Available online at www.sciencedirect.com
ScienceDirect
Appetite 51 (2008) 50–57
Appetite
www.elsevier.com/locate/appet

Research report

Lack of energy compensation over 4 days when white button mushrooms are substituted for beef

Lawrence J. Cheskin *, Lisa M. Davis, Leah M. Lipsky, Andrea H. Mitola, Thomas Lycan, Vanessa Mitchell, Brooke Mickle, Emily Adkins

Center for Human Nutrition, Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe Street, E2537, Baltimore, MD 21205, USA

Received 29 July 2007; received in revised form 28 October 2007; accepted 28 November 2007

Abstract

Increasing intake of low energy density (ED) foods in place of high ED foods has been proposed as a strategy for preventing or treating obesity. This study investigated how substituting mushrooms for beef in a test lunch affected energy intake, fat intake, palatability, appetite, satiation and satiety in normal weight, overweight and obese adults. Each subject consumed a total of eight test lunches in our lab over two consecutive weeks. The order of presentation of four consecutive meat lunches and four consecutive mushroom lunches was randomized. Energy content of meat and mushroom lunches varied (783 kcal versus 339 kcal), while volume was held constant. Energy intakes were significantly higher during meat lunches than mushroom lunches (730 ± 7.9 kcal versus 310 ± 5.8 kcal). Subjects exhibited only partial compensation (11.4 ± 12.0%) for this difference over 4 days. Total daily energy intake and fat intake were significantly greater in the meat condition than in the mushroom condition, while ratings of palatability, appetite, satiation and satiety did not differ significantly. These results suggest that substituting low ED foods for high ED foods in otherwise similar recipes can be an effective method for reducing daily energy and fat intake.

Keywords: Energy density; Food intake; Energy compensation; Human studies

Introduction

The rise in prevalence of obesity over the last two decades in the United States (Flegal, Carroll, Kuczmarski, & Johnson, 1998; Ogden et al., 2006) has been accompanied by an increase in high ED (kcal/g) foods in the country's food supply (Drewnowski, 2004). In addition, epidemiologic evidence has shown that the overconsumption of high ED foods is positively associated with body mass index (BMI, kg/m^2) and risk for obesity (Howarth, Murphy, Wilkens, Hankin, & Kolonel, 2006; Ledikwe et al., 2006; Mendoza, Drewnowski, & Christakis, 2007). Experimental evidence suggests that these trends may be due in part to a limited ability of humans to regulate energy intake in response to changes in ED (Poppitt & Prentice, 1996; Rolls, 2000). Further research is therefore needed to determine the most effective ways to reduce dietary ED for US populations.

Much recent research has been devoted to understanding the phenomenon of passive overconsumption of energy resulting from the availability of high ED, inexpensive, and palatable foods. Passive overconsumption would be expected to lead to an increase in an individual's body weight and risk for obesity. Conversely, the substitution of low ED foods for high ED foods has been proposed as a means of preventing, or reversing, this increase. Several laboratory-based studies that have experimentally manipulated the ED of a test meal have shown to varying degrees that ED is directly related to energy intake (EI) in the short and medium term (Bell & Rolls, 2001; Devitt & Mattes, 2004; Foltin, Fischman, Emurian, & Rachlinski, 1988; Kral, Roe, & Rolls, 2004; Louis-Sylvestre et al., 1989; Louis-Sylvestre, Tournier, Chapelot, & Chabert, 1994; Mazlan, Horgan, & Stubbs, 2006; Poppitt & Swann, 1998; Rolls et al., 1999; Rolls, Roe, & Meengs, 2006; Stubbs, Ritz, Coward, & Prentice, 1995; Stubbs, Johnstone, O'Reilly, Barton, & Reid, 1998). These studies typically alter ED by varying the proportionate amounts or formulation of ingredients. These manipulations are typically covert so that subjects are unaware of the difference in energy content. In addition, food selection is

* Corresponding author.
E-mail address: cheskin@jhmi.edu (L.J. Cheskin).

