates called fructans, a generic term that is used to describe all oligo and polysaccharides of fructose of vegetal origin (Carabin & Flamm, 1999). Inulin is a storage carbohydrate found mainly in chicory root (*Cichorium intybus*) and Jerusalem artichoke (*Helianthus tuberosus*) and, structurally, is composed of β-D-fructofuranose polymers joined by β(2 → 1) links, with a degree of polymerization that can reach 70 (Roberfroid & Delzenne, 1998). Oligofructose is obtained through partial hydrolysis of chicory inulin and subsequent purification, and its degree of polymerization ranges from 2 to 8 (Biedrzycka & Bielecka, 2004; Roberfroid, 2005).

Prebiotics can be applied to a variety of foods. Inulin and oligofructose present, respectively, 10 and 35% of the sweetness power of sucrose (Franck, 2002), allowing them to partially replace sucrose in some formulations (De Castro, Cunha, Barreto, Amboni, & Prudencio, 2009; Villegas, Tárrega, Carbonell, & Costell, 2010; Wang, 2009). Because of gelling characteristics, inulin allows the development of low-fat foods through the replacement of significant amounts of fat and the stabilisation of the emulsion, without compromising texture (Franck, 2002; González-Tomás, Coll-Marqués, & Costell, 2008; O'Brien, Mueller, Scannell, & Arendt, 2003; Paseephol, Small, & Sherkat, 2008). Prebiotics can also increase product flavours, such as citrus aroma and flavour perception of probiotic fermented milks (Sendra et al., 2008), lemon flavour of dairy desserts (Arcia, Costell, & Tárrega, 2011) and vanilla flavour intensity of custards (Tárrega, Rocafull, & Costell, 2010). However, prebiotics can also impair some sensory characteristics of food, such as a thickening in dairy desserts (Arcia et al., 2011), hardness and cohesiveness in cakes (Moscatto, Borsato,

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Bona, Oliveira, & Hauly, 2006) and higher firmness and lower acceptability of sponge cakes (Ronda, Gómez, Blanco, & Caballero, 2005). Gonzalez, Adhikari, and Sancho-Madriz (2011) found that peach-flavoured yogurts with fructooligosaccharide show similar sensory profile and acceptability, but fructooligosaccharide with added *Lactobacillus acidophilus* (synbiotic ingredient) present a negative impact on sensory acceptability.

Incorporation of prebiotics into baked goods allows the replacement of sugar, enriches fibre and improves moisture retention properties (Franck, 2002; Wang, 2009). Some studies have been conducted on adding fructans to cakes (Devereux, Jones, McCormack, & Hunter, 2003; Moscatto et al., 2006; Ronda et al., 2005), in which the cakes were evaluated regarding physical properties (texture, colour and volume) and sensory acceptability, but no studies evaluated the effects of prebiotic addition on the sensory profile of cakes.

Certain health benefits can be claimed for products containing inulin and oligofructose as prebiotics, but the official rules about the use and exact wording of these claims vary from country to country. In Brazil, legislation approves the claim that inulin and oligofructose help to balance the intestinal flora, since their consumption is associated to a balanced diet and healthy lifestyle, provided that consumption of the product is accompanied by liquid intake. Moreover, solid food servings should contain at least 3 g of inulin or oligofructose, or both, for the claim to be made (ANVISA, 2011).

Therefore, functional foods for which prebiotic claims can be made must contain a minimum quantity of inulin and oligofructose and be accepted by consumers, as well as being presentable as commercial products. Since inulin and oligofructose have some technological functions, as described above, it is expected that their incorporation in cakes will cause changes to the sensory attributes of the products, which may also influence their acceptability among consumers. Therefore, the aim of this study was to evaluate the sensory profile and preference mapping of orange cakes with addition of the prebiotics inulin and oligofructose.

2. Materials and methods

2.1. Experimental design

Inulin and oligofructose/inulin were added to orange cakes to obtain functional foods for which prebiotic claims can be made. The sensory profiles of these products and of a standard cake (without prebiotics) were obtained by Descriptive Quantitative Analysis. The products were also evaluated for sensory acceptability and preference mapping in relation to three commercially produced orange cakes.

