

USE OF YACON *IN NATURA* AND ITS FLOUR IN THE DEVELOPMENT OF DIET AND CONVENTIONAL CAKES

USO DO YACON IN NATURA E EM FARINHA NO DESENVOLVIMENTO DE BOLOS DIET E CONVENCIONAL

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ABSTRACT: Yacon is a tuberous root that has bioactive components in its composition, such as fructooligosaccharides (FOS). The objective of this study was to evaluate physicochemical and sensory characteristics of diet and conventional cakes made with yacon *in natura* and its respective flour. Cakes were prepared in chocolate and carrot flavors with the addition of 50% yacon *in natura* and 70% yacon flour. Cakes prepared with 50% yacon *in natura* with the addition of sucrose in the formula showed physical aspects closer to conventional cakes. The yield of the cakes was considered satisfactory at around 90%, regardless of yacon *in natura* or yacon flour usage. The chocolate cakes had higher ratings regarding the sensory attributes and the purchase intent in relation to the carrot cakes, especially when using yacon *in natura* in the formula. The cakes containing sweetener were rated as good as those with sucrose, especially in regards to the flavor of the chocolate cakes. According to the chemical composition, cakes with 70% yacon flour had higher dietary fiber content as well as FOS, giving credit to their claim as a bioactive component.

KEYWORDS: *Smallanthus sonchifolius*. Cakes. Chemical composition. Nutrition. Bioactive. Fructooligosaccharides.

INTRODUCTION

Yacon (*Smallanthus sonchifolius* Poepp. Endl) is a tuberous root from the *Asteraceae* family found in the Andes region and introduced in Brazil in the 90s by Japanese immigrants in the state of São Paulo (SANTANA; CARDOSO, 2008). Yacon roots have a long history of safe use in South America and elsewhere with potential health-promoting properties, including prebiotic, antidiabetic, antioxidative and antimicrobial effects (OJANSIVU et al., 2011). The characteristic sweetness is related to the presence of carbohydrates, particularly in the form of fructooligosaccharides (FOS) (DELGADO et al., 2013). FOS is a soluble dietary fiber, belonging to fructans class, with prebiotic properties since they are not digested by enzymes of the human digestive tract, but are fermented in the colon by intestinal health promoting bacteria, especially by the bifidobacteria and lactobacilli, stimulating their growth and activity and inhibiting *Clostridium*, *Salmonella*, *Shigella*, *Listeria*, *Campylobacter* and *Coliform* (CAMPOS et al., 2012). This prebiotic also works to reduce the risk of cancer, improves bowel function, has cholesterol lowering effect and improves the immune response (VOS et al., 2007).

Yacon has been used as a food supplement in the preparation of different products for presenting contents of oligofructans (FOS) which may vary from 19% (VASCONCELOS et al., 2010) to 44% (GENTA et al., 2005), depending on the cultivation period, harvest, storage duration and conditions. This tuberous root has been used as an ingredient in various formulas, such as cakes (ROSA et al., 2009; MOSCATTO et al., 2004), jams (SALVADOR et al., 2012), bread (ROLIM et al., 2011), yogurt (VASCONCELOS, 2010), juices (GUIMARÃES; BOEKEL, 2006) and candies (MALDONADO; SINGH, 2008), both *in natura* and as flour.

Products prepared with ingredients in the form of flour have a longer shelf life when compared to *in natura* products with higher moisture content. However, the use of *in natura* ingredients becomes an alternative that is easy to reproduce, particularly for homemade preparation. In this context, the objective of this study was to evaluate physicochemical and sensory characteristics of diet and conventional cakes made with yacon, noting possible differences in the use of this tuber both in its *in natura* form and as flour.

