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Original

Macrocospic and physiochemical characterization of a sugarless and gluten-free cake enriched with fibers made from pumpkin seed (*Cucurbita maxima*, L.) flour and cornstarch

Caracterização macroscópica e físico-química de bolo isento de açúcar, com fibra e sem glúten a base de farinha mista de semente de abóbora (Cucurbita maxima, L.) e amido de milho

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Abstract

The Consumers' interest for products with caloric reduction has increased, and their development is a technological challenge. The consumption of cakes has grown in importance and the demand for dietary products has stimulated the use of sweeteners and the optimization of bakery products. The consumption of fibers is related to chronic diseases prevention. Pumpkin seeds (*maximum Cucurbita*, L.), rich in fibers, can be used as a source of fiber in food products. A gluten-free diet is not easy to follow since gluten free products are not always available. The objective of this work was to perform a physicochemical characterization of cakes prepared with flours blends (FB) based on Pumpkin Seed Flour (PSF). The cakes were elaborated with FB in the ratios of 30:70 (C30) and 40:60 (C40) of PSF and cornstarch (CS), respectively. The results showed gluten absence and near-neutral pH. The chemical analysis of C30 and B40 showed increase of ashes, lipids, proteins, and insoluble dietary fiber and a decrease in the content of carbohydrates and calories. The chemical composition of C40 presented the greatest content of lipids, proteins, and dietary fibers, the lowest content of calories, and the best physical parameters. Therefore, both products proved suitable for human consumption.
Keywords: *pumpkin seed flour; cake; fiber; dietary; gluten.*

Resumo

O interesse do consumidor por produtos com redução calórica é crescente e seu desenvolvimento um desafio tecnológico. O produto bolo vem adquirindo crescente importância de consumo e a demanda por produtos dietéticos vem estimulando a utilização de edulcorantes e a otimização de produtos panificados. O consumo de fibra alimentar associa-se à prevenção de doenças crônicas, e a semente da abóbora *(Cucurbita maxima,* L.*)*, rica em fibra alimentar, pode ser utilizada como fonte, em produtos alimentícios. Uma dieta isenta de glúten não constitui prática fácil, sendo raros os produtos panificados deste tipo. O objetivo deste trabalho é caracterizar de forma físico-química bolos elaborados com Farinhas Mistas (FM) à base de Farinha de Semente de Abóbora (FSA). Os bolos foram elaborados com FM nas proporções 30:70 (B30) e 40:60 (B40) a partir de FSA e Amido de Milho (AM), nesta ordem. Os resultados mostraram ausência de glúten e pH próximo à neutralidade. As análises químicas de B30 e B40 mostraram aumento no teor de cinzas, lipídios, proteínas e fibra alimentar insolúvel e, por outro lado, diminuição no teor de carboidratos e calorias. A composição química do B40 apresentou os melhores parâmetros físicos, e a composição química mostrou maior teor de lipídios e fibra alimentar e menor de calorias.
Palavras-chave: *farinha de semente de abóbora; bolo; fibra; dietético; glúten.*

1 Introduction

There has been an increase in the worldwide interest in improving the quality of nutrition and reducing health care costs through the prevention of chronic diseases and extended life expectancy (STRINGHETA et al., 2007). The Non-Transmissible Chronic Diseases (NTCDs) are associated to the most common causes of death including obesity, diabetes, high blood pressure, stroke (cerebrovascular accident (CVA)), osteoporosis, cancer, and coronary diseases (BRASIL, 2005; FERREIRA; LANFER-MARQUEZ, 2007).

Gluten, present in wheat, is responsible for the texture of bakery products and is a composite of the proteins gliadin and glutenin. Celiac Disease (CD) expresses gliadin sensitivity. It is one of the most common causes of chronic diarrhea in children resulting in poor intestinal absorption of vitamins. The only possible and efficient treatment is a life-long gluten-free diet avoiding the consumption of gliadin (HADJIVASSILOU et al., 1996; SDEPANIAN; MORAIS; FAGUNDES-NETO, 1999; MAHAN; ESCOTT-STUMP, 2002; ORNELLAS, 2002;

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**A quem a correspondência deve ser enviada*

CAFÉ et al., 2003; GALVÃO et al., 2004; RAUEN; BACK; MOREIRA, 2005; ANJUM et al., 2007).

Recently, the search for vegetables that can be used whole in order to minimize losses and increase the foods' nutrient content has increased. This includes the use of leaves, stalk, and seeds which are commonly discarded in traditional cuisine although they are actually by-products that can be used in the industry due to their rich nutritional composition (DIGA..., 1992; ESTEVES et al., 1993; DOURADO et al., 2000; TURANO et al., 2000).

