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SWEET POTATO FLOUR AS SUBSTITUTE FOR WHEAT FLOUR AND SUGAR IN COOKIES PRODUCTION

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ABSTRACT

Changes in eating habits of people increased the search for different food formulations to meet the nutritional needs, both for aesthetic reasons or medical restrictions. In this sense, sweet potato provides a valuable product, due to its nutritional and functional properties, being a source of carbohydrates, proteins, vitamins, and minerals. In this research, we evaluate the potentialities of sweet potato flour (SPF) in the production of biscuits for total and partial substitution of wheat flour (WF) and sugar. We prepared a control treatment (B1) with 100% WF and three other formulations with 100%, 75%, and 50% of WF substituted by SPF. Also, we reduced the percentages of brown sugar by 30%, 22.5%, and 15%, according to a pre-test, aiming to balance the carbohydrate values in all products. The total and partial substitution of WF by SPF was satisfactory, with no changes in lipid and protein contents and the maintenance of total carbohydrates percentages and the energetic value, even with the reduction of sugars. The treatment B2 stands out by the replacement of 100% of usual flour and reduction of 30% of brown sugar. Therefore, the biscuits produced with sweet potato flour proved to be a nutritionally suitable alternative for bakery sector.

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INTRODUCTION

The search for a healthier and diversified eating has increased, as well the use of traditional products (Silva, 2007). The search for a healthy diet has increased wether by pathologies, ideology or self-realization for a healthy body, due to the high index of adult and child obesity. Food reeducation has led to an increase in the demand for new products (Silva *et al.*, 2015; Silva, 2017), as dishes based on sweet potatoes. Sweet potatoes have high nutritional value, and they are a source of carbohydrates, protein, vitamins, and minerals (Pereira *et al.*, 2005, Leivas, 2012). Carbohydrate content varies from 25% to 30%, from which 98% are easily digestible, besides the high content of carotenoids, vitamin B, potassium, iron, and calcium.

The sweet potatoes seem an excellent food supplement for low-income families, in comparison with others basic foods, like rice (Silva, 2010). Also, sweet potatoes have low lipid content and no cholesterol. Each gram of sweet potatoes supplies 10% of an adult need of thiamine, niacin, vitamin B6, and folic acid, 50% of vitamin C and 10% of proteins. Sweet potatoes can be used in natura or as chips, cooked in the production of cakes and pies, like starch or powder for consumption as a food supplement or in the elaboration of several products, like bread (Moyer, 1985; Silva, 2010). Due to its physicochemical characteristics, its use has increased, and with more intensity by individuals that practice physical exercises. Taking in to account the benefits of sweet potatoes, this work aims to evaluate the potential of the powder of sweet

potatoes for the production of cookies, as a partial replacement of wheat flour and brown sugar.

MATERIALS AND METHODS

Raw material extraction and flour preparation

We obtained the sweet potatoes samples at the free Market of Pombal, Paraíba, Brazil, packed in isothermal boxes and analyzed at the Laboratory of Water Analysis of the Center for Agricultural Sciences and Technology (CCTA) of Federal University of Campina Grande (UFCG), at the city of Pombal. The potatoes were washed and sanitized with a chlorinated solution during 20 minutes (200 ml of sodium hypochlorite for 10 liters of water). Then, they were washed with distilled water in three replicates, cut in a stick shape and dried at a temperature of 65 ºC (± 2 ºC) during 48 hours, until reaching less than 13% of moisture. We used an air circulation oven of Telga brand. A knife mil was used to grind the material (SPLabor brand), and the powder produced was submitted to heat treatment in a sterilization oven (SPLabor brand) for 3 min at a temperature of 100 ºC. After that, the powder was packed in plastic bags, which were cleaned before with 70% alcohol, and stored in a dry environment.

Elaboration of cookies with different concentrations of sweet potatoes

A standard cookie was prepared (B1) following the recipe of the website www.meumundofit.com.br, which consist of a cookie made by wheat flour, eggs, yeast, oats, vegetable oil and brown sugar. For the cookies based on sweet potatoes, the wheat flour was replaced by sweet potato flour at the percentages of 100, (B2) 75 (B3) and 50% (B4). Sugar content was reduced to 30%, 22.5% and 15% , respectively. The reduction in sugar was based on a pilot experiment, in which a reduction of sugar of 100, 50 and 30% was tested in cookies with 100% of sweet potatoes flour. Comparing this pilot cookies with the standard cookie (B1) we found that with 30% of replacement the levels of carbohydrates were similar to that one of the standard cookies, defining this value as the maximum of sugar, and for the remainder treatments, the amount was proportional. The remaining ingredients were kept unchanged (Table 1).