2.2. Materials

The fructans Orafti®GR and Orafti®Synergy1 were provided by Beneo-Orafti, a Belgian company that extracts and produces inulin and oligofructose. Orafti®GR is composed of ≥90 g/100 g of inulin (average degree of polymerization ≥ 10) and ≤10 g/100 g of glucose + fructose + sucrose. Orafti®Synergy1 is composed, approximately, of 46 g/100 g of oligofructose, 46 g/100 g of inulin and 8 g/100 g of glucose + fructose + sucrose. Beneo-Orafti does not provide degree of polymerizations of inulin and oligofructose present in Orafti®Synergy1.

The other ingredients used in cake formulations were purchased in a local market (Carrefour Comércio e Indústria Ltda, São José do Rio Preto, Brazil) and the same brand and specification were used for all formulations.

The orange cakes were developed containing sufficient inulin and oligofructose/inulin to obtain functional foods for which prebiotic claims could be made. A standard cake, without prebiotics, was also developed (Table 1). The cakes were prepared under identical conditions.

The total fructan content of the cakes with inulin and with oligofructose/inulin, were evaluated in triplicate by means of the enzymatic-colorimetric method (McCleary & Rossiter, 2004) using the FRUCTAN HK kit (Megazyme, Ireland), was 9.0 and 8.3 g/100 g, respectively. These values corresponded, respectively, to 5.4 and 5.0 g of fructans in a 60 g serving of cake, thus enabling prebiotic claims for both products.

Three commercial orange cakes were purchased in local market (Carrefour Comércio e Indústria Ltda, São José do Rio Preto, Brazil) to compare the sensory acceptability to the developed cakes.

2.3. Descriptive quantitative analysis

Panellists were recruited from among the students, staff and professors of the Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista "Júlio de Mesquita Filho" (IBILCE). A Descriptive Quantitative Analysis was performed in accordance with Stone and Sidel (1993).

Fourteen panellists, out of the 39 recruited, were preselected through a basic taste recognition test (minimum of 6 correct responses in a total of 9 solutions; Meilgaard, Civille, & Carr, 1999), an odour recognition test (minimum of 7 correct responses in a total of 10 odours; Meilgaard et al., 1999) and triangle tests using the sequential analysis of Wald (Shirose & Mori, 1984). The parameters of Wald analysis were: $p_0 = 1/3$ (maximum unacceptable ability, that is, the probability of accidentally guessing correctly), $p_1 = 2/3$ (minimum acceptable ability), $\alpha = 0.05$ (probability of selecting an unacceptable panellist, without sensory acuity) and $\beta = 0.10$ (probability of not selecting an acceptable panellist).

The sensory attributes were generated by the fourteen panellists, using the Kelly Repertory Grid method (Moskowitz, 1983). After discussions to reach a consensus, the descriptive terms that were most important for characterizing the appearance, aroma, texture and flavour of the cakes were selected. The sensory panel also defined the attributes, the references for each of these and the product evaluation form.

After the training stage, which took seven sessions, the panellists were selected according to their discriminative capacity ($F_{sample} \leq 0.50$), reproducibility capacity ($F_{repetition} \geq 0.05$) and consensus with the panel (ASTM, 1981; Damásio & Costell, 1991). Only eight of the fourteen panellists were selected to conduct analyses on the sensory profile of the cakes.

Table 1
Formulations of the standard cake, cake with inulin and cake with oligofructose/inulin.