Pumpkin seeds (PS), which used to be discarded after the pre-processing of the fruit, have been, nowadays, subjected to industrial processing and have been commonly commercialized as a savory appetizer. The application of these seeds can be considered a good alternative for the nutritional enrichment of food products. Pumpkin seeds are rich in iron and therefore can be used in regions which lack this mineral. They are rich in fats (40 to 60%) and proteins (25.2 to 40%) and have low contents of free sugars and starch. The majority of the oils present in PSs are unsaturated such as the oleic (C18:1) and the linoleic oil (C18:2), which account for 26.3 and 52.4% of the seeds composition, respectively. The unsaturated fatty acid, linoleic, produces beneficial effects on the human body, immune system, cardiovascular diseases, diabetes, and cancer (YOUNIS; GHIRMAYB; AL-SHIHRYC, 2000; EL-ADAWY; TAHA, 2001a,b; MURKOVIC et al., 2004; FUNCK; BERRERRA-ARELLANO; BLOCK, 2006; KALLUF, 2006).

Some authors studied the anthelmintic and toxic effects of pumpkin seeds. Del-vechio et al. (2005) investigated the toxicological characteristics of the pumpkin seed (*C. maxima*) flour (PSF) made from seeds treated differently: raw, cooked by boiling at the ratio of 1:10 for 10 minutes, and roasted at 100 °C for 90 minutes. These authors found that the PSF made from raw, cooked, and roasted seeds presented 7, 4.4, and 5.52 mg.100 g^{-1} of cyanide, respectively. According to them, the lethal dose of cyanide varies within 0.5 and 3.5 $mg.kg^{-1}$ of body weight and the recommended maximum intake (or safe limits) of PSF is 250 g. Nevertheless, it is necessary to study its cumulative effects on the body.

On the other hand Dallemole-Giaretta et al. (2009) found that the aqueous extract of the pumpkin seed flour have effects on the hatching of nematode eggs and inactivation of this parasite , which causes deterioration and spoilage of root vegetables.

The dietary fiber (DF) is an edible plant material, not hydrolyzed by the endogenous enzymes of the human digestive tract, which aids constipation treatments. Its physiological effect depends on the kind of fiber (soluble or insoluble). Constipation can be caused by poor hydric ingestion, but its major cause is insufficient consumption of fibers. In addition, the ingestion of dietary fibers, mainly insoluble fibers, can decrease the risk for obesity, type II diabetes (DMNID), and cardiovascular diseases (BRASIL, 2003, 2005; POSSAMAI, 2005; BORGES et al., 2006; CERQUEIRA, 2006; SANTANGELO, 2006; STRINGHETA et al., 2007).

Pumar et al. (2008) studied the physiological effects of the whole, sifted and residual pumpkin seed flour fibers on rats and found that the group treated with PSF presented more compact fecal matter and increased volume of feces. The feces expelled were associated to the higher content of insoluble fiber, which indicated the physical influence of the dietary fiber present in PSF, especially residual PSF.

Flour quality can be defined based on its product's sensory characteristics such as taste and odor, as well as high nutritional value and low cost. The absorption capacity of the all purpose flour varies between 55 e 65% (POSSAMAI, 2005). Loss of nutrients can occur during flour processing, and therefore it is necessary to join the properties of previously processed flour to the optimum nutritional characteristics of wheat flours such as PSF. The use of PSF in animal feed, sweets, and biscuits among other products has been investigated to determine whether flour blends have chemical, physical, and functional characteristics that can result in high quality commercial products (PEREIRA et al., 2009; PUMAR et al., 2008; BERETTA, 2007).

Diet and light brands of food products account for only 5% of the Brazilian food and beverage market, but the use a wide variety of low calorie and sugarless products has been increasing. Diet food products are intended for people with diabetes, but they can be consumed by everyone else. The use of sweeteners to replace sugar in conventional formulations is complex, and some sweeteners affect food products' stability. In order to achieve the appearance and texture found in conventional food products, some industries increase the content of other components such as fat, which results in a product as high in calories as conventional products (CARDELLO; DAMÁSIO, 1997; CAMPOS, 2007).

Cake consumption and commercialization have been growing in importance in Brazil mainly due to the technical development that has allowed small-scale industries become large-scale industries such as those that produce the "ready to eat cake" and cake mix. (MOSCATTO; PRUDÊNCIO-FERREIRA; HAULY, 2004; PAVANELLI; CICHELLO; PALMA, 2005).

Therefore, the objective of the present work was to prepare gluten-free, diet English cakes enriched with fibers using PSF and cornstarch as ingredients to study the macroscopic and chemical characteristics of such formulations.

2 Materials and methods

2.1 Materials

Flour made from pumpkin seed and cornstarch

The "in natura" seeds of the pumpkin (*Cucurbinata maxima,* L.*)* seed flour were washed and spread evenly on aluminum trays. The seeds were then subjected to dehydration in a Fanen forced ventilation drying and sterilization oven (Model 330) at isothermal temperature of 70 °C for 13 hours. Next, the seeds were dried and ground using a regular 2-liter blender (*Performa Magiclean Chrome Arno)* for 50 seconds by pressing and holding the pulse buttom every 10 seconds (BERETTA et al., 2007; CARESTIATO et al., 2005). The powder was sifted and the residue was subjected to fractionation using an analytical mill (JK A10), at 20000 rpm, for 1 minute. The material was then sifted once more (BERETTA et al., 2007; CARESTIATO et al., 2005).

Cake formulations

In order to begin the preparation of the experimental cakes, a cake was prepared using simple flour blend (FB), based on wheat flour and cornstarch, and it was considered the Standard Cake (SC).

