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Research report

Enrichment of biscuits and juice with oat β-glucan enhances postprandial satiety ☆

Saara Pentikäinen [a,*], Leila Karhunen [b], Laura Flander [a], Kati Katina [a], Alexandra Meynier [c], Pierre Aymard [c], Sophie Vinoy [c], Kaisa Poutanen [a,b]

[a] VTT Technical Research Centre of Finland, P.O. Box 1000, 02044 VTT, Finland
[b] Department of Clinical Nutrition, Institute of Public Health and Clinical Nutrition, University of Eastern Finland, 70211 Kuopio, Finland
[c] Mondelēz International – R&D, 6 rue Razel, 91400 Saclay, France

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ABSTRACT

Effects of fibre and β-glucan on satiety have been reported in many studies, but no consensus has been reached. The aim of this study was to examine the effects of breakfasts varying in the dose of oat bran (4 g or 8 g β-glucan). The approach was to study whether the food matrix (solid or liquid) into which the oat bran is incorporated influences postprandial satiety in otherwise similar meal settings. Thirty healthy females were offered four different breakfasts: biscuits + juice (0 g β-glucan), enriched biscuits + juice (4 g β-glucan), biscuits + enriched juice (4 g β-glucan) and enriched biscuits + enriched juice (8 g β-glucan) in a random order on separate test days. The sensations associated with hunger and satiety were evaluated using visual analogue scales (VAS) before and after ingesting the test breakfasts and every 30 min until 210 min. Oat bran addition in breakfasts increased postprandial satiety especially when both juice and biscuits were enriched (8 g of β-glucan). Addition of oat bran to juice enhanced satiety and related feelings more effectively than the addition into biscuits.

Introduction

Adequate dietary fibre consumption provides extensive health benefits, including beneficial effects on GI function, lipid metabolism and body weight regulation (Ye, Chacko, Chou, Kugizaki, & Liu, 2012; Slavin & Green, 2007; Slavin, 2005). β-Glucan is a major constituent of grain fibres, abundant especially in barley and oats. It consists of glucose molecules bound to each other with β-(1 → 4) and β-(1 → 3) linkages (Barsanti, Passarelli, Evangelista, Frassanito, & Gualtieri, 2011). β-Glucan exhibits high viscosity at relatively low concentrations (1%) (Sadiq Butt, Tahir-Nadeem, Khan, Shabir, & Butt, 2008). Viscosity in the lumen of the gut is suggested to be important for the physiological properties of β-glucan (Wood, 2007). The benefits of β-glucan on health, including improvement of cholesterol and glucose metabolism, are well known (EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 2011; Food and Drug Administration, HHS, 2002). In addition, β-glucan has been proposed to contribute to enhanced satiety. Enhanced satiety offers many potential benefits to consumers with weight management goals (Hetherington et al., 2013). Reductions in perceived deprivation during energy restriction, improved compliance with healthy eating and mood benefits have been suggested.

In one recent review on the effects of dietary fibre intake on appetite, energy intake and body weight and in another concerning dietary fibre and satiety, it was concluded that different dietary fibres have different effects on appetite and acute energy intake (Wanders et al., 2011; Slavin & Green, 2007). According to these authors, more viscous fibres efficiently reduce appetite. This is suggested to be a consequence of increased exposure time in the oral cavity, greater water holding capacity and subsequently increased stomach distension and gastric vagal signalling due to delayed gastric emptying as well as increased release of appetite-regulating peptides throughout the intestine (Wanders et al., 2011).

The ability of oat bran to enhance subjective postprandial satiety has been studied in different experimental settings (Beck, Tosh, Batterham, Tapsell, & Huang, 2009; Hlebowicz, Darwiche, Bjorgell, & Almer, 2008; Juvonen et al., 2011; Lyly et al., 2009, 2010). The results have been mixed. In the first three studies the results showed positive effects on satiety, whereas in the last two β-glucans had no significant effect on satiety. In a study by Beck et al. (2009), varying doses of β-glucans (2.16; 3.82; 5.45 and 5.65 g per serving) in extruded breakfast cereals increased fullness significantly as compared to a control product with no β-glucans. However, there were only trends but no significant differences in other scores (hunger, satiety, prospective food consumption). Similarly, in a

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* Corresponding author.
E-mail address: saara.pentikainen@vtt.fi (S. Pentikäinen).

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study by Lyly et al. (2009), a beverage with 30 g of oat bran (about 5 g of β-glucans) induced a significant effect on fullness compared to control beverage, but there were only insignificant trends in other hunger- and satiety-related scores.

Lyly et al. (2010) also compared beverages at two energy levels (700 kJ and 1400 kJ) and with different fibre contents (0, 5 and 10 g dietary fibre containing 0, 2.5 or 5 g β-glucans, respectively). Among the beverages with 700 kJ, both fibre-containing beverages decreased hunger and increased satiety as compared with the non-fibre control. The fibre content did not make a difference. The significant effect of the highest amount of dietary fibre (10 g) on increased satiety and decreased hunger was similar at the two energy levels. Juvonen et al. (2011) compared postprandial appetite ratings after eating puddings with added oat bran (30 g) or wheat bran (19 g) or with no added fibre. They observed no significant difference in appetite ratings. Hlebowicz et al. (2008) also observed no significant effects of β-glucans on satiety. In their study, β-glucans (4 g) were added to muesli that was eaten with vanilla yoghurt.

