Rev Inst Adolfo Lutz
DOI: 10.18241/0073-98552014731604

Physicochemical and sensory characteristics of *diet* and regular biscuits prepared with yacon (*Smallanthus sonchifolius*)

Características físico-químicas e sensoriais de biscoitos diet e comuns preparados com yacon (*Smallanthus sonchifolius*)

RIALA6/1604

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Recebido: 14.02.2014 - Aceito para publicação: 24.05.2014

ABSTRACT
Diet and regular biscuits were prepared using fresh yacon (*in natura)*, besides those including 20 % and 40 % of yacon flour. The physical, chemical and sensory characteristics of these biscuits were evaluated**.** The addition of sugar in the biscuits made from yacon flour (20 % and 40 %) increased the diameter values. The addition of sweetener (replacing the sugar) in biscuits made from fresh yacon increased the specific volume value. Regarding to the physical characteristics, no significant differences were evidenced among the formulated biscuits and their respective controls. In relation to the sensory analysis, biscuits made from fresh yacon presented acceptable means, as well as the biscuits made from 20 % yacon flour (with sugar or sweetener). No significant differences were found between the sugar-added biscuits and the sweetener-added cookies**,** except for those made from 40 % yacon flour and containing sugar, which did not show good acceptability, and neither for purchase intention. Biscuits prepared with yacon flour showed significantly high fiber contents, being considered as fiber-rich and low-calorie products**.** This investigation evidenced that biscuits made from fresh yacon are an excellent option for easy homemade preparations.
Keywords. bakery products, dietary fiber, prebiotics.

RESUMO
Biscoitos convencionais e do tipo *diet* foram elaborados utilizando-se yacon fresco (*in natura*), além da adição de 20 % e 40 % de sua farinha. Os biscoitos foram avaliados quanto às características físicas, químicas e sensoriais. A adição de açúcar nos biscoitos elaborados com farinha de yacon (20 % e 40 %) provocou aumento nos valores de diâmetro. A substituição de açúcar por adoçante, nos biscoitos elaborados com yacon fresco, favoreceu o aumento do volume específico. Não foram evidenciadas diferenças significativas nas características físicas entre os biscoitos formulados e os respectivos controles. Em relação à análise sensorial, os biscoitos elaborados com yacon fresco apresentaram médias aceitáveis, bem como os biscoitos preparados com 20 % de farinha de yacon (*diet* e convencional). Não houve diferenças significativas entre os biscoitos elaborados com açúcar ou com adoçante, exceto para àqueles preparados com 40 % de farinha de yacon (com açúcar)**,** que não demonstraram boa aceitabilidade, tampouco quanto à intenção de compra. Os biscoitos preparados com farinha de yacon apresentaram maior conteúdo de fibra**.** Portanto, estes são produtos ricos em fibras e de baixa caloria. É importante ressaltar que os biscoitos elaborados com yacon fresco são excelente opção para serem reproduzidos em preparações caseiras.
Palavras-chave. panificados, fibra alimentar, prebióticos.

INTRODUCTION

Demand for health-oriented bakery products with low sugar and high fibercontents is increasing. Incorporating dietary fiberand replacing sugar in biscuit dough tends to require some cares[1]. Biscuits are consumed daily by the majority of the population[2], especially by the teenagers[3] and, for years, the food industry has focused on increasing the nutritional value of these products. Enhancing the dietary fiber and replacing sugar of baked products is challenging, and to this day such products are not widely accepted by the consumers. As new sources of fiber become available, and consumers are moving towards healthier diets, research on the use of fiber as functional ingredientin baking is becoming more extensive[2]. Obviously, this food cannot be faced as a unique solution to promote health as it only works in support of it.

Among the compounds with functional features, it can be pointed out that soluble fibers like those contained in yacon roots, are important compounds for health care. Among these fructoligosaccharides (FOS)[4] and inulin can be found which can be classified as prebiotics, once they are either hydrolyzed or absorbed in the upper digestive tract; they can be fermented by bacteria in the colon and positively change the colonic microbiota[5,6].

