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Acute consumption of yacon shake did not affect glycemic response in euglycemic, normal weight, healthy adults

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ABSTRACT

Yacon (*Smallanthus sonchifolius* (Poepp.) H. Rob) is a natural source of fructooligosaccharides (FOS) studied for its potential as a functional food for prevention and management of chronic diseases, in part associated with its positive impact on glycemic response and body weight. However, yacon beneficial effect on glucose response and food intake control are still controversial. We investigated the acute effect of yacon consumption on glycemic response, subjective appetitive sensations, and food intake in a crossover trial. Fifteen healthy adults consumed 350 mL of yacon (21 g of yacon flour with 7.4 g of FOS) or control shake, on two non-consecutive days (washout). Yacon shake did not affect glycemic response, appetite or food intake. However, it is possible that positive effects of yacon consumption may turn evident only after its chronic consumption. Further studies are needed to assess the long-term effect of yacon consumption on glucose response and body weight control.

1. Introduction

Diabetes mellitus is a complex metabolic disorder characterized by high blood glucose concentrations, resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association, 2017b). > 422 million people worldwide have diabetes. The increasing prevalence of type 2 diabetes mellitus (T2DM) associated with obesity drives the global prevalence of diabetes (World Health Organization, 2016).

Lately, > 2 million deaths were attributed to high blood glucose (World Health Organization, 2016). The reduced post-prandial glycemic response can modulate appetite, promoting body weight management (Brand-miller, Holt, Pawlak, Mcmillan, & Al, 2006). On the other hand, high glucose concentrations promote oxidative stress, inflammation, increasing the risk of chronic diseases (Domingueti et al., 2016). Hence, maintaining optimal postprandial blood glucose is essential in people with and without diabetes (Augustin, Kendall, Jenkins, Willett, & Astrup, 2015).

The consumption of nutraceutical foods such as yacon may prevent the risk of chronic diseases manifestation. Yacon (*Smallanthus sonchifolius* (Poepp.) H. Rob) is an herbaceous plant from Asteraceae family, native to the Andean regions of South American. > 70% of yacon roots' fresh weight is water, while the major portion of dry matter consists of oligofructans or fructooligosaccharides (FOS). Due to naturally high concentrations of FOS, yacon roots are widely studied for its potential as a functional food (Caetano et al., 2016). However, shortly after yacon is harvested, FOS hydrolysis starts, leading to large amounts of free sugars as degradation products of FOS depolymerization (Graefe, Hermann, Manrique, Golombek, & Buerkert, 2004). Contrarily, yacon flour obtained from dehydration of yacon roots without added preservatives or chemicals is a simple process to guarantee a natural product with great FOS stability (Campos et al., 2016).

FOS consumption regulates endogenous gut peptides production, favoring food intake and obesity control (Cani et al., 2005; Daud et al., 2014; Parnell & Reimer, 2009). Besides, the glucose-lowering beneficial response of yacon has been attributed to its inhibitory effects on α-glucosidase. α-Glucosidase hydrolases maltose, sucrose, and other oligosaccharides in the intestine. Therefore, inhibition of α-glucosidase reduces the digestion and absorption of glucose in intestine, reducing the postprandial rise in blood glucose concentrations (Zhen-yuan et al., 2014). The results of some (Genta et al., 2009; Scheid, Genaro, Moreno, & Pastore, 2014) but not all studies (Satoh, Kudoh, & Hasegawa, 2014) suggest that yacon consumption has a beneficial effect on blood glucose concentrations. The differences in the results of these studies may be

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associated with the different forms that yacon is consumed, which in turn may affect its FOS content.

Therefore, the purpose of this study was to develop a palatable shake containing yacon flour and investigate its effect on glycemic response, subjective appetitive sensations and food intake in euglycemic, normal weight, healthy adults.

2. Material and methods

2.1. Subjects

Healthy men, and nonpregnant and nonlactating woman were recruited from community, faculty, staff, and students by direct contact. The inclusion criteria of both sexes in our study were done since no differences have been observed in glycemic response between males and females. Accordingly, there are no grounds to avoid this common practice in a study (Brouns et al., 2005). Furthermore, irrespective of gender, islet cell dysfunction is a significant contributing factor to abnormal glucose metabolism with aging (Kalyani & Egan, 2013; Reaven, 2003). Thus, glucose concentrations tend to rise with age, which is the major risk factor for diabetes (American Diabetes Association, 2017a). Therefore, we choose to select only healthy adults aged 18–40 y.