MATERIAL AND METHODS

Yacon flour processing

Yacon (*Smallanthus sonchifolia* Poepp. Endl) was acquired from CEASA (Central de Abastecimento) in Cariacica (Espírito Santo – Brazil). The tubers were washed and sanitized in a sodium hypochlorite solution at 200mg/L for 15 minutes. They were peeled with a potato peeler and processed according to the preliminary tests. The tests were conducted in order to avoid the enzymatic browning that is expected during the drying process of fruits and vegetables. This way, different treatments were applied, considering different ways of yacon processing (REBELO; CASALI; BERTOLDI, 2008; PADILHA et al., 2008; SARAIVA et al., 2011). Among the performed tests with yacon, the treatment using citric acid was capable to produce a product almost free of browning keeping visual features and thus, a lighter flour. The yacon was cooked with the peel (for 2 minutes), which was removed by friction. Afterwards, it was cut into slices (chips) of 2mm by using stainless steel knives. The tubers were placed in a 1% citric acid solution for 20 seconds. Later on, they were drained and put in a tray dryer with air circulation at 60°C during 24 hours and grinded in a disc mill in order to obtain the flour. Then, they were packed in vacuum sealed plastic bags, properly labeled and kept in a dry and ventilated place. The flour yield was calculated by the following formula: % Y = (flour weight x 100)/pulp weight.

Development of cakes

Two cake flavors were prepared: chocolate and carrot. Both flavors were formulated containing yacon *in natura* and yacon flour (a treatment containing sucrose in the formula and another treatment using the artificial sweetener as a sucrose substitute). Also, control cakes (without the addition of yacon) were prepared. The proportions of yacon as well as other ingredients can be checked in Table 1. A proportion of 50% yacon *in natura* was used in relation to the total wheat flour, and for the formula of the cakes with flour, different tests were performed with different percentages of it replacing wheat. These percentages were 50%, 60%, 70%, 80% and 100% in order to add more than 40% content to the formula, which was used in the study of Padilla et al. (2010). The formula containing 70% yacon flour in the

preliminary tests showed typical characteristics of a cake. The sensory characteristics were significantly altered when above that percentage (data visually analyzed). Thus, the liquid ingredients were blended and placed in a container after being homogenized, where the dry ingredients were added. After mixing, the dough was placed in a greased cake pan and taken to a preheated oven for 40 minutes at 180 °C.

Physical characteristics

Six cakes of each preparation from the same batch were analyzed according to the methodology proposed by the American Association of Cereal Chemists - AACC (1995). The weight loss was measured in a RadWag® scale, model WPT-6C/1 (0.1g). The apparent volume (increase of volume) was measured, where the height reached by the cake was marked on the cake pan used. The cake pans were filled with water to the marks and the volume was measured in the measuring cylinder. The difference between the pre and post-baking volumes was calculated and expressed in milliliter. The thermal factor and the yield of the formulas were calculated according to Araújo and Guerra (1995).

Sensory analysis

Sensory analysis was conducted on four different days as the number of samples could overload the judges and adversely affect the results. Thus, the judges could evaluate the cakes with yacon *in natura* on two different days (one flavor for each day) and the cakes with yacon flour on another two days, as well as their respective controls. The cakes were evaluated by an acceptability test through a nine point hedonic scale (9 = I really liked it and 1 = I really disliked it) according to the following attributes: appearance, flavor, color, texture and overall acceptance (DUTKOSKI, 2007). Furthermore, the purchase intent was also evaluated using a nine point scale (9 = I would definitely buy it and 1 = I would definitely not buy it). Sixty non-trained judges took part in these tests, all of them aged 18 years or older that enjoy cakes and signed a Consent Form. The current study was approved by the Research Ethics Committee of the Espírito Santo North University Center – CEUNES (Espírito Santo – Brazil) (n° 051/2011).

