



Preference for salt in a food may be alterable without a low sodium diet



Nuala Bobowski^{a,*}, Aaron Rendahl^b, Zata Vickers^a

^a Department of Food Science & Nutrition, University of Minnesota, 1334 Eckles Avenue, St. Paul, MN 55108, USA

^b School of Statistics, University of Minnesota, 224 Church Street SE, Minneapolis, MN 55455, USA

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ABSTRACT

In response to current efforts to reduce population-wide dietary salt intake, the objective of this study was to determine whether liking for reduced sodium and low sodium tomato juice could increase following repeated exposure over an extended period. Eighty-three adult subjects participated in a three-part study: an initial taste test, a 16-week longitudinal study, and a final taste test. Subjects gave liking ratings of four tomato juice samples ranging in sodium from 640 mg (a concentration comparable to a commercially available product) to 136 mg per 237 ml serving (a low sodium concentration) at both taste tests. For the longitudinal study, subjects were divided into two balanced groups based on PROP sensitivity, hedonic sensitivity to salt, and motivation to reduce dietary salt intake; the abrupt group received tomato juice reduced in sodium to reach a low sodium target at week four, and the gradual group received juice reduced in sodium via difference thresholds to reach the same target at week 14. Though liking for the juice with the highest salt content was unchanged between taste tests, liking for all reduced salt juices increased at the final taste test relative to the initial taste test among subjects in both salt reduction groups. In addition, subjects in both groups experienced a downward shift in preference for salt in tomato juice, indicating that repeated exposure may be sufficient to alter preference for salt in a food in the absence of a low sodium diet. That salt preference may be altered by exposure alone within the context of a high salt diet is promising for both the food industry and individual consumers.

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Introduction

The average American consumes 3400 mg of sodium per day, exceeding the Dietary Guidelines for Americans recommended daily intake by nearly one and a half times (U.S. Department of Agriculture, 2010). Because high sodium intake is associated with a number of negative health outcomes, including hypertension, there is wide support for population-wide dietary salt reduction via an industry-level approach (Institute of Medicine, 2010). In addition to evidence indicating consumers are generally uninformed about what constitutes salt intake within healthy limits (International Food Information Council, 2011) and that salt added to foods at home is a minimal contributor to overall intake (Beauchamp, Bertino, & Engelman, 1987), the highest proportion of dietary salt comes from processed foods (Mattes & Donnelly, 1991). Taken together, this evidence suggests the most effective intervention to reduce salt intake on a national level would be one that minimized salt during food manufacturing, before consumer point of purchase.

For all of the important contributions made in the past few years that have aided in a better understanding of how to approach salt reduction, it remains a complicated issue. Salt as an ingredient is important for product functionality, preservative and antimicrobial properties, and taste—in imparting saltiness, as a flavor enhancer, and in suppression of bitterness (Breslin & Beauchamp, 1995; Gillette, 1985). We do not know what type of national salt reduction strategy would be effective for reducing dietary salt, not only because of the important role salt plays in food manufacturing, but also because reducing a population's salt intake to levels as low as those recommended has never been attempted. Both the United Kingdom and Finland are often cited as examples of successful population dietary salt intake; however, the last estimates from both nations suggested that their reduced intakes were roughly equivalent to the current intake of Americans (Department of Health, 2012; He & MacGregor, 2009; Institute of Medicine, 2010). Although reduction of sodium has been demonstrated in foods by various strategies without affecting acceptability (for example, Braschi, Gill, & Naismith, 2008; Girgis et al., 2003; Grummer, Bobowski, Karalus, Vickers, & Schoenfuss, 2013; Hooge & Chambers, 2010; Lawrence, Salles, Septier, Busch, & Thomas-Danguin, 2009; Lawrence et al., 2011; Noort, Bult, & Stieger, 2012; Noort, Bult, Stieger, & Hamer, 2010), reduced salt

* Corresponding author. Present address: Monell Center, 3500 Market Street, Philadelphia, PA 19104, USA. Tel.: +1 651 769 4806.

E-mail addresses: bobo0005@umn.edu (N. Bobowski), rend0020@umn.edu (A. Rendahl), zvickers@umn.edu (Z. Vickers).

foods are generally disliked. Thus, maintenance of liking will remain one of the most important difficulties likely to be encountered with any sizeable salt reduction in foods at the industry level. Additional research is required to understand potential consumer response to a reduced salt food supply, particularly in terms of whether consumers can 'learn' to like low sodium foods that might otherwise be deemed unpalatable.

