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Effect of Yacon *(Smallanthus sonchifolius)* on Colonic Transit Time in Healthy Volunteers

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Key Words
Yacon · Fructooligosaccharides · Gastrointestinal motility · Diabetics · Constipation

Abstract
Background: Yacon is a root crop which contains high amounts of fructooligosaccharides (FOS). The aim of this study was to investigate the effects of yacon syrup on colon transit time in healthy volunteers. ***Methods:*** In a placebo-controlled, double-blind study yacon was administered to 16 healthy individuals (8 males, 8 females) in a dose of 20 g daily (equal to 6.4 g FOS) in a 2-week crossover design. Each period was interrupted by a 2-week wash-out phase. Transit time was assessed by a radio-opaque marker technique. ***Results:*** Transit time (mean ± SEM) through the gastrointestinal tract was significantly decreased from 59.7 ± 4.3 to 38.4 ± 4.2 h ($p < 0.001$). Yacon was well tolerated with an excellent side effect profile. Bloating is not an uncommon side effect observed with FOS, but bloating-related disturbances were not significantly more often reported with yacon compared to placebo. Stool frequency increased from 1.1 ± 0.1 to 1.3 ± 0.2 times per day and the consistency showed a tendency for softer stools as assessed by a numerical depicted stool protocol. Neither parameter did, however, reach statistical significance. ***Conclusion:*** Yacon markedly accelerates colonic transit in healthy individuals. Further studies are needed in constipated patients to confirm these preliminary data. Due to the low caloric content of yacon, the root could be a useful treatment in constipated diabetics or obese patients.

Introduction

Yacon is a scientifically little known root crop taxonomically classified under the Asteraceaea family that is native to the Andean region [1, 2]. It is cultivated up to a height of 3,200 m above sea level and consumed since pre-Inca times. Interest in this crop has increased as it is a plant source with the largest content of fructooligosaccharides (FOS). Yacon was recently introduced to several different regions with varying climates: Brazil, Czech Republic, China, Korea, Japan, New Zealand, Russia, Taiwan and the United States [1, 2]. Yacon is well tolerated with no known toxic effects [3].

FOS are accepted in most countries as food ingredients that can be used without restrictions in food formulations [4]. FOS are low in calories and consumption is known to promote health of the intestinal tract. FOS resist the hydrolysis of enzymes in the human digestive system and are therefore able to reach the colon without being digested or metabolized. In the colon, FOS are com-

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pletely fermented [5] to short fatty acids (e.g. butyrate, acetate propionate) [6]. These effects can prevent and control constipation [7] and make the FOS an interesting substance.

Yacon syrup is a novel product, which contains up to 50% FOS, made by concentrating the juice of the tuberous storage roots of yacon. Production technology depends on an evaporator, which is commonly used for the production of maple syrup. The physical and sensorial characteristics of yacon syrup are similar to those of honey, maple syrup or sugar cane syrup with the advantage of low caloric intake (even to be recommended for diabetics) [8, 9]. However, clinical studies are required to substantiate the benefits of yacon consumption. To our knowledge, there have been no human placebo-controlled studies that demonstrate the laxative effect of yacon. The aim of this study was therefore to investigate in healthy volunteers the effects of yacon syrup on gastrointestinal motility quantified by colon transit time measurement. We hypothesized that yacon syrup would accelerate colon transit time in comparison to placebo.

Methods

The study was conducted as a randomized, placebo-controlled study at the University Hospital of Basel. The local ethical committee approved the protocol and all subjects gave written informed consent. 16 healthy volunteers (8 females, 8 males) aged 18–57 years of age (mean age of 29.3 ± 4.9 years) were recruited for the study. Exclusion criteria were chronic constipation (less than 3 bowel movements per week and ROME criteria), diarrhea (more than 3 bowel movements per day), IBS symptoms according to ROME II criteria, relevant concomitant cardiovascular, renal, hematological, neurological, psychiatric, hepatological, intestinal disease including abdominal operation (exception appendectomy) and pregnancy. Any kind of medication that could potentially influence bowel activity was prohibited (intake of laxatives and bran). Body size and weight had to be within normal ranges. For all females, a pregnancy test was obligatory. Physical activity was only allowed in moderate limits within individual habits.

