Appetite 79 (2014) 158–165

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Supplementing chicken broth with monosodium glutamate reduces energy intake from high fat and sweet snacks in middle-aged healthy women ☆

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ARTICLE INFO

Article history:
Received 25 March 2013
Received in revised form 7 April 2014
Accepted 14 April 2014
Available online 23 April 2014

Keywords:
Umami
MSG
Satiety
Energy intake
Food choice
Appetite

ABSTRACT

Monosodium L-glutamate (MSG) and inosine monophosphate-5 (IMP) are flavor enhancers for umami taste. However, their effects on appetite and food intake are not well-researched. The objective of the current study was to test their additions in a broth preload on subsequent appetite ratings, energy intake and food choice. Eighty-six healthy middle-aged women with normal body weight received three preload conditions on 3 test days 1 week apart – a low-energy chicken flavor broth (200 ml) as the control preload, and broths with added MSG alone (0.5 g/100 ml, MSG broth) or in combination with IMP (0.05 g/100 ml) (MSG+ broth) served as the experimental conditions. Fifteen minutes after preload administration subjects were provided an *ad libitum* testing meal which consisted of 16 snacks varying in taste and fat content. MSG and MSG+ enhanced savory taste and broth properties of liking and pleasantness. In comparison with control, the MSG preload resulted in less consumption of total energy, as well as energy from sweet and high-fat snacks. Furthermore, MSG broth preload reduced added sugar intake. These findings were not observed after MSG+ preload. Appetite ratings were not different across the three preloads. Results suggest a potential role of MSG addition to a low-energy broth preload in subsequent energy intake and food choice. This trial was registered at clinicaltrials.gov as NCT01761045.

Introduction

Monosodium L-glutamate (MSG) has been used as a flavor enhancer since 1908, when it was identified as the source of umami taste (pleasant savory taste) (Ikeda, 2002). Later on, nucleotides including 5′-ribonucleotides of inosine monophosphate (IMP) were also found to elicit the taste of umami. Further studies show a large synergistic enhancement on umami taste when glutamate and nucleotides are mixed in certain ratios (Kumazawa & Kurihara, 1990; Schiffman, Frey, Luboski, Foster, & Erickson, 1991; Yamaguchi, 1967). Supplementing glutamate salts including MSG either alone or in combination with IMP has been found to allow for sodium reduction without sacrificing taste and pleasantness of foods (Carter, Monsivais, & Drewnowski, 2011a; Okiyama & Beauchamp, 1998; Roininen, Lähteenmäki, & Tuorilla, 1996). The effect of umami substance supplementation on food intake is under investigation. One notion is that umami-rich foods may be especially satiating given that sweet taste serves to signal high-energy sources, whereas umami may serve to signal amino acids and protein (Chaudhari & Roper, 2010). Previous findings demonstrated that taste sensitivity to MSG is associated with an increased liking of dietary protein (Luscombe-Marsh, Smeets, & Westerterp-Plantenga, 2007). In addition, MSG interacts with protein influenced gastric emptying as well as subsequent appetite and energy intake, although the results are inconclusive (Luscombe-Marsh, Smeets, & Westerterp-Plantenga, 2009; Masic & Yeomans, 2013; Zai et al., 2009). The potential effect of MSG on satiety is supported by the evidence that umami taste receptors and signaling molecules are expressed in gastrointestinal enteroendocrine cells (Nakamura, Hasumura, San Gabriel, Uneyama, & Torii, 2010; San Gabriel, Maekawa, Uneyama, Yoshie, & Torii, 2007), while glutamate application stimulates these cells and promotes satiety-related hormone release, such as cholecystokinin (CCK) and glucagon-like peptide-1 (GLP-1) in rodents and humans (Daly et al., 2013; Hosaka et al., 2012).

In long-term clinical studies when MSG was used to manipulate palatability of various foods within a meal, it affected mealtime food selection; although there was no influence on sustained

☆ *Acknowledgment*: We would like to thank Dr. Adam Drewnowski and Brett Carter for helping us with the study design and for their valuable comments on this manuscript.
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http://dx.doi.org/10.1016/j.appet.2014.04.011
0195-6663/

energy intake and body weight (Bellisle et al., 1991, 1996; Essed, Kleikers, van Staveren, Kok, & de Graaf, 2009; Toyama, Tomoe, Inoue, Sanbe, & Yamamoto, 2008). However, these studies were conducted in institutional elderly people in an attempt to improve their food intake and nutritional status, and thus may not represent healthy subjects. The few studies that have investigated acute effects of MSG on appetite ratings and energy intake using a preload paradigm have reported inconsistent results. The addition of MSG to a consommé preload was found to have had no significant effect on subsequent appetite and energy intake (Rogers & Blundell, 1990). MSG addition to a high-protein meal has been shown to increase energy intake at the next meal, although no effect on appetite was observed (Luscombe-Marsh et al., 2009). However, the addition of MSG to a low-energy chicken broth was found to decrease hunger and desire to snack, though its effect on energy intake failed to reach a significant level (Carter, Monsivais, Perrigue, & Drewnowski, 2011b). A recent study suggests that MSG may have a biphasic effect on appetite, with reduced satiation mediated by effects on palatability, but also may have potential for enhanced postingestive satiety, particularly in the context of protein ingestion (Masic & Yeomans, 2013).