The ingredients of the SC were flour blend, refined sugar, whole milk, eggs, margarine, yeast powder, and salt.

The SC formulation was used as a parameter for the development of the formulations of the experimental cakes. At the beginning of the study two cakes were prepared. One was prepared using flour blend (FB) made from cornstarch and PSF (30:70), and the other was prepared with wheat flour and PSF (30:70). Both cakes presented similar sensory characteristics. Nonetheless, the gluten-free cake prepared using the blend flour made from PSF and cornstarch was used in the rest of the experimental study.

Cakes were prepared with different mixing ratios of 30:70, 50:50, and 70:30 of PSF and cornstarch, respectively. The yields of these cake formulations were 85.6, 89.8, and 89.3%, respectively, indicating that the yield increased with the increase in the PSF content. The following dimensions of the cakes were measured: length, height, and width (cm).

Despite the good yield and different dimensions, the cakes with 70 and 50% of PSF presented some characteristics that affected their appearance, such as dark color, and the texture of the batter. Hence, the formulations containing 30 and 40% of PSF were chosen to be investigated in this study.

It was necessary to adapt the baking temperature according to the different experimental cakes used. In preliminary studies, it was verified that temperatures higher than 165 °C cooked the outside of the cake but not the inside. Reducing the baking temperature to 150 °C, resulted in a more evenly baked cake.

Nevertheless, reducing the temperature revealed the need to increase the experimental cakes' baking times. Specific baking time and temperatures were set for the preparation of each experimental cake, as described in Figure 1.

The concentration of the flour blends made from PSF and cornstarch used were 30 and 40%, FB30 and FB40, respectively, The FB30 and FB40 were used to prepare C30 and C40. The ingredients used in these two formulations were *Tal & Qual®*, artificial sweetener, skim milk, eggs, margarine, yeast powder, salt, and an emulsifier (Mix®). Table 1 shows these formulations.

2.2 Methods

Cakes' preparation

The ingredients were weighed. The eggs yolk, margarine, and sugar, in the case of SC, or the artificial sweetener, in the

Table 1. Ingredients of standard cake (SC) and experimental cakes.

Ingredients	Formulations[1]					
	SC		C30		C40	
	unit (g)	%	unit (g)	%	unit (g)	%
Mixture flour[2]						
Wheat flour	38.9	54.5	-	-	-	-
Corn starch	32.5	45.5	56.9	70.0	48.8	60.0
Pumpkin seed flour	-	-	24.2	30.0	32.5	40.0
Other ingredients[3]						
Sweeteners	-	-	8.1	10.0	8.1	10.0
Sugar	84.5	118.4	-	-	-	-
Egg yolk	24.2	33.9	30.3	37.3	30.3	37.3
White egg	42.5	59.5	106.3	130.8	106.3	130.8
Milk (mL)	64.9	90.9	-	-	-	-
Skimmed milk (mL)	-	-	65.0	80.0	65.0	80.0
Margarine	12.9	18.1	9.8	12.1	9.8	12.1
Baking powder	1.3	1.8	4.9	6.0	4.9	6.0
Emulsify (Mix®)	-	-	2.2	2.7	2.2	2.7
Salt	0.03	0.04	0.08	0.1	0.08	0.1

[1]Quantitaty and percentage in relation of total ingredients of cooking cake english type of 250 g; [2]percentage for mixture flour in relation of total weight flour in formulation; and [3]percentage of ingredients in relation of weight flour mixture.

case of C30 and C40, were homogenized using a mixer (*Arno*) for 2 minutes on medium speed.

Next, the emulsifier, flour blend, and milk were added, separated from each other, every 2 minutes on low speed. The yeast powder was also added to the batter on low speed. The whipped egg white, added with salt, was manually and smoothly mixed into the batter. The industrial oven was pre-heated for 10 minutes to each specific baking temperature. The batter was then spread on an aluminum tray lined with butter paper and taken to the oven for 20 minutes at 180 °C, in the case of SC. The batter of the experimental cakes C30 and C40 were prepared in the same way at 150 °C for 30 and 28 minutes, respectively. After baking, the oven was turned off and the batter was allowed to cool to room temperature, for all experimental cakes. The different baking conditions to which the C30 and C40 cake and the SC were submitted were based on the better conditions found for the experimental cakes, previously established, since the experimental cakes exhibited different behavior from that of the SC during baking.

Macroscopic characterization of the cakes

The morphological characteristics of the inside and crust of the SC, C30 and C40 cakes were obtained from a digital image recorded for further aspect evaluation. The images were taken using a 6.0 Mega Pixel Sony camera.

Physical parameters

Yield

The total yield of the cakes was determined according to AACC (AMERICAN..., 1995). The data were obtained through the mean of five samples using Equation 1:

$$Total\ yield\ (\%) = \frac{After\ baking\ weight\ (g)\ \times\ 100}{Pre-baking\ weight\ (g)} \quad (1)$$

Pre-baking conditions

The baked cakes were measured with a 30 cm ruler to determine length, width, and maximum and minimum height (Figure 2). In order to determine height, the maximum and minimum mean of the height was considered. The medium height, length, and width parameters were multiplied to obtain the dimension of the cakes. The data were obtained through the mean of the five samples.