Yacon roots are a promising source of inulin type fructans (35 g/100 g dry matter) with a total amount of dietary fiber of about 45 g/100 g dry matter[7]. Scientific evidences show yacon as an inulin and especially fructoligosaccharides source (FOS)[8,9,10], reducing the risk cancer, and having a hypocholesterolemic effect; improving the gastrointestinal transit, the immune response[11], minerals absorption, and being related to vitamin synthesis[4,12]. In order to obtain yacon flour, more specific processing techniques are required, such as drying and the use of antioxidants to avoid the raw material browning. By using yacon flour in food, with the reduction of water (about 80-90 % of the total mass), there was a significant increase of the other compounds such as total fiber.

From a technical point of view, not only the inulin but also the FOS are used as total/partial sugar substitutes or as additional ingredients in low-calory or enriched ones products, with satisfying features[13]. However, in order to get the inulin or FOS, it would be necessary to process the source raw materials in order to extract them, which may financially overtax the final product. Additionally, yacon roots present about 38 % of FOS and 26 % of inulin in the fresh pulp[14] and its use can be easily reproduced in homemade preparation techniques.

Studies based on the development of new products containing yacon are still scarce. Yacon-added bakery products such as loaf[15] and cakes[16] presented good acceptability, not differing (sensory) from products produced without this tuber. The same was evidenced when this raw material was added to processed orange juices[17].

In this way, this turns out to be a substitute food and therefore, due to the growing population concern about health and fisiological effects of the soluble fiber, and new product developments like biscuits containing functional compounds, this is a promising food source carrying health benefits. The aim of this study was to evaluate the physical, chemical and sensory characteristics of diet and regular biscuits using fresh yacon (fresh roots) and its flour.

MATERIAL AND METHODS

Material

Fresh yacon (*Smallanthus sonchifolia Poepp. Endl*) was acquired at the CEASA (Central de Abastecimento) in Cariacica (Espirito Santo, Brazil). Tubers were washed and sanitized in a sodium hypochlorite solution at 200 ppm for 15 minutes. They were peeled with a potato peeler and processed according to their use. The other ingredients, such as margarine, corn starch, milk, sugar/sweetener (sodium cyclamate and saccharine proper to oven) and rice starch were acquired in the local market (Alegre, Espirito Santo, Brazil).

Yacon flour process

In order to obtain the yacon flour, some preliminary tests were carried out according to Figure 1. The tests were conducted in order to avoid the enzymatic browning that is expected during the drying process of fruits and vegetables. In this way, different treatments were applied, considering different ways of yacon processing[18,19].

For the first treatment, yacon was cooked with the peel (for 2 minutes), which was removed by friction and then submerged in distilled water (± 5 °C) to

complete the blanching process. Afterwards, it was cut into slices (chips) by using stainless steel knives. For the second treatment thermic shock was applied (blanching) in order to avoid enzymatic activity. After, the yacon was cut into slices. For the third treatment, yacon was only peeled and sliced.

In all the treatments half of the tubers were placed in a 1 % citric acid solution and the rest in a 0.5 % citric acid and 0.5 % ascorbic acid solution for 20 seconds. Later on, they were drained and put in a tray dryer with air circulation at 60 ºC during 24 hours and grinded in a blender in order to obtain the flour. Next, they were packed in vacuum sealed plastic bags, properly labeled and kept in a dry and airy place. The flour yield was calculated by the following formula: % R = (flour weight x 100)/pulp weight.

Preliminary tests (biscuits formulation)

For the formulations containing fresh yacon, the maximum yacon quantity was used, totaling 800 g for a whole recipe which resulted in 200 biscuits ± 3g each. For biscuits made with yacon flour, a 20 % and 40 % substitution in relation with corn and rice starch respectively was proposed. Higher proportions of yacon would significantly affect the sensory qualities due to the higher higroscopicity of this tuber. By the preliminary tests, the mixture of corn and rice starches resulted in more aerated and soft biscuits. Corn starch, given its characteristics, is capable of start the retrogradation process faster when compared with rice starch, yielding biscuits with a harder texture. All the experiments were done using sugar and sweetener (sodium cyclamate and saccharine proper to oven). The tests were carried out using the formulations showed in Table 1.

