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Sensory profile, acceptability, and their relationship for diabetic/reduced calorie chocolates

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ABSTRACT

The purpose of this study was to determine the sensory properties and acceptability of lab developed prototypes of conventional, diabetic (with no sugar), and diabetic/reduced calorie milk chocolates (no sugar and 25% calorie reduction) with high-intensity sweeteners, sucralose and stevioside, and partial fat replacement with whey protein concentrate (WPC). PLS was performed in order to relate sensory properties and consumer acceptability and to determine drivers of liking and disliking. There was no difference between conventional, diabetic and diabetic/reduced calorie milk chocolates for brightness, cocoa aroma, cocoa butter aroma, and cocoa flavor ($p > 0.05$). Acceptability was higher for sucrose substitution by sucralose than by stevioside and partial fat replacement reduced acceptability of flavor even more ($p \leqslant 0.05$). Crucial attributes which determine consumer acceptability in samples are sweet aroma, melting rate, and sweetness, whereas bitterness, bitter aftertaste, adherence, and sandiness were drivers of disliking.

1. Introduction

There is an increasing interest in low-calorie foods and beverages (Parpinello, Versari, Castellari, & Galassi, 2001). Alternatives to sucrose serve a number of purposes. It is important that such alternatives don't cause significant changes in the sensory characteristics of the product (Bolini-Cardello, Da Silva, & Damasio, 1999). It is also very important that diabetic (with no sugar) or reduced calorie foods have as few differences as possible from conventional foods. A very effective way of comparing conventional food with lab developed prototypes of diabetic or reduced calorie food is to perform sensory evaluations, such as descriptive analysis and consumer affective testing. Prindiville, Marshall, and Heymann (1999) suggested that consumers consider flavor quality when selecting the level of fat in foods they purchase. Sensory evaluation gives a realistic opinion about the likes and dislikes of a particular flavor (Hariom, Shyamala, Prakash, & Bhat, 2006).

Descriptive techniques are frequently used in product development to measure how close a new introduction is to the target or to assess suitability of prototype products (Lawless & Heymann, 1999). In consumer sensory analysis the investigator is interested in weather the consumer likes the product, prefers it to another product, or finds the product acceptable based on its sensory characteristics (Lawless & Heymann, 1999). Preference mapping is a sensory tool to accomplish integration between consumer reactions and descriptive data (Geel, Kinnear, & de Kock, 2005). By relating consumer data with descriptive data, the researcher can discover the relationships between product attributes and the ultimate bottom line, consumer acceptance (Meilgaard, Civille, & Carr, 1999). One of the more recent topics in product research is the notion of "drivers of liking", or the nature of sensory features that drive acceptance (Moskowitz, Gofman, & Beckley, 2006).

Sensory properties are some of the most important factors on consumer liking and preference; thus, it is very important to determine factors affecting the product attributes, acceptance and preference especially for foods and drinks (Dos, Ayhan, & Sumnu, 2005). Understanding what sensory properties drive consumer liking is critical for maximum market share (Thompson, Drake, Lopetcharat, & Yates, 2004). Luckow and Delagunty (2004) reported that consumers would not be interested in consuming a functional beverage if the ingredients caused noticeable off-flavors that consumers found unpleasant despite the added health advantages. However, conflicting research does exist. A study performed with elderly consumers demonstrated that sensory appeal was less important than health perception and fat content, with regard to the purchase intent of fat-modified foods. Although high-intensity sweeteners are essentially calorie free, some of these sweeteners impart undesirable flavors and aftertastes, such as bitterness, that can limit their applications in foods and beverages. However, sucralose is reported to have a relatively clean, sweet taste with little persistence of bitterness (Zhao & Tepper, 2007).

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During the rush of publicity of the new nutritional recommendations in the early 1980s, the first strategy to evolve was simply to remove fat from standard products, such as milk or meat, without any attempt to address the organoleptic changes resulting from the reduction in fat. Such a strategy is not feasible for most other food products (as milk chocolate) because physical stability, functional properties and microbiological stability may be adversely affected. The major challenge in the development of reduced-fat foods is to achieve fat reduction while matching as closely as possible the flavor and mouthfeel of traditional full-fat products (Jones, 1996). Whey protein-based fat replacers can mimic milk fat in terms of texture and flavor retention (Prindiville, Marshall, & Heymann, 2000).

The objective of this study was to study the influence of sucrose and fat replacement and to correlate consumers' data with sensory dat. Traditional milk chocolate was compared with lab developed prototypes of diabetic and diabetic/reduced calorie chocolates as well as with a diabetic but not reduced calorie commercial product (Com), using quantitative descriptive analysis (QDA), principal component analysis (PCA), affective testing, internal preference mapping, and partial least squares (PLS) regression to relate consumer preference data to data from QDA.