Screening examination included body weight (Toledo®, Model 2096PP, Brazil, graduation 50 g), height (WISO®, graduation 0.1 cm), umbilical waist and hip circumference (inelastic tape, graduation 0.1 cm), body fat (Model 310, *Biodynamics Corporation*), blood pressure (Omron Healthcare, Inc., Model OMRON HEM 7200, USA), fasting capillary blood glucose (Accu-Chek Active®, Brazil), medical and family history. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (WHO, 2017). We included euglycemic (< 100 mg/dL), normal weight (18.5–24.9 kg/m^2), healthy subjects with body fat percentage of 20–30% for women and 12–20% for men (Salas-Salvadó et al., 2007). Exclusion criteria were: subjects with type 1 or 2 diabetes; pre-diabetes (fasting blood glucose between 100 and 125 mg/dL); first-degree family history of diabetes mellitus; recent digestive, hepatic, renal, cardiovascular, thyroid or inflammatory diseases, diagnosis of cancer in the previous year; smokers; alcohol intake greater than two doses (> 20 mL) per day; weight instability (± 3kg over the last 3 months); on a diet to control body weight; use of medications that affect metabolism and/or appetite; allergy or aversion to tested foods.

The study was approved by local ethical committee (Universidade Federal de Viçosa). Written informed consent was obtained from all subjects, according to the general recommendations of the Declaration of Helsinki (World Medical Association, Review, Communication, Principles, 2013).

2.2. Study design

This was a single-blinded, randomized, controlled, acute crossover study. After a 10–12 h overnight fast, subjects received two breakfast meals (test or control) in random order during a single visit, to consume within 15 min, on two non-consecutive days (washout period). Randomized block design (random.org) was adopted to determine the order in which the test meals were consumed by each subject. Sixty minutes after the test meal, subjects consumed a glucose load (25 g) diluted in 150 mL of water, within 10 min. Subjects kept physical activity to a minimum (sitting regime) for the following 3-h capillary postprandial glycemia, and appetitive sensations assessments. They were not allowed to consume any food or water during that period. At the end of each experimental session, all subjects received a standardized meal and were instructed to record the types and amount of foods and beverages consumed for the following 24 h.

To minimize possible interferences on glycemic response, on the evening before each test meal, all subjects consumed a standard dinner consisting of 200 mL of fruit juice (grape or passion fruit), 85 g of spaghetti and 80 g of seasoned shredded chicken with tomato sauce and carrots (621 kcal, 58.5% CHO, 15.3% PTN, 26.2% LIP). Nutritional composition of that evening meal was determined according to the label information and nutritional composition tables (Lima et al., 2011). All subjects were encouraged to maintain their regular physical activity and lifestyle throughout the study. Anthropometric measurements (body weight, height, waist and hip circumference) were taken before each test meal to evaluate any variation.

2.3. Chemical composition of yacon

The chemical composition of yacon flour was determined using official methods of analysis of AOAC International (Horwitz & William, 2002). The total dietary fiber contents in yacon flour was determined independently, obtained from the amount of fiber from AOAC enzymatic-gravimetric method, using Total Dietary Fiber Assay Kit from Sigma-Aldrich® plus FOS content determined according to the methodology described by Pedreschi, Campos, Noratto, Chirinos, and Cisneros-Zevallos (2003) with some modifications (Pedreschi, et al., 2003).

