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Research report

Positive effect of mushrooms substituted for meat on body weight, body composition, and health parameters. A 1-year randomized clinical trial ☆

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ABSTRACT

Reducing energy density (ED) of the diet is an important strategy for controlling obesity. This 1-year, randomized clinical trial examined the effect of substituting mushrooms for red meat ('mushroom diet'), compared to a standard diet ('meat diet'), on weight loss and maintenance among 73 obese adults (64 women, 9 men). The subjects completed anthropometric measurements and 7-day food records four times during a standardized weight loss and maintenance regimen. At the end of the 1-year trial, compared to participants on the standard diet, participants on the mushroom diet ($n = 36$) reported lower intakes of energy (mean ± [SE] = −123 ± 113 kcals) and fat (−4.25 ± 6.88 g), lost more pounds and percentage body weight (−7.03 ± 3.34 lbs, 3.6%), achieved lower body mass index (−1.53 ± 0.36), waist circumference (−2.6 ± 3.5 in.) and percent total body fat (−0.85 ± 0.53), and had lower systolic and diastolic pressure (−7.9 and −2.5 mmHg); their lipid profile and inflammatory markers also improved. After initial weight loss, subjects following the mushroom diet maintained that loss well. Those who completed the full 12-month trial still weighed a mean of 7 lbs less than baseline. Thus, encouraging adults to substitute mushrooms for red meat was a useful strategy for enhancing weight loss, weight maintenance, and health parameters.

Introduction

Obesity is reaching epidemic proportions across race, gender, and age groups in the United States (Flegal, Carroll, Ogden, & Curtin, 2010; Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). While there are some reports that the rising trend in overweight (defined as BMI: 25–29.9 kg/m^2) and obesity (defined as BMI: >30.0 kg/m^2) may be stabilizing, the prevalence is still high, with more than two-thirds of American adults overweight or obese (Flegal et al., 2010).

The rise in prevalence of obesity in the US can largely be attributed to positive energy balance, which is associated with excessive energy intake (Prentice & Jebb, 2004). Decreased physical activity, along with increased intake of energy-dense foods is well recognized as one of the main environmental factors associated with the rise in rates of obesity (Ershow, 2009; Prentice & Jebb, 2004). Several studies show that overconsumption of foods that are high in energy, and notably, high in fat, are associated with overweight status in individuals who are susceptible to weight gain (Bes-Rastrollo et al., 2008; Blundell, Lawton, Cotton, & Macdiarmid, 1996; Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007; Howarth, Murphy, Wilkens, Hankin, & Kolonel, 2006; Kant & Graubard, 2005; Ledikwe et al., 2006; Savage, Marini, & Birch, 2008; Vergnaud et al., 2009). High dietary fat consumption has been shown to have weak effect on satiation (Ledikwe et al., 2006) which may limit an individual's capacity to regulate energy intake in response to changes in energy density in the diet. American diets are high in fat and energy density (Bachman, Reedy, Subar, & Krebs-Smith, 2008) and individuals may be inclined towards consuming more of these foods due to easy access, lower cost, and preferred taste. This makes passive overconsumption of energy likely, leading to weight gain and obesity (Drewnowski, 2004; Kuczmarski, Mason, Schwenk, Evans, & Zonderman, 2010; Thompson et al., 2009; Westerterp, 2006). Concomitantly, the consumption of red and processed meats has risen significantly (Daniel, Cross, Koebnick, & Sinha, 2011; Wang, Beydoun, Caballero, Gary, & Lawrence, 2010) and is associated with obesity (Wang & Beydoun, 2009). Many of these foods that are high in fat comprise a significant source of saturated fat and cholesterol intake in the US diet (Bachman et al., 2008; Nicklas, Farris, Myers, & Berenson, 1995; Zanovec, O'Neil, Keast, Fulgoni & Nicklas, 2010).

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Several specific types of diets have been promoted for weight loss, such as high protein, low-carbohydrate, low fat and reduced calorie (Foreyt et al., 2009; Westerterp-Plantenga, Lemmens, & Westerterp, 2012). Reduction of calorie intake is important in addressing obesity, but achieving compliance with the necessary dietary behaviors can prove challenging (Rothman, Gillespie, & Johnson-Askew, 2009). Although there are a multitude of factors influencing caloric intake in free-living populations, energy density of the diet appears to have the greatest ability to affect energy consumption, accounting for 7% of variance in intake (Stubbs & Whybrow, 2004). The energy density of a food is affected most by its water and fat content, with high-fat foods such as red meat being more energy dense, and high-water foods being less energy dense (Blundell & Stubbs, 1999). Several studies have shown that consumption of foods lower in energy density is associated with reduced energy intake (Stubbs & Whybrow, 2004) and lower body weight (Bes-Rastrollo et al., 2008; Ello-Martin et al., 2007; Ledikwe, Blanck, Kettel, et al., 2006; Savage et al., 2008) and at the same time provides high nutrient quality (Kant & Graubard, 2005; Ledikwe, Blanck, Khan, et al., 2006). In addition, foods lower in energy density have been positively associated with satiety (Cheskin et al., 2008; Rolls, Roe, & Meengs, 2004), one of the key elements in regulating body weight. Substitution of high energy density foods with lower energy density foods may be an effective way to reduce energy intake and treat obesity.