Specific volume

The specific volume ($cm^3.g^{-1}$) was determined using the millet seed moving method (SILVA; BORGES; MARTINS, 2001; PEREZ, 2002; MOSCATTO; PRUDÊNCIO-FERREIRA; HAULY, 2004; ZAMBRANO et al., 2005). After the cakes were removed from the oven and cooled to room temperature, they were weighed in an analytical balance. The weighing (g) procedures were done in triplicate for the SC, C30, and C40 cakes. In a beaker containing millet seeds, the volume of the cakes was determined (Figure 3), as shown by Equation 2:

$$Specific\ volume\ (cm^3) = \frac{Volume\ of\ 3\ cakes\ (cm^3)}{Weight\ of\ 3\ cakes\ (g)} \quad (2)$$

Raw batter density

The raw batter was transferred into a 1 L graduate cylinder, previously recalibrated, and the quantity of mass that occupies one unit of volume in the graduated cylinder (mL) and the weight of the batter (g) were measured in a digital balance. The weight and volume of the raw batter were related (ZAMBRANO et al., 2005; BORGES et al., 2006) as shown in Equation 3:

$$Raw\ batter\ density\ (g.mL^{-1}) = \frac{Raw\ batter\ weight\ (g)}{Raw\ batter\ volume\ (mL)} \quad (3)$$

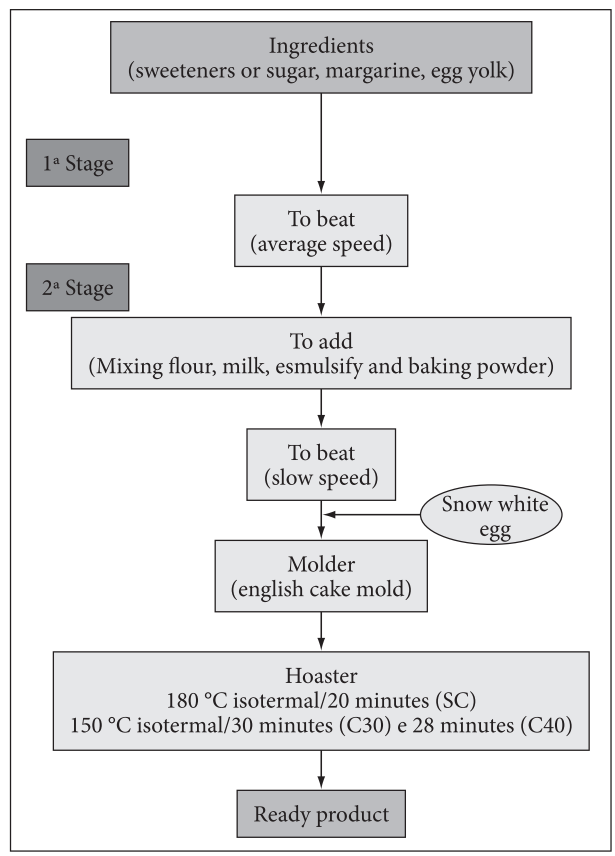

Figure 1. Diagram of standard cake (SC) and experimental cakes (C30 and C40) formulations.

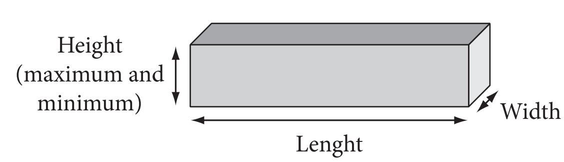

Figure 2. Roasted cake measurement.

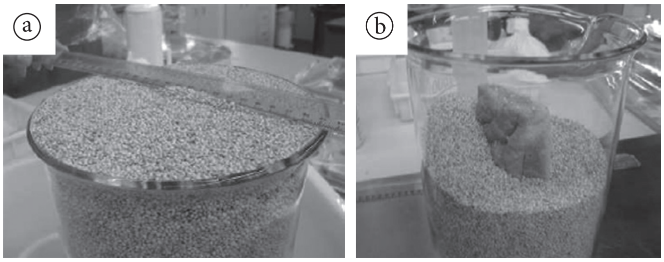

Figure 3. a) Leveling of pearl millet seeds in becher; and b) measurement of cake in central and vertical with after filling and leveling of pearl millet.

Chemical composition of the formulations

The chemical compositions of the SC, C30 (30%), and C40 (40%) cakes were determined as described by IAL (INSTITUTO..., 2005) in triplicate. In order to determine the moisture content, the samples were kept in the FANEM 215SE oven, at 105 °C, until a constant weight was reached. The ashes content was obtained by incineration in a Lavoisier oven.

In order to determine the lipids, the methodology 032 was applied by Soxhlet extraction; the methodology 037 was applied to determine proteins, and the classical Kjeldahl methodology was applied to determine the gross protein content by converting the nitrogen into factor 6.25 (INSTITUTO..., 2005).