FOS determination was based on quantification of glucose, fructose, and sucrose present in the sample before and after enzymatic hydrolysis of fructooligosaccharides. The sugars were measured by high-performance anion-exchange chromatography with pulsed amperometric detection (HPAEC-PAD) (Metrohm, Herisau, Switzerland) through a column Metrosep Carb 2 (dimensions 150 × 4.0 mm) (Metrohm, Herisau, Switzerland). The mobile phase used was NaOH 0.2 mol L^{-1}, a flow rate of 0.5 mL min^{-1} and temperature 30 °C column. To determine the initial amounts of sugars, the yacon flour was diluted (0.5 g of flour in 50 mL of ultrapure water) and centrifuged at 7000*g* for 20 min. Before injection into the chromatograph, 200 µL of the supernatant were removed and diluted in 10 mL of ultrapure water. For enzymatic hydrolysis, 100 µL of the supernatant was removed and mixed with 50 µL of the inulinase solution (Megazyme, County Wicklow, Ireland) in 50 mM acetate buffer, pH 4.5. The mixture was incubated in a 40 °C water bath C for 30 min. The sugars were identified and quantified by comparing the retention times of previously analyzed standards. The concentration of FOS was calculated according to Prosky and Hoebregs (1999) and Pedreschi et al. (2003):

$$G = Gt - S/1.9 - Gf \quad (1)$$

$$F = Ft - S/1.9 - Ff \quad (2)$$

where

G = glucose from FOS or inulin, Gt = total glucose released after enzymatic hydrolysis, F = fructose from FOS or inulin, Ft = total fructose released after enzymatic hydrolysis, S/1.9 = glucose or fructose from of initial sucrose, Gf = initial free glucose and Ff = initial free fructose.

The total content of FOS was the sum of G and F, and corrected for the loss of water during the hydrolysis. Thus:

$$FOS = k(G + F) \quad (3)$$

where, $k = 0.925$, for FOS (average degree of polymerization = 4).

Yacon flour contained 3.23% (w/w) proteins, 0.99% (w/w) lipids and 85.33% (w/w) carbohydrates. Total fiber was 48.15% (w/w) of which 35.18% (w/w) were FOS.

2.4. Breakfast meals

Participants received two different breakfast meals, on separated occasions. Yacon shake (test) and control shake contained similar amount of available carbohydrate, energy and macronutrient content (Table 1). Yacon shake had the maximum tolerable amount of yacon flour to make it palatable. The ingredients of each meal were blended for 5 min and immediately offered to the participants.

Table 1
Ingredients and nutritional composition of the tested meals.

Shakes	Nutritional composition*							
	Ingredients	Quantity (g)	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Available carbohydrate (g)	Fiber (g)
Control	Milk powder	34.30	123.10	18.18	11.90	0.31	18.18	0.00
	Crystal sugar	21.00	83.92	20.92	0.06	0.00	20.92	0.00
	Soybean oil	12.50	112.50	0.00	0.00	12.50	0.00	0.00
	Mango pulp	100.00	52.00	13.00	0.00	0.00	11.90	1.10
	Water	200.00	–	–	–	–	–	–
	Total	≈350 mL	371.52	52.10	11.96	12.81	51.00	1.10
Yacon	Milk powder	30.00	107.67	15.90	10.41	0.27	15.90	0.00
	Crystal sugar	11.00	43.96	10.96	0.03	0.00	10.96	0.00
	Soybean oil	12.50	112.50	0.00	0.00	12.50	0.00	0.00
	Mango pulp	100.00	52.00	13.00	0.00	0.00	11.90	1.10
	Yacon flour	21.00	76.26	17.92	0.68	0.21	7.81	10.11
	Water	200.00	–	–	–	–	–	–
	Total	≈350 mL	392.39	57.78	11.12	12.98	46.57	11.21

* Nutritional composition was determined according to the ingredients label information or nutritional composition tables (LIMA et al., 2011). Yacon composition was determined by physical–chemical analysis.

2.5. Postprandial glycemic response

Capillary finger-stick blood samples were taken at −65 and −60 min (fasting state), and at 0, 15, 30, 45, 60, 90 and 120 min after the consumption of the glucose load (Fig. 1). Glucose was measured using the glucometer Accu-Chek Active® (Roche, Germany).

2.6. Dietary assessment

Habitual dietary habits were assessed by a semi quantitative food frequency questionnaire before the study (Ribeiro et al., 2006). Food intake was also assessed on each test day through 24-h dietary records after test meals. Subjects were given a detailed explanation to record the food consumed, and they also received written instruction with examples. Records were checked with the participant for completeness and accuracy. A single researcher converted food portion sizes to grams to estimate daily intake of calories, carbohydrate, protein, lipid and fiber, using the *software* Diet Pro® v. 5.8 (Agromídia Software, Brazil).