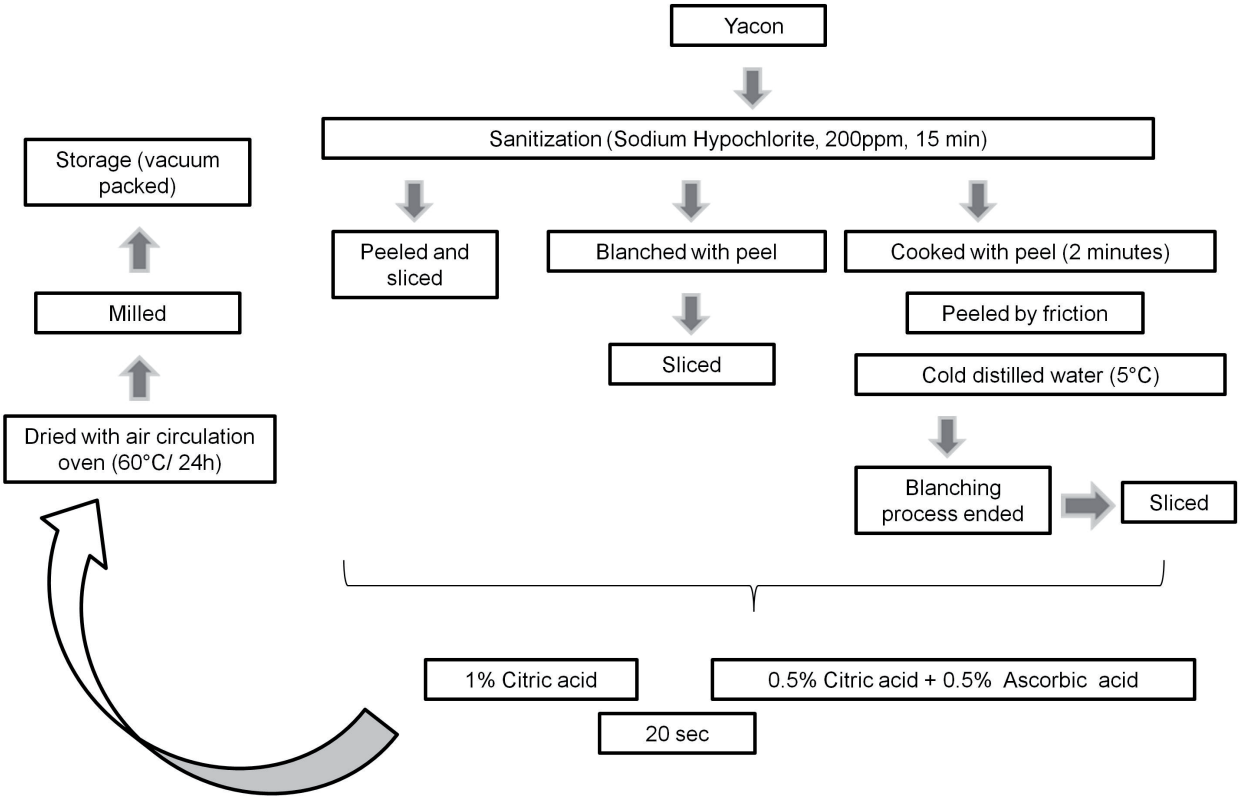

Figure 1. Yacon flour processing

Table 1. Ingredients used in the formulation of yacon biscuits and their controls

Ingredients (g)	**CBsg	CBsw	YBsw	YBsg	BF_{20sg}	BF_{20sw}	BF_{40sg}	BF_{40sw}
Fresh Yacon/ Yacon Flour	-	-	800	800	112	112	224	224
Margarine	200	200	200	200	200	200	200	200
Sweetener (powder)*	-	38.43	38.43	-	-	38.43	-	38.43
Refined Sugar	291.2	-	-	291.2	291.2	-	291.2	-
Corn starch	280	280	280	280	224	224	168	168
Rice starch	280	280	280	280	224	224	168	168
Whole milk	160	160	160	160	160	160	160	160
Whole dry milk	160	160	160	160	160	160	160	160