Ingredients	Standard cake	Cake with inulin	Cake with oligofructose/inulin
Wheat flour (g)	260	290	310
Orafti®GR (g)	0	77.7	0
Orafti®Synergy1 (g)	0	0	77.7
Refined sugar (g)	398	398	398
Soy oil (mL)	200	200	200
Commercial orange juice (mL)	250	250	250
Egg (unit)	3	3	3
Orange essence (drop)	10	10	10
Baking powder (g)	10	10	10

The sensory analysis was performed in individual booths, under white light and temperature at 22 °C. The cakes were presented on plastic plates coded with three-digit random numbers and were evaluated in quadruplicate by the eight panellists. The sample presentation was balanced with complete blocks that were randomized and monadic and an unstructured linear intensity scale of 90 mm length was used for each descriptor.

The means of the sensory attributes were compared using variance analysis followed by the Tukey test (significant difference when $p \leq 0.05$), using the PASW Statistics 18 software (SPSS Inc.). The results were also subjected to Principal Component Analysis, using the Statistica 7.0 software (StatSoft, Inc.).

2.4. Sensory acceptability test and preference mapping

The standard cake and cakes with prebiotics were compared to three commercially produced orange cakes regarding sensory acceptability and preference.

The acceptability of the appearance, aroma, texture and flavour and the overall acceptability were evaluated using a verbal hedonic scale of nine points (1 – disliked extremely; 5 – neither liked nor disliked; 9 – liked extremely) (Meilgaard et al., 1999).

An incomplete block design was used: in each block, there were a total of six consumers; each of them evaluated four samples and each sample was evaluated four times. The block was repeated thirteen times, thus totalling 52 analyses for each sample and 78 consumers (Meilgaard et al., 1999).

The 78 untrained consumers were recruited from among the students, staff and professors of the IBILCE. The sensory analysis was performed in individual booths, under white light and temperature of 22 °C. The cakes were presented on plastic plates coded with three digits. Within each block, the sample presentation was balanced, randomized and monadic.

The means of the sensory attributes were compared using variance analysis followed by the Tukey test (significant difference when $p \leq 0.05$), using the PASW Statistics 18 software (SPSS Inc.). The cakes were considered acceptable when at least 50% of the consumers gave them a score greater than or equal to 6 (liked slightly) (Conti-Silva, Silva, & Arêas, 2011).

The preference mapping was evaluated in relation to overall acceptability. First, cluster analysis was applied to the samples, using mean substitution as the data deletion method because of the incomplete blocks. After this, the resultant matrix was subjected to multidimensional scaling analysis. The Statistica 7.0 software (StatSoft, Inc.) was used.

2.5. Ethical issues

The ethical issues of the sensory analysis were approved by the Research Ethics Committee of the IBILCE.

3. Results and discussion

3.1. Descriptive quantitative analysis

Most of the fourteen panellists were female (93%), aged between 19 and 27 years (100%), who like cakes very much (100%) and consume cakes weekly (29%) and fortnightly (36%).

The cakes were described using five attributes for appearance, one for aroma, two for flavour and four for texture (Table 2).

The addition of prebiotics enhanced crust brownness and dough beigeness of the cakes in comparison to the standard cake (Table 3). Fructans are polymers of fructose linked by linear or branched connections, through β(2 → 1) or β(2 → 6) (Carabin & Flamm, 1999), and since fructose is a reducing sugar (Amrein, Schönbächler, Escher, & Amado, 2004; Damodaran, Parkin, & Fennema, 2008), this may favour the Maillard reaction, thereby contributing towards browning the crust and dough of the cakes.

The cakes with fructans presented greater hardness and lower crumbliness in relation to the standard cake (Table 3), what was

Table 2
Definitions and references for sensory attributes of the orange cakes.