The dietary fiber (DF) value was obtained from the literature on soluble fibers according to data found by Santangelo (2006). The soluble dietary fiber was also obtained from the literature (MENDEZ et al., 2001). The carbohydrates or nifext fraction were obtained by difference after the calculations of the fractions above. In order to determine the total caloric heat, factor 4 was applied for the proteins and carbohydrates and factor 9 for the lipids, according to the Atwater system (SOUTHGATE, 1981).

Physicochemical characterization

The pH values of the SC, C30, and C40 cakes were determined according to IAL (INSTITUTO..., 1995) using 10 g of the sample cake , previously ground, added with 100 mL of distilled water, and agitated for 30 minutes and left undisturbed for 10 minutes. The pH was determined using a Procyon PHD-10 potenciometer.

The Total Titulable Acidity of the SC, C30, and C40 cake samples was determined from 2 g of flour in sodium hydroxide (0,1N) using phenolphetalein as the indicator (INSTITUTO..., 1995).

The Total Soluble Solids (TSS) of the SC, C30, and C40 cakes were determined by adding 100 mL of distilled water into 10 g of cake, previously ground, agitated for 30 minutes and left undisturbed for 10 minutes. The TSS was determined by optical refractometry, and thus the refraction index determined the soluble solids and sugars present. The refractometer reading was corrected according to the room temperature during the analysis (IAL, 1995).

The analyses of pH, Total Titulable Acidity (TTA), and TSS by refractometry were performed in triplicate.

The relationship between TSS and TTA was established by triplicates for the cakes using the results obtained through the ratio between themselves (MATSUURA et al., 2001; WUTKE et al., 2004).

The gluten content was determined in triplicate for the flours according to the IAL (INSTITUTO..., 1995) methodology. Therfore, the gluten content in the SC was determined by mathematical calculation from the results obtained with the SC blend flour. Similarly, since the cornstarch and PSF are gluten-free, there was no need to determine the presence of gluten in the C30 and C40 experimental cakes since the other ingredients used in the cakes, except for the SC, were also gluten free.

The Standard cake (SC) and experimental cakes (C30 and C40) baked and cooled were sliced as homogeneous as possible. Next, the analyses of moisture of the central part and external ring were performed, both in triplicate, using the oven method at 105 °C (INSTITUTO..., 1995). The moisture gradient was determined by the difference between the mean moisture values between the two parts evaluated.

Statistical analysis

The statistical analyses were performed using the Statistica software for windows, version 4.0, Statsoft, Inc, (1993). The physicochemical data of the C30 and C40 cakes were analyzed using analysis of variance (ANOVA) and the Tukey Test in order to compare the means at 5% level of significance.

3 Results and discussion

The centesimal composition of the PSF obtained was 5.12% of moisture, 3.69% of ashes, 36.12% of lipids, 33.65% of proteins, 29.50% of insoluble dietary fiber, and traces of carbohydrates. The caloric content was 461.56 kcal.100 g^{-1} of flour. A commercial cornstarch product was added to the PSF flour in the experimental cake mixes used.

3.1 Macroscopic characterization of the cakes

Figure 4 shows a commercial cake and the cakes prepared, SC, C30, and C40 sliced transversally, and it can be seen that C40 grew more homogeneously that C30.

The distribution of aeration in the C40 cake was more uniform than that of C30. The inside of the C30 and C40 cakes were more yellowish compared to that of the SC, which is similar to the color of commercial whole bakery products. The coloration of the crust was shiny golden brown in the C30 and C40 cakes, whereas it was pale golden brown in the SC cake. The baked batter of the C30 and C40 cakes was firmer that of a commercial sugarless and fiberless cake that crumbled when sliced.

3.2 Physical parameters

There was no significant difference between the yields of the C30 and C40 experimental cakes ($p > 0.05$), but it was lower when compared to the SC ($p < 0.05$). These results indicate that when the flour blend (FB) was added, the liquid evaporation was reduced during baking are shown in Table 2. Perez (2002) found the same results in a study with biscuits based on wheat and eggplant flour (EF), for which the result was: the higher the content of fiber in the flour, the lower the moisture loss.

There was no significant difference in the dimension and specific volume of the SC, C30, and C40 cakes. There was an increase in the dimension in relation to the raw batter after baking of 22.9, 22.8, and 21.2% for the SC, C30, and C40 cakes, respectively. The decrease in the dimensions of C30 and C40 cakes is probably due to the fiber increase in the product.

Studying the specific volume of cakes made from WF and yacon flour and WF and yacon and inulin flour, Moscatto, Prudêncio-Ferreira and Hauly (2004) found that although the specific volumes of the experimental cakes were higher, they did not present significant difference when compared to the SC.

The value of density obtained was lower in the two experimental cakes, C30 (0.81 g.mL^{-1}) and C40 (0.77 g.mL^{-1}) indicating more possibility of aeration for the raw batter. On the other hand, the C30 and C40 specific volumes (1.89) and (1.94) were lower than those found by Marangoni (2007) with yacon flour and linseed. There was no significant difference between the density values of C30 and C40 cakes compared to that of the SC.