Table 1. Formulation of the cookies

	Formulation			
Ingredients	B1	B2	B3	B4
Special Wheat Flour (g)	165.00	0.00	41.25	82.50
Sweet Potato Flour (g)	0.00	165.00	123.75	82.50
Oats (g)	80.00	80.00	80.00	80.00
Brown sugar (g)	100.00	70.00	77.50	85.00
Eggs (g)	100.00	100.00	100.00	100.00
Corn oil (g)	90.00	90.00	90.00	90.00
Yeast (g)	10.00	10.00	10.00	10.00

The cookies were prepared using a mixer (Arno Brand, 300w), where all ingredients were placed and mixed at speed 3, until reaching a uniform pasty mass. The cookies were molded and arranged with the aid of a dessert spoon in a traditional roast anointed with oil and wheat flour. After that, the cookies were baked in an industrial electric oven at a temperature of 180ºC during 25 minutes. Finally, they were cooled to room temperature and packed in polystyrene trays covered with PVC film.

Physical and Chemical Characterization of Flour and Elaboration of Cookies

Parameters evaluated were titratable acidity (%), pH, moisture (%), ash (%), lipid (%) and proteins (%). We followed the methods described by A.O.A.C. (2012) and IAL (2008). The content of total soluble sugar (%) was determined by the Antrona method described by Yemn & Willis (1954). Total carbohydrates (%) were calculated as the sum of the percentages of moisture, ash, lipids, and proteins, subtracted from 100, following Brasil (2010). The energy content was evaluated using the equation provided by RDC n° 360, from December 23, 2003 (Brasil, 2003). The conversion factors for the amounts of carbohydrates, lipids, and proteins were applied (Equation 1).

Equation 1: Energy value of food

Energy Value = (%Total Carbohidrates x correction fator 4kcal/100g) + (%Proteins x correction fator 4kcal/100g) + (%Lipids x correction fator 9kcal/100g)
Source: ANVISA, 2003.

Statistical Analysis

We used an Analysis of Variance (ANOVA) in a completely randomized design to compare the characteristics of the cookies. T-test and Tukey test were performed for paired comparisons, at a level of 5% (Silva & Azevedo, 2016). All data were evaluated using the software ASSISTAT, version 7.7.

Microbiological Evaluation of Sweet Potato Flour and Cookies

Samples were submitted to microbiological characterization, using the description given by the resolution RDC n° 12, January 02, 2001 (ANVISA – Agência Nacional de Vigilância Sanitária) (Brasil 2001). We analyzed Coliformes at 35 ºC and 45 ºC (NMP/g), *Salmonella* sp. (Presence and Absence), filamentous fungi and Yeast (UFC/g) following the methodology described in APHA (2001).

RESULTS AND DISCUSSION

Acidity, pH, moisture, ash, lipids, total soluble sugar, total carbohydrates, and proteins from sweet potato flour are shown in Table 2. The drying stages used for the preparation of the flour did not affect the values of pH in comparison with the results of samples of sweet potato in natura given by Huerta *et al*. (2016), with pH close to 6.13. Silva (2010), Andrade & Martins (2002) and Noleto *et al*. (2015) found pH values of sweet potato flour close to 5.5, which were lower than the values found here. The flour of sweet potato has a pH value close to the values of wheat flour (6.1 to 6.8) (ICTA/UFRS, 2012) and cassava flour (Dias, 2006). The acidity was high (3.23%) in comparison to samples in natura investigated by Huerta *et al*. (2016). Values of acidity for sweet potato flour are variable in the literature, varying from 1.35 to 22.5 (Leonel and Cereda 1998, Fontes 2010, Sousa 2015, Franco 2015). Different cultivation regions, soil quality, irrigation process and climatic conditions are responsible for the high variability in acidity, besides the reduction in moisture after drying. The recommendation of the National Health Surveillance Agency

(ANVISA, 1978) is that the values of acidity for cassava, common and integral wheat should be 2.0%, 3.0%, and 4.0%, respectively. The flour of sweet potato shows values of acidity next to the values of common and integral wheat, therefore, is ideal for consumption and processing of bread products. The sweet potato flour was found within the established standard for moisture, that is, values lower than 13% (values established by the Ministry of Agriculture, Livestock and Food Supply 2011). Other authors found different values of moisture from that one described in this work (Table 2). Pagani *et al*. (2015) found values from 4.48 to 5.11%, while Franco (2015) obtained values of 9.18%. The differences in drying temperature are probably responsible for the differences in moisture percentage. Studies with other flour varieties show higher values of moisture (see Dias *et al*., 2006 and Souza 2008, for cassava flour, Ortolan 2006 for wheat flour). The maximum content of ash recommended by ANVISA (ordinance 354/96) is 2.0 to 2.5%. Values higher than that are regarded as external contaminants. Therefore, the values found in this work are within the standard established (Table 2). Pagani *et al*. (2015) found values of ash higher than 2.5. The cultivation methods and edaphoclimatic factors can explain the raw material used in the present work. The mineral content is higher in the sweet potato flour than those normally marketed, which seem when we compare with the low values of ash of cassava and wheat flour (Ferreira Neto 2003, Souza 2008, Gutkoski 1999).