Edible mushrooms are "macrofungi" and contain a distinct fruiting body. White button mushrooms are the most common species found in the West and belong to the *Agaricus bisporus* family of mushrooms. *A. bisporus* species are (3 g/100 g) fresh mushrooms and low in fat (<1%) (Chang, 1996). Edible mushrooms are also valuable sources of many important nutrients and bioactive components (Bano & Rajarathnam, 1988; Barros, Cruz, Baptista, Estevinho, & Ferreira, 2008; Mattila, Salo-Väänänen, Könkö, Aro, & Jalava, 2002; Oyetayo, Akindahunsi, & Oyetayo, 2007) and possess desirable features like flavor, aroma, taste (Chang, 1996), satiety, palatability, and low energy density (Cheskin et al., 2008), an important element in weight regulation. In addition, they possess anti-inflammatory (Yu, Weaver, Martin, & Cantorna, 2009) and anti-oxidative stress properties (Lo & Cheung, 2005), which are often associated with obesity, and implicated in the development of numerous health complications (Iyer, Fairlie, Prins, Hammock, & Brown, 2010).

We (Cheskin et al., 2008) showed that substituting edible mushrooms for meat lowered total short-term energy intake by nearly 20% in normal, overweight and obese individuals. The study also found that mushrooms are satiating and palatable for most individuals, and a mushroom-rich diet meets the Acceptable Macronutrient Distribution Range of 10–35% for protein, as established by the Institute of Medicine (Manore, 2005).

The present study builds on the short-term trial described above by utilizing a naturalistic study of the longer-term effect of mushroom substitution for red meat. The primary aim was to assess weight loss and weight maintenance efficacy with white button mushrooms as a substitute for red meat over 1 year. It was hypothesized that individuals substituting white button mushrooms for meat in the diet (intervention group) would lose more weight than participants following a standard diet, achieve improved body composition, and maintain favorable body composition changes after the initial weight loss phase. It was further hypothesized that the intervention group would have a better macronutrient intake profile than the control group (less fat and saturated fat, e.g.). The secondary objective of the study was to assess health parameters on the mushroom diet vs. the meat diet, including blood pressure, lipid profile, and biochemical indicators of inflammation and oxidative stress.

Methods

The study was approved by the Institutional Review Board of Johns Hopkins Bloomberg School of Public Health. Informed consent was obtained from each participant.

Study subjects

Subjects were recruited by advertisements through local newspapers and flyers. The study enrolled 209 overweight or obese men and women aged 18–65 years who reported a desire to lose weight. Final analysis included 74 participants with complete data. The non-completion rate was 65% after 12 months.

Subjects inclusion/exclusion criteria

Adult men and women aged 18+ years, BMI 25–40, who were interested in losing weight and reported a willingness to substitute mushrooms for beef in their daily meals. The participants had no known history of HIV, carcinoma, rheumatoid arthritis, or other uncontrolled chronic health conditions. Participants were excluded if they reported regular use of medications and/or supplements that could affect their weight, or if they were pregnant or nursing. Participants enrolled in the study were not known to be allergic to mushrooms, and were recruited without regard to gender, race, or ethnicity.

Study design and procedures

Participant screening and randomization

This randomized clinical trial was single blinded (the interventionist was blinded to the group in which the participant was enrolled, though it was not possible to blind the participants to the foods they were being asked to consume). Potential participants were screened for eligibility by phone, and those who met eligibility criteria were invited to an in-person screening visit, when informed consent was obtained, with a 10-question quiz verifying the participants' understanding of the study protocol (80% correct required to pass). Participants were weighed on an electronic scale, height measured by stadiometer, waist circumference obtained via measuring tape, and historical medical and baseline dietary information obtained via questionnaire.

Participants who met study criteria were invited to return (Visit 1, Week 0) for baseline blood tests and dietary instructions. Prior to Visit 1, eligible participants were randomized into one of two treatment groups: weight loss using a USDA Food Guide Pyramid-based diet prescription ("standard diet"), or the same diet, plus the recommended mushroom substitution ("mushroom diet") (Fig. 1).

Testing protocol

Weight loss phase (biweekly visits—first 6 months)

Visits 1 through 15 comprised the weight-loss phase. At these biweekly visits, participants received diet counseling. Since the study was single blinded, the study counselor was not made aware of the group to which the participant had been randomized, and the participants were instructed not to disclose their diet assignment to the counselor.

Weight maintenance phase (monthly visits—second 6 months)

Visit 16 through endpoint (Visit 22) comprised the weight-maintenance phase. At these monthly visits, data were collected without providing diet counseling. If participants had specific diet questions, however, they were answered.