*66 g of sweetener substitutes 500 g of sugar (sodium cyclamate and saccharine proper to oven). ** Tests: CBsg (control biscuit with sugar), CBsw (control biscuit with sweetener), YBsg (fresh yacon biscuit with sugar), YBsw (fresh yacon biscuit with sweetener), BF_{20sg} (biscuit with 20 % yacon flour and sugar), BF_{20sw} (biscuit with 20 % yacon flour with sweetener), BF_{40sg} (biscuit with 40 % yacon flour with sugar) and BF_{40sw} (biscuit with 4 0% yacon flour with sweetener)

Biscuits formulation

In order to make biscuits from fresh yacon the tubers were cleaned, peeled and cooked, to avoid enzymatic browning. Later, they were cooled down, grinded and manually squeezed in order to take water out. Thus, all the ingredients (Table 1) were mixed up, homogenized, moulded and baked (210 °C/ 15 min).

After obtaining yacon flour, the biscuit formulations also followed as shown on Table 1. So, all the ingredients were homogenized, moulded and baked (210 °C/ 15 min).

Physical characteristics evaluation

The biscuits were analyzed regarding their weight, diameter and thickness before and after cooking. They were weighed in a RadWag® scale, model WPT-6C/1 (0.1 g). Their diameter and thickness were measured with 150 mm x 0.05 mm Vernier Caliper paquimeter. The expansion factor was obtained by the ratio of diameter and thickness values[20]. The apparent volume (mL) was determined by the seed displacement method, and the specific volume was calculated by the ratio between the apparent volume and the weight of the biscuits, expressed in $mL.g^{-1}$ [20]. The tests were conducted in ten biscuits, randomly chosen.

Sensory analysis

The biscuits were evaluated by an acceptability test through a hedonic nine point scale (9= I liked very much and 1 = I disliked very much) according to the following attributes: appearance, flavor, color, texture and global acceptance[21]. Furthermore, the purchasing intention was also evaluated through a nine point scale (9= I would definitely buy it and 1= I would definitely not buy it). At first (first sensory test) the judges evaluated the biscuits made with fresh yacon. Afterwards (second sensory test) they evaluated biscuits made with yacon flour. The control samples (with sugar and sweetener) were used in both sensory tests. Sixty non-trained judges took part in these tests, all of them 18 years or older that liked biscuits and signed a Consent Form informing that they did not present any intolerance and/or allergy to the basic ingredients, poor health conditions or any other situation that may difficult the information gathering. The current study was submitted and approved by the Research Ethics Committee of the Centro Universitário Norte do Espírito Santo – CEUNES (Espírito Santo, Brazil).

Proximate composition

Biscuit preparations selected by the sensory analysis were evaluated by their proximate composition, in triplicate, according to the AOAC methods[22]. Fiber content was calculated through the Brazilian Food

Composition Table[23] as well as by Vasconcelos et al[14]. Available carbohydrates were calculated by difference: 100 – (moisture + proteins + lipids + ash + fiber). The energy value was determined in Kcal.

Data analysis

The results were grouped using Excel 2007 and submitted to variance analysis (ANOVA) followed by the average comparison test (Tukey), at 5 % probability, using Statistica 10.0 software. The other results were expressed in arithmetic averages and shown in tables.

RESULTS AND DISCUSSION

Yacon flour processing

Among the performed tests with the yacon, those with 1 % citric acid, without thermic shock (blanching) were those which provided chips almost free of browning, keeping visual features and thus, a clearer flour. After obtaining yacon flour, it was verified that the yield of the flour was 10.5 %, very close to values found by other researches[9,19].

Physical characteristics of yacon biscuits

In order to compare the phisycal characteristics of biscuits made with sugar and sweetener, all the formulations were compared in the same analysis (including their controls). It was observed (Table 2) that each biscuit lost between 0.38 and 0.63 g of its mass, which means a 13 to 21 % weight loss. These values were lower to those found by Feddern et al[24] (around 1g of weight loss), that developed cookies made with wheat bran and rice, and also lower, when compared with Assis et al[25] study (1.62 – 2.27 g weight loss), producing biscuits with oatmeal and parboiled rice flours. It could be observed, by Guimarães et al[26] that moisture and weight increased when fiber contents, from watermelon rind, increased. This fact can be explained due to the capacity of soluble fibers to keep water in their structure during the cooking process. The FOS present available hydroxil groups that interacts with the water by hydrogen links, making the evaporation process difficult. Assis et al[25] also found that biscuits made only with parboiled rice flour lost more weight when compared with biscuits made with oatmeal flour (more fiber content). The weight loss of all biscuits made with yacon and their respective controls did not presented significative difference, showing homogeneity during the processing and of the final products.