2.7. Subjective appetitive sensations and test meals palatability

Subjective hunger, satiety, fullness and prospective food consumption sensations were assessed by 10 cm visual analogue scales (VAS) (Adapted from Flint et al., 2000). Visual appearance, smell, taste, aftertaste and palatability of the test meals were assessed using the 10 cm VAS (Flint et al., 2000). Subjects were instructed on how to complete the VAS by trained research assistants and were asked to fill in the VAS in fasting state (−60 min), immediately after test meal consumption (−45 min), before glucose load (0 min), and subsequently at 30, 60, 90 and 120 min after glucose load. Palatability was filled right after test meal consumption. Scales were scored by measuring the distance (in cm) from 0 with a ruler. Appetite and palatability scores were calculated according to Joanna & Craig (2013). Lower appetite scores are associated with greater suppression of appetite, and higher palatability scores represents the meal is more palatable.

2.8. Statistics analyses

Sample size calculations (Mera, Thompson, & Prasad, 1998) indicated that 9 subjects would permit a detectable reduction of 6.3 mg/dL in blood glucose (Cândido, Tadeu, Ton, De Cássia, & Alfenas, 2015) with a statistical power of 99% ($\alpha = 0.05$).

The normal distribution of variables was tested with Shapiro-Wilk's normality test. Non-parametric data were log transformed. Data are expressed as mean ± SEM. Differences in glucose concentrations, subjective appetite scale and appetite score were tested with two-way ANOVA with repeated measures, followed by the post hoc Bonferroni's multiple comparisons test or paired *t* test. In these analysis, we studied the statistical effects of the time alone (within-subject effect), the effect of the meal independently of the time (between-subject effect) and the interaction of both factors (meal × time) which is indicative of the magnitude of the postprandial response in each meal. Glucose incremental area under the curve (iAUC) was calculated from 0 to 120 min, using the trapezoid rule in GraphPad Prism v. 6.01 (GraphPad, La Jolla, CA, USA). One way ANOVA with repeated measures, followed by the post hoc Bonferroni's multiple comparisons test, tested differences in daily intake (calorie, carbohydrate, protein, fat and fiber) of yacon and control shakes. Glucose iAUC, palatability and palatability score for control and test meal were compared by paired t tests. All analyses were performed with SPSS 23 for Windows (SPSS, Inc., Chicago, IL, USA). The differences were considered statistically significant at $\alpha \le 0.05$ for all data analyses.

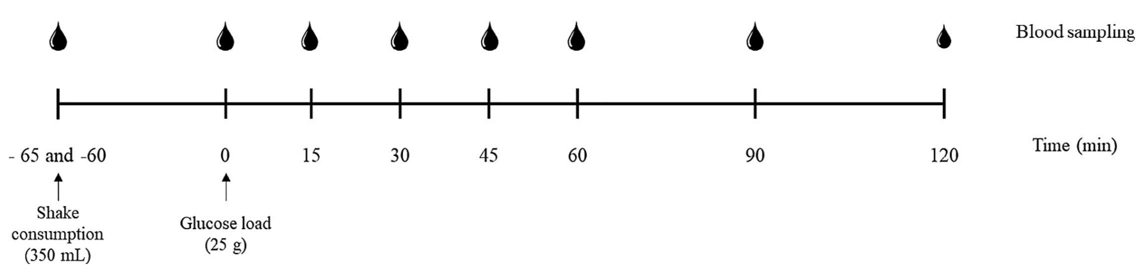

Fig. 1. Experimental design of the study. After 10–12 h overnight fast, capillary (finger stick) glucose was assessed. Subjects consumed the yacon shake (21 g of yacon flour with 7.4 g of FOS) or a control shake, followed by a glucose load (25 g) after 60 min. Postprandial glucose concentrations were determined at 0 (immediately before glucose load ingestion), 15, 30, 45, 60, 90, 120 min after glucose load consumption.

