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Effect of Oat-Based Ready-to-Eat 70 g Break-Fast on Appetite Control, Satiety and Perspective Food Intake Versus 55 and 35 g: A Randomized, Crossover Study

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Abstract: Aim of the study was to establish the impact of most widely sold oat-based ready-to-eat breakfast cereal (RTEC) currently provided in different portions on appetite control until lunch. Thirty healthy participants (16 males and 14 females) were involved in a randomized double blind crossover study. Mean age -39 ± 13.5 ; normal body mass index -22.3 kg/m^2 . Female subjects also completed a menstrual cycle questionnaire so that breakfast test days would fall within the luteal phase of the menstrual cycle. Participants kept records on amounts of food intake during the entire study period. The diet of the subjects was monitored throughout the entire survey process. The subjects had to eat in the usual way and not make any dietary changes. The subjects over a 9-day period daily consumed different RTEC breakfasts varied in dry weight (70, 55, 35 g). These different breakfast foods were selected randomly and taken for 9 consecutive days at the same time. Visual analog scales for appetite measurements were administered before breakfast at 07:00 and repeatedly until 12:00 before lunch. Paired t-tests were performed for comparison of appetite ratings between different products. This study showed that 70 g of RTEC versus 35 and 55 g reduced hunger, increased sensation of fullness, decreased desire to eat and satisfaction after meal were significantly prolonged and greater in every time point ($p < 0.05$). It is concluded that 70 g of RTEC is an appropriate portion to effectively increased satiety, subsequent decreased hunger and desire to eat up to 4 h after consumption.

Key words: Cereal, visual analog scale, ready-to-eat, satiety

INTRODUCTION

It's well known that obesity is at the focus of many public health efforts (Ogden *et al.*, 2014). The prevalence of obesity remains high and it is still 3 times greater than in 1980 (Ogden *et al.*, 2014; Hennekens and Andreotti, 2012). Relationship between the global food system and the worldwide rapid increase of obesity and related diseases is not well understood yet. The reason is that the full impact of industrialized food processing on dietary patterns remains overlooked and underestimated (Monteiro *et al.*, 2013). There is a relationship between increased snacking 'in-between meals' and obesity (Monteiro *et al.*, 2013). The decision to eat often arises as a consequence of appetite as opposed to the need for energy and the chronic energy imbalance can cause obesity risk (Rebello *et al.*, 2013). Oats are a uniquely nutritious food as they contain an excellent lipid profile and high amounts of soluble fibre beta-glucan known to affect appetite and prevent chronic energy imbalance from overeating of high caloric food (Decker *et al.*, 2014; Beck *et al.*, 2009).

The global economy and open worldwide market trade policies have increased the availability of various fast food products, resulting in a wide variety of oat based ready-to-eat commercial breakfast cereals classified as

"high fibre" and low in energy density (Falcon-Villa *et al.*, 2014; Enwere and Ntuen, 2005; McMackin *et al.*, 2013). Oat flakes often used in the production of breakfast cereals can be the effective part of diet strategy, increasing portions of foods low in energy density rather than limiting portions of all foods (Rolls, 2014). For this day it is shown that if people lower the energy density of their diet, they can eat satisfying portions while still managing their body weight (Rolls, 2014).

Soluble and insoluble fibres, amino acids, minerals and vitamins found in significant amounts in oat kernels, exhibit a high viscosity at relatively low concentrations (Sadiq *et al.*, 2008). Variations in the source, processing procedures, manufacture of a product and interactions with other constituents in the food matrix affect the amount, molecular weight, solubility and structure of the beta-glucan in the products (Skendi *et al.*, 2003). This impacts the differences on functionality of beta-glucan from one product to another. Nevertheless, scientific research results show that in the composition of unprocessed or slightly processed oats, beta-glucans make up the major part of fibrous substances-approximately 3-6% of dry oat weight (Kale *et al.*, 2013). Therefore, irrespective of different nutrient composition of RTEC cereals selected by us, we have surmised that

namely dry matter content in the cereal will have the most significant influence on the sensation of fullness, not a greater quantity of fats, carbohydrates or sugar. The satiating effect of carbohydrates is determined by the type and form of carbohydrate.

