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Textural, physical and sensory impacts of the use of green banana puree to replace fat in reduced sugar pound cakes

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ABSTRACT

Green banana puree (GBP) was used to replace fat at different levels (0%–100%) in pound cakes, followed by sugar reduction (0%–50%). Sensory profile by Check-All-That-Apply (CATA) tests and acceptance were applied to settle the best formulation in each step. The cakes with the best acceptances were characterized by physical and textural analyses. GPB cakes with sugar reductions of 20% and 40% showed the highest acceptance. According to CATA, replacing fat with GBP causes changes in color, slice size, compaction, and some attributes of odor, flavor, and texture. Sugar reduction impaired the appearance acceptance and led to a higher proportion of big alveoli, beige or dark beige color, mild taste, and wheat flour flavor. The reduction of sugar led to the increase of the cake cooking factors. The control cake sample had the lower specific volume. The cakes with GBP presented higher firmness (20%: 9.4 N; 40%: 11.2 N) and springiness (20%: 51%; 40%: 51%) than the control (6.6 N, 44.1%). GBP replacement and reduction of sugar increased luminosity, color saturation and hue angle in the crust of the product. Results indicate that GBP replacing fat is feasible at 25% with a reduction of 20% and 40% of sugar.

1. Introduction

Chronic diseases (CD) are increasing and represent about 65% of human deaths worldwide (Scheen & Van Gaal, 2014; WHO, 2017). A major risk factor for CD is unhealthy feeding, which is associated with health problems such as overweight, diabetes, dyslipidemias, and cardiovascular diseases (Mastellos, Gunn, Felix, Car, & Majeed, 2014).

To improve health and quality of life, the World Health Organization (WHO) (WHO, 2004) published the Global Strategy for the Promotion of Healthy Eating, Physical Activity and Health. WHO recommends that governments develop national guidelines to improve diet nutritional quality. Following this recommendation, the Brazilian Department of Health and food sector signed the Cooperation Agreement to promote healthy lifestyles, which include a healthy and adequate diet. In this context, Brazil promoted the Strategic Action Plan against Chronic Diseases (Brazil, 2007; WHO, 2004).

Among the proposed strategies, the identification of food or ingredients that are important sources of sugar and unhealthy fat for human consumption must be highlighted, as research has shown that populations that consume diets with high sugar, saturated, or trans fatty acid content tend to take in more energy from food. They also tend to present overweight; to show high levels of serum cholesterol; to present a higher prevalence of diabetes, coronary and heart disease; and to increase the risk of death (Dhaka, Gulia, Ahlawat, & Khatkar, 2011; Hung et al., 2016; Michas, Micha, & Zampelas, 2014). Among these products, we highlight bakery, confectionery, and pastry products, especially cakes, which can be classified as unhealthy food owing to their usual sugar and unhealthy fat content (Schirmer, Jekle, Arendt, & Becker, 2012). Cakes are baked products relished by consumers and are available worldwide.

Global cake consumption is estimated at about 4500 thousand tons per year; in Brazil, consumption is about 33 thousand tons of cakes per year (ABIMAPI, 2016). Interest in nutrition has been driving consumer demand to lower unhealthy fats and sugar levels, as well as calorie consumption. Therefore, it is necessary to improve the nutritional composition of cakes to reduce the negative impact of their

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consumption on health. Nevertheless, the reduction of fat and sugar levels in cakes affects their technological and sensory properties (O'Sullivan & O'Sullivan, 2017b, 2017a).

Fat, sugar and flour replacements for bakery products that increase their nutritional value and health benefits have been studied (Bajerska, Mildner-Szkudlarz, Górnaś, & Seglina, 2016; Cortez Ginani et al., 2010; Farzi, Saffari, & Emam-Djomeh, 2015; García, Salvador, & Hernando, 2014; Gómez, Ronda, Caballero, Blanco, & Rosell, 2007; Górnaś et al., 2016; Kocer, Hicsasmaz, Bayindirli, & Katnas, 2007; Schirmer et al., 2012; Segundo, Román, Gómez, & Martínez, 2017; Struck, Jaros, Brennan, & Rohm, 2014). There are few studies evaluating the reduction of fat and sugar content in cakes using inulin and/or oligofructose (García et al., 2014; Khouryieh, Aramouni, & Herald, 2005); polydextrose (Kocer et al., 2007); N-Flate® with aspartame, fructose, and polydextrose (Pong, Johnson, Barbeau, & Stewart, 1991).

To the best of our knowledge, there are no studies that evaluate the impact of the use of green banana puree (GBP) as a substitute for fat in cakes, and especially accompanied by sugar reduction. In our study, we evaluated the impact of GBP as a replacement for fat in cakes along with sugar reduction based on hedonic and descriptive sensory methods to develop a healthier cake. GBP was used as a fat substitute because of the presence of hemicellulose and resistant starch (RS), which promotes (respectively) moisture and softening in cake batter (Baixauli, Salvador, Martínez-Cervera, & Fiszman, 2008; McGee, n.d.; Sanz, Salvador, Baixauli, & Fiszman, 2009). In addition, RS and hemicellulose should be associated with health benefits such as glycemic and cholesterol control, intestinal regulation, and satiety (Homayouni et al., 2014; Rabbani, Larson, Islam, Saha, & Kabir, 2010).