According to Borges et al. (2006), density is a measurement of incorporation and retention of air into the batter of the cake. A lower value of density means higher incorporation of air, and higher values of density affect the volume of the product by resulting in a closer, more compact, and undesirable inside. By adding 45% of oatmeal to a wheat flour cake, the authors found that the aspect of the cakes was affected. According to Pavanelli, Cichello and Palma (2005), cakes such as sponge cake presented very low density values (0.35 and 0.45) and the "neutral" cakes (ordinary cake) were denser (0.70 and 0.85). The density values found for the C30 and C40 experimental cakes is within the "neutral" range.

3.3 Chemical composition of the formulations

The chemical composition of the SC, C30, and C40 cakes are shown in Table 3. The C30 and C40 cakes presented higher moisture values than that of the SC. The moisture content of the C30 and C40 cakes was 66.3 and 66.4% higher than that of the SC, respectively. The C40 moisture content was 1% higher than that of the C30. The higher percentage of the experimental cakes indicates a hygroscopic influence of the fibers. Oliveira and Reyes (1990), found that the biscuits made from corn fiber residue (23.2% of fiber) presented more water retention and therefore reduced moisture loss. Similar results were found in the present work.

In the thermogravimetric analysis (TGA), the raw batter of C30 and C40 cakes presented higher contents of moisture than that of the SC. The raw batter of the C30 and C40 cakes was 29.50 and 55%, respectively, during the water decomposition

Table 2. Physical parameters of standard cake (SC) and experimentals cakes (C30 and C40).

Physical parameters	SC		C30		C40	
	%	SD	%	SD	%	SD
Total yield[1]	87.63[a]	±1.07	84.79[b]	±0.16	85.17[a]	±0.55
Dimensions after baking[2] (cm^3)	496.3[a]	±48.2	540.0[a]	±36.9	492.3[a]	±44.2
Specific volume[2] (cm^3)	1.92[a]	±0.25	1.89[a]	±0.08	1.94[a]	±0.16
Crude mass density[2] (g.mL^{-1})	0.79[a]	±0.007	0.81[a]	±0.05	0.77[a]	±0.02

Avarages with the same letters, in the same line, not have difference between itself at Tukey test (p ≥ 0,05); SC - Standard Cake, C30 - Cake with 30% of PSF, C40 - Cake with 40% of PSF; SD - Standard Deviation; ND - Not Determined; Fiber estimate: insoluble fiber C30 and C40 had to reference Santangelo (2006), and soluble and insoluble fiber of SC had to reference Mendez et al., (2001); [1]Average of five repetitions; [2]Avarage of three repetitions.

Table 3. Centesimal composition of standard cake (SC) and experimentals cakes.

Determinations[1]		SC		C30		C40	
		%	SD	%	SD	%	SD
Humidity		30.26[b]	±0.69	50.33[a]	±0.78	50.23[a]	±2.37
Ashes		0.81[b]	±0.09	1.81[a]	±0.09	1.79[a]	±0.27
Lipids		6.50[c]	±0.09	8.96[b]	±0.21	10.74[a]	±0.11
Proteins		5.71[c]	±0.14	10.38[b]	±0.08	12.28[a]	±0.18
	Total	4.15[a]	-	ND		ND	
Alimentary Fiber	Soluble	2.77[a]	-	ND		ND	
	Insoluble	1.38[c]	-	7.9[b]	-	10.2[a]	-
Carbohydrates[2]		52.57[a]	-	20.62[b]	-	14.63[c]	-
Calories[3] (Kcal)		291.62[a]	-	204.64[b]	-	204.30[c]	-

Avarages with the same letters, in the same line, not have difference between itself at Tukey test (p ≥ 0,05); SC - Standard Cake, C30 - Cake with 30% of PSF, C40 - Cake with 40% of PSF; SD - Standard Deviation; ND - Not Determined; Fiber estimate: insoluble fiber C30 and C40 had to reference Santangelo (2006), and soluble and insoluble fiber of SC had to reference Mendez et al., (2001); [1]Average of three repetitions, in % drought base; [2]estimate for diference; [3]estimate for convertion factor of Atwater: 4 (proteins and carbohydrates), 9 (lipids).

process and 34.42 and 58% when baked, respectively (SILVA, 2007). The results obtained in the TGA analysis and those of oven dehydration were close.

There was no significant difference between the ash content of the C30 and C40 experimental cakes, but a significant difference was found between these values and that of the SC. This is due to the higher content of minerals present in the C30 and C40 cakes, especially the iron content in the PSF (FRANCO, 2002).

The lipid content of the cakes increased with the addition of PSF to the flour blend. The lipid content of the C30 and C40 cakes was 37.85 and 65.32% higher than that of the SC, respectively, and the C40 cake presented 19.87% more lipids than the C30 cake.

The protein content was statistically different for all cakes. The protein content of the C30 and C40 cakes was 81.79 and 115.06% higher than that of the SC, respectively. The C40 cake presented 18.30% more protein than the C30 cake. It can be said that the addition of PSF contributed to the increase in the protein content of the experimental cakes.

In the thermogravimetric analysis (TA/TGA), the whole PSF and the BF 40 added to the cakes showed protein presence at 220 °C. Nonetheless, the raw and baked batter of the C30 and C40 cakes did not show protein decomposition but the SC cake did (SILVA, 2007). In 2007, Silveira studied the decomposition of biscuits made from flour blend pumpkin seed. Through the analysis of TA/TGA, the author found 14% of decomposition of the material in terms of protein at 222 °C. Through oven analysis, the author found 6.41% of protein.