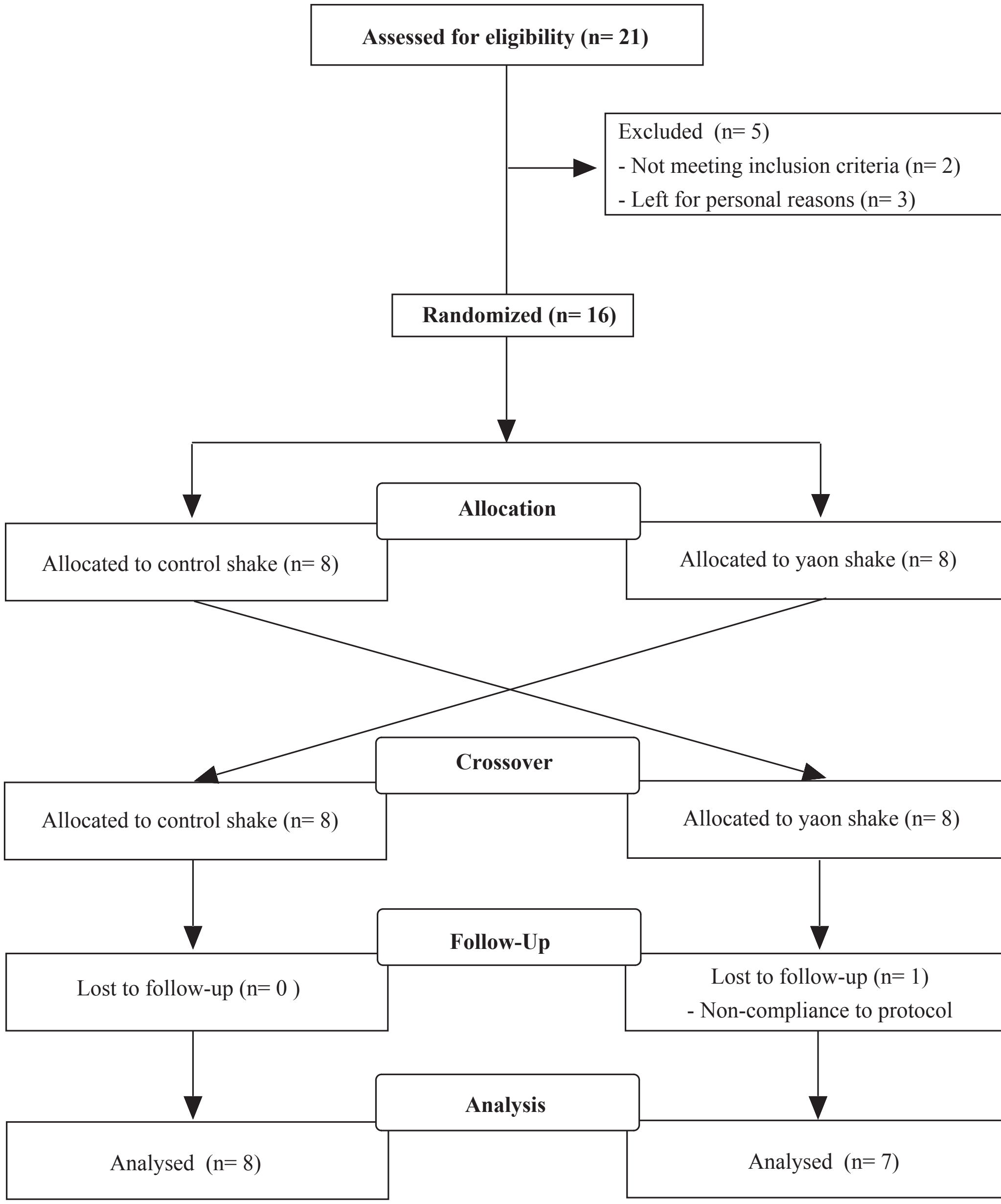

Fig. 2. CONSORT study flow diagram.

