ELSEVIER

Nutrition 21 (2005) 308–311

NUTRITION

www.elsevier.com/locate/nut

Applied nutritional investigation

Effects of thickened beverages fortified with inulin on beverage acceptance, gastrointestinal function, and bone resorption in institutionalized adults

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Manuscript received March 24, 2004; accepted June 17, 2004.

Abstract

Objectives: We wanted to develop thickened beverages that contain soluble fiber (inulin) with acceptable consistency, taste, and texture and to determine the effects of these beverages on bone resorption markers (to determine calcium retention), bowel frequency, and indicators of gastrointestinal function in institutionalized adults bound to wheelchairs.

Methods: A double-blind, 3-wk, cross-over study testing 13-g/d inulin-fortified versus isocaloric standard modified starch-thickened beverages was conducted in institutionalized adults who were bound to wheelchairs and had dysphagia or did not have dysphagia. Beverage acceptability, as assessed by discriminative and descriptive sensory testing, bowel frequency, fecal output, and laxative use, were determined by direct testing or by nursing charts. Bone resorption was measured by using the urinary excretion of fasting calcium and of cross-linked N-telopeptides of collagen.

Results: Sensory panelists were unable to detect a difference between beverages thickened with modified starch and those fortified with inulin. Few differences were found between the control and inulin-fortified beverages for sensory descriptors. No significant difference was found in frequency of bowel movements between treatments; however, weighted bowel movement frequency increased by 13% with inulin ($P < 0.01$), whereas enema and laxative administration decreased by 13% ($P < 0.05$). Bone resorption, as an indicator of calcium retention, remained unchanged.

Conclusions: Inulin was incorporated into thickened beverages, with no decrease in acceptability; when consumed, perceived stool output increased in residents of long-term care facilities. © 2005 Elsevier Inc. All rights reserved.

Keywords: Dysphagia; Inulin; Calcium; Fiber; Laxatives

Introduction

A significant proportion of institutionalized adults have dysphagia and are unable to control the fast oropharyngeal transit of thin liquids and thus are provided with thickened liquids for hydration [1,2]. Consuming sufficient dietary fiber by institutionalized individuals with dysphagia may be a significant challenge because food intake may be marginal [3]. Thickened beverages may offer a possible vehicle for fiber supplementation. Although thickened beverages have traditionally been prepared with only modified starch [1], soluble fiber ingredients could provide texture modification and fiber enhancement [4].

Inulin, a polymer of fructose residues linked together with $\beta_{1\text{-}2}$ linkages and a single glucose unit at the terminus, is found in onion, leek, asparagus, garlic, chicory, and Jerusalem artichoke [5]. Inulin, extracted and purified from the chicory root, is sold as a food ingredient in two major formats, long-chain viscous inulin (5 to 50 fructose units) and short-chain inulin, known as fructose-oligosaccharide

This study was supported by the Canadian Foundation of Dietetic Research. Study beverages were supplied by Private Recipes Ltd., Brampton, Ontario, Canada. Inulin was provided by Frank E. Demsey and Sons, Toronto, Ontario, Canada.

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0899-9007/05/$ – see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1016/j.nut.2004.06.025

(<10 fructose units) or oligofructose (2 to 4 fructose units) [6]. Because inulin is easily dispersed in water, it has potential as a fiber source in beverages [4,7]. Intake of inulin in the U.S. diet has been estimated at 1 to 5 g/d [8]; however, the acceptable daily intake is estimated to be 40 g/d [9].

Like other dietary fibers, inulin does not undergo digestion in the small intestine. Instead, inulin passes into the colon, where bacteria metabolize it for energy through anaerobic fermentation that produces short-chain fatty acids and intestinal gases [10]. Inulin is the preferred substrate for bifidobacteria, which are classified as prebiotic [5]. Consumption of inulin has been shown to increase the fecal levels of bifidobacteria [11]. Inulin has also been found to contribute to fecal bulking [12,13].

