



Subjective feelings of appetite of wholegrain breakfasts evaluated under controlled, laboratory and ‘at home’ conditions



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ABSTRACT

Background: Appetite regulating properties of foods are usually investigated under laboratory conditions, whereas in real life, foods are consumed under at home conditions. The objective of this study was to compare the acute effects of breakfasts when tested in a laboratory condition and in an at home condition. Appetite regulating properties of two bread breakfasts and two cereal breakfasts were also compared.

Subjects and methods: In this randomized cross-over trial balanced for laboratory and at home test conditions, thirty-two women consumed five breakfasts, i.e. two bread breakfasts, two cereal breakfasts and one fried-egg breakfast. Visual analogue scales for measuring appetite were captured via an on-line scoring system and were analyzed as incremental area under the curve, as satiation phase and as satiety phase.

Results: Location effects were limited to two small effects only. An overall location effect in hunger feelings was observed ($p = 0.040$), which occurred specifically during the short satiation period ($p = 0.0002$) where hunger feelings scored higher under laboratory conditions. Similarly, a location effect was observed for desire to eat ($p = 0.001$); this was again higher under laboratory conditions. No other location effects were observed.

Bread breakfasts did not differ in their appetite regulating properties. The Steel Cut oatmeal breakfast was reported to be more satiating ($p = 0.001$) as compared to the ready-to-eat cereal.

Conclusions: Whereas the five breakfasts varied somewhat in their appetite regulating properties, evaluation under laboratory conditions overall did not result in different appetite scores compared to the at home conditions. This suggests that at home testing may be a useful alternative to laboratory test conditions for nutrition research.

1. Introduction

The prevalence of obesity continues to rise worldwide. By 2025, global obesity prevalence is predicted to reach 18% in men and exceed 21% in women; severe obesity ($> 35 \text{ kg/m}^2$) is predicted to surpass 6% in men and 9% in women [1]. Obesity is associated with higher all-cause mortality in four continents [2]. Strategies to combat the entire spectrum of excess adiposity in many populations are needed.

Prospective epidemiological studies demonstrate that a higher intake of whole grains is associated with lower BMI and body weight gain [3]. As such, whole grain may play a role in reducing early mortality outcomes [4,5], which has been reported in various prospective

observational studies [6]. In contrast with epidemiological evidence, however, clinical trials do not always confirm that a whole grain low-calorie diet is more effective in reducing body weight than a refined cereal diet [7]. In separate studies, whole grain breads and oatmeal were shown to increase subjective feelings of appetite and other satiety measures as compared to refined grains, but with beneficial effects on subsequent energy intake observed with the latter, but not the former [8,9]. In addition, the way in which whole grains are processed can greatly impact their effects on subjective feelings of appetite. Rebello et al. demonstrated that the less processed oatmeal provided greater viscosity leading to higher feelings of fullness, lower feelings of hunger [10, 11, 12], and less calories consumed at the subsequent meal than

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Table 1
Energy content (kcal) and macronutrient composition (amount (grams (g)) and energy percentage (en%)) of the breakfasts.

Breakfast	Picture (lab)	Energy		Fat		Protein		Carbo-hydrates		Mono- & disaccharides		Fiber	
		Kcal	g	en%	g	en%	g	en%	g	en%	g	en%	
Bread (yeast) (B1)		328	11.2	31	11.1	14	42.1	51	2.2	3	7.4	5	
Bread (sourdough) (B2)		331	10.9	30	11.1	13	43.6	53	1.9	2	7.0	4	
Steel cut oat (Quaker™) (B3)		371	4.5	11	19.5	21	59.8	64	17.8	19	6.7	4	
Cheerios™ (B4)		396	5.3	12	18.6	19	64.7	65	16.9	17	7.5	4	
Fried-egg (B5)		278	9.8	33	11.1	17	33.1	49	17.5	26	1.4	1	

Breakfast B1 and B2 were prepared by the Netherlands Bakery Center and differed in fermentation procedure; Breakfast B3 and B4 were breakfast products from PepsiCo, Inc. and contained cereals; B5 was a traditional, standardized breakfast. See for further details of the breakfasts in the Methods section.

the isocaloric oat-based ready-to-eat cereal [10].

Appetite regulating properties of foods and meals like breakfasts [13] are being investigated extensively [14]. Humans do, however, not only eat in response to satiating sensations; they also respond to other internal, external and social signals (cues). In that context, free-living and/or at home studies may provide improved external validity as compared to laboratory studies [15], because free-living studies take the habitual cues into account [16,17]. In addition, studies performed at home may be cheaper to perform and more people may participate because of easy accessibility, further supported by the wide availability of new technology such as smart phones, online data collection and web-based tests [18–20]. Also, evaluating foods in a more familiar environment may potentially lead into more reliable estimates of intervention effects [21]. On the other hand, laboratory studies have a high internal validity since they offer a high degree of control over the intervention and the outcome measures. As such, the optimal experimental protocol in appetite research is likely to remain elusive because of the complex and multi-faceted nature of eating and should depend on the research question at hand. The effect of specific food products or ingredients should preferably be studied in a lab under well-controlled conditions. The effect of complete breakfast consumption normally consumed on appetite feelings, should be studied at home, for more ecological validity [14].

