



## A longitudinal comparison of two salt reduction strategies: Acceptability of a low sodium food depends on the consumer



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### ABSTRACT

In their 2010 publication, *Strategies to Reduce Sodium Intake in the United States*, the Institute of Medicine suggested the FDA mandate salt reduction at the food industry level via a strategy of gradual, step-wise decline. The objective of this study was to compare the acceptability trajectories of a gradual to an abrupt salt reduction strategy of a high sodium food, and to determine if these trajectories were impacted by an individual's hedonic sensitivity to salt and/or motivation to reduce dietary salt intake. Eighty-three subjects participated in a three-part study: an initial taste test, a 16-week longitudinal study, and a final taste test. At the initial and final taste tests, subjects indicated liking of tomato juice at four salt concentrations ranging from 136 mg sodium/serving (low sodium) to 640 mg sodium/serving (comparable to a commercially available product). To create two groups for the 16-week study, subjects were balanced for 6-n-propylthiouracil sensitivity, motivation to reduce dietary salt intake, and hedonic sensitivity to salt (the difference in liking between the highest and lowest salt concentrations in tomato juice served at the initial taste test). One group received juice abruptly reduced in salt at week 4 to a target low sodium level; the second group received juice gradually reduced in salt via difference threshold steps determined in a preliminary study (cumulating reductions of 12% each), to reach the target at week 14. We observed no overall difference in liking for low sodium juice at the end of the study as a result of salt reduction strategy; however, the trajectory of liking ratings over time differed between groups. Gradual salt reduction was more effective than the abrupt salt reduction because the abrupt reduction was accompanied by a large immediate drop in liking whereas the gradual reduction better maintained acceptability throughout the process. Subjects with low hedonic sensitivity responded favorably to both salt reduction strategies and would likely have no difficulty in adjusting to the taste of reduced salt foods. However, subjects with high hedonic sensitivity disliked reduced salt juice at some point during the study, regardless of strategy, and would likely have difficulty in adjusting to the taste of reduced salt foods.

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### Introduction

In April, 2010, the Institute of Medicine (IOM) published *Strategies to Reduce Sodium Intake in the United States*, a manual in which mandatory gradual step-wise salt reduction at the food industry level was suggested as a means by which to reduce population dietary salt intake to levels recommended by the 2010 Dietary Guidelines, thereby reducing associated rates of hypertension and healthcare costs. Proponents of a salt reduction mandate contend that national initiatives of the past, including setting target goals for sodium intake, advertisements alerting consumers to the health

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risks associated with a high-salt diet, and voluntary efforts by way of the food industry to reduce salt in processed foods, have done little to change food manufacturing practices or to curb dietary salt intake among Americans. According to the IOM, these findings, in addition to the fact that the relative contribution of processed foods to daily salt intake is over 75% (Mattes & Donnelly, 1991), indicate a mandatory approach is the only feasible option for addressing what is regarded as a serious public health problem. Despite widespread support for a salt mandate and the strategy of gradual salt reduction, there is little evidence to support usefulness of this initiative. Whether gradual salt reduction is the most effective strategy for adjusting a population to a reduced salt food supply, and whether individuals can grow to like reduced-salt and low sodium foods despite overall 'dietary freedom' remain unknown. From a sensory perspective, considerable research is required to better understand how consumers might respond to

the IOM's suggested salt mandate in terms of acceptability of lower sodium foods.

#### *Understanding salt reduction*

Relative successes in reducing population dietary salt intake in both Finland and the United Kingdom are often cited as evidence in support of an American salt mandate. Between 1972 and 2002, Finland succeeded in reducing average sodium intake of its citizens from 5600 to 3200 mg/day through implementation of government regulation of salt and public health awareness. In 2004, the UK initiated a salt reduction campaign that although voluntary, has been effective at reducing salt in the food supply by approximately 30% (He & MacGregor, 2009). Current sodium recommendations in the US suggest a maximum intake of 2300 mg sodium/day (USDA, 2010); there is no known initiative that has been implemented or has succeeded in bringing a population's dietary salt intake to levels this low—in fact, average dietary salt intake in both Finland and the UK has now only just been reduced to levels comparable to current salt intake among Americans (approximately 3400 mg sodium/day (IOM, 2010)). In addition, salt reduction in Finland is largely attributed to a decrease in home salt use (IOM, 2010), a source of sodium of little concern in the US because of its minimal contribution to overall sodium intake (Mattes & Donnelly, 1991), and because Americans generally do not compensate for sodium reduction in foods through addition of salt (Beauchamp, Bertino, & Engelman, 1987). Because efforts to reduce population dietary salt intake to the extent suggested by the 2010 dietary guidelines have not been attempted, it is difficult to predict how consumers might respond to significant salt reductions despite accomplishments in other countries.

