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Sodium and potassium mixtures can reduce sodium levels

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The association between excessive sodium intake and the development of hypertension and cardiovascular disease is well documented (1-4). Concern about this association is widespread as evidenced by these findings: dietary guidelines to limit salt in 14 of 17 countries (5); the consuming public (44%) who read food labels with the purpose of avoiding or limiting salt (6); and physicians who place

approximately 13% of the US population on a sodium-restricted diet (7).

Many consumers are reluctant to sacrifice taste for the health benefits of low-sodium foods; consequently, the challenge is to develop products that match the acceptability of salted foods (8). Many studies indicate that commercially available salt substitutes (9-14) could provide substantial reduction in sodium levels without affecting the acceptability of food. We conducted a series of experiments in which consumers rated the acceptance and perceived saltiness of food items that varied in sodium content according to combinations of sodium chloride (NaCl), potassium chloride (KCl), or a mixture of NaCl and KCl.

METHODS

Subjects and Procedure

Subjects consisted of 348 military and civilian volunteers from the US Army Natick Research, Development, and Engineering Center in Massachusetts. They were randomly selected from a panel of 500 volunteers, 21% women and 79% men, aged 17 to 70 years.

The study consisted of four experiments. The same procedure was followed for each experiment. Subjects were asked to rate two identical samples of mashed potatoes or vegetable juice. Within each experiment, type and concentration of salt were between-subject variables. After rinsing their mouth with bottled water, subjects rated each sample for saltiness and acceptability. Saltiness was rated on a scale from 0 to 9 in which 0=not at all, 1=low salt, and 9=extremely salty. Acceptance was rated using a 9-point hedonic scale in which 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely.

Materials

Test foods included a simple product (mashed potatoes) and a complex one (vegetable juice); this rating was based on the number of ingredients (15). The levels of sodium in mashed potatoes (0.03% to 0.14%) and vegetable juice (0.03 to 0.60%) were based on studies indicating that the most acceptable sodium concentration was 0.14% for mashed potatoes and between 0.25% and 0.60% for vegetable juice (16). Recipes for mashed potatoes were prepared with (a) no added salt, (b) NaCl (c) a 1:1 mixture of NaCl and KCl, or (d) KCl. Vegetable juice was purchased with and without added salt. Samples of vegetable juice included the added salt sample and those prepared by adding (a) NaCl, (b) a 1:1 mixture of NaCl and KCl, or (c) KCl to the juice with no added salt.

RESULTS

Saltiness and Acceptance

Figure 1 shows the effect of sodium concentration on saltiness and acceptability ratings of mashed potatoes in experiments 1 and 2. No significant differences in saltiness were found. The data show, however, that the sample containing only KCl was rated lower than the sample with no added salt, although both contained approximately the same sodium concentration. Acceptability for mashed potatoes varied considerably in experiment 1; however, only the 0.14% NaCl sample was found to be significantly different from the sample with no added salt [$f(3,56)=3.11; P<.05$]. In experiment 2, neither the perception of saltiness nor the acceptability of the products differed significantly.

Figure 2 shows the data for saltiness and acceptability ratings of vegetable juices in experiments 1 and 2. In experiment 1, the perception of saltiness increased as the concentration of sodium increased. Analysis of variance showed a significant main effect of concentration on saltiness. The Newman-Keuls post hoc test demonstrated differences between the lower concentrations, 0.03% to 0.14% sodium, and the higher concentrations, 0.25% to 0.27% sodium ($f[4,125]=7.97$; $P<.001$). Similar differences were found in experiment 2 between the lower and higher concentrations of sodium ($f[4,145]=4.2$; $P<.01$). Acceptability in experiment 1 was highest for vegetable juice between 0.14% and 0.27% sodium. The same level of 0.03% sodium using vegetable juice as the vehicle and prepared either with no added salt or KCl was less acceptable than vegetable juices prepared with higher concentrations of sodium—0.14% to 0.27% ($f[4,135]=13.73$; $P<.05$). In experiment 2, acceptance ratings did not differ across concentrations.

Pearson r correlations performed on vegetable juice resulted in the following correlations: +0.69 ($P>.001$) for saltiness and +0.64 ($P<.001$) for acceptance. These data indicate that consumers can use these scales consistently.

DISCUSSION

The range of sodium concentrations in the mashed potato experiments was narrow; therefore, it is not surprising that only one significant difference was found. The sample containing the KCl was perceived as less salty than the sample with no added salt, which contained the same sodium concentration. These two samples were rated as less acceptable than the other samples and so were excluded from the second study. Experiments 1 and 2 showed that the 0.09% sample was similar to the 0.14% in perceived saltiness, whether composed of NaCl or NaCl and KCl.

Sodium concentrations in the vegetable juice experiments covered a broad concentration range, 0.03% to 0.60%. In contrast to what was found for mashed potatoes, perception of saltiness varied significantly. At the higher concentrations, the perception of saltiness was the same even though the concentrations differed. Similar findings were reported by Lynch (17). The lower concentrations in each study differed significantly from the higher concentrations.

