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Appetite and food intake after consumption of sausages with 10% fat and added wheat or rye bran ☆

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ABSTRACT

The use of dietary fibers as fat-replacers in sausages gives less energy-dense and thereby healthier foods. Also, dietary fibers have been shown to induce satiety. The objectives of this study were to investigate if appetite sensations and energy intake was affected by (1) addition of dietary fibers to sausages, (2) type of dietary fibers and (3) the food matrix of the dietary fibers. In this randomized cross-over study 25 young men were served four test meals; wheat bran sausages, rye bran sausages, rye bran bread and wheat flour sausages. The test meals were served as breakfast after an overnight fast. Appetite sensations were evaluated by visual analogue scales (VAS) assessed every 30 min for 240 min followed by an *ad libitum* lunch meal where energy intake was calculated. Both rye bran and wheat bran sausages increased satiety ($P < 0.01$) and fullness ($P < 0.02$) and decreased hunger ($P < 0.001$) and prospective consumption ($P < 0.001$) compared to wheat flour sausages. Furthermore, rye bran sausages increased satiety ($P < 0.05$) and fullness ($P < 0.02$) and decreased prospective consumption ($P < 0.01$) compared to rye bran bread. No differences in subsequent energy intake were observed. In conclusion, wheat and rye bran added to sausages decreased appetite sensations and thereby has a potential added health benefit beyond the role as fat-replacer. The satisfying effect of dietary fibers appears to be more pronounced when added to sausages than when added to bread, stressing the importance of food matrix and food processing.

Introduction

Energy density of foods has been identified as an important factor in body weight management in both children and adults (Perez-Escamilla et al., 2012). Fat is the most energy-dense macronutrient (37 kJ/g), while dietary fibers on the other hand contribute with only 8 kJ/g. An increase in dietary fiber content as well as a reduction in fat content therefore represents two ways of reducing energy content of a food product. Frankfurter sausages represent a food product that traditionally has a high fat content as they contain up to 25% fat (w/w). However, maintaining quality attributes such as juiciness, firmness, and mouth feel, is important when fat is removed from sausages. Dietary fiber could be used as a potential fat substitute due to the water binding and fat emulsifying abilities of dietary fibers which to a certain degree can compensate for some of the sensory attributes of the full fat product (Glicksman, 1991). Addition of dietary fiber to sausages may additionally result in a healthier food product due to their ability to induce satiety. However, as dietary fibers are not natural components of meat products, previous satiety studies of dietary fibers have mainly used cereal food products as interventions (Howarth, Saltzman, & Roberts, 2001; Slavin & Green, 2007; Wanders et al., 2011). Thus, it is unknown how dietary fibers in the matrix of sausages affect appetite.

Observational studies consistently show an inverse relation between dietary fiber intake and body weight gain. Interestingly, this

Abbreviations: RBS, Rye bran sausage meal; RBB, Rye bran bread meal; WBS, Wheat bran sausage meal; WFS, Wheat flour sausage meal.

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association was recently found only to account for cereal fibers, and not fruit and vegetable fibers, among European men and women (Du et al., 2010). This is likely due to a higher dietary fiber content of cereals, particularly wholegrain cereals. Cereal fibers are concentrated mainly in bran fractions (Glitsø & Knudsen, 1999; Knudsen & Hansen, 1991). Both wheat bran and rye bran contain cellulose, lignin, arabinoxylans and β-glucans, but the amount, solubility and viscosity of these dietary fibers differ between sources. Arabinoxylans are the main dietary fiber in both wheat bran and rye bran (Knudsen & Hansen, 1991; Nilsson & et al., 1997); however, while ~16% of the arabinoxylans in wheat bran are soluble (Knudsen & Hansen, 1991), up to ~27% of the arabinoxylans in rye bran are classified as soluble (Glitsø & Knudsen, 1999). Thus, rye bran is expected to induce viscosity to a greater extent than wheat bran due to its higher content of soluble fibers.

It has been concluded that viscous dietary fibers have a greater effect on short-term satiety and subsequent energy intake than less viscous dietary fibers (Slavin & Green, 2007; Wanders et al., 2011). One theory for the satiating properties of viscous dietary fibers is that the efficient water binding ability in the gastrointestinal tract will increase bolus volume and viscosity. This will lead to delayed gastric emptying and gastric distension resulting in afferent vagal signaling of fullness and satiety to the brain (de Graaf, Blom, Smeets, Stafleu, & Hendriks, 2004; Kristensen & Jensen, 2011). Secondly, increased viscosity of the digesta will result in prolonged small intestinal transit time and decreased nutrient absorption rate. This will further facilitate increased interaction between nutrients and intestinal cells stimulating the release of different satiety-inducing hormones such as CCK and GLP-1 (Burton-Freeman, 2000; Kristensen & Jensen, 2011).