Many dysphagic individuals are also bound to wheelchairs and develop bone loss due to inactivity that can lead to greater disability throughout adulthood. Therefore, the potential effect of inulin on calcium retention in this population is of interest. Soluble fiber undergoes fermentation that produces volatile fatty acids that may facilitate mineral absorption [10]. Coudray et al. [14] reported that adding 40 g/d of inulin in the diets of adults improved the absorption of calcium but not of magnesium, and that calcium absorption was improved without a change in calcium excretion, suggesting calcium retention. A more recent study indicated a sustained benefit of inulin on calcium absorption in women in late but not early menopause [15]. In a double-blind, cross-over study in 10 adult patients with ileostomy, Ellegard et al. [16] found no effect of 17 g/d of inulin or short-chain oligofructose on calcium absorption. However, they used urinary excretion of calcium as their only measurement of retention. A positive effect of oligofructose or inulin is seen primarily in adolescents or menopausal women who have a greater requirement for calcium. Thus, oligofructose may improve calcium retention in situations where calcium retention is needed, as it would be in wheelchair-bound adults.

Our hypothesis was that inulin, provided through thickened beverages, would result in acceptable thickened beverages that, when offered daily, would improve gastrointestinal functioning (as demonstrated by bowel frequency and laxative use) in institutionalized wheelchair-bound adults. In addition, we sought to determine whether daily inulin would decrease bone resorption (due to improved calcium retention as a consequence of improved calcium absorption) in these patients.

Materials and methods

Standard 125-mL thickened orange, apple, and cranberry juices, with and without inulin, were commercially produced by Private Recipes Limited (Brampton, ON, Canada). Juices were thickened with modified starch (Ultrasperse, National Starch, Indianapolis, IN, USA) in control beverages and with modified starch and 3 g of inulin (Fruitifit Inulin IQ, Sensus Inc., Roosendaal, The Netherlands) in treatment beverages to achieve a pudding-like, spoon-thick consistency. Viscosity of 400-mL samples of thickened beverages was determined with a Brookfield viscometer with spindle 5 at 30 rpm (Model DV-111, Brookfield Engineering Laboratories of Middleboro, MA).

Ethical approval was obtained from the University of Saskatchewan committee on human experimentation (biomedical). A panel of 20 consenting university students and staff completed triangle tests and “simple-preference” tests [17] on control and inulin-fortified thickened orange and apple juices. Fifteen wheelchair-bound institutionalized adults volunteered to compare inulin-fortified with control thickened beverages using the simple-preference method of sensory evaluation [17]. A sensory questionnaire using a five-point Likert scale was completed by both sets of subjects for sweetness (5 = very sweet, 1 = not sweet at all), flavor (5 = strong apple flavor, 1 = tasteless), mouth coating (5 = very mouth coating, 1 = no mouth coating), mouth wetting (5 = very moist, 1 = drying), and overall liking (5 = liked very much, 1 = not liked at all).

A double-blind, 3-wk, cross-over study compared the physiologic effects and acceptance of 15-g/d inulin-fortified versus standard modified starch-thickened beverages. Fifteen wheelchair-bound (10 with dysphagia and 5 without dysphagia) institutionalized adult subjects younger than 60 y who resided in a long-term care facility were recruited (Table 1). Subjects were randomized to consume each type of thickened beverage, one for 3 wk followed by the other, in a cross-over fashion. The maximum amount of inulin (15 g/d) or corresponding control was given in five 125-mL beverages. Weighed intakes of thickened beverages were carried out. Chart records were used to determine baseline and treatment bowel frequencies and laxative administrations. Chart notes indicating size of output (small = weighting of 1, medium = weighting of 2, large = weighting of 3, extra large = weighting of 4, extra extra large = weighting of 5) were used to determine weighted bowel movement frequency. Interviews with study subjects were carried out to monitor beverage acceptability and gastrointestinal tolerance of inulin supplementation.

Duplicates of fasting morning urine samples were collected from 13 subjects on 2 d in week 2 of the control and treatment weeks. One subject was omitted from urine analysis because the amount of urine collected was very small. Urine was immediately frozen and subsequently analyzed for calcium by a colorimetric assay (Calcium Reagent Kit 1250-125, DMA Inc., Arlington, TX, USA), sodium and potassium by flame photometry (Corning Flame Photometer 410, Corning Medical and Scientific, Corning, NY, USA), and N-telopeptides of type I collagen (NTx; Osteomark, www.ostex.com). The latter analysis was preformed at the Department of Human Nutrition, University of Manitoba; the intra-assay coefficient of variation was 7%. NTx is a

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