Study Design

The trial was conducted as a randomized, placebo-controlled, two-period, crossover study. Each period lasted for 2 weeks. In one period, subjects received 20 g placebo syrup (20 g molasses) per day, in the second period 20 g yacon syrup per day. The chemical composition of the yacon syrup we used is shown in table 1. A pharmacist, who was not involved in the trial, prepared the bottles with the respective syrups. The two preparations were morphologically identical and delivered in brown containers together with a dosing cup of 20 ml, thereby making it possible to dose them in a double-blind fashion. The color, smell and taste of both syrups were similar: brown and sweet.

Table 1. Chemical composition of tested yacon syrup sample

Total carbohydrate, %	67
FOS, %	32
Simple sugars (glucose, fructose, sucrose), %	35
Protein, %	2.3
Fat, %	0.4
Ash, %	3.2
Water, %	29.5
Potassium, mg/kg	9,838.5
Sodium, mg/kg	830.38

Yacon syrup was prepared according to technical standards published [7].

The sequence of treatment was randomized. A washout period of 2 weeks was applied between two study periods. The primary endpoint of the study was the colonic transit time (CTT) using the radio-opaque marker technique. In brief, 10 radio-opaque markers were ingested on 6 consecutive days (from day 9 to day 14 of each period); 24 h after ingestion of the last set of markers, a plain abdominal X-ray picture was taken in the supine position. CTT was calculated as previously described [10]. As secondary endpoints daily stool frequency, and stool consistency and side effects were assessed using questionnaires. For assessment of stool consistency, a standardized stool protocol was used as depicted in figure 1 [11].

Calculations and Statistics

Data are presented as mean ± SD unless indicated otherwise. Transit times (segmental and total colonic transit) were compared between the treatment groups by analysis of variance using sex as a covariate. The level of significance was $p = 0.05$. Tests were performed using SPSS for Windows v15.0.

Results

Colonic Transit Time

The results on CTT are depicted in table 2 and figure 2. Yacon treatment induced a marked acceleration of CTT, $p < 0.001$. The effect was mainly due to an acceleration of transit in the right colon. There was no significant effect of gender on transit time.

Stool Parameters

Stool frequency with placebo averaged 1.1 (SD 4.2) bowel movements per day (range 0.6–2.4 bowel movements per day), whereas stool consistency according to visual scoring (fig. 1) averaged 2.7 (SD 0.7, range 1.5–4.0). Bloating measured as days with bloating was less than 1 day out of 14 days with placebo treatment (mean 0.87, SD

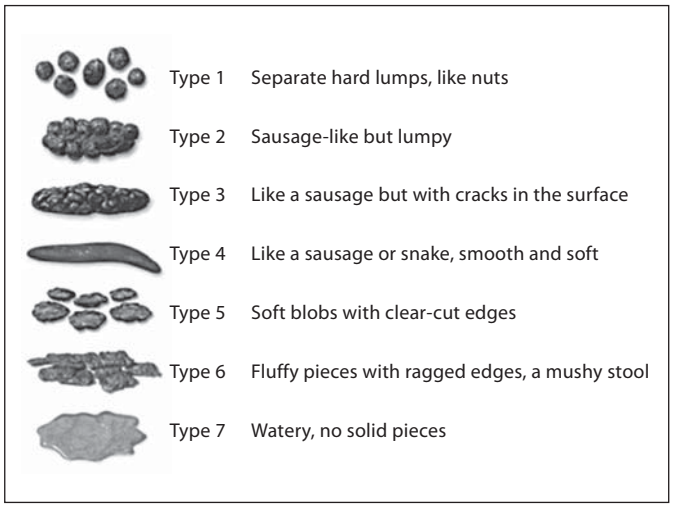

Fig. 1. Stool consistency as depicted by the Bristol Stool Form Scale [11].