The objectives of this study were to investigate if appetite sensations and energy intake were affected by (1) the presence of dietary fibers in the sausages (bran vs. flour), (2) the type of dietary fibers (wheat vs. rye), and (3) the food matrix of the dietary fibers (sausage vs. bread). We hypothesized that addition of bran to sausages with 10% fat would induce satiety and reduce subsequent *ad libitum* energy intake compared to wheat flour sausages, that rye bran, due to its greater proportion of soluble fiber, would proof more efficacious than wheat bran. We had however no *a priori* hypothesis on whether sausage or bread as food matrix would be most efficacious.

Subjects and methods

Subjects

In total, 28 young healthy men were recruited through advertising at university campuses in the Copenhagen area. The inclusion criteria were as follows: age between 20 and 40 years and BMI ranging from 19 to 28 kg/m^2. The exclusion criteria were as follows: known chronic illnesses, regular use of prescription medication, smoking, participation in other clinical studies, use of dietary supplements and food intolerance or dislikes of relevance to the study. All study subjects gave written consent after having received verbal and written information about the study. The study was carried out at the Department of Nutrition, Exercise and Sport, Faculty of Science, University of Copenhagen, Denmark. The study was assessed by the Ethical Committee of the Capital Region, Denmark, as not requiring ethical approval as no biological material was obtained in the study (H-3-2012-FSP27).

Study design

Four different iso-caloric meals were tested in a randomized double-blinded cross-over design. Test meals were kept blinded to subjects and staff, until all data was collected. Subjects were randomly assigned to the sequence of the test meals and the test meal days were separated by a minimum of three days. Prior to each test meal day, the subjects were instructed to follow a standardized fasting procedure including abstention from alcohol and hard physical activity for 24 h prior to the serving of the test meal. On the evening before each of the test meal days the subjects were instructed to consume the same evening meal no later than 8 pm. They were allowed 500 mL of water between 8 pm and the time of the test meal the following day.

Prior to the first test meal day the height of the subjects was measured to the nearest 0.5 cm using a wall mounted stadiometer. On the test meal day the subjects arrived in the morning at the Department of Nutrition, Exercise and Sports, University of Copenhagen, and upon arrival the weight of the subjects wearing only underwear and after emptying their bladder was measured to the nearest 0.05 kg (Lindell Tronic 8000, Samhall Lavi, Sweden). In the fasting state (time point 0 min) the subjects' appetite sensation was assessed using visual analogue scales (VAS). Hereafter the test meal was consumed, for which the subjects were allowed a maximum of 10 min. After consumption (time point 10 min) the appetite sensation as well as palatability were assessed using VAS. Appetite sensation was continuously assessed every half hour for 4 h (time point 30–240 min). The subjects were not allowed any food or drinks throughout the test meal day, but were allowed to read, use their computers and walk around the department. The subjects were allowed to talk to each other as long as the conversation did not involve food, appetite or related topics, and they were monitored throughout the day.

After the appetite sensation assessed 240 min after the test meal, an *ad libitum* meal consisting of pasta Bolognese and 300 mL of water was served. The subjects were instructed to drink all the water and eat until feeling comfortably satiated. The meal was consumed in an isolated room and the subjects were not allowed to read, use their computer or similarly during the eating session. The amount of food consumed was registered and the energy intake calculated. Finally, appetite sensation was assessed after the consumption of the *ad libitum* meal.

Test meals

The four test meals were served as breakfast meals and each test meal had an energy content of ~3000 kJ (Table 1). The test meals all consisted of 3 sausages (~184 g) served with 1 bread roll (~150 g), 50 g of ketchup and 300 mL of water. However, the test meals differed with respect to dietary fiber content, source (wheat or rye bran, provided by Valsemøllen A/S, Denmark), and food matrix to which the bran was added (sausage or bread). The meal with wheat flour sausages and bread without bran (WFS) was used as a control. Macronutrient composition of the meals was calculated using Dankost (Dankost, version 3.0, Denmark). The test meals

Table 1
Composition of the four test meals.

	WFS	WBS	RBS	RBB
Meal weight (g)[a]	373	382	388	381
Total dietary fiber (g)	4.4	10.4	9.8	10.6
Energy (kJ)	2753	2902	2875	2745
– Carbohydrate (E%)	51.0	49.3	49.8	50.4
– Protein (E%)	19.5	20.6	20.4	20.0
– Fat (E%)	29.5	30.1	29.8	29.6

WFS: wheat flour sausage meal, WBS: wheat bran sausage meal, RBS: rye bran sausage meal, RBB: rye bran bread meal.

[a] Meal weight is calculated as an average of the actual weight of the served meals.