3. Results

Twenty-one screened subjects were accessed for eligibility in the study. However, two subjects did not meet the inclusion criteria and other three dropped out for personal reasons. Then, 16 subjects were enrolled in the study and randomly assigned to yacon or control interventions. Due to non-compliance with the protocol, one subject was excluded from analysis. Thus, fifteen (1 man and 14 women) adults (24.87 ± 0.71 y) with fasting glycemia of 87.88 ± 1.21 mg/dL, BMI of 21.06 ± 0.28 kg/m^2 and body fat of 23.23 ± 1.19% participated in the study (Fig. 2 and Table 2). During the study, there was no change in baseline fasting blood glucose, physical activity level or anthropometric measurements (body weight, height, waist and hip circumference).

The acute consumption of a shake containing 21 g of yacon flour (7.4 g of FOS), followed by a glucose load (25 g) had no impact on glycemic control of health subjects, in comparison to a control shake presenting similar caloric and macronutrients composition (Fig. 3). Also, daily energy, carbohydrate, protein, fat and fiber intakes (Fig. 4) and subjective appetitive sensations (Supp. Fig. 1) were not affected in

Table 2
Subjects baseline characteristics.

Characteristics	Mean ± SEM
Age (years)	24.87 ± 0.71
Weight (kg)	57.81 ± 1.34
Height (m)	1.66 ± 0.02
Body mass index (kg/m^2)	21.06 ± 0.28
Fasting blood glucose (mg/dL)	87.88 ± 1.21
Systolic blood pressure (mmHg)	107.00 ± 1.16
Diastolic blood pressure (mmHg)	66.33 ± 1.79
Waist circumference (cm)	76.71 ± 0.81
Hip circumference (cm)	97.24 ± 1.07
Waist-hip Ratio	0.79 ± 0.01
Body fat (%)	23.23 ± 1.19
Basal metabolic rate (kcal)	1349.73 ± 46.09

Data expressed in mean ± SEM.

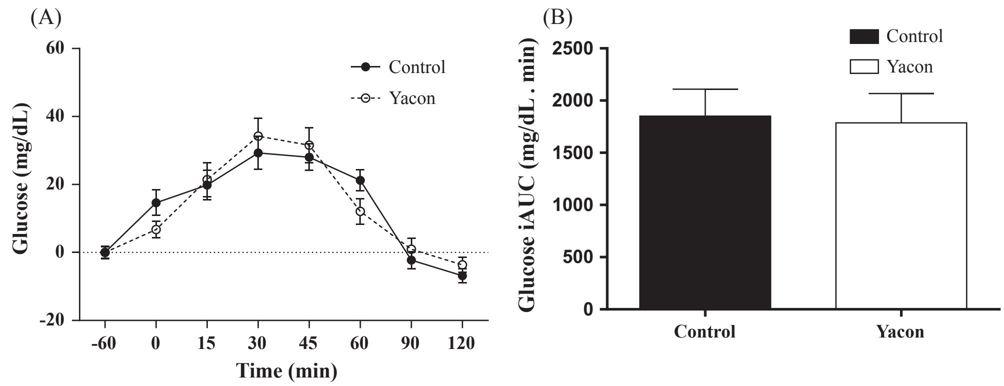

Fig. 3. Changes in glucose concentrations (A), and incremental area under the glucose response curve (iAUC) (B) after consumption of a glucose load (25 g) with 350 mL of a control or yacon shake (n = 15). Data expressed as mean ± SEM. Two-way repeated measures ANOVA ($p > 0.05$) or paired t test ($p > 0.05$).

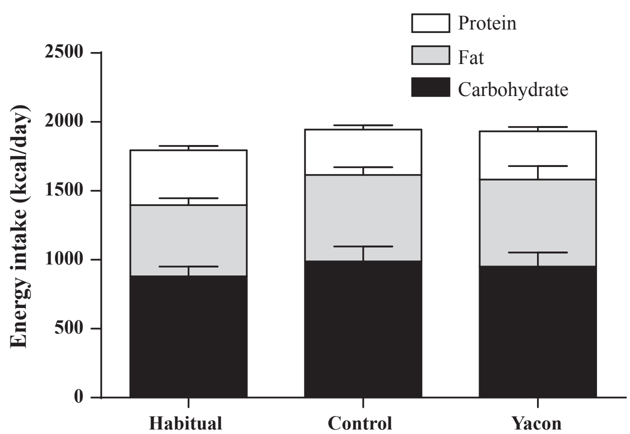

Fig. 4. Energy and macronutrients habitual intake and during 24-h after test meals consumption (n = 15). Data expressed as mean values. One-way repeated measures ANOVA ($p > 0.05$).

response to the acute consumption of a shake containing 21 g of yacon flour (7.4 g of FOS).