Sensory attribute	Definition	References
Appearance		
Crust brownness	Degree of brown colour of regular cake crust	Low: Milk biscuit High: Glucose syrup
Dough beigeness	Degree of beige colour of regular cake dough	Low: White bread crumb High: Milk biscuit
Crust brightness	Ability to reflect light	Low: Milk biscuit High: "Brigadeiro" (Brazilian sweet made of chocolate and condensed milk)
Crust uniformity	Homogeneity of the crust in relation to presence of air bubbles	Low: Bath sponge High: Commercial orange cake
Size of the bubbles in the dough	Size of the cavities formed by air bubbles	Small: Commercial orange cake Large: Bath sponge
Aroma		
Orange aroma	Characteristic orange aroma	None: Filtered water High: Orange juice
Flavour		
Orange flavour	Characteristic orange flavour	Low: 100 mL of orange juice diluted with 200 mL of filtered water High: Orange juice
Sweet taste	Characteristic sweet flavour	Low: White bread crumb High: Caramelized milk sweet
Texture		
Hardness	Minimum force necessary to compress the sample between the teeth	Low: White bread crumb High: Commercial orange cake
Moisture	Sensation caused by the amount of water presented in the cake	Low: Milk biscuit High: One slice of commercial orange cake moistened with 10 mL of milk
Crumbliness	Ease of breaking off a slice of cake with the fingers and dissolving in the mouth	Low: Commercial orange cake High: White bread crumb
Stickiness	Force required to overcome the traction between the food and the palate	Low: White bread crumb High: "Sequilho" (dry biscuit)

Table 3
Intensity of sensory attributes for standard cake, cake with inulin and cake with oligofructose/inulin (mean data ± SD, $n = 32$).

Attributes	Standard cake	Cake with inulin	Cake with oligofructose/inulin
Crust brownness	4.5 (1.2)^{b}	6.7 (1.4)^{a}	6.6 (1.4)^{a}
Dough beigeness	3.6 (1.3)^{b}	5.5 (1.7)^{a}	5.4 (1.7)^{a}
Crust brightness	5.5 (1.6)^{a}	4.8 (1.9)^{a}	4.7 (1.9)^{a}
Crust uniformity	4.4 (1.8)^{a}	4.9 (1.9)^{a}	5.2 (2.1)^{a}
Size of the bubbles in the dough	3.5 (1.8)^{a}	2.8 (1.8)^{ab}	2.4 (1.6)^{b}
Orange aroma	3.6 (1.9)^{a}	3.1 (1.9)^{a}	3.0 (2)^{a}
Orange flavour	3.7 (2)^{a}	3.3 (1.9)^{a}	3.2 (2)^{a}
Sweet taste	5.5 (1.3)^{a}	5.3 (1.9)^{a}	5.2 (2)^{a}
Hardness	3.9 (2.3)^{b}	5.6 (2)^{a}	5.3 (2.2)^{a}
Moisture	5.2 (1.7)^{a}	5.0 (1.5)^{a}	4.4 (1.5)^{a}
Crumbliness	5.5 (1.5)^{a}	3.0 (2)^{b}	2.6 (1.5)^{b}
Stickiness	4.0 (1.9)^{b}	6.2 (1.3)^{a}	5.5 (1.6)^{a}

Different letters in the same line indicate different means ($p \leq 0.05$).

expected since fructans are soluble fibres, compounds that can impair the texture of baked goods (Pomeranz, Shogren, Finney, & Bechtel, 1977; Wang, Rosell, & Barber, 2002). Higher concentrations of inulin resulted in higher hardness values of bread crumbs in relation to breads containing fat (O'Brien et al., 2003) and oligofructose enhanced firmness of sponge cake in relation to cake with sucrose (Ronda et al., 2005). Moreover, the higher hardness and lower crumbliness of prebiotic cakes may be related to lower size of the bubbles in the dough, because lower bubbles can indicate less air incorporated to the dough during baking, which may contribute towards making the cake harder and less fragile. Stickiness of the cakes enhanced after fructans addition, probably because of the ability of the inulin to uptake water during baking (Ronkart, Paquot, Fougnies, Deroanne, & Blecker, 2009).

Despite literature pointing to an increase in aroma and flavour with addition of prebiotics, orange aroma and flavour were not affected by addition of fructans. As this work, addition of 1 and 2 g/100 g of tagatose (prebiotic ingredient) in bakery products (cinnamon muffins, lemon cookies and chocolate cakes) resulted in a similar flavour to control products with added sucrose (Armstrong, Luecke, & Bell, 2009).