Therefore, it is interesting to compare subjective feelings of appetite measured in the laboratory with those measured at home. In the present study we investigated the effects on appetite of two types of breakfasts: bread containing breakfasts and cereal containing breakfasts, both in a controlled laboratory condition as well as in a free-living, less controlled ‘at home’ condition. Appetite regulating properties of these two types of breakfasts were also compared independent of location, namely the two bread breakfasts and the two cereal breakfasts.

2. Subjects and methods

2.1. Ethics and good clinical practice

This study was performed according to the Declaration of Helsinki following Good Clinical Practice standards. The Clinical Study Protocol as well as the informed consent form were approved by the Independent Ethics Committee (IEC) “Medisch Ethische Toetsings Commissie Brabant” on July 29th 2015 (NL53772.028.15). The trial was registered at ClinicalTrials.gov under number NCT02575131.

2.2. Subjects

Seventy women had the study procedures explained to them of which fifty nine women gave informed consent. Thirty-three women were eligible to participate in the study and thirty-two completed the study (one subject withdrew before the first day). Eligible women were 18–50 years of age, had normal Dutch eating habits (e.g. usually eat bread and cereal types of breakfasts; consume three main meals a day), were healthy as assessed by questionnaire, consumed dietary fibres

(intake between 10 and 30 g/day), had a BMI between 22 and 32 kg/m² and were non-restrained eaters as assessed by the Dutch Eating Behavior Questionnaire [22] (DEBQ score of ≤ 3.4). Subjects needed to have their own laptop and to be acquainted with the internet. Women were excluded when pregnant, postmenopausal or having menstrual problems; were currently or recently treated for specified chronic diseases; reported dysfunction of the digestive tract; were following a diet or with reported food allergy/intolerance to the supplied breakfast products (or disliked the breakfast products used in the study); undertook a high level of physical activity (> 5 h intense activity/week); reported unexplained weight loss of > 2 kg in the 3 months prior to the study; were smokers or heavy drinkers (> 14 alcoholic drinks/week). This group of women was selected because they represent the population that consumes these types of breakfasts. Especially the overweight subjects, as this group is known to be concerned with body weight, and therefore willing to increase appetite feelings by various means to potentially reduce food intake and maintain body weight.

2.3. Investigational breakfasts

A range of different commonly consumed breakfasts were tested, namely two bread breakfasts (B1 & B2, Table 1), two cereal breakfasts (B3 & B4, Table 1) and a fried-egg breakfast (B5, Table 1).

This range of breakfasts was chosen to compare the two types of bread (specifically developed for this study) and the two types of cereal (commercial cereal products) for their effects on appetite, the fried-egg breakfast was included for comparison with literature data (or traditional, international breakfast) [23, 24]. The two partners involved in the project both had different breakfast focuses for this study: the Netherlands Bakery Center, Wageningen, The Netherlands had an interest in bread and the Quaker Oats Center of Excellence, PepsiCo, Barrington, IL, United States had an interest in cereal breakfast products.

The five breakfasts consisted of; bread breakfast 1 (B1): four slices of whole wheat bread (98 g) (‘whole wheat breads’ under Dutch law 100% whole grains) prepared with yeast served with low-fat spread (30 g), and consumed with either 200 mL black coffee (without milk and sugar) or 200 mL tea (without milk or sugar) or 200 mL water; bread breakfast 2 (B2): four slices of whole wheat bread (98 g) (‘whole wheat breads’ under Dutch law 100% whole grains) prepared with whole wheat sourdough served with low-fat spread (30 g), and consumed with 200 mL of black coffee (without milk and sugar) or 200 mL tea (without milk and no sugar) or 200 mL of water; cereal breakfast 1 (B3): Quaker™ Steel Cut oatmeal is made of 100% whole grain oats. To prepare Steel Cut oats 66.8 g were boiled in 500 mL water for 25 min (275 mL remained after cooking) and consumed with 307 g of skim milk; cereal breakfast 2 (B4): Cheerios™, ready-to-eat oat cereal (70 g) (made with 100% whole grain oats) was prepared by adding 307 g of skim milk and consumed with 275 g of water (the volume of water remaining after cooking breakfast B3, to allow for the consumption of the same volume of liquids with each breakfast); fried-egg breakfast (B5): One slice of white bread with a fried egg and 200 mL orange juice.

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