Salt preference is in large part dictated by overall dietary salt intake—individuals who consume a high sodium diet generally prefer saltier foods (Bertino, Beauchamp, & Engelman, 1986) and individuals who consume a low sodium diet generally prefer less salty foods (Bertino, Beauchamp, & Engelman, 1982; Blais et al., 1986; Elmer, 1988). Whether preference for a low sodium food can increase without a low sodium diet has been studied only minimally. Methven, Langreny, and Prescott (2012) compared liking ratings of a no salt added soup and a high salt soup between pre- and post-study taste tests, separated by eight exposures to the no salt added soup. Liking for the no salt added soup increased after three exposures, and generally continued to increase over the duration of the eight day study. In addition, liking for the no salt added soup was significantly higher at the post-study taste test than at the pre-test. Methven et al. (2012) hypothesized that because salt preference is developed within the context of the salt level most often consumed in a food, repeatedly consuming the same food with a reduced salt content was enough to significantly increase liking for the new, lower salt level. The increase in liking for the no salt added soup did not translate into a decrease in liking for the high salt soup, however, which remained preferred overall at both taste tests. These results illustrate two concerns regarding population dietary salt reduction: (1) whether consumers can shift salt preference while continually exposed to salty tasting foods, and (2) whether a coordinated approach in which salt reductions are made across the food supply is necessary to achieve this preference shift (Institute of Medicine, 2010).

The main objective of this research was to determine whether liking for reduced sodium and low sodium tomato juice could increase following repeated exposure over an extended period. In order to address this objective, subjects' liking of four tomato juices ranging in salt content were compared between an initial and a final taste test, separated by a 16-week period during which subjects consumed juice either abruptly reduced in salt to a low sodium target at week four, or juice gradually reduced in salt to reach the same target at week 14.

Materials and methods

Overall study design

The study comprised three phases: an initial taste test used to assess subjects' liking for different levels of sodium chloride in tomato juice, a 16-week longitudinal study used to compare two salt reduction strategies (abrupt and gradual), and a final taste test used to assess any change in liking for different levels of sodium chloride in tomato juice relative to the initial taste test. Subjects were assigned to the abrupt and gradual salt reduction groups in a manner that balanced the groups for perceived 6-n-propylthiouracil (PROP) intensity, hedonic sensitivity to salt and self-reported motivation to reduce dietary salt intake. Only data from the taste tests are reported here; data from the longitudinal study are reported elsewhere (FQAP-D-14-00053).

Subjects

One hundred and four adult subjects were recruited through a University of Minnesota database of students and staff who had

previously expressed interest in participating in studies via the University's Sensory Center, and through advertisements posted on campus. A recruitment questionnaire was used to screen individuals for several factors: current dieting status in terms of restriction of calories, fat, carbohydrates, salt, and sugar; presence of food allergies; and motivation to make a number of diet-related changes, namely motivation to consume a diet lower in calories, fat, sugar, and salt; motivation to eat less 'junk food' and fast food; and motivation to eat more fruits and vegetables, organic foods, and whole grains. These screening questions were selected as items generally related to consumption of a healthy diet in order to disguise the study focus of salt intake. Subjects were also asked to indicate their liking for and willingness to consume tomato juice (the food used to test study objectives). Subjects already restricting salt use, those with food allergies, and those that disliked tomato juice were rejected as participants. Based on these exclusion criteria, 96 subjects were initially enrolled in the study. Thirteen subjects stopped participating over the course of the study primarily due to scheduling conflicts and time commitment, for a final total of 83 subjects. Testing procedures were approved by the University of Minnesota Institutional Review Board. Subjects were compensated for participating.

Products

Tomato juice was made using a basic recipe of one part tomato paste (Contadina®, Del Monte Foods, San Francisco, CA) to four parts distilled water, with enough sodium chloride (Fisher Scientific, Fair Lawn, NJ) added to meet a specific sodium concentration. Juice was refrigerated for no more than five days before being served to subjects. Subjects were served four samples of tomato juice at the taste test, ranging in sodium content from a concentration comparable to a commercially available juice (640 mg sodium/237 ml juice), to a concentration low enough to meet FDA low sodium guidelines (136 mg sodium/237 ml juice). The two remaining samples were reduced in sodium by roughly 25% and 50% from the highest sodium sample (472 mg and 304 mg sodium/237 ml juice, respectively). The three samples with a salt content reduced from the highest salt sample will be referred to collectively as the 'reduced salt samples', and the sample containing 136 mg of sodium will be referred to as the 'low sodium sample'.

Experimental procedure

Initial taste test

Each subject received a tray containing four samples of tomato juice at each sodium level (640 mg, 472 mg, 304 mg, and 136 mg per 237 ml serving), a cup of water, and approximately 10 ml of PROP dissolved in distilled water at a concentration of 0.0032 M in a 30 ml lidded plastic soufflé cup. Juices were served in 90 ml samples in plastic soufflé cups blinded with random 3-digit codes, balanced among subjects for order and carryover effects. Before tasting each sample, subjects were instructed to rinse their mouth with water and were forced to wait one minute before beginning evaluations. After one minute had passed, subjects were instructed to shake the first tomato juice sample up and down three times, remove the lid, one mouthful, and evaluate the sample for overall liking and flavor liking on labeled affective magnitude scales (LAM) (Schutz & Cardello, 2001). Subjects were instructed to consume a second mouthful of the sample and to rate saltiness intensity on the general labeled magnitude scale (gLMS) (Bartoshuk et al., 2003). This process was repeated for sourness, sweetness, and bitterness. The same procedure was followed to evaluate the remaining three tomato juices.

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