The fructans did not affect crust uniformity, although oligofructose enhanced appearance uniformity of sponge cake in relation to cake with sucrose (Ronda et al., 2005). It also did not affect sweet taste and moisture content, probably because of the high quantity of sugar already used in the cake formulations and because the standard cake was already moist, respectively.

Zahn, Pepke, and Rohm (2010) added inulin Orafti®GR as a margarine replacer in muffins and applied the Quantitative Descriptive Analysis. This replacement had some similar effects on sensory profile in relation to our work: higher tough (intensity of a perceived chewing resistance) and similar smell (intensity of product-typical smell, comprising fresh and sweetish), sweet (sweetness intensity) and dry (mouth-feel during chewing which gives an impression of missing moisture). In another work, the simplex-centroid design for mixtures of inulin, oligofructose and gum acacia was used to optimize a cereal bar formulation. The linear terms of inulin and oligofructose influenced brightness (although did not change in our work), dryness, cinnamon odour, sweetness, hardness, crunchiness and chewiness, besides the interaction of inulin and oligofructose to cinnamon odour and chewiness (Dutcosky, Grossmann, Silva, & Welsch, 2006).

The type of fructan used, only inulin or oligofructose/inulin, did not affect any attribute, therefore, the sensory profile of the cakes with prebiotics is the same (Fig. 1). Both of the cakes with prebiotics were characterized by crust brownness, dough beigeness, hardness and stickiness, while the standard cake was characterized by crumbliness.

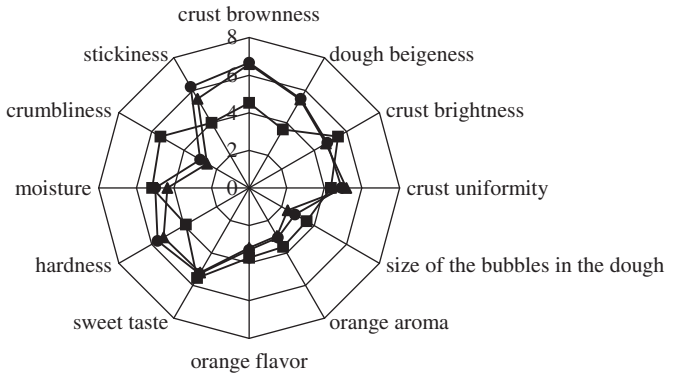

Fig. 1. Spider-graph for the sensory profile of orange cakes. —■— Standard cake; —●— Cake with inulin; —▲— Cake with oligofructose/inulin.

Principal Component Analysis (Fig. 2) showed that the first and second principal components explained, respectively, 69.5 and 10.7% of the observed variation (80% in total), thus indicating that the panellists were able to discriminate satisfactorily between the samples analyzed, in relation to the descriptor terms. The cake with inulin presented higher reproducibility of the results, because the vertices of the quadrilateral were close, while the other two showed lower reproducibility. Again, the cakes with prebiotics presented similar sensory characteristics, but different from those of the standard cake, since the latter was distant from the other two in the vector space.

The attributes of crust brownness, dough beigeness, hardness and stickiness made a great contribution towards distinguishing the cakes with prebiotics from the standard cake, while the latter was distinguished more by the crust brightness, size of the bubbles in the dough, orange aroma and flavour and crumbliness. The attributes of crust uniformity, sweet taste and moisture did not contribute towards differentiating between any of the samples.

3.2. Sensory acceptability

Most of the 78 consumers were female (73%), aged between 17 and 25 years (88%), who eat cakes weekly (24%) and fortnightly (36%).

Comparing the prebiotic cakes to the standard cake, all attributes had similar acceptability, except for texture (Table 4). The fact that the cakes with inulin and oligofructose/inulin were harder, crumblier and stickier than the standard cake (Table 3) probably contributed towards reducing their acceptability. The acceptability was also similar for all six cakes, for all the attributes. Flavour was the only attribute accepted in the same way for all cakes. The standard cake was the most acceptable regarding all attributes.