Biscuits made with yacon flour (20 % and 40 %), with sugar added, presented higher diameter (2.95 cm and 2.50 cm, respectively) when compared with the same treatments formulated with sweetener (1.35 cm and 1.20 cm, respectively). This fact can be due to the solids increase, providing a higher "performance" in bakery products. Biscuits with 20 % yacon flour (with sugar) presented higher diameter value (2.95 cm) when compared with other biscuits made with sugar: control - CBsg (1.75 cm) and with fresh yacon - YB_{sg} (1.65 cm). This same increase, in the final diameter values, was verified by Larosa et al[27] when fibers were added to biscuits, producing biscuits with 4.03 cm. According to the authors, this value is higher when compared with its respective control and a commercial biscuit. Furthermore, Feddern et al[24] observed that the addition of 30 % of rice bran reduced the diameter of the biscuits.

Regarding thickness, biscuits made with sugar (fresh yacon, 20 % and 40 % yacon flour) did not differ from biscuits made with sweetener, except for the control (CB_{sw}) who presented lower thickness (0.25 cm). Differences between biscuits made with fresh yacon and with yacon flour were not evidenced.

Biscuit expansions varied between 2.09 and 2.47. These values are similar to those found by Feddern et al[24] using 15 % to 45 % of wheat bran (2.04 to 2.29) and 10 % to 30 % of rice bran (2.59 to 3.09) to prepared biscuits. According to Table 2 it was not evidenced differences between biscuits made with sugar ou sweetener, as weel as biscuits made with fresh yacon and 20 % and 40 % yacon flour. Expantion factor values have been used to predict biscuit quality, thus, those with extremely high or low expansion factor are not suitable for the industry, as they turn to be small products or too heavy[28].

Regarding the apparent volume, it was not observed significant differences between all the formulations, however the specific volume of biscuits made with fresh yacon (with sweetener – YB_{sw}) was significantly higher (2.64 $mL.g^{-1}$), differing from their control (2.00 $mL.g^{-1}$). Those values are higher when compared to the study of Feddern et al[24] (1.55 to 1.65 $mL.g^{-1}$), Assis et al[25] (0.92 to 1.76 $mL.^{g-}1$) and Clerici et al[29] (1.13 and 1.37 $mL.g^{-1}$). Also, biscuits YB_{sw} presented higher specific volume value when compare to the same samples with sugar (1.62 $mL.g^{-1}$), suggesting that, the addition of fresh yacon and sweetener affected the specific volume of the biscuits increasing them. On other hand, Silva et al[30] observed that the increase of fibers provokes specific volume reduction.

Table 2. Physical characteristics of yacon biscuits and their controls

Physical Parameters Evaluated	* Tests (n=10)							
	CB_{sw}	CB_{sg}	YB_{sw}	YB_{sg}	BF_{20sw}	BF_{20sg}	BF_{40sw}	BF_{40sg}
Weight loss (g)	0.63±0.13[a]	0.55±0.08[a]	0.63±0.32[a]	0.61±0.39[a]	0.63±0.10[a]	0.43±0.08[a]	0.50±0.08[a]	0.38±0.07[a]
Diameter (cm)	0.60±0.45[cd]	1.75±0.63[bc]	1.12±0.95[c]	1.65±0.97[bcd]	1.35±0.78[cd]	2.95±0.80[a]	1.20±0.58[cd]	2.50±0.84 [ab]
Thickness (cm)	0.25±0.42[b]	1.3±0.67[a]	1.00±0.57[ab]	1.60±0.93[a]	1.00±0.40[ab]	1.10±0.73[a]	1.05±0.36[ab]	1.15±0.47[a]
Expansion factor	2.41±0.63[ab]	2.47±0.82[a]	2.41±0.97[ab]	2.23±0.61[ab]	2.09±1.27[b]	2.33±1.26[ab]	2.09±0.58[b]	2.36±1.56[ab]
Apparent volume (mL)	4.75±0.79[a]	5.75±2.37[a]	5.00±0.57[a]	5.75±1.05[a]	4.50±1.05[a]	6.00±2.10[a]	6.00±2.10[a]	4.75±0.79[a]
Specific volume ($mL.g^{-1}$)	2.00±0.34[b]	2.11±0.60[ab]	2.64±0.37[a]	1.62±0.37[b]	1.87±1.30[b]	2.13±0.60[ab]	2.10±0.46[ab]	1.62±0.28[b]