Table 1. Ingredients used in the development of cakes with yacon *in natura* and yacon flour.

| Ingredients | Formulations (chocolate flavor) | | | | | | Formulations (carrot flavor) | | | | | |
|----------------------------|---------------------------------|--------|-------|-------|-------|-------|------------------------------|--------|-------|-------|-------|-------|
| | CChCSu | CChCSw | T1 | T2 | T3 | T4 | CCaCSu | CCaCSw | C1 | C2 | C3 | C4 |
| Wheat flour (g) | 200.0 | 200.0 | 200.0 | 60.0 | 200.0 | 60.0 | 200.0 | 200.0 | 200.0 | 60.0 | 200.0 | 60.0 |
| Cocoa powder (g) | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 | - | - | - | - | - | - |
| Carrot (g) | - | - | - | - | - | - | 135.8 | 135.8 | 135.8 | 135.8 | 135.8 | 135.8 |
| Boiling water (mL) | 180.0 | 180.0 | 180.0 | 180.0 | 180.0 | 180.0 | - | - | - | - | - | - |
| Sucrose (g) | 140.0 | 0 | 140.0 | 140.0 | 0 | 0 | 164.0 | 0 | 164.0 | 164.0 | 0 | 0 |
| Sweetner in powder** (g) | 0 | 19.0 | 0 | 0 | 19.0 | 19.0 | 0 | 22.0 | 0 | 0 | 22.0 | 22.0 |
| Yacon <i>in natura</i> (g) | 0 | 0 | 100.0 | 0 | 100.0 | 0 | 0 | 0 | 100.0 | 0 | 100.0 | 0 |
| Yacon flour (g) | 0 | 0 | 0 | 140.0 | 0 | 140.0 | 0 | 0 | 0 | 140.0 | 0 | 140.0 |
| Vegetable oil (mL) | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 |
| Baking powder (g) | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 16.0 | 16.0 | 16.0 | 16.0 | 16.0 | 16.0 |
| Egg (unit) | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Salt (g) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | - | - | - | - | - | - |

***CChCSu** (control chocolate cake with sucrose), **CChCSw** (control chocolate cake with sweetner), **T1** (chocolate cake with 50% yacon *in natura* and with sucrose), **T2** (chocolate cake with 70% yacon flour and sucrose), **T3** (chocolate cake with 50% yacon *in natura* and sweetner), **T4** (chocolate cake with 70% yacon flour and sweetner). **CCaCSu** (control carrot cake with sucrose), **CCaCSw** (control carrot cake with sweetner), **C1** (carrot cake with 50% yacon *in natura* and with sucrose), **C2** (carrot cake with 70% yacon flour and with sucrose), **C3** (carrot cake with 50% yacon *in natura* and with sweetner), **C4** (carrot cake with 70% yacon flour and with sweetner). ** Sweetener in powder consisting of cyclamate and saccharin suitable for cooking.

Chemical characterization

Cakes selected by the sensory analysis were evaluated by their proximate composition, in triplicate, according to the Association of Official Agricultural Chemists - AOAC (2005) methods: moisture, determined in an oven at 105 °C until constant weight; protein by the Kjeldahl method using the factor 6.25; lipids by the method of extraction with petroleum ether in a Soxhlet equipment; and ash by burning the sample in an oven at 550 °C until constant weight. The dietary fiber content of the cakes was determined by the enzymatic-gravimetric method of the AOAC (2005). The oligofruktan content was determined by High Performance Liquid Chromatography (HPLC) using an Alliance chromatograph (model Waters 2695) with an Alliance fluorescence detector (model Waters 2475) - USA, according to the methodology used by Rodrigues et al. (2001) and Vasconcelos et al. (2010). A commercial oligofruktose sample with 85% purity was used as standard. Available carbohydrates were calculated by difference: 100 – (moisture + proteins + lipids + ash + fiber). Total carbohydrates were calculated excluding fiber content. The energetic value was determined in Kcal.

Data analysis

The results were grouped using Excel 2007 and submitted to analysis of variance (ANOVA) followed by the average comparison test (Tukey) at 5% probability, using Statistica 10.0 software.

RESULTS AND DISCUSSION

Yacon flour yield

After obtaining yacon flour, the yield was 10.5%, very close to values found in other research (RIBEIRO, 2008; SANTANA; CARDOSO, 2008; PADILHA et al., 2009).