Yacon shake palatability scale and palatability score was lower when compared with the control shake ($p < 0.05$; data not showed). However, although the control was more palatable then yacon shake, both shakes presented good palatability scores (8.92 ± 0.24 and 5.69 ± 0.48, respectively).

4. Discussion

To our knowledge, this is the first study to evaluate the effect of yacon consumption on glycemic response, subjective appetitive sensations, and food intake in euglycemic, normal weight, healthy adults over a single day trial.

Yacon is considered a functional food due to its bioactive compounds (antimicrobial, antioxidant and probiotic substances) that exert beneficial effects on health (Aparecida, Paula, Abranches, & Luces, 2013). There are few studies assessed the functional effects of yacon. However, they showed promising good effects such as weight management (Genta et al., 2009), improvement in lipid profile (Aybar, Sánchez Riera, Grau, & Sánchez, 2001; Genta et al., 2009) and antioxidant properties (Simonovska, Vovk, Andrensek, Valentová, & Ulrichová, 2003). Besides, the high contents of fructans (inulin and FOS) presented in yacon are linked to beneficial modulation of gut microbiota (Aparecida et al., 2013; Campos et al., 2012). Thus, yacon may be considered also a prebiotic food (Campos et al., 2012). Therefore, FOS is an inulin-type fructans of yacon has been attributed to the glucose-lowering response due to inhibitory effects of α-glucosidases, which reduces the digestion and absorption of glucose in intestine, reducing the postprandial rise in blood glucose concentrations (Zhenyuan et al., 2014).

In our study, a shake containing 21 g of yacon (*Smallanthus sonchifolius* (Poepp.) H. Rob) flour (7.4 g of FOS), followed by a glucose load (25 g) had no impact on glycemic control of healthy subjects (Fig. 3). It is not our knowledge short-term studies with yacon. Nevertheless, results of long-term studies that assessed the effect of yacon consumption on blood glucose concentrations show controversial results. Daily consumption of freeze-dried powdered yacon (18 g with 7.4 g of FOS) reduces fasting blood glucose in elderly subjects (103.38 ± 20.53 g/dL to 97.35 ± 19.02 g/dL), after 9 weeks of intervention (Scheid et al., 2014). In another study involving insulin-resistant obese pre-menopausal women, although the consumption of yacon syrup (0.14 g FOS/kg body weight/day, during 17 weeks) did not affect fasting blood glucose, it reduced insulin and HOMA-IR (Genta et al., 2009). However, in subjects with type 2 diabetes, 100 g of yacon (8 g of FOS) consumption did not change fasting blood glucose, insulin, glycated albumin, and HOMA-IR, after 5 months (Satoh et al., 2014).

In animal studies, the literature suggests a beneficial effect of yacon on glucose control, especially in T2DM rats, which may be related to an increase of insulin secretion. A yacon supplementation (340 or 6800 mg FOS/kg body weight/day) for 17 weeks did not change the glycemic response of non-diabetic rats to an oral load of glucose (2 g/kg body weight), compared to control (Genta, Cabrera, Grau, & Sánchez, 2005). Besides, the consumption of yacon-enriched diet (6.5% of yacon), during 5 weeks, did not significantly alter fasting plasma glucose concentration and insulin sensitivity in insulin-resistant Zucker fa/fa rats (Satoh, Audrey Nguyen, Kudoh, & Watanabe, 2013). However, in T2DM rats, the consumption of FOS-rich yacon flour (340 or 6800 mg FOS/kg body weight/day) for 13 weeks, prevented the increase in fasting plasma glucose concentrations, probably due to raise of insulin secretion in these animals, which was not observed in the control group whose glycemia increased after the intervention (Habib, Honoré, Genta, & Sánchez, 2011).