Thus, considering considerable public health concern regarding the influence of fat and sugar consumption on the health of the population, the goal of this study was to evaluate the impact of GBP as a replacement for fat in pound cake, followed by sugar reduction. This is the first study focused on the use of sensory analysis to drive the reduction of fat and sugar content in cakes by using GBP as fat replacer, and to further support scientifically government strategies to improve the nutritional composition of foods.

2. Material and methods

2.1. Cake formulations

The control cake sample was made according to the traditional Le Cordon Bleu(Le Cordon Bleu, 2010) pound cake recipe, comprising wheat flour (Dona Benta®, Rio Grande do Sul, Brazil), chemical yeast (Royal®, Paraná, Brazil), sugar (União®, São Paulo, Brazil), butter (Itambé®, Goiás, Brazil), eggs (Uniovo®, Goiás, Brazil) and salt (Cisne®, Rio de Janeiro, Brazil) (Table 1). First, we mixed the eggs for 5 min (maximum speed) with an electric mixer (Walitta®, Brazil). In another container the sugar and butter were mixed for 5 min (maximum speed) with an electric mixer (Walitta®, Brazil). The creams formed in the previous two steps were mixed and the mixture of wheat flour, salt and chemical yeast were added. Finally, the batter was baked at 190 °C for 25 min in a Bundt pan (diameter = 20 cm; height = 8 cm).

For the modified samples, the GBP were added to replace fat in increments of 0 %–100% (Table 1). At this stage, the aim was to choose the cake with GBP replacement that obtained the highest sensory quality according to acceptance and descriptive tests. The most accepted sample (25% of fat replaced with GBP) was used in the next step to lower sugar content. The tests were carried out with sugar reduction in increments of 0 %–50% (Table 1). Despite the changes in the ingredients, the method of cake preparation was maintained excepting the bakery time. The baking temperature was the same (190 °C) but the dough was baked until completely cooked (ranging from 40 to 49 min). As a well-established culinary procedure, completely cooking was checked by inserting a thin bladed knife in the center of the cake and we checked for residue remaining in the utensil. A clean blade indicated cooking was concluded.

2.1.1. Green banana puree preparation

GBP was produced according Cassettari protocol (Cassettari, 2015) by washing 280 g of whole green bananas (GB) on the second stage of maturation (green with a trace of yellow) (Tapre & Jain, 2012) and cooking them under pressure (120 °C) for 8 min. GB was stripped and the pulp (183 g) was mashed up for 5 min in a multiprocessor (Wallita®, Brazil) with 100 g of water. Water was added to green banana to achieve the texture of the puree, according to Cassettari (2015).

2.2. Sensory analysis

Cake samples (20 g) were served to the assessors on monadic presentation, in random and balanced order (Bassinello, Rocga, & Cobucci, 2004). For each assessor, six different samples of cake were served with filtered water at room temperature to cleanse the palate between a pair of samples. Samples were evaluated for acceptance and sensory characterization with the Check-All-That-Apply (CATA) test. Descriptor elicitation for CATA was carried out in a first session with 15 assessors. These tests were performed with 108 consumers to evaluate samples with fat replacement and with 101 consumers to characterize samples with lower sugar content.

2.2.1. Descriptor elicitation

For each CATA test, appearance, odor, flavor and texture lexicons were developed according to the Repertory Grid method (Kelly, 1955), with 15 cake consumers. Samples were presented in groups of three, consisting of two similar samples and a third very different one. The assessors were asked to evaluate samples and indicate similarities and differences between them for each sensory modality. For the first CATA test, the Repertory Grid was performed with control cake and samples with 25%, 50%, 75%, and 100% of fat replaced by GBP. Furthermore, the sample with 50% fat was repeated to act as a control in the test. For the second CATA test, samples applied to the Repertory Grid were control cake and cake with 25% of fat replaced by GBP and with sugar

Table 1
Formulations of the different batters and cakes.

	CakeSamples[a]									
	0–0	25–0	50–0	75–0	100–0	25–10	25–20	25–30	25–40	25–50
Wheat flour with chemical yeast (g)	100	100	100	100	100	100	100	100	100	100
Sugar (g)	100	100	100	100	100	90	80	70	60	50
Butter (g)	100	75	50	25	–	75	75	75	75	75
Green banana puree (g)	–	25	50	75	100	25	25	25	25	25
Egg (g)	100	100	100	100	100	100	100	100	100	100
Salt (g)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total weight (raw dough) (g)	400.5	400.5	400.5	400.5	400.5	340.5	380.5	370.5	360.5	350.5

[a] The first digit corresponds to the fat replacement level (%) and the second digit corresponds to the percentage of sugar that was removed from the cake (%).