Physical characterization

Results from the physical characterization of cakes prepared with yacon can be seen in Table 2. Among the chocolate cakes made with yacon, sample T1 had the greatest post-baking weight loss, which was similar ($P > 0.05$) to the control samples (CchCSu and CChCSw). The results of the volume increase in samples T1 and T2 (both with sucrose in the formulation) were similar to the control sample with sucrose (CChCSu) with the highest volume gain among treatments. That is, even losing less weight,

sample T2 increased its volume resulting in a more aerated and soft product (data visually analyzed). When sucrose was replaced by the sweetener, samples T3 and T4 lost less weight and had lower volumes, resulting in cakes with an internal structure with fewer openings and “heavy” aspect.

According to Akesson (2009), this phenomenon can be explained by the lower capacity of the used sweetener to retain air. Furthermore, one of the sucrose functions is to provide softness and volume increase to the dough (ESTELLER et al., 2004). Additionally, sucrose is an important substrate for yeast growth during fermentation, contributing to gas production and consequently increasing cake volume. Although cakes made with yacon had less weight loss, they had similar yields to each other, including greater yields than the control sample with sucrose. The same effect was also evident for the thermal factor, since this is related to how much the cakes yield. The weight loss during baking demonstrates the ability of the dough to retain water, while the volume becomes important to verify the flour's ability to expand and retain the gas within the dough during baking (ESTELLER; LANNES, 2005). Thus, considering the ingredients used in the formulas for chocolate cakes, samples T1 (prepared with yacon *in natura* and sucrose) and T2 (prepared with yacon flour and sucrose) are those that are closer to the desirable characteristics for cakes, as moderate weight loss (thus avoiding excessively humid and heavy cakes) and increases in post-baking volume, resulting in a product with good volume increase, homogeneity and the typical aerated structure.

Unlike the chocolate cakes, carrot cakes had less weight loss and greater volume gain for most samples, except treatment C4 (Table 2). The variations in the physical characteristics of carrot cakes, regarding chocolate cakes, were mostly due to the ingredients used in the formulation of the cakes. Among the cakes made with yacon *in natura*, the one with sucrose (C1) had a greater weight loss, similar to its control (CCaCSu). However, among the cakes made with yacon flour, the one made with sweetener (C4) had greater weight loss, but less than its control (CCaCSw). Furthermore, sample C4 had a lower post-cooking volume among all samples, resulting in “heavy” cakes. Other carrot cakes have a similar volume increase among themselves ranging between 360 and 436 mililiters, but less than the control sample with sucrose (CCaCSu). When sucrose is

replaced or removed from the formulation of breads and cakes, the dilution of gluten-forming proteins may occur and it may lead to decreased volume and change in the final product texture (GOMEZ et al., 2003). Silva et al. (2010) showed a greater volume increase in breads made with FOS, whose formula contained sucrose. Sample C1 showed both the highest yield and thermal factor. However, the other treatments were very similar, including the controls.

Sensory evaluation

The results of sensory evaluation of all prepared cakes are shown in Table 3. To clarify the discussion, the results and discussion are divided into cakes made with yacon *in natura* and cakes made with yacon flour. The results were analyzed according to each day of sensory evaluation.

Cakes made with yacon *in natura* (1st and 2nd days of analysis)

Regarding the taste of chocolate cakes, only sample T1 obtained a significantly lower result ($P < 0.05$) to its control (CChCSu). Cakes made with sweetener had a good evaluation in the corresponding hedonic scale between "like moderately" and "really liked" being similar to their respective control (CChCSw). This feature is interesting since bakery products containing sucrose usually tend to have better evaluation when compared with products containing a sweetener. Regarding the purchase intent, it could be observed the interest in purchasing the product if it were available on the market. In assessing the taste of carrot cake made with yacon *in natura* (Table 3), a significant difference between the cakes containing yacon and their respective controls was not observed. On the other hand, cakes made with sucrose showed better evaluation in this aspect. When analyzing the texture, the carrot cake made with yacon *in natura* and sweetener was better rated than its respective control. However, the control sample with sucrose (CCaCSu) was the one that had the best average. Regarding the appearance, color and overall acceptability, the control cake with sucrose (CCaCSu) got the best average compared to the other treatments. Regarding the purchase intent, the judges showed doubt about the acquisition of cakes made with yacon.