content between 7.65 and 15.6%, as shown by Hacineaza *et al*. (2010) and Noleto *et al*. (2015). However, flour of sweet portato has carbohydrate levels of 78%, which is similar to the values found by Franco (2015). There was no degradation of the protein content during the drying process, allowing its concentration. The protein content in samples of sweet potato in natura is around 1.35% (Huerta *et al*., 2016), with the concentration by drying process we found a value of 10.45%. Lower values of protein on the flour were found by Silva (2010), Franco (2015), Bezerra *et al*. (2015). The energetic value of the flour was close to conventional flours and cassava (Dias *et al*., 2006), and nonconventional flours, like almond and pepper (Silva, 2013, Silva, 2017). The results found for the flour of sweet potato shows its quality for baking and confectionary. The sweet potato flour was used to produce the cookies in replacement of wheat flour and to decrease the levels of sugar used. The replacement changed the pH of the cookie. Therefore the cookies were found more acidic than the standard cookies (Table 3). There was a significant statistical difference ($p<0.05$) between the traditional cookie (B1) and the cookies with sweet potato (B2, B3, and B4), and between B4 and B2/B3. The legislation does not delimit pH values in biscuits, which allows the release for commercialization of all the samples produced, but studies with different formulations of biscuits elaborated by Maciel *et al*. (2008) and Baptista *et al*. (2012)

Table 2. pH, acidity, moisture, ash, lipids, total soluble sugar, total carbohidrates, proteins and energy value from sweet potato flour

Parameters	Mean values ± standard deviation
pH	6.09±0.017
Acidity (%)	3.70±0.16
Moisture (%)	7.31±0.21
Ash (%)	2.47±0.09
Lipids (%)	0.425 ± 0.08
Total Soluble Sugar - TSS (%)	2.98 ± 0.121
Total Carbohidrates (%)	78.86 ± 0.66
Proteins (%)	10.45 ± 0.45
Energy Value (kcal/100 g)	360.99 ± 1.07

Table 3. Mean values and standard deviation of pH, acidity, moisture, ash, lipids, TSS5, carbohidrates, proteins and energy value of the cookies

Parâmetro	B1	B2	B3	B4
pH	8.11±0.029^{a}	7.59±0.046^{c}	7.60±0.051^{c}	7.75±0.015^{b}
Acidity (%)	0.045±0.145^{c}	1.029±0.057^{a}	1.002±0.116^{a}	0.787±0.102^{b}
Moisture (%)	6.02±0.136^{a}	6.50±0.029^{a}	6.44±0.248^{a}	6.60±0.135^{a}
Ash (%)	2.00±0.037^{c}	2.76±0.036^{a}	2.47±0.108^{b}	2.21±0.120^{c}
Lipids (%)	22.51±0.065^{a}	23.35±0.139^{a}	22.75±0.199^{a}	23.69±0.236^{a}
TSS* (%)	3.99±0.183^{ab}	3.76±0.043^{b}	4.66±0.353^{a}	4.51±0.460^{ab}
Carbohidrates %)	64.77±0.24^{a}	62.89±0.39^{a}	63.66±0.550^{a}	62.79±0.441^{a}
Proteins (%)	4.69±0.242^{a}	4.50±0.264^{a}	4.69±0.208^{a}	4.70±0.161^{a}
Energy value (kcal/100 g)	480.49±0.893^{a}	479.74±0.629^{a}	478.14±1.819^{a}	483.23±0.922^{a}

The sweet potato flour has a low lipid content, 0.42 (Table 2) in comparison to values to other studies (Nascimento 2013, Franco 2015, Noleto *et al*., 2015), which is probably due extraction methods or agronomic characteristics. Studies with casava flour showed higher values of lipids, above 0.5 (Chisté 2010, Cardoso Filho *et al*., 2012). The low lipid content in sweet potato flour makes it a good choice for the elaboration of food for diets or with dietary restrictions. There is no standard value established for total soluble sugars. We found a value of 2.98%, but other flours types, seems to have similar content of sugar, like the cassava flour (3.35%) showed by Dias *et al*. (2006). Sweet potato in natura has a carbohydrate