It has been observed that the textural properties of foods also affect satiation and satiety (de Graaf, 2012). Solid foods are more satiating than liquids even if the energy and macronutrient contents are the same. It has been suggested that the effect of texture on satiety is mediated by the oral residence time of food in the mouth, meaning that foods that need more oral processing spend more time in the mouth and induce a stronger cephalic phase response, which in turn could contribute to greater satiety (de Graaf, 2012). This interpretation supports the idea of fibre-enriched solid food as a potential enhancer for satiety, as potentially more chewing would be needed. On the other hand, food matrix influences the fibre hydration rate, which may be an important factor determining satiety response (Wanders et al., 2011). High water content favours hydration, suggesting that liquid food matrix would enhance the effect of fibre on satiety.

The current study examined the satiating effect of oat bran-enriched biscuits and/or juice consumed as part of a breakfast. The specific aims of the study were to evaluate: (1) the dose–response effect of oat β-glucans (0, 4, 8 g per breakfast) and (2) the influence of food matrix (solid or liquid) enriched with oat bran on perceived satiety in healthy, lean women. We hypothesised that addition of oat bran in juice or biscuits would enhance satiety compared to the control breakfast, and that addition of oat bran in juice would be more effective than addition of oat bran in biscuits. Furthermore, we hypothesised that addition of a double dose of oat bran would further enhance satiety.

Methods

Participants

30 Females were recruited to the study through advertising and email lists from universities and polytechnics in the Espoo region. To participate, candidates had to be of normal weight and in the habit of eating breakfast. Exclusion criteria were overweight (BMI > 25), underweight (BMI < 18.5), restrictive diet or remarkably restrained eating patterns (cognitive restraint score over 15 in the Three Factor Eating Questionnaire) (Stunkard & Messick, 1985), physical or mental illness or medication likely to interfere with metabolism or dietary habits, food allergies relevant to this study, pregnancy or lactation, participation in another clinical trial, general anaesthesia in the month prior to the study, significant changes in body weight (±4 kg) during the previous year and regular smoking. The baseline characteristics of the participants are shown in Table 1. The participants gave written informed consent to their participation in the study. Ethical approval was obtained from the Ethics Committee of the Hospital District of Helsinki and Uusimaa.

Procedure

This was a crossover, single blind study. Each participant tested four different breakfasts on four separate days. The order of the test breakfasts was randomized. There were at least two washout days between two consecutive study visits. The participants were instructed to follow their usual eating and exercise habits and to avoid alcohol consumption during the day preceding each study visit. They were also instructed not to smoke in the morning before and during the visits.

The participants came to the study visits in the morning between 7 and 9 a.m. after a minimum of 10 h fast. They were instructed to drink a glass of water in the morning before the study visit if they were thirsty. The four test breakfasts were presented to each participant in a random order. Participants were instructed to eat the test breakfast at their own pace but not to spend more than 10 min on eating. The participants evaluated their sensations before eating (T0) and repetitively after eating the breakfast.

The participants were familiarised with the study procedure at a visit preceding the beginning of the actual study. During this initial visit the subjects were trained to use the rating scales with a test breakfast containing white wheat bread and juice as the test products. In addition, baseline measurements (weight, height, blood pressure, heart rate, and waist circumference) were made to confirm the suitability of the participants for the study.

Satiety ratings

The satiety-related sensations were evaluated using 10 cm visual analogue scales (VAS), as recommended by Blundell et al. (2010). The evaluated sensations were *hunger, fullness, satiety, desire to eat and prospective food consumption* (“How much would you be able to eat right now?”). In addition, the ratings of the *thirstiness* and *pleasantness of the test breakfast* were included in the ratings. Evaluations were made before and after ingesting the breakfast and every 30 min until 210 min after breakfast consumption. Pleasantness of the test breakfast was evaluated only once, immediately after ingestion. The VAS scores were collected by using a computerised data-collecting system (CSA, Computerised Sensory Analysis System, Compusense, Guelph, Canada, Compusense five 5.2). The areas under the curves (AUC, cm × min) were calculated for describing the overall changes in the sensations during the 210 min follow-up period. Average appetite (Average appetite = [desire to eat + hunger + (10-fullness) + prospective food consumption) was calculated according to Anderson, Catherine, Woodend, and Wolever (2002) in order to provide a general view of desire to eat, hunger, fullness and prospective food consumption. Eating times were assessed by giving the participants timers and asking them to mark down the time spent on eating.

Test products

Test breakfasts consisted of biscuits and juice. There were two kinds of biscuits: normal wheat biscuits (“biscuits”) with no β-glucan and oat bran biscuits (“enriched biscuits”) with 5.1 g of β-glucan per 100 g). The average weight of one biscuit was 13 g. Oat bran concentrate (Oatwell22, CreaNutrition) was added to the dough in order to provide the targeted amount of β-glucan in enriched biscuits.

Similarly, there were two kinds of juices: normal orange juice (“juice”) and orange juice with added oat bran having high β-glucan content (“enriched juice”). Normal juice consisted of 55% orange juice and 45% water and contained no β-glucan.