Cakes made with yacon flour (3rd and 4th days of analysis)

With regards to the texture and appearance of the chocolate cakes, the control cake with sucrose (CCaCSu) had the highest average, similar to cakes made with sweetener (control CChCSw and T4). Compared to other attributes, there were no differences of significance between treatments ($P > 0.05$). The judges showed a tendency to purchase these cakes, according to the assessment of the purchase intent, unlike the study of Padilha et al. (2010). Moscatto et al. (2004) showed in chocolate cakes made with 20% and 40% of yacon flour (with sucrose) that the attributes color and overall acceptability did not differ statistically from the control samples. In contrast, cakes made with 20% yacon flour had better reviews regarding taste. In assessing carrot cakes made with 70% yacon flour, samples C2 and C4 showed lower averages than their respective controls (CCaCSu and CCaCSw). The judges were unsure about the acquisition of carrot cakes made with yacon flour. This fact can be explained by the darkened appearance of the cake when the yacon flour was added.

Chemical characterization

The results of chemical characterization of chocolate and carrot cakes are shown in Table 4. The moisture content in the samples ranged from 19.87 to 43.90%, while the cakes made with yacon *in natura* showed higher moisture contents, especially diet cakes (with sweetener). This can be primarily explained by the high moisture content in the root in its *in natura* form which is 91.1% (VASCONCELOS et al., 2010). Furthermore, the presence of hydroxyl groups available in the composition of FOS present in yacon can interact with water through hydrogen bonding, hindering its evaporation during cooking (ROBERFROID; GIBSON; DELZENNE, 1993).

Table 2. Physical characteristics of cakes made with yacon *in natura* and yacon flour.

| Physical characteristics | Formulations (chocolate flavor) | | | | | | Formulations (carrot flavor) | | | | | |
|--------------------------|---------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|
| | CChCSu | CChCSw | T1 | T2 | T3 | T4 | CCaCSu | CCaCSw | C1 | C2 | C3 | C4 |
| Weight loss (g) | 164.66± 1.11 ^a | 86.50± 1.16 ^b | 106.80± 1.41 ^{ab} | 60.54± 1.89 ^c | 52.00± 1.30 ^c | 52.43± 1.08 ^c | 38.56± 1.08 ^b | 54.37± 1.98 ^a | 39.10± 1.07 ^b | 19.97± 1.57 ^c | 15.10± 1.87 ^c | 39.56± 1.57 ^b |
| Volume increase (mL) | 405.33± 0.01 ^a | 205.34± 1.30 ^b | 251.33± 0.57 ^{ab} | 327.34± 1.14 ^{ab} | 190.00± 1.63 ^b | 192.66± 1.21 ^b | 729.33± 1.71 ^a | 382.00± 1.58 ^b | 390.67± 1.01 ^b | 360.66± 0.01 ^b | 436.33± 1.37 ^b | 80.66± 1.62 ^c |
| Yield (%) | 80.94± 1.26 ^b | 110.08± 0.43 ^a | 92.76± 0.76 ^a | 90.51± 0.31 ^a | 92.61± 0.28 ^a | 89.70± 0.20 ^a | 94.60± 0.32 ^b | 92.27± 0.42 ^b | 106.83± 1.35 ^a | 92.42± 0.37 ^b | 95.33± 1.68 ^b | 94.36± 0.55 ^b |
| Thermal factor | 0.80± 0.12 ^b | 1.10± 0.04 ^a | 0.92± 0.00 ^a | 0.90± 0.00 ^a | 0.92± 0.00 ^a | 0.89± 0.00 ^a | 0.94± 0.00 ^b | 0.92± 0.00 ^b | 1.06± 0.01 ^a | 0.92± 0.00 ^b | 0.95± 0.01 ^b | 0.94± 0.00 ^b |