Evidence supporting habituation to a reduced salt diet is based primarily on studies that have demonstrated alteration in liking for salt as a result of exposure to high sodium (Bertino, Beauchamp, & Engelman, 1986) or low sodium diets (Bertino, Beauchamp, & Engelman, 1982; Blais et al., 1986; Elmer, 1988); those consuming a high dietary salt intake prefer saltier foods, and those consuming a low dietary salt intake prefer less salty foods. The change in salt liking is thought to be due to context: within the context of a high salt diet anything low in salt is perceived as less pleasant, and within the context of a low salt diet, anything high in salt is perceived as less pleasant. Based on these observed changes in salt preference, the IOM has suggested that the same phenomenon could possibly occur on a population-wide basis should salt be gradually reduced in processed foods. Foods would be reduced in salt by small increments and consumers' salt preferences would naturally shift downwards to match a new reduced dietary salt intake; however, the data supporting this hypothesis suggests that a decrease in salt preference typically occurs eight weeks following the start of a low sodium diet. As a result, the IOM has outlined several concerns regarding the feasibility of population-wide dietary salt reduction. For example, the average American would not already be consuming a low sodium diet when first introduced to a national salt reduction initiative. As such, would a coordinated approach by the food industry in which all processed foods are reduced at the same rate be necessary in order to ensure consumer acceptability? Would exposure to salty tasting foods during this process interrupt habituation to the taste of a lower salt food supply?

#### *Motivation and dietary behavior*

Current research on motivation as it relates to dietary behavior has focused primarily on the link between weight maintenance and motivation to adopt and sustain a healthful diet, and the role of motivation quality in predicting outcome success. Specifically,

intrinsic or self-determined motivation has been shown to be more successful for longer-term behavior change than extrinsic motivation; the former is driven by a personal interest and the latter by an outside source such as a financial incentive or expected negative consequence. Relative to extrinsic motivation, self-determined motivation is thought to be more successful at altering long-term behavior because of an associated sense of autonomy and ownership over one's own decisions, and a greater sense of responsibility to follow through on a course of action than one might have had a decision been dictated by another individual (Teixeira, Patrick, & Mata, 2011). Pelletier, Dion, Slovinec-D'Angelo, and Reid (2004) reported a positive association between self-determined motivation and a reduction in intake of calories from fat and saturated fat at the end of a 26 week study examining the role of motivation in eating regulation. Mata et al. (2009) found that self-determined motivation for exercise and weight control was predictive of eating self-regulation over a one year period. Similar to differences in motivation in terms of source of reinforcement, Stone and Pangborn (1990), in a study linking sugar and salt intake to personality traits, determined that subjects who felt they had self-control over their health liked lower levels of salt in beef broth more than subjects who thought their health was largely determined by other people or by fate. Should motivation or one's own beliefs about health have an impact on salt intake, improving motivation to alter dietary behavior may be an important strategy for reducing dietary salt intake, particularly in light of evidence that maintaining a diet that both complies with sodium intake guidelines and is nutritionally adequate would require a large deviation from current eating patterns (Maillot & Drewnowski, 2012).

#### *Study hypotheses*

Data presented here are from the second phase of a larger research project (phase one is detailed in a corresponding manuscript) (Bobowski, Rendahl, & Vickers, 2015). This part of the project was designed to address two hypotheses: (1) that gradual salt reduction via cumulative unnoticeable steps down in salt to a low sodium target would produce a more effective trajectory for maintaining acceptability of a low sodium food during the reduction process than abrupt salt reduction in one step to the same low sodium target, and (2) that individuals motivated to reduce dietary salt intake would have higher liking scores for a low sodium food than those unmotivated to reduce dietary salt intake. Should FDA move forward with a salt mandate, this research could provide insight into relative usefulness of salt reduction strategies and whether inherent differences among people in perception of and preference for salt might influence effectiveness of attempts to reduce dietary salt intake on a national level.

#### **Materials and methods**

The longitudinal study detailed here was preceded by an initial taste test and followed by a final taste test of four tomato juice samples ranging in salt content from high to low sodium: 640, 472, 304, and 136 mg sodium per 237 ml juice. Data collected at each taste test were used to determine each subject's most liked level of salt in tomato juice, and was used to assess changes in liking following the longitudinal phase of the study. The taste test data are discussed in a corresponding manuscript (Bobowski et al., 2015).

#### *Subjects*

One hundred and four adult subjects were recruited through a University of Minnesota database of students and staff who had previously expressed an interest in participating in studies via the

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