0195-6663/$ – see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2007.11.007

by and large dictated by researchers. While such methods increase internal validity, it can be argued that generalization of such results may be problematic, given the lack of resemblance to the free-living environment, where individuals are often quite aware of the energy differences of the foods they may choose for a meal, and control food selection. In fact, large discrepancies exist between current projected reductions in energy intakes from experimental settings and the reported effects on body weight exhibited in free-living humans (Stubbs & Whybrow, 2004).

The present study sought to examine the effects of varying the energy content of a test meal on subsequent daily energy intake as well as on subjective ratings of palatability, appetite, satiation (post-meal fullness) and satiety (general fullness). Effects on daily fat intake were also examined. To produce the difference in energy content, test meals incorporated the same volume of either a high energy ingredient (lean ground beef) or a low energy ingredient (white button mushrooms). Potential baseline predictors of compensation for the energy manipulation were also examined. A primary aim of this study was to evaluate these effects in normal weight, overweight and obese adults. It was hypothesized that the energy content of the test meal would be positively related to daily energy intakes, and that this relationship would depend on subject characteristics. It was further hypothesized that subjective ratings would be similar across test conditions.

Methods

Subjects

Potential subjects were recruited by advertisements through the local newspaper, and by flyers posted around the campus of Johns Hopkins University. Subjects were screened initially over the telephone, then in-person, when informed consent was obtained, and height and weight were measured. Subjects completed the Three-Factor Eating Questionnaire (TFEQ) to measure cognitive dietary restraint, disinhibition, and hunger (Stunkard & Messick, 1985). In addition, subjects sampled all lunch entrées in order to measure palatability and ensure acceptability of recipes.

Subjects met inclusion criteria if they were between 18 and 65 years of age, had a BMI of 18–45 kg/m^2, were willing and able to comply with the protocol requirements and to give informed consent, and had a regular source of health care and permission from their primary care provider. Subjects with any uncontrolled physical or psychological health problems, other than obesity or type-2 diabetes, were excluded from the study. Other exclusion criteria included having a score of 30 or more on the Eating Attitudes Test (EAT-26) (Garner, Olmsted, Bohr, & Garfinkel, 1982), a score of 15 or more on a standard depression screening questionnaire (Beck, Ward, & Mendelson, 1961), a dislike of the foods used in the study, pregnancy, lactation, use of appetite-affecting medications not on an established and stable dose, or use of weight loss drugs. The Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health approved the study protocol, and subjects were compensated for their participation.

Study design and procedures

This study utilized a randomized, crossover design, whereby each subject served as his/her own control. Subjects reported to the Center for Human Nutrition at the Johns Hopkins Bloomberg School of Public Health for lunch on four consecutive weekdays for two consecutive weeks, for a total of 8 test meals. The two, four-day test periods were separated by a three-day washout period in order to prevent carry-over effects.

Manipulated entrées

Recipes were developed in order to create meat and mushroom versions of four distinct lunch entrées (see Table 1). Meat and mushroom versions of Lasagna, Savory Napoleon, Sloppy Joe, and Chili were prepared and presented to all subjects in similar volume (recipes available upon request). Mean energy contents of meat and mushroom entrées as served in the study were 783 and 339 kcal, respectively (Table 1). Subjects were randomized to consume all four meat entrées or all four mushroom entrees in the first week (subjects consumed the alternate mushroom or meat versions of the same entrees in the second week) in order to control for possible order effects. Meal types were constant between subjects.

Meal conditions

Subjects consumed prepared meals in a testing room at tables separated by partitions. Subjects were aware of the presence of other subjects, but could not see other subjects, or what other subjects were eating. Subjects were permitted to read, but not to converse, while eating. Subjects were asked to consume as much of the test meal as possible, and were given no time restrictions. Subjects were provided water to drink ad

Table 1
Macronutrient composition of test lunches

	Lasagna		Savory Napoleon		Sloppy Joe		Chili	
	Meat	Mushroom	Meat	Mushroom	Meat	Mushroom	Meat	Mushroom
Energy (kcal)	1026	451	679	359	822	248	604	300
Carbohydrate (g)	33	41	43	49	40	48	38	41
Protein (g)	88	30	29	10	71	14	33	14
Fat (g)	57	19	45	17	42	4	31	5