***CChCSu** (control chocolate cake with sucrose), **CChCSw** (control chocolate cake with sweetner), **T1** (chocolate cake with 50% yacon *in natura* and with sucrose), **T2** (chocolate cake with 70% yacon flour and sucrose), **T3** (chocolate cake with 50% yacon *in natura* and sweetner), **T4** (chocolate cake with 70% yacon flour and sweetner). **CCaCSu** (control carrot cake with sucrose), **CCaCSw** (control carrot cake with sweetner), **C1** (carrot cake with 50% yacon *in natura* and with sucrose), **C2** (carrot cake with 70% yacon flour and with sucrose), **C3** (carrot cake with 50% yacon *in natura* and with sweetner), **C4** (carrot cake with 70% yacon flour and with sweetner). *Same letters in the same line indicate no significant difference between the results, considering $p > 0.05$ (Tukey test).

Table 3. Sensory evaluation of cakes made with yacon.

| Items evaluated | Chocolate and carrot cakes prepared with yacon <i>in natura</i> | | | | | | | | Chocolate and carrot cakes prepared with yacon flour | | | | | | | |
|--------------------|--|-------------------|--------------------|--------------------|-------------------|--------------------|-------------------|-------------------|---|-------------------|--------------------|--------------------|-------------------|-------------------|--------------------|-------------------|
| | 1st day | | | | 2nd day | | | | 3rd day | | | | 4th day | | | |
| | CChCSu | T1 | CChCSw | T3 | CCaCSu | C1 | CCaCSw | C3 | CChCSu | T2 | CChCSw | T4 | CCaCSu | C2 | CCaCSw | C4 |
| Taste | 7.94 ^a | 7.26 ^b | 7.68 ^{ab} | 7.61 ^{ab} | 7.60 ^a | 6.84 ^{ab} | 6.44 ^b | 6.18 ^b | 7.62 ^a | 7.24 ^a | 7.26 ^a | 7.54 ^a | 7.67 ^a | 6.30 ^b | 7.42 ^a | 6.18 ^b |
| Texture | 7.98 ^a | 7.84 ^a | 7.47 ^a | 7.38 ^a | 8.00 ^a | 7.10 ^b | 6.17 ^c | 7.03 ^b | 7.64 ^a | 6.58 ^b | 7.10 ^{ab} | 7.26 ^{ab} | 7.65 ^a | 6.03 ^b | 6.94 ^{ab} | 6.17 ^b |
| Appearance | 7.92 ^a | 8.19 ^a | 8.21 ^a | 7.85 ^a | 8.20 ^a | 5.87 ^{bc} | 6.53 ^b | 5.22 ^c | 7.56 ^a | 6.54 ^b | 7.18 ^{ab} | 6.98 ^{ab} | 7.78 ^a | 5.61 ^b | 7.88 ^a | 5.26 ^b |
| Color | 8.15 ^a | 8.29 ^a | 8.22 ^a | 8.17 ^a | 8.34 ^a | 5.34 ^c | 7.25 ^b | 4.81 ^c | 7.62 ^a | 7.14 ^a | 7.38 ^a | 7.40 ^a | 7.88 ^a | 5.50 ^b | 7.98 ^a | 5.19 ^b |
| Overall acceptance | 7.92 ^a | 7.43 ^a | 7.64 ^a | 7.64 ^a | 7.91 ^a | 6.44 ^b | 6.25 ^b | 6.06 ^b | 7.54 ^a | 7.10 ^a | 7.08 ^a | 7.42 ^a | 7.61 ^a | 5.75 ^b | 7.48 ^a | 5.75 ^b |
| Purchase intent | 8.15 ^a | 7.73 ^a | 7.59 ^a | 8.01 ^a | 7.56 ^a | 5.43 ^b | 5.65 ^b | 4.87 ^b | 7.68 ^a | 6.40 ^a | 6.70 ^a | 7.22 ^a | 7.44 ^a | 4.76 ^b | 7.05 ^a | 4.88 ^b |