Some studies also have shown that the higher protein quality breakfast significantly influenced fullness in various food products, therefore, in order to verify whether the protein content in cereals has the slightest effect on the subjective evaluation of sensation of fullness, we, having analyzed composition of cereals provided by manufacturers, selected those, in the composition of which there were different contents of proteins (Bayham *et al.*, 2014).

It is not surprising that oats due to their unique composition for a long time have been considered one of the best options to choose for a full and healthy breakfast. Fewer calories and enhanced sensation of fullness assist you in your body weight managing or prevention of chronic non-communicable diseases, such as asthma, diabetes and metabolic syndrome (Davy *et al.*, 2002; Virtanen *et al.*, 2010; Lammert *et al.*, 2008). Despite the light of the potential health benefits, fibre intakes in developed countries are generally still below those recommended by relevant authorities (Yuan *et al.*, 2014; Stevenson *et al.*, 2012; Popkin, 2006). Since in recent years, manufacturers have been developing and selling various popular oat-based RTEC products "conferring fullness until lunch", there is a growing need to determine the real impact of different quantities of these products on human appetite control. The aim of this study was to establish the impact (and identify the amount of cereals that would be optimal for breakfast) of most widely sold oat-based ready-to-eat breakfast cereal (RTEC) currently provided in different portions on greater appetite control until lunch, satiety and perspective food intake.

MATERIALS AND METHODS

Subjects: Thirty healthy subjects (16 men and 14 women) desk workers were enrolled in a study. All subjects participated in an initial screening that involved the measurement of body weight, height, waist and hip circumferences, vital signs (blood pressure, pulse rate). Questionnaires related to dietary restraint (Eating Inventory) (Stunkard and Messick, 1985), which have been used extensively to measure individual variability in eating behavior (Chambers and Yeomans, 2011), were completed to exclude restrained eaters. Also, all subjects had completed the approved International Physical Activity Questionnaires, so that their activity would be monitored throughout a day. Female subjects also completed a menstrual cycle questionnaire so that breakfast test days would fall within the luteal phase of the menstrual cycle (Dye and Blundell, 1997).

Criteria for inclusion: mean (age 39 ± 13.5); normal body mass index (BMI) ($22.3 \text{ kg/m}^2 \pm 1.8$); regular eating habits according to questionnaires (consumption of breakfast, lunch, dinner daily according to eating inventory). All participants signed a written informed consent. Exclusion criteria: an allergy or intolerance to oats; fasting glucose 4-6 mmol/l; intake of medicine likely to affect appetite or food intake; any medical condition involving the gastrointestinal tract; eating disorder; smoking; consumption of greater than three cups of coffee per day; change of body weight by more than 10% three months prior to screening; consumption of any specific diet such as vegan or vegetarian; pregnancy, lactation or wish to become pregnant during the study period. All participants met the criteria listed above and the health parameters were within the reference intervals.

Study design: The subjects over a 9-day period daily consumed different RTEC breakfasts varied in dry weight (70, 55, 35 g). These different breakfast foods were selected randomly and taken for 9 consecutive days at the same time. Breakfasts were prepack in identical white on the go cups with the given specific code (A, B or C). On each test day participants randomly received one of three combinations of RTEC: the combinations were referred to as A, B or C and were eaten in a randomized order during each test day by each subject. The day prior to each test day the participants were instructed: not to conduct any exercise or drink any alcoholic beverages and take no medications. The subjects were requested to avoid eating and drinking after 19:00 and to eat a similar type and amount during all day after breakfast, not to alter the usual amount of food portions, followed the same meal time mode every test day. During the entire study the only dietary change was the randomly chosen different (A,B,C) morning breakfast cup. All subjects had been fasting for 12 h. The breakfast was provided to eat at home at 07:00 meal and had to be entirely consumed. Electronic 100 mm visual analog scales (VAS) (Flint *et al.*, 2000) were administered shortly before breakfast at 07:00 and then repeatedly every half hour from 08:00 and thereafter hourly from 10:00 until 12:00 before lunch at 12:15. Visual analog scales were scored by the computer on a 0 to 100 unit scale and the score was sent directly to the database.