In the present work, the presence of protein was confirmed using the IAL (INSTITUTO..., 2005) methodology; nevertheless it was not confirmed by thermal analysis. Therefore, further investigation is needed.

The fiber content of the C30 and C40 cakes was higher than that of the SC even when comparing the insoluble fiber content of C30 (7.9%) and C40 (10.2%) with the total fiber content of the SC (41.5%). With the addition of PSF to the flour blends, the insoluble fiber content increased in the cakes. The C40 presented 29.11% more fiber content than the C30 and 145.78% more than the SC, and the insoluble fiber content of the C30 cake was 90.36% higher than that of the SC.

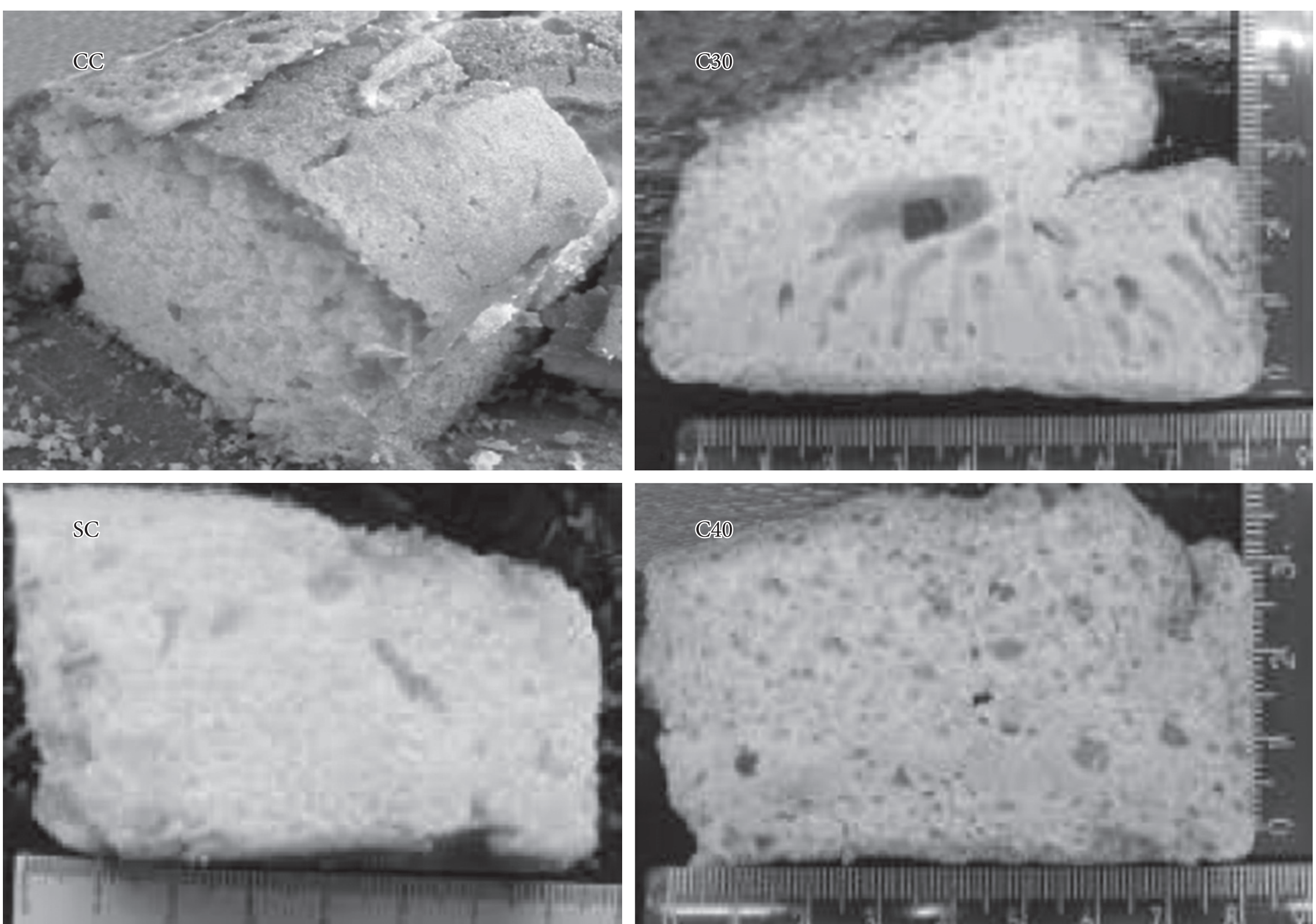

Figure 4. Transversal cut of Commercial (CC), SC, C30 and C40 cakes.