The purpose of this study is to investigate the effects of MSG and IMP supplementation in low-energy broth preloads on subsequent appetite, energy intake and food choice using a large sample. MSG was added to a low-energy control broth preload, either alone or in combination with IMP. The main hypothesis was that MSG and IMP supplementation would decrease energy intake and would influence food choice. Added sugar and sodium are nutrients of public interest; thus, the amounts of intake were also analyzed.

Methods

Subjects

The study was conducted at the IBERICA Clinical Research Center (Eatontown, New Jersey, USA). Subjects were recruited in Eatontown and surrounding areas using flyers. Individuals who responded to the flyers were interviewed by phone to ensure that they met the following criteria: female, 30–45 years old, normal body-mass index (BMI), nonsmoking, non-heavy-drinking, not dieting to gain or lose weight, not pregnant or breast feeding, free from food allergies and willing to consume the test foods, no history of type 1 or 2 diabetes mellitus and other uncontrolled endocrine diseases, and free of dysgeusia and digestive diseases.

Potential subjects who met these initial criteria came to the clinic to complete additional screening materials. Included in the screening materials were “Eating Disorder Index” (Garner, Olmstead, & Polivy, 1983), which evaluates the presence of eating disorders and “Three Factor Eating Questionnaires” (Stunkard & Messick, 1985), which measures dietary restraint, disinhibition, and perceived hunger. Trained clinical personnel took height and weight measurements. Potential subjects who had a BMI of 18.5–25.0 kg/m^2, Eating Disorder Index of less than 23 and Three Factor Eating Questionnaire of less than 10 were eligible (Carter et al., 2011b) for urine screening tests of drug use, alcohol, cotinine (a metabolite of nicotine) and pregnancy. At the screening visit, subjects were asked if they were willing to consume the preload broth and snack foods. Qualified subjects also were willing to consume all of the preload broths and at least two items of snacks in each category of the test meal (Table 2). Subjects were told that the purpose of the study was to evaluate the effects of MSG and IMP on taste and gastrointestinal sensation. All subjects signed the informed consent and were financially compensated for participation in the study. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and approved by the Schulman Associates Institutional Review Board (IRB), Inc. The Schulman IRB approval number is 10-4474-0.

Table 1
Test broth characteristics.

	Control broth	MSG	MSG+
Serving size (g)	200	200	200
Energy (kJ)	35	35	35
Protein (g)	0.60	0.60	0.60
Carbohydrate (g)	0.78	0.78	0.78
Fat (g)	0.18	0.18	0.18
Sugar (g)	0.14	0.14	0.14
Total sodium (mg)	755	755	755
Sodium as NaCl (mg)	755	395	395
Sodium as MSG (mg)	0	360	360
MSG (g)	0	1	1
Nucleotides (mg)	0	0	100

Study design

The study used a crossover design with each subject serving as his/her own control. Qualified subjects came to the clinical center once a week for 3 weeks, for a total of three test sessions of *ad libitum* snack intake. On each test day, a standard lunch (400 kcals, 1674 kJ) was consumed at noon in order to ensure a consistent level of hunger before snack session. Subjects were required to consume the entire lunch within 30 minutes. Snack meal test sessions were scheduled 2 hours after lunch. At 15 minutes before each snack session, subjects were served one of three soup preloads. Subjects were required to consume the entire preload within a period of 10 minutes. The test snack meal was served 15 minutes after the preload in the same way across the three test sessions. Subjects could eat or drink as much or as little as they wanted until they were comfortably full. The order of test preload conditions was randomized across subjects. The phase of menstrual cycle of the subjects was not controlled for the three test sessions.

Test preload composition

The test preloads were chicken flavored and formulated in powder form by Ajinomoto North America, Inc. The control preload consisted of salt, maltodextrin, chicken broth, sugar, dried chicken, chicken fat, hydrolyzed soy protein, chicken flavor, fermented wheat protein, onion powder, white pepper and turmeric. The MSG preload contained an additional 1 g of MSG (Ajinomoto North America, Inc., Fort Lee, NJ), while the MSG+ preload contained an additional 1 g of MSG and 0.1 g of IMP. Salt level was adjusted to have an equal amount of sodium across the three preloads. All preloads were prepacked as 4 g per sachet (SENBA USA, Inc., Hayward, CA). The preload (one sachet) was reconstituted using 200 ml of water prior to serving and served in a bowl with a spoon, at a temperature of 65 °C. All preparation methods were standardized in order to ensure that the preload broths were of the same consistency for every subject. The final concentration of MSG was 0.5% (1 g/200 ml water) and IMP 0.05% (0.1 g/200 ml water). These concentrations were within the range typically added to foods for flavor enhancement (Yamaguchi, 1991). Table 1 lists the broth preload characteristics.

Lunch and test snack meal composition

Lunch was prepared by dieticians in the clinical center. It consisted of a turkey sandwich, an apple, a potato salad and 12 ounces (355 ml) of water, for a total energy amount of 400 kcal (1674 kJ).

The test snack meal consisted of 16 snacks varying in taste and fat content with a total energy amount of 2,230 kcal (9,330 kJ). There were four high-fat savory snacks, four low-fat savory snacks, three high-fat sweet snacks and five low-fat sweet snacks. Table 2 provides snack information. Pringles original potato chips, dry-roasted salted peanuts, M&M’s fun-size packages, Klondike ice cream bars,