Hunger, fullness, stomach fullness, desire to eat and prospective intake were assessed. Satisfaction, which introduces a hedonic component into the measurement of satiety, was included to determine whether satiety measures were judged from a comparable baseline during the repeated testing (Rebello *et al.*, 2013). During each day of the study the subjects were restricted to low-level activities at the day work routine. After work at 17:00

the subjects provided to have an afternoon snack and were instructed not to eat anything until 19:00. The subjects were allowed to consume food freely but were instructed to carefully record amounts of food intake and type of foods eaten until breakfast the day before and during entire study period. We asked the participants to eat in the usual way during the survey and not change their usual diet; the subjects kept records on food consumed before breakfast and after it.

Breakfast meals: The test breakfasts contained ready to eat whole grain cereals: A-70 g 281 kcal raspberry flavor, B-55 g 213 kcal strawberry flavor and C-35 g 113 kcal raspberry flavor served as a hot oat porridge. A nutrient analysis of breakfasts per portion is presented in Table 1. All RTEC meals were prepared by adding the same 150 ml amount of hot water and were eaten after 5 to 10 min.

Statistical analyses: Statistical analyses were conducted using SPSS version 22.0. A significant difference between the compared values was indicated when the error did not exceed 5% ($p < 0.05$). Paired t-tests were performed for comparisons of appetite ratings between different products. The data were processed by non-parametric Friedman test revised and estimated by Wilcoxon test.

RESULTS

Intake of the test meals: All thirty subjects finished the breakfast meals completely according to instructions. There were no adverse events and no one had problems finishing the test meals.

Subjective appetite measures: At each test day before breakfast participants rated their appetite similarly. That is, there was no significant difference for the mean rated hunger, satiety or desire to eat at baseline between the nine test days. The mean values at each day after breakfast showed a clear impact of time. A comparison among the RTEC meal A (35 g), B (55 g) and C (70 g) shows that the reduction in hunger was significantly greater after consuming 70 g of RTEC breakfast compared to the 35 g and 55 g at each time point between 08:30 and 12:00. At 8:30 ($p < 0.05$), between 9:00 and 12:00 ($p < 0.05$) (Fig. 1a). No statistically significant changes were found between comparisons of 35 and 55 g RTEC.

Increase in the sensation of fullness (Fig. 1b) was significantly greater after consuming 70 g of RTEC compared to the 35 g and 55 g at each time point between 08:30 and 12:00. At 8:30 RTEC of 70 g versus 55 g ($p < 0.05$) and 70 g versus 35 g ($p < 0.05$), between 9:00 and 12:00 70 g versus 55 and 35 g significant change remained the same ($p < 0.05$).

Table 1: Energy and nutrient content of breakfast meals

	70 g	55 g	35 g
	RTEC meal*		
Kilocalories	281	213	130
Fat (g)	6.0	6.11	1.89
Saturated fatty acids (g)	2.2	2.92	0.39
Protein (g)	7.2	5.67	4.2
Carbohydrates (g)	49.6	30.75	22.75
Of which sugars (g)	14.3	12.43	7.35
Fibre (g)	5.7	6.11	3.15
Salt	0.8	0.33	0.46

*All additional foods were obtained from a local store. Values are calculated from manufacturer's standard values

Reduction in the desire to eat represented at Fig. 3c was significantly greater after consuming 70 g RTEC versus 55 and 35 grams. At 8:30 RTEC of 70 g versus 55 g ($p < 0.05$) and 70 g versus 35 g ($p < 0.05$), between 9:00 and 12:00 70 g versus 55 and 35 g significance was the same ($p < 0.05$).

The responses to how satisfied the subjects felt were significantly different as depicted in Fig. 1d, between the 70 g versus 55 g and 35 g breakfast meals. At each time point between 8:30 and 12:00 after consuming 70 g RTEC breakfast statistical significant change was the same ($p < 0.05$). No statistically significant differences between sensation of hunger of male and female representatives have been found.