** The same letters on the same line show no significant differences between the results considering $p > 0.05$ (Tukey test)

* CBsw (control biscuit with sweetener), CBsg (control biscuit with sugar), YBsw (fresh yacon biscuit with sweetener), YBsg (fresh yacon biscuit with sugar), BF_{20sw} (biscuit with 20 % yacon flour with sweetener), BF_{20sg} (biscuit with 20 % yacon flour and sugar), BF_{40sw}(biscuit with 40 % yacon flour with sweetener) and BF_{40sg} (biscuit with 40 % yacon flour with sugar) .

Sensory analysis of biscuits made with fresh yacon, 20 % and 40 % yacon flour

The results of the sensory analysis of biscuits made with fresh yacon, 20 %, 40 % of yacon flour can be observed in Table 3. This analysis was carried out in two days non consecutive, using their respective control samples - CBsg and CBsw (without yacon, with sugar/sweetener). The biscuits made with fresh yacon and sugar (YBsg) had a higher average for the flavor, differing from its control (CBsg), but it was statistically similar when compared with biscuits formulated with sweetener. Regarding the texture, biscuits formulated with sweetener showed better evaluation. For the rest of the evaluated items (color, appearance, global acceptance and purchasing intention) no significant differences among the tests was observed. When referring to purchasing intention, the average was around 5.0 (five) showing doubt regarding it. Maybe because it is a new and an unknown product. Besides, the consumption of yacon is still not part of the population food habits.

It was noticed that only biscuits made with 40 % yacon flour and sugar (BF_{40sg}) presented lower means for all sensory attributes as well as the purchasing intention. Regarding flavor, appearance and color, all the other samples (CBsw, CBsg, BF_{20sw}, BF_{20sg} and BF_{40sw}) presented similar means, which is interesting because some of them were prepared with sweetener, replacing sugar in the formulation. According to texture, samples made with sweetener (control and 20 % of yacon flour) presented the highest means. Additionally, biscuits made with 40 % yacon flour (with sweetener) differed from their control (CBsw) for the global acceptance. The other samples did not showed significant differences between them. The same was observed for the purchasing intention that presented higher means (around 6.0), specially for samples with 20 % of yacon flour and their control, when compared with samples made with fresh yacon.

According to Pereira et al[31], biscuits prepared with 40 %, 60 %, 80 % and 100 % of yacon flour, replacing sugar content, have had better grades than those preparared with 20 % and 30 % of this flour. As stated by Feddern et al[24], in order to have a product considered as accepted, it is necessary that the acceptance rate be at least 70 % which means an average grade of 6.3 in the nine point scale. In this way, biscuits prepared with yacon can be considered as acceptable with a favorable average.

Table 3. Sensory analysis of biscuits made with fresh yacon, 20%, 40% of yacon flour and their respective controls