show maximum pH values of 8.0 and 6.75, respectively, which confirm pH variations in this type of bakery product, but are also close to those verified in this work, confirming the possibility of substitution of wheat flour by that of sweet potato. The results for acidity content support the pH values, meaning that the increase in replacement of wheat flour by sweet potato flour increased the acidity, decreasing the pH value. The values of acidity of cookies with sweet potato flour were significantly different from that one with standard cookies ($p<0.05$, Table 3). Other authors found higher values of acidity for cookies made by cassava and passion fruit flour (Santana *et al*., 2011), which is due to the natural organic

acids of the product, chemical or microbial alterations during the process or addition of additives. The moisture value of cookies with sweet potato flour was not significantly different from cookies made with only standard flour ($p>0.05$, Table 3). The replacement process, therefore, does not change aspects as texture, filamentous fungi, and yeast (microbial aspect). Besides, the processed cookies are within the standards of the legislation that determines a maximum humidity of 14% (Cauvain and Young, 2002). Higher values of moisture in cookies were found by (Baptista *et al*., 2012, Zuniga *et al*., 2012; Costa *et al*., 2015). The content of ash on cookies were lower than 3% (Table 3), which is within the established and released for marketing. The values of ash of standard cookies differed from cookies with a higher amount of sweet flour ($p<0.05$, Table 3), meaning a higher mineral content that was proportional to the percentages of substitution of wheat for sweet potato flour. Different studies present values of ashes close to those verified in this research (Baptista *et al*., 2012; Cunha *et al*., 2015). Salts are added during the processing of making cookies so that there is a variation in ash values from different works (Silva, 2017). Lipid content does not differ between the standard cookies and cookies with sweet potato (Table 3), does not affecting the percentual of fat. The levels of lipids in commercial cookies may vary between 9 and 23% (Cunha *et al*., 2015; Santana *et al*., 2011; Fasolin *et al*., 2007), and the values found here were around 22 and 23%. When analyzing the values obtained for total soluble sugars, it can be verified that biscuits produced with reduction of the brown sugar, according to percentages of insertion of the flour of sweet potato, managed to maintain similar levels of soluble sugars. But, there was a significant difference at the level of 5% ($p <0.05$), by the concentrations of 75/25 (B3) and 50/50 (B4), confirming the possibility of sugar deduction and substitution of wheat flour. The soluble sugars content in cookies may vary considerably depending on the formulation adopted, as in the case of the data presented by Silva (2017) for cookies made with peppermint bran replacing the ammonia and Miamoto (2008) in cookies produced with yam flour.

The total carbohydrate content confirms that the reduction of brown sugar with the use of sweet potato flour was efficient, there was no statistical difference at the level of 5% between the samples, also affecting other properties, such as the sensorial characteristics of sweetness, for example. Santos *et al*. (2011) analyzing cookies with the substitution of wheat flour for sour sprinkles and orange albedo flour obtained mean values from 74.69% to 76.68%, data higher than those found in this study. As discussed previously, the differences in carbohydrate contents can be justified by the farinaceous types used, as well as the sugars content adopted. Regarding the protein content, the samples did not differ statistically, maintaining approximate percentages in all treatments (Table 3), regardless of the difference in proportions of wheat and sweet potatoes flour. Values close to the ones found here are shown by Silva (2017), Santana *et al*. (2011), Pereira *et al*. (2009) and Fasolin *et al*. (2007). The caloric values of the cookies were also similar, with no statistical difference ($p <0.05$), which also confirms that the process of using sweet potato flour in different proportions to substitute wheat flour allowed the reduction of brown sugar used in the elaboration was efficient, not altering the caloric value of the different formulations. However, the cookies prepared here shows a high caloric content in comparison with other studies (Silva 2017; Santana *et al*., 2011; Pereira *et al*., 2009). Low bacterial contamination (<3.0 NMP / g for Coliforms at 45ºC and absence for *Salmonella* spp. And *Staphylococcus* spp.) and fungal contamination (101 CFU / g), was found at the formulated cookies confirming the adoption of good manufacturing practices, from the processing stages to the storage. The concentrations were found within the standards and parameters required by current legislation - RDC No. 12/2001 of ANVISA, also, to ensure the integrity and health of consumers.

Conclusion

This research confirmed that sweet potato flour is an excellent alternative for the food sector, presenting physical and chemical characteristics that differ from other flours, such as low lipid content and high levels of proteins and carbohydrates, besides a considerable mineral content, thus contributing to common or restricted diets. The cookies formulated in this study, with different percentages of sweet potato flour, can prove the possibility of reducing the use of brown sugar by up to 30%, being able to maintain the total soluble sugars, total carbohydrates and the energy value in levels close to standard recipes. The sweet potato flour can be an alternative for the bakery sector, which will have gains with the reduction of ingredients and maintenance of the nutritional value, as well as for the people who look for differentiated foods that contribute with their daily physical practices or diet restrictions, according to medical guidelines.

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