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Saltiness potentiation in white bread by substituting sodium chloride with a fermented soy ingredient

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ABSTRACT

Impacts of sodium reduction and replacement using Natural Flavor Enhancer (NFE), a fermented soy ingredient, on white bread characteristic are investigated. Bread samples using only table salt or NFE as a main source of sodium were prepared and sodium levels were reduced from 10% to 50%. A trained descriptive panel ($n = 13$) evaluated the saltiness of these samples and found that breads made with NFE scored higher in saltiness than the corresponding sodium reduction made with table salt. In the replacement study, white bread samples were made using table salt and then replacing 25%, 50%, and 100% of the sodium with NFE. Increased levels of NFE substitution caused darkening of loaf crumb and crust. Bread volume was affected by addition of NFE. Consumer sensory analysis revealed that overall preference and overall liking were statistically similar for breads made with table salt and with 25% NFE replacement.

1. Introduction

Sodium is an essential nutrient needed by the body in small quantities and is primarily consumed as NaCl (sodium chloride). However, high levels of sodium intake are associated with increased blood pressure, which can lead to adverse cardiovascular health. In 2010, the U.S. Department of Agriculture and the U.S. Department of Health and Human Services published the Dietary Guidelines for Americans 2010, where they established that the upper tolerable sodium intake for adults is 2300 mg per day; Americans consume an average of 3400 mg of sodium per day.

Anderson et al. (2010) reported that bread products are one of the largest sources of sodium in the US and UK. Even a moderate reduction of sodium content in bread products would have the potential to significantly reduce daily sodium intake in the population.

Sodium chloride plays important roles in bread production, as it influences gluten behavior, strengthens dough structure, slows down gas production by decreasing yeast activity in the dough, and enhances bread flavor (Miller and Hoseney, 2008). Lynch et al. (2009) showed that reducing salt from 1.2% to 0.3% in wheat bread has no significant effect on the texture, and a minor effect on the flavor, but that the complete removal of salt from the formulation generates bread with a harder texture and increased sour and yeasty flavors.

Previous research has shown that the use of naturally brewed soy sauce and a soy sauce-derived ingredient called Natural Flavor Enhancer (NFE), which is produced using a soy sauce fermentation process with modified temperature and time parameters, and then pasteurized and spray dried using maltodextrin as the carrier, can increase overall flavor intensity, salty taste, and overall liking in frankfurters (McGough et al., 2012a, 2012b), salad dressing, tomato soup, and stir-fried pork (Kremer et al., 2009; Goh et al., 2011) due to the umami-compounds they contain.

Although there is information regarding the impact of umami imparting substances in the perception of taste (Yamaguchi and Takahashi, 1984), as well as information on the effect of reducing sodium in wheat bread (Belz et al., 2012), there is little information regarding the effect of adding umami imparting ingredients, such as naturally brewed soy sauce and NFE, on the flavor and texture characteristics of wheat bread manufactured with reduced amounts of sodium. Therefore, the objectives of this study were to investigate the impact on flavor and functionality that NFE has in white bread and to determine the impact on consumer preference of incorporating NFE to white bread.

2. Materials and methods

2.1. Materials

Bleached, enriched, pre-sifted flour (General Mills Sales, Inc., Minneapolis, Minnesota, USA) and active dry yeast (Lesaffre Yeast

Abbreviations: NFE, Natural Flavor Enhancer; JAR, Just About Right.

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Corporation, Milwaukee, Wisconsin, USA) were used for all bread making. Table salt (Table salt without Iodine, Morton International, Inc., Chicago, Illinois, USA), or a powdered form of NFE (NFE-P, Kikkoman Foods Inc., Walworth, Wisconsin, USA) were used in varying amounts.

NFE is made by using water, soybeans, wheat, and sodium chloride in a process similar to naturally brewed soy sauce, but using different temperature and time parameters. The ingredient is then pasteurized and spray dried using maltodextrin as the carrier. The typical composition of NFE is: 22.0% sodium chloride, 17.