Evaluated Items*	Biscuits made with fresh yacon				Biscuits made with yacon flour					
	Averages (n = 60)**				Averages (n = 60)**					
	CB_{sw}	CB_{sg}	YB_{sw}	YB_{sg}	CB_{sw}	CB_{sg}	BF_{20sw}	BF_{20sg}	BF_{40sw}	BF_{40sg}
Flavor	7.16^{ab}	6.71^{b}	6.80^{ab}	7.43^{a}	7.26^{a}	7.18^{a}	7.30^{a}	7.18^{a}	6.55^{ab}	6.21^{b}
Texture	6.46^{a}	5.15^{b}	5.83^{ab}	5.35^{b}	7.53^{a}	6.43^{bc}	7.28^{ab}	6.40^{bc}	6.20^{c}	4.51^{d}
Appearance	7.36^{a}	7.38^{a}	7.58^{a}	7.41^{a}	7.61^{a}	7.78^{a}	7.31^{ab}	7.35^{ab}	7.11^{ab}	6.68^{b}
Color	7.48^{a}	7.33^{a}	7.53^{a}	7.58^{a}	7.65^{a}	7.71^{a}	7.31^{ab}	7.35^{a}	7.01^{ab}	6.58^{b}
Global acceptance	6.20^{a}	5.75^{a}	5.46^{a}	6.65^{a}	7.48^{a}	6.95^{ab}	7.31^{ab}	6.80^{ab}	6.45^{b}	5.35^{c}
Purchasing intention	5.48^{a}	5.40^{a}	4.75^{a}	5.23^{a}	6.91^{a}	6.21^{ab}	6.80^{ab}	6.11^{ab}	5.48^{b}	4.03^{c}

*Same letters on the same line have no significant differences between the results, $p > 0.05$ (Tukey test). ** Averages of the following tests: CBsw (control biscuit with sweetener), CBsg (control biscuit with sugar), YBsw (in natura yacon biscuit with sweetener), YBsg (in natura yacon biscuit with sugar), BF_{20sw} (biscuit with 20 % yacon flour with sweetener), BF_{20sg} (biscuit with 20 % yacon flour and sugar), BF_{40sw}(biscuit with 40 % yacon flour with sweetener) and BF_{40sg} (biscuit with 40 % yacon flour with sugar)

Proximate composition

According to the best results of the sensory analysis, chemical tests were performed on fresh yacon (sweetener and sugar), as well as biscuits prepared with 20 % yacon flour (sweetener and sugar) and their controls (Table 4).

The Brazilian law for biscuits establishes a limit of 14 % of moisture in the final formulation[32]. According to this, biscuits made with fresh yacon and yacon flour presented about 6 % of moisture, meeting the current standard. The moisture is a very important component of new products because it establishes a microbiological parameter on food quality control, as well as water activity. It can then be inferred that low moisture content (about 4-5 % or less) gives the product a higher physical, chemical and microbiological stability if its adequately formulated and stored. Regarding protein content, it was found that the samples with sweetener presented higher values than those with sugar, being even higher for those prepared with fresh yacon. According to fat content, there were not any significant differences among all the samples.

Biscuits made with 20 % yacon flour and sweetener presented higher mineral content, when compared with other biscuits. These results are in accordance with Rosa et al.[16] study in which they could show that when replacing wheat flour with yacon, the ash content increased. The ash content observed in this study for biscuits made with yacon are in accordance with the Brazilian law for biscuits, that limits to 3.0 % of ashes in the final formulation[32].

As it was expected and observed by Teixeira et al[33] fiber content increased as long as yacon content increased. It was observed that biscuits prepared with yacon flour (sugar and sweetener) presented fiber contents above 50 %. According to Brazilian law for labeling (nutritional complementary information)[34], in order to consider a product as a fiber source it is necessary to have at least 3 % fiber in the final portion and at least 6 % of fibers in the final portion to be considered "high fiber content". As such it can be inferred that fresh yacon biscuits are considered a fiber source food as well as biscuits made with yacon flour can be considered rich in fiber.

Moreover, the high content of FOS and inulin provenient from yacon can suggest functionality according to Brazilian law for functional foods. This means that a new product is considered with functional capacity when it has at least 3 g of FOS in the final portion[35].

Considering the available information regarding FOS quantity in 100 g of yacon[14] it can be estimated that a portion of 8 (eight) fresh yacon biscuits (24 g) and 6 (six) biscuits made with 20 % yacon flour (18 g) can meet the minimum suggested quantity of 3 g/day of FOS[35]. These recommendations cover the daily recommended quantity for biscuits (30 g)[36].