CChCSu (control chocolate cake with sucrose), **CChCSw** (control chocolate cake with sweetener), **T1** (chocolate cake with 50% yacon *in natura* and with sucrose), **T2** (chocolate cake with 70% yacon flour and sucrose), **T3** (chocolate cake with 50% yacon *in natura* and sweetener), **T4** (chocolate cake with 70% yacon flour and sweetener). **CCaCSu** (control carrot cake with sucrose), **CCaCSw** (control carrot cake with sweetener), **C1** (carrot cake with 50% yacon *in natura* and with sucrose), **C2** (carrot cake with 70% yacon flour and with sucrose), **C3** (carrot cake with 50% yacon *in natura* and with sweetener), **C4** (carrot cake with 70% yacon flour and with sweetener). *Same letters in the same line indicate no significant difference between the means ($p > 0.05$ - Tukey test), considering each block (day) of evaluation individually.

Table 4. Chemical composition of chocolate and carrot cakes made with yacon.

| Composition (g/100g) | Chocolate cakes made with yacon <i>in natura</i> and yacon flour | | | | Carrot cakes made with yacon <i>in natura</i> and yacon flour | | | |
|-------------------------|--|--------------------------|--------------------------|---------------------------|---|--------------------------|---------------------------|--------------------------|
| | T1 | T2 | T3 | T4 | C1 | C2 | C3 | C4 |
| Moisture | 39.78±0.25 ^b | 21.05±0.35 ^c | 43.90±0.14 ^a | 32.05±0.16 ^c | 40.27±0.02 ^b | 19.87±0.04 ^f | 43.31±0.16 ^a | 30.43±0.47 ^d |
| Protein | 12.63±0.25 ^{ab} | 12.52±1.09 ^{ab} | 12.12±0.99 ^{ab} | 10.64±0.17 ^b | 11.15±0.79 ^{ab} | 10.40±0.55 ^b | 14.96±1.24 ^a | 11.78±1.05 ^{ab} |
| Lipids | 17.59±0.80 ^d | 11.18±0.57 ^c | 16.73±0.55 ^d | 20.82±0.06 ^c | 28.60±0.19 ^b | 20.83±0.28 ^c | 29.71±0.28 ^b | 31.88±0.08 ^a |
| Ash | 3.74±0.24 ^a | 3.73±1.39 ^a | 4.39±0.57 ^a | 3.11±0.06 ^a | 3.38±0.26 ^a | 4.53±0.19 ^a | 4.16±0.19 ^a | 4.16±0.28 ^a |
| Dietary fiber | 0.44±0.03 ^b | 10.10±0.06 ^a | 0.45±0.02 ^b | 11.52±0.07 ^a | 0.48±0.02 ^b | 11.15±0.06 ^a | 0.52±0.02 ^b | 13.90±0.08 ^a |
| Oligofractans | 0.17±0.02 ^b | 4.14±0.04 ^a | 0.17±0.03 ^b | 4.72±0.05 ^a | 0.18±0.02 ^b | 4.57±0.07 ^a | 0.20±0.01 ^b | 5.69±0.07 ^a |
| Available carbohydrates | 25.82±0.55 ^d | 41.42±1.71 ^a | 22.41±1.98 ^d | 21.86±0.12 ^c | 16.12±1.28 ^c | 33.22±0.50 ^b | 7.34±1.44 ^f | 7.85±1.39 ^d |
| Total carbohydrates | 26.26±0.47 ^d | 51.52±1.25 ^a | 22.86±1.65 ^d | 33.38±0.24 ^c | 16.60±1.14 ^c | 44.37±0.67 ^b | 7.86±1.42 ^f | 21.75±1.54 ^d |
| Energetic value (kcal) | 313.87±1.09 ^e | 356.78±1.31 ^d | 290.51±1.04 ^f | 343.44±0.72 ^{cd} | 368.34±0.16 ^c | 426.54±1.33 ^b | 358.66±1.38 ^{cd} | 421.04±1.45 ^a |

T1 (Chocolate cake with 50% yacon *in natura* and with sucrose), **T2** (chocolate cake with 70% yacon flour and sucrose), **T3** (chocolate cake with 50% yacon *in natura* and sweetner), **T4** (chocolate cake with 70% yacon flour and sweetner). **C1** (carrot cake with 50% yacon *in natura* and with sucrose), **C2** (carrot cake with 70% yacon flour and with sucrose), **C3** (carrot cake with 50% yacon *in natura* and with sweetner), **C4** (carrot cake with 70% yacon flour and with sweetner). Same letters in the same line indicate no significant difference between the results (p>0.05 - Tukey Test).