The percentages of the consumers that gave scores greater than or equal to six, for the standard cake, cake with inulin, cake with oligofructose/inulin, commercial cakes 1, 2 and 3, respectively, were: 88 (aroma and flavour), 81 (texture), 77 (aroma), 85 (texture), 75 (texture) and 75 (texture). This indicates that all the cakes were well accepted and the acceptability for cakes with prebiotics was even greater than for the commercial cakes.

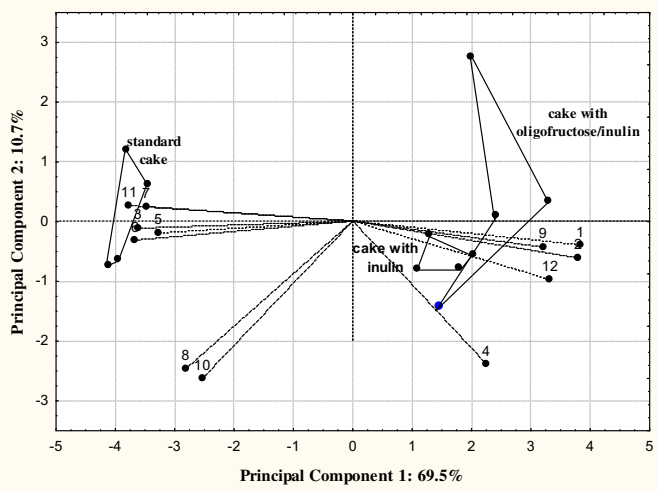

Fig. 2. Principal Component Analysis on descriptor terms for orange cakes. Each vertex of the quadrilateral corresponds to one repetition of the sensory analysis. Legend: (1) crust brownness; (2) dough beigeness; (3) crust brightness; (4) crust uniformity; (5) size of the bubbles in the dough; (6) orange aroma; (7) orange flavour; (8) sweet taste; (9) hardness; (10) moisture; (11) crumbliness; (12) stickiness.

Table 4
Sensory acceptability for standard cake, cake with inulin, cake with oligofructose/inulin and three commercial orange cakes (mean data ± SD, $n = 52$).

Attributes	Standard cake	Cake with inulin	Cake with oligofructose/inulin	Commercial cake 1	Commercial cake 2	Commercial cake 3
Appearance	7.6 (1.0)^{a}	7.0 (1.4)^{b}	7.1 (1.4)^{ab}	7.3 (1.4)^{ab}	6.7 (1.6)^{b}	6.9 (1.5)^{b}
Aroma	7.2 (1.4)^{ab}	7.1 (1.3)^{ab}	6.8 (1.5)^{b}	7.6 (1.3)^{a}	7.1 (1.4)^{ab}	7.2 (1.5)^{ab}
Texture	7.8 (1.0)^{a}	6.7 (1.7)^{bc}	6.9 (1.6)^{bc}	7.1 (1.6)^{ab}	6.4 (1.8)^{bc}	6.5 (1.7)^{c}
Flavour	7.3 (1.4)^{a}	7.0 (1.5)^{a}	6.8 (1.6)^{a}	7.1 (1.7)^{a}	6.9 (1.5)^{a}	6.7 (1.8)^{a}
Overall acceptability	7.5 (1.0)^{a}	6.9 (1.3)^{ab}	6.9 (1.4)^{ab}	7.2 (1.4)^{ab}	6.8 (1.6)^{ab}	6.8 (1.7)^{b}

Different letters in the same line indicate different means ($p \leq 0.05$).

Moreover, the sensory acceptability of the cakes tested in this study was greater than or equal to other results obtained with fructans reported in literature (Devereux et al., 2003; Ronda et al., 2005).

3.3. Preference mapping

The multidimensional scaling presents the spatial dispersion of the consumers in relation to their preference for the cakes. Each consumer was represented as a point and individuals with similar preferences were close to each other. The number of consumers around a sample indicated how much this one was preferred over others. Moreover, cluster analysis performed before applying the multidimensional scaling was able to group the samples as a - function of consumer preferences.