Biscuits made with 20 % yacon flour, besides

Table 4. Proximate composition of biscuits prepared with yacon (*fresh*, flour and controls)

Evaluated items (in 100g)**	Samples* (n = 3)					
	CB_{sw}	CB_{sg}	YB_{sw}	YB_{sg}	BF_{20sw}	BF_{20sg}
Moisture (%)	5.93 ± 0.20^{ab**}	5.42 ± 0.45^{b}	6.04 ± 0.07^{ab}	6.14 ± 0.40^{ab}	6.16 ± 0.19^{ab}	6.41 ± 0.23^{a}
Proteins (%)	8.25 ± 0.98^{ab}	6.86 ± 0.14^{b}	9.06 ± 3.50^{a}	6.64 ± 1.18^{b}	8.22 ± 0.24^{ab}	6.40 ± 1.03^{b}
Fat (%)	18.72 ± 2.59^{a}	17.68 ± 1.15^{a}	18.16 ± 1.86^{a}	16.69 ± 1.07^{a}	19.87 ± 0.62^{a}	17.55 ± 0.17^{a}
Ashes (%)	1.82 ± 0.03^{b}	1.31 ± 0.03^{d}	1.86 ± 0.10^{b}	1.38 ± 0.05^{d}	2.25 ± 0.04^{a}	1.64 ± 0.05^{c}
Fiber (%)	1.23 ± 0.25^{c}	1.4 ± 0.20^{c}	3.7 ± 0.20^{b}	3.6 ± 0.36^{b}	51.4 ± 0.26^{a}	51.60 ± 0.36^{a}
Available carbohydrates (%)	63.21 ± 2.02^{ab}	67.31 ± 1.13^{a}	62.00 ± 2.71^{b}	65.53± 1.96^{ab}	12.08 ± 0.56^{c}	16.38 ± 0.96^{c}
Energy value (kcal)	457.63 ± 14.75^{a}	455.92 ± 6.54^{a}	444.25 ± 8.45^{a}	438.94 ± 5.63^{a}	260.12 ± 3.82^{b}	249.17 ± 1.55^{b}

* CBsw (control biscuit with sweetener), CBsg (control biscuit with sugar), YBsw (fresh yacon biscuit with sweetener), YBsg (fresh yacon biscuit with sugar), BF_{20sw} (biscuit with 20 % yacon flour with sweetener), BF_{20sg} (biscuit with 20 % yacon flour and sugar).**Same letters on the same line show that there are not any significant differences between the results, considering $p > 0.05$ (Teste Tukey)

presenting a higher content of fibers, showed a low content of available carbohydrates as well as energy value. This evidence can be explained because as the fiber concentration increases, the energy rate is reduced. The same was observed by Moscatto et al[37] in chocolate cakes using inulin and yacon flour. These authors checked that the cake made with 40 % of yacon flour and 6 % of inulin presented a lower energy value compared to the standard cake prepared exclusively with wheat flour. Considering energy content, just the biscuits prepared with yacon flour presented important differences compared to the other tests, being classified as a product with energy reduction.

CONCLUSION

According to this study it was possible to verify the feasibility of preparing biscuits containing fresh yacon, 20 % and 40 % yacon flour (diet and regular biscuits). According to the physical characterization, it was observed that, the addition of sugar in biscuits made with yacon flour (20 % and 40 %) increased diameter values. Moreover, the addition of sweetener in biscuits made with fresh yacon increased the specific volume value. According to the other parameters it was not evidenced significant differences between the formulated biscuits and their respective controls.

Regarding the acceptability analysis, biscuits made with fresh yacon presented good acceptability means in relation to the evaluated sensory attributes, as well as, biscuits made with 20 % yacon flour (with sugar or sweetener). No significant differences between biscuits made with sugar or sweetener were observed, except for those made with 40 % of yacon flour, especially with sugar that, did not present good acceptability, even for purchasing intention. Biscuits prepared with yacon

flour showed significantly higher values of fiber, being considered products rich in this component as well as low in calories. It is important to point out that biscuits made with fresh yacon are an excellent option for easy homemade preparations.

ACKNOWLEDGMENTS

The authors thank to Federal University of Espirito Santo ("Pró-Reitoria de Pesquisa e Pós-Graduação") and to the "Program of Scientific Initiation" for the opportunity.

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