DISCUSSION

In the past few years various monitoring programs for determination the impact of changes in food environment on health outcomes, such as obesity, have increasingly been developing (Ni Mhurchu *et al.*, 2013). It was found that the whole grain contribute to the health benefits associated with the consumption of whole grain cereal products, including reduced risk of obesity, type 2 diabetes, cardiovascular disease and colorectal cancer but, despite this, the research in positive effects on health, consumption of whole grain foods in some countries is insufficient (Fardet, 2010; Lafiandra *et al.*, 2014; Belobrajdic and Bird, 2013).

Ready to eat oat porridge is one of the most available fast food products on today markets. Manufacturers usually promote the use of these products on the basis that they are healthy and saturated. Some studies have shown that regular consumption of healthier ready-to-eat cereals which are enriched with protein and extra fibres was effective in lowering cholesterol (Ni Mhurchu *et al.*, 2013; Ogden *et al.*, 2014; Ortinou *et al.*, 2014).

Besides some positive effects of regular consumption of ready-to-eat cereals nutrient comparison of three ready to eat oat porridges in our study have shown that the highest dietary protein amount was in 70 g of RTEC-7.2 g compared to 5.67 g in 55 g and 4.2 g in 35 g porridge (Table 1). Furthermore, RTEC porridge, as low energy dense food, confirmed by two well-established dietary