Moscatto et al. (2004) showed moisture content at about 38% for chocolate cakes made with 40% of yacon flour replacing wheat. Regarding protein, all cakes were very similar to each other, averaging around 12g/100g. The lipid content was higher in the carrot cakes since the formula of these cakes had more vegetable oil. In regard to the mineral residue (ash), there was no difference between the formulas as observed by Moscatto et al. (2004). The dietary fiber content of cakes made with yacon flour was superior to those cakes containing yacon *in natura*. The cakes made with 70% yacon flour, regardless of the use of sucrose or not and their flavor, can be considered foods high in dietary fiber (BRAZIL, 2012). The cakes made with 70% yacon flour had higher oligofructan content. Considering a 60g portion of the product, cakes made with 70% yacon flour fit within the parameters of functional foods, given their dietary fiber content (BRAZIL, 2008). However, due to the content of oligofructans present in the samples, only the sample C4 (diet carrot cake with 70% yacon flour) can be considered a product with bioactive components.

We note that yacon consumption is still very small in the Brazilian population. The insertion of this tuberose in food and bakery products is still a challenge. The use of yacon flour requires special equipment, which requires time and more costs to the final product. However, its use in nature is possible and feasible considering the homemade preparation.

CONCLUSIONS

The cakes prepared with 50% yacon *in natura* with the addition of sucrose in the formula had physical aspects closer to conventional cakes.

The yield of the cakes around 90% was considered satisfactory, regardless of the use of yacon *in natura* or as flour.

The chocolate cakes obtained higher rates regarding sensory attributes and purchase intention than the carrot cakes, especially when yacon *in natura* was used in their formulation.

The cakes containing sweetener were rated as good as those with sucrose, especially regarding the flavor of the chocolate cakes.

The cakes made with 70% yacon flour had higher dietary fiber content as well as fructooligosaccharides. If the sucrose is excluded, this ingredient must be replaced by sweeteners comprised of structuring agents such as maltodextrin. Furthermore, the use of growth favoring agents, such as the enzymes amylases, as well as the addition of gluten, contributes to obtaining baked products with desirable physical and sensory characteristics.

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RESUMO: O yacon é uma raiz tuberosa que possui em sua composição, componentes bioativos como fruto-oligossacarídeos (FOS). O objetivo deste estudo foi avaliar características físico-químicas e sensoriais de bolos diet e convencionais elaborados com yacon *in natura* e sua respectiva farinha. Foram elaborados bolos, nos sabores chocolate e cenoura, com adição de 50% de yacon *in natura* e 70% de farinha de yacon. Os bolos elaborados com 50% de yacon *in natura*, com a adição de sacarose na formulação apresentaram aspectos físicos mais próximos aos bolos convencionais. O rendimento dos bolos, em torno de 90% foi considerado satisfatório, independente da utilização do yacon *in natura* ou farinha. Os bolos de chocolate obtiveram notas mais elevadas quanto aos atributos sensoriais e intenção de compra, em relação aos bolos de cenoura, em especial quando se utilizou o yacon *in natura* nas formulações. Os bolos contendo adoçante foram tão bem avaliados quanto àqueles que possuíam sacarose, em especial, em relação ao sabor dos bolos de chocolate. De acordo com a composição química, os bolos com 70% de farinha yacon apresentaram maiores teores de fibra alimentar bem como de FOS, sendo considerados alimentos com alto teor de fibras, sugerindo-se também sua alegação como um componente bioativo.

PALAVRAS-CHAVE: *Smallanthus sonchifolius*. Bolos. Composição química. Nutrição. Bioativo. Fruto-oligossacarídeos.

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