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

Daniela Mayumi Usuda Prado Rocha[a,*], Priscila Vaz de Melo Ribeiro[a], Ana Paula Silva Caldas[a], Bárbara Pereira da Silva[a], Alessandra da Silva[a], Alinne Paula de Almeida[a], Nayara Benedito Martins da Silva[b], Adriane Moreira Machado[a], Rita de Cássia Gonçalves Alfenas[a]

[a] *Department of Nutrition and Health, Universidade Federal de Viçosa, Viçosa, MG, Brazil*
[b] *Department of Food Technology, Universidade Federal de Viçosa, Viçosa, MG, Brazil*

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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

* Corresponding author at: Departamento de Nutrição e Saúde, Universidade Federal de Viçosa, Av. PH Rolfs s/n, Viçosa, MG 36570-900, Brazil.
E-mail address: mayumi.dani@gmail.com (D.M.U.P. Rocha).

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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.