FOS consumption may favor appetite and obesity management by regulating the endogenous production of gut peptides (Cani et al., 2005; Daud et al., 2014; Parnell & Reimer, 2009). The consumption of 21 g of FOS, during 12 weeks, led to a reduction in self-reported energy intake followed by weight loss in overweight (> 25 kg/m^2) adults compared with the control (maltodextrin). These results coincided with an increase in peptide YY (PYY), and suppression of ghrelin, and leptin secretions. But GLP-1 and GIP concentrations were not affected (Parnell & Reimer, 2009). However, 6 weeks of FOS (30 g/day) supplementation enhanced plasma PYY concentrations and suppressed subjective appetite sensation, but did not elicit weight loss or adiposity reduction in overweight (> 25 kg/m^2) adults (Daud et al., 2014). Besides the suppression of appetite sensation by gut hormones modulation, the results of these two studies suggest that FOS has to be consumed for > 6 weeks for body weight reduction to occur.

Although FOS supplementation showed a regulation food consumption and appetite, the same result was not found in long-term studies with yacon consumption as a FOS source of supplementation. The consumption of freeze-dried powdered yacon (7.4 g of FOS) for 9 weeks by elderly subjects showed a reduction in energy intake, but identical to the placebo group ($p > 0.05$), suggesting that the observed effect was not due to yacon consumption (Scheid et al., 2014). Similar results were verified in a study involving obese pre-menopausal insulin resistance women. In that study, food intake and subjective satiety sensation were not affected after 17 weeks of intervention (Genta et al., 2009). In accordance, in our study, the acute consumption of yacon (7.4 g of FOS) was ineffective to reduce food intake (Fig. 4) and subjective appetitive sensations (Supp. Fig. 1).

There is a growing trend for healthy, attractive and palatable food products by many segments of the population that search for the pleasure of eating combined with health benefits and life quality (Rocha et al., 2014). Considering the scarcity of healthy nutraceutical and potential functional food products on the market, the development of yacon products, as source of FOS, could be a good opportunity for innovation. Food palatability is defined as the positive hedonic evaluation of food's sensory characteristics (Mccrickerd & Forde, 2015). In our study, both control and yacon shake presented good palatability score, but the control was more palatable then yacon shake (8.92 ± 0.24 vs 5.69 ± 0.48, $p < 0.05$, respectively). Also, palatability scale was lower for yacon shake in comparison with control ($p < 0.05$; data not showed).

Despite the acute consumption of yacon (7.4 g of FOS), in our study, had no effect on glucose control, regular consumption of a yacon-based product (10 g of FOS) for a month improved the growth of *Bifidobacterium* spp. and reduce *Clostridium* spp. counts (de Souza Lima Sant'Anna, 2015). This bifidogenic effect of yacon also verified in clinical trials with FOS supplementation, could negatively modulate the production expression of proinflammatory cytokines (Joossens et al., 2011; Langlands, 2004). In fact, the concentration of TNF-α significantly reduced after a 5-week consumption of yacon-enriched diet (6.5% of yacon), insulin resistant Zucker fa/fa rats. This proinflammatory cytokine plays an important role in the development of insulin resistance (Satoh et al., 2013). Therefore, a benefit of long-term yacon consumption on glucose control is suggested.

The present data are relevant to clinicians and nutritionists, adopting diabetes prevention strategies. Overall, the results of these above-mentioned studies and of our study indicate that acute yacon consumption does not regulate food intake. However, as indicated by the results of some studies, yacon may be effective on blood glucose and food intake control when it is consumed on a long-term basis. Though, more studies are needed to evaluate the long-term effect. Nevertheless, we have developed a yacon shake with good acceptance and potential functional properties. This could encourage industry to produce similar products food with potentially beneficial to health.

Our study was designed to present a good statistical power. In order to minimize possible interferences in the glycemic response on test days, we provided a standard meal to our subjects to be consumed on the evening before.

5. Conclusions

The acute consumption of yacon shake containing 21 g of yacon flour (7.4 g FOS) did not affect glycemic response, subjective appetitive sensations and food intake in health adult subjects. Future studies are needed to assess its long-term effect on chronic diseases control.

Acknowledgement

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Conflict of interest

The authors declare no conflict of interest.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jff.2018.02.029.

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