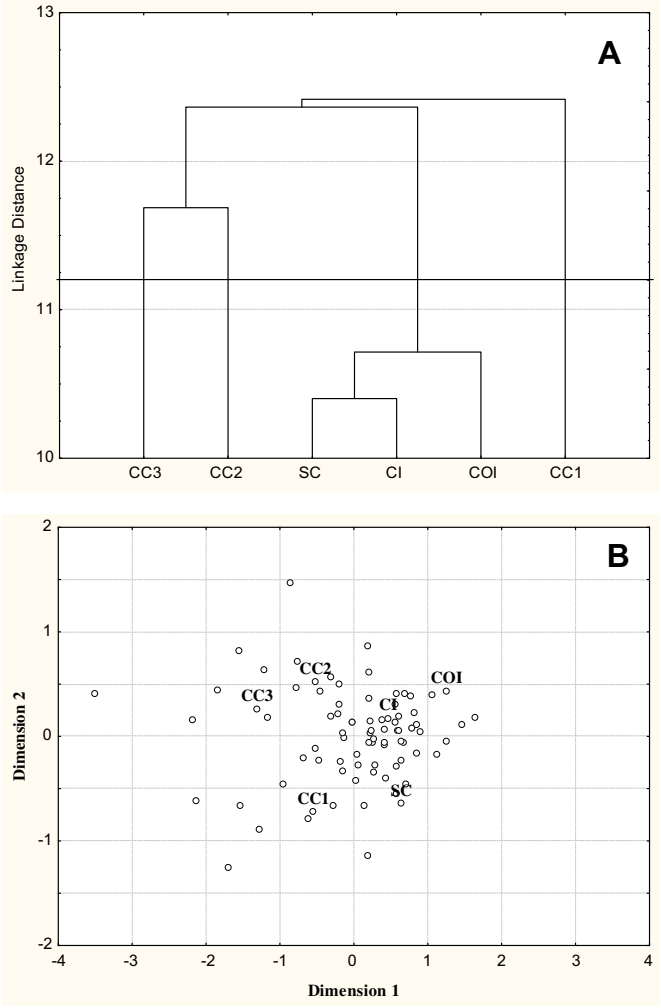

Fig. 3. Euclidean distances diagram (A) and preference mapping (B) for orange cakes. Legend: SC (standard cake); COI (cake with oligofructose/inulin); CI (cake with inulin); CC1 (commercial cake 1); CC2 (commercial cake 2); CC3 (commercial cake 3).

The multidimensional scaling can be evaluated by the stress value, which indicates the goodness-of-fit of the model. Stress values below 0.01 indicate that data are behaved and the model is well adjusted (Johnson & Wichern, 1992; Kruskal & Wish, 1978), and stress value of our work was 5.4×10^{-6}.

The orange cakes were divided into four groups, based on Euclidean distances diagram (Fig. 3A): one group was formed by cakes with inulin, with oligofructose/inulin and standard cake, while commercial cakes 1, 2 and 3 were kept in separate groups (Fig. 3B). A higher number of consumers were observed around the standard and prebiotic cakes, thus indicating a preference for these cakes in relation to the commercial cakes. Furthermore, there were some consumers who did not prefer any cake, given that some points were distant from all the samples.

The cakes acceptability shown as means (Table 4) indicates that the cakes with inulin, with oligofructose/inulin and standard cake were as widely accepted as the commercial, while the preference mapping (Fig. 3B) shows a preference for cakes developed in this work.

4. Conclusions

Addition of the prebiotics inulin and oligofructose changes the attributes of crust brownness, dough beigeness, stickiness, hardness and crumbliness of the standard cake, independent of the type of prebiotic. The acceptability and preference among consumers are similar for the orange cakes with prebiotics and the standard cake, and higher than for the commercially produced orange cakes. Therefore, addition of prebiotics to orange cakes is feasible, based upon sensory results, which may facilitate marketing of this functional food with sensory qualities equivalent to conventional products.

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