According to Silva, Borges and Martins (2001), the addition of two different *Jatobá* flours increased the content of ashes and total dietary fibers. Similar results were found by using PSF in the present work. The content of carbohydrates was statistically different among the cakes evaluated. The C30 and C40 cakes presented, respectively, 60.78 and 72.1% less carbohydrates than the SC. The C40 cake presented 29.05% less carbohydrates than the C30. The caloric content of the C30 and C40 cakes was 29.83 and 29.94% lower than that of the SC, respectively. The higher calorie content of the SC is related to the presence of carbohydrates. The calorie content of the C40 is slightly higher than that of the C30 (0.17%) due to the lower content of carbohydrates and higher fiber content although it has higher lipid and protein content than that of C30.

Moscatto, Prudêncio-Ferreira and Hauly (2004), verified that the addition of inulin flour to wheat flour decreased significantly the calorie content. Zambrano et al. (2005) managed to reduce the calorie content of cakes by replacing fats with gums. In the present work, the flour blend with PSF, which was added to the C30 and C40 cakes, also decreased the calorie content compared to that of the SC. However, such decrease was primarily due to the presence of dietary fibers.

Final solid products, such as cakes, should have at least 3 g of fiber in order to be considered a source of fiber and at least 6 g of fiber.100 g^{-1} to be considered a rich source of dietary fiber (BRASIL, 1998). The C30 and C40 cakes are therefore considered products rich in dietary fiber although only the insoluble fiber content is considered.

3.4 Physicochemical characteristics

The results of the analysis of pH, Total Titulable Acidity (TTA), and Total Soluble Solids (TSS), of the gluten content and the moisture gradient in the SC and the C30 and C40 experimental cakes are shown in Table 4.

It can be seen that the pH of the C30 and C40 cakes presented significant differences in relation to the SC, but not between each other. All cakes presented close to neutral pH values.

The Total Titulable Acidity (TTA) presented no significant difference between C30 and C40 but presented significant difference between SC and C40. It can be seen that the acidity of the cakes increased with the addition of PSF, probably due to the presence of fatty acids. There is no minimum acidity limit value established for cakes according to legislation.

The C30 and C40 cakes presented significant statistical differences in terms of TSS. It is worth noting that the C30 and C40 experimental cakes have less content of soluble solids than that of the SC, characteristic attested by the addition of the blend flours used.

The TSS/TTA ratio presented significant difference for all cakes. The SC presented a higher ratio than that of the experimental cakes. The C40 cake presented a 3.4% higher ratio than that of the C30 cake. The C30 cake ratio was way lower than that of the C40 cake due to their lower content of carbohydrates and also due to the higher content of good quality fatty acids. Only the SC has gluten. The experimental cakes are made from gluten-free ingredients.

The moisture gradient characterizes the difference between the moisture of the inside and crust of the baked products. There was a significant difference for all cakes evaluated. The C30 cake gradient was 67.07%, and the C40 was 68.81% higher than the SC cake.

The C40 cake moisture gradient was 1.04% higher than that of the C30 cake. Such difference between the SC and the C30 and C40 experimental cakes can be explained by the higher water retention of products enriched with fiber. Hence, the C40 moisture gradient was higher since it has higher fiber content that of the other cakes evaluated. The C30 and C40 cakes presented higher water retention, and a greater difference between the moisture content in the crust and in the inside of the cake was observed due to the external layer evaporation. The presence of dietary fiber confirmed the hygroscopic power in the C30 and C40 cakes. The SC presented a way lower moisture gradient than that of the C30 and C40 cakes.

Santangelo (2006) verified that the moisture gradient of *panetone* (a sweet bread loaf originally usually prepared and enjoyed for Christmas) with 30% of PSF was lower than that of the control *panetone*, 5.91 and 0.44 % respectively. This characteristic is due to the higher fiber content in the *panetone* with PSF.

Table 4. Physiochemical determination of cakes.

Determinations[1]	SC		C30		C40	
	%	SD	%	SD	%	SD
pH	6.79[b]	±0.19	7.74[a]	±0.04	7.47[a]	±0.09
TA (% mL/g)	0.36[b]	±0.06	0.54[ab]	±0.01	0.63[a]	±0.15
SST (%)	3.98[a]	±0.17	1.61[b]	±0.25	1.94[b]	±0.14
Relation SST/TA	11.05[a]	-	2.98[c]	-	3.08[b]	-
Gluten (%)	4.62[a]	±0.69	0.00[b]	-	0.00[b]	-
Humidity gradient (%)	15.52[c]	-	25.93[b]	-	26.20[a]	-

Avarages with the same letters, in the same line, not have difference between itself at Tukey test ($p \geq 0{,}05$); SC - Standard Cake, C30 - Cake with 30% of PSF, C40 - Cake with 40% of PSF; SD - Standard Deviation; [1]average of three repetitions, in % drought base.

4 Conclusions

Base on the findings, it can be concluded that flour blends with PSF and cornstarch proved adequate ingredients for the preparation of the experimental cakes since both the macroscopic and chemical characteristics showed satisfactory results. The cakes presented higher soluble fiber content and less calorie content than those of the Standard Cake. The C40 cake presented the best macroscopic and physical results compared to those of the C30 cake.

The experimental cake formulations proved technological viability and offered a novel product to the market of gluten-free, diet products enriched with dietary fiber and low in calories, which is beneficial to human health, especially in special diets reaching a broad age range.

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