Acceptance was related to salt concentrations in these vegetable juice experiments. The perception of saltiness was lower for products containing KCl and varied among those containing NaCl or NaCl/KCl. When comparing the same concentrations of sodium (0.14%) using either NaCl or NaCl/KCl in the vegetable juice, the perception of saltiness was similar and the acceptability ratings did not differ from the higher concentrations (0.25% to 0.60%). Results indicate that a commercial salt substitute containing equal concentrations of NaCl and KCl can replace higher concentrations of NaCl without affecting consumer acceptance. Ainsworth et al (18) reported similar findings.

APPLICATIONS

The findings of this study have the following implications for commercial processing: (a) reduce added sodium by one third or more without affecting acceptance, (b) develop and revise recipes using 0.15% to 0.30% sodium concentration as the baseline for initial acceptance testing, and (c) reformulate food and beverage products by reducing the sodium content by 30% to 50%. Such food alterations and less restrictive low-sodium diets may result in improved compliance. ■

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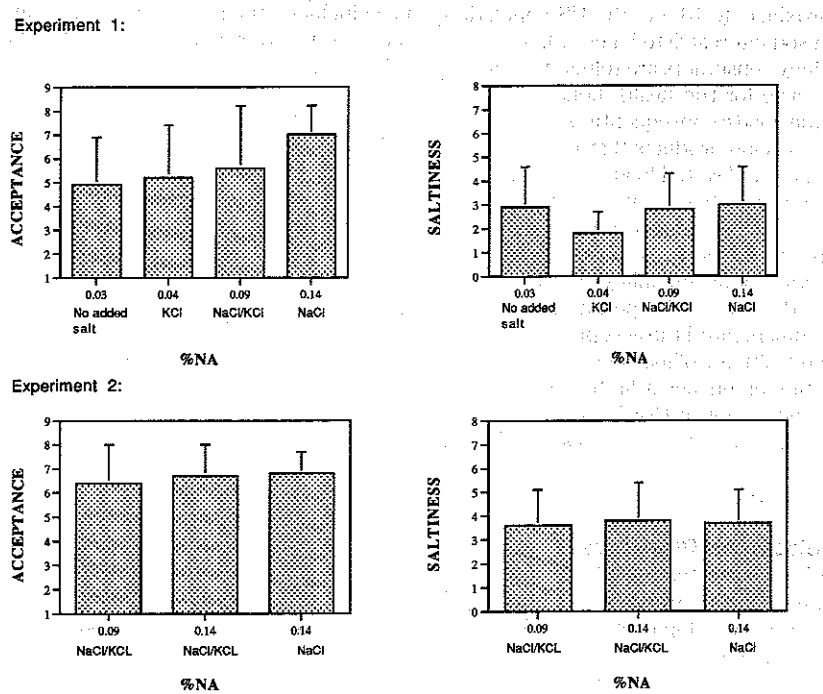

FIG 1. Mean saltiness and acceptance ratings for mashed potatoes. Key: Na = sodium; NaCl = sodium chloride; KCl = potassium chloride.

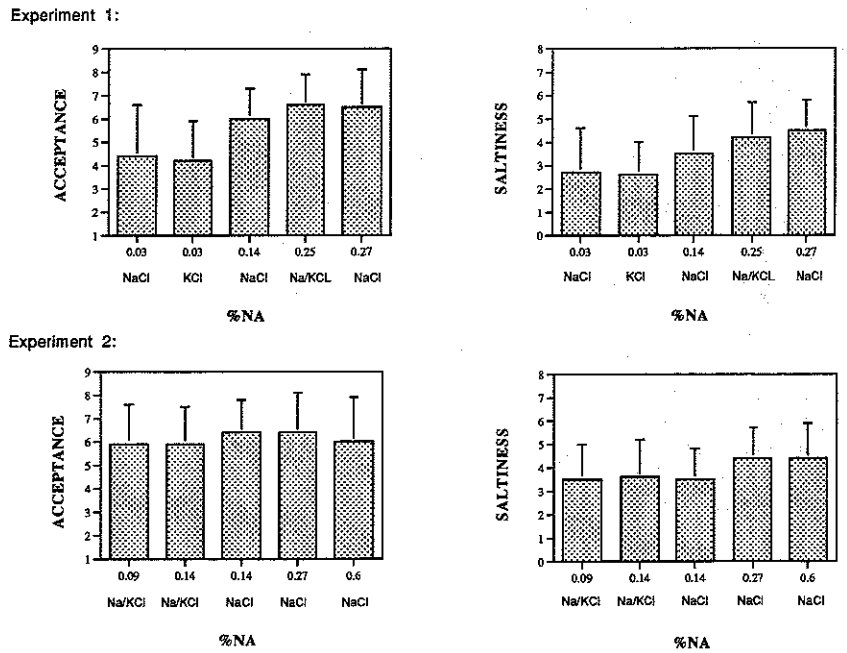

FIG 2. Mean saltiness and acceptance ratings for vegetable juice. Key: Na = sodium; NaCl = sodium chloride; KCl = potassium chloride.