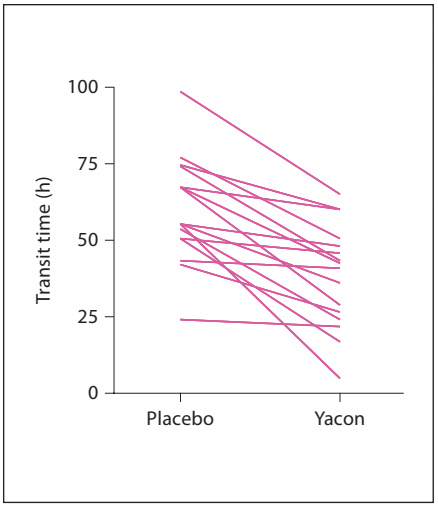

Fig. 2. Individual transit times during placebo versus yacon treatment. CTT was markedly accelerated in all 16 subjects.

Table 2. Effect of yacon on segmental and total transit time (h) in 16 healthy volunteers

	Placebo	Yacon	p value
Right colon	22.8 ± 4.0	10.5 ± 2.4	0.013
Left colon	24.0 ± 2.9	20.3 ± 3.1	NS
Sigmoid rectum	14.5 ± 4.1	9.6 ± 2.3	NS
Total CTT	59.7 ± 4.3	38.4 ± 4.2	0.001

Data are means ± SEM.

1.1; range 0–3). With yacon treatment, the mean stool frequency was slightly, albeit nonsignificantly increased from 1.1 to 1.3 (range 0.6–2.4; p = 0.17), as was the stool consistency, which marginally increased from 2.7 to a value of 2.8 (range 1.7–4.1; p = 0.48). The mean number of days with bloating was not significantly different between the two groups (placebo 0.87, SD 1.1; yacon 0.6, SD 1.0). The risk profile was excellent and no treatment-associated side effects were reported during the study.

Discussion

The results of the present study can be summarized as follows: in this placebo-controlled crossover study, yacon syrup in a dose of 20 g daily (equal to 6.4 g FOS) induced a marked acceleration of CTT in healthy volunteers as assessed by a radio-opaque marker technique. All subjects demonstrated a marked decrease in CTT. In addition, we observed a trend for slightly increased stool frequency and for softer stool consistency, although both parameters did no reach statistical significance.

Oligofructose is a dietary fiber with a potential for clinical application. FOS resists digestion by gastric acid and pancreatic enzymes in vivo. A key property of these fibers lies in the indigestibility of oligosaccharides, which gives rise to fermentation in the large intestine followed by an increase in Bifidobacteri and Lactobacilli. The process results in an increased short-chain fatty acid production (prebiotic effect). In 21 human subjects taking 6 g of FOS, the number of Bifidobacteri clearly increased within a week [12]. This property can induce several effects. First, normalization of stool frequency with an improvement of constipation [6, 13] has been reported, suggesting that FOS is acting as a laxative. Second, mineral absorption is increased, which leads to a rise in bone density [14–16]. Third, an immunomodulatory effect and a potential for cancer prevention have been postulated [5].

Through the stimulation of bacterial growth and production of short-chain fatty acids as a major product of bacterial fermentation, bowel habits are affected and FOS is acting as a laxative. A Taiwanese group conducted a controlled pilot study in 5 constipated subjects for twice 30 days [6]. In the 30-day period in which 10 g FOS was supplemented, defecation frequency, daily stool weight, and weight per individual stool were significantly augmented. In addition, calcium and phosphate levels in

plasma were increased. The authors concluded that supplementation of FOS was able to alleviate constipation in elderly men [6]. In the present study, we can document that FOS in the form of yacon syrup accelerates colonic transit; the findings form the basis for a controlled clinical evaluation of yacon in patients with constipation.

Yacon was well tolerated in the present study in healthy subjects and no severe side effects were observed. FOS at high doses can increase flatulence and osmotic pressure and therefore cause intestinal discomfort [3]. There was, however, no statistical difference in bloating scores between yacon treatment and control (molasses) in our study.

Further studies in constipated patients are needed to confirm the data of this preliminary study in healthy individuals. Dose-response relationships should be performed in constipated subjects and a probably higher dose than 20 g yacon daily needs to be tested for a more potent action as a laxative. Because yacon syrup has a low caloric content, constipated obese persons or diabetics would be an ideal target group. Beside the laxative effect of yacon, other effects such as the probiotic, calcium absorptive, cholesterol- and triglyceride-reducing effects as shown in animal models [13–16] should be investigated in human studies.

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