2. Materials and methods

2.1. Samples

The lab developed prototype of conventional milk chocolate was prepared with sucrose (Sucro). Diabetic prototypes were prepared substituting sucrose with high-intensity sweeteners, sucralose (Sucra) or stevioside (Ste), and a polydextrose/lactitol (60/40) blend as a bulking agent. Both conventional and diabetic chocolates were formulated to be equi-sweet at the most acceptable sweetness intensity as determined by the time-intensity methodology by Melo, Bolini, and Efraim (2007a). Diabetic/reduced calorie milk chocolates were prepared through substitution of sucrose in the same way as diabetic chocolates but with partial replacement of cocoa butter with whey protein concentrate (WPC) in order to reduce the calorie content by 25% (Sucra/WPC and Ste/WPC) (Melo, Bolini, & Efraim, 2007b). A 25% calorie reduction was considered because Brazilian Legislation determines that this is the minimum calorie reduction in order to use a "low-calorie" or "reduced calorie" claim. Chocolates were conventionally produced following the steps of mixing, in a KITCHEN AID planetary mixer, model K5SS (Kitchen-Aid, St. Joseph, MI); refining, in a DRAISWERK GMBH three-roll refiner (Draiswerke GmbH, Manheim Waldo, Mahweh, NJ); conching in a FRIWESSA longitudinal conche (Friwessa, Parsippany, NJ); temper in a ACMC laboratory temper (ACMC, Bohemia, NY); moulding in polycarbonate molds; cooling in a SIAHT tunnel cooler (Siaht, Jundiaí, SP, Brazil) and packaging (Beckett, 1994). Chocolates were produced in batches of 1250 g. Formulations developed on this work are presented in Table 1. Cocoa mass and cocoa butter were provided by Barry Callebaut Brasil S/A, sucralose by Danisco do Brasil, stevioside by Sterviafarma Industrial S.A., polydextrose and lactitol by Danisco do Brasil and WPC by Kraki Kienast & Kratschmer Ltda. The commercial (Com) product (diabetic but not reduced calorie) was produced and provided by Nestlé Brasil Ltda.

Table 1
Formulations of diabetic and reduced calorie milk chocolates

Ingredient (%)	Sample				
	Sucro	Sucra	Ste	Sucra/WPC	Ste/WPC
Sucrose	43	–	–	–	–
Sucralose	–	0.061	–	0.061	–
Stevioside	–	–	0.22	–	0.22
Polydextrose	–	25.8	25.8	25.8	25.8
Lactitol	–	17.2	17.2	17.2	17.2
Cocoa mass	14	14	14	14	14
Cocoa butter	21.4	21.4	21.4	15.8	15.8
WPC	–	–	–	5.6	5.6
Powdered milk	12	12	12	12	12
Skim powdered milk	9	9	9	9	9
Soy lecithin	0.5	0.5	0.5	0.5	0.5
Vanilla flavor	0.1	0.1	0.1	0.1	0.1

2.2. Quantitative descriptive analysis

Judges generated 16 attribute terms with definitions and references through Kelly's Repertory Grid Method (Moskowitz, 1983), using same lab developed prototypes and other commercial non-diabetic and diabetic chocolates (Table 2). References were determined by consensus of all judges and then panelists were further trained on the product attributes using identified references. Analysis of variance (ANOVA) for each panelist and each attribute was employed and ten panelists out of eighteen were chosen for participation according to their discriminating capability ($p \leqslant 0.30$) and repeatability ($p > 0.05$), using data collected during training sessions; individual consensus was also considered (Damasio & Costell, 1991). The experimental samples were used during attribute determination, panelist selection and training sessions. The ten selected panelists were further trained and samples were evaluated using previously determined references in four replications for all attributes using a 9-cm unstructured line scale with anchors "none" or "weak", depending on the attribute, and "strong". Samples were presented monadically on disposable plates bearing appropriate three-digit codes using a balanced block design (MacFie, Bratchell, Greenhoff, & Vallis, 1989). Sensory analyses were carried out in individual air-conditioned (22 °C) booths with white light. Crackers and taste-free water were provided for palate cleansing.

2.3. Affective testing

Consumers evaluated both the lab developed chocolate and commercial chocolate to determine liking of appearance (APP), aroma (ARO), flavor (FLV), texture (TEX) and overall linking (OAL). They were recruited to taste regular, diabetic and diabetic/reduced calorie chocolates but they were not informed which ones they were tasting and about ingredients. Consumer affective testing was carried out using a 9-cm unstructured line scale with anchors "dislike extremely" and "like extremely". Sensitivity in defining consumer perception is greater with use of line scales than with the 9-point hedonic scale (Greene, Bratka, Drake, & Sanders, 2006). Samples coded with three-digit numbers were presented monadically in a balanced block design to 116 chocolate consumers on disposable plates. The 116 consumers consisted of 38.8% men and 61.2% women who consume milk chocolate at least once a week. Age distribution was 18–29:57.8%; 30–39:22.4%; 40–49:15.5%; and 50–69:4.3%. Sensory tests were carried out in individual air-conditioned booths. Crackers and taste-free water were provided for palate cleansing. Consumers' decisions were based solely on the sensory characteristics of the chocolates, since product information and formulation were not provided.

2.4. Statistical analyses

QDA results were analyzed by ANOVA, using two factors (panelist and sample) and interaction amongst them, followed by a Tukey's honestly significant difference (HSD) test. The acceptability results were analyzed by ANOVA, using two factors (consumer