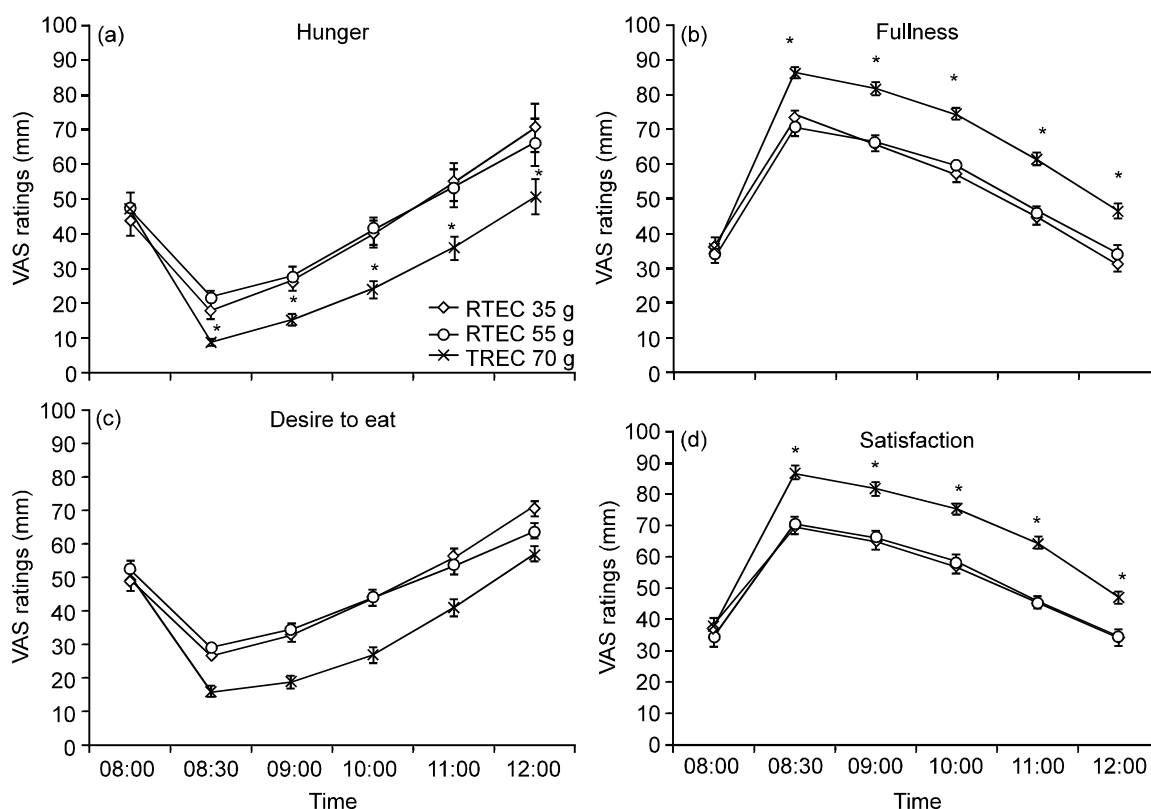


Fig. 1: Visual analog scale ratings (n = 30) before and after consumption of 35, 55, 70 g of RTEC.*denotes significance between 70 g versus 35 g and 55 g RTEC (p<0.05)

factors that consistently can have impact on appetite control, satiety and/or reduce daily food intake (Ortinou *et al.*, 2014; Rebello *et al.*, 2013). Although we have not evaluated blood glycemic response after the breakfast, some pieces of research point out that the inclusion of oat bran into the various food products appeared to extend the glycemic response of individuals compared to the control foods. This positive expression suggests a possibility of prolonging glucose release and potentially affects satiety responses' impact on oxidative stress or inflammation as well (Brennan *et al.*, 2012; McGeoch *et al.*, 2013). The positive effect without the side effect of oxidative stress in attenuating glucose response shows that fibre combined with an optimal food portion size could be a target for inclusion in daily food industry to effectively manipulate postprandial glucose response and satiety of individuals as well (McGeoch *et al.*, 2013; Fisher *et al.*, 2015).

The inconsistent findings of healthier fast food involve in regular eating inventory and its impact on participants' health and satiety may be attributed to the differences in portion size, macronutrient content, energy content and energy density. Rapid growth and expansion of fast and healthier food industry raises concerns over the influence of different portions of food not only on objective sensation of fullness, but also on the

subjective one, because, as research shows, (de Vet *et al.*, 2015) if a person has not experienced sensation of fullness and is slightly hungry, he or she will tend to snack and overeat throughout the day and especially in the evening. These "frequent" snacks and overeating may lead to metabolic disorders, overweight or even obesity.

The results obtained by us and other authors (Beck *et al.*, 2009) allow us to maintain that even consumption of instant breakfast cereals positively influences the sensation of fullness foods with less energy value to compare with usual breakfast allow having sensation of fullness for up to 4 h. In our view, the measured portions can be perfect fast food alternatives if you want to have fuller and healthier meals and not spoil your healthy diet plans. Certainly, each cereal product is unique in terms of its composition, nutrient and energy values and content and influences differently the sensation of fullness. VAS scales used during our survey reflected subjective sensations of the subjects and allowed us to show the effect of different portions of three cereal types most popular in the Baltic States market on a person's sensation of fullness.

Our study showed that the consumption 70 g portion of RTEC porridge led to the most efficient reductions in hunger before lunch. RTEC breakfast resulted in a

greater increase in perceptions of fullness and a greater decrease in perceptions of hunger, desire to eat and prospective intake in the 4 h period postprandial compared with the 35 and 55 g portions. The current amount of 55 and 35 g does not reduce hunger efficiently and cannot replace a full-fledged breakfast and may lead to an increased snacking in-between meals.

Limitation: This study had some limitations. We sought to compare the satiety effects following the consumption of most commercially-available in our region, commonly consumed breakfast RTEC porridges. In using this approach, we were unable to tightly control macronutrient quantity and quality. Some studies also have demonstrated greater reductions in hunger and/or greater increases in satiety following the consumption of complex versus simple carbohydrates and saturated versus polyunsaturated fatty acids consumption (Aller *et al.*, 2011; Kozimor *et al.*, 2013). Other limitations include the limited assessment of only including perceived sensations of hunger and satiety in normal weight, adult.

Conclusion: This study has shown that 70 g is the appropriate portion of ready to eat breakfast based on whole grain oat flakes served as a hot porridge. It increased satiety effectively, decreased hunger and desire to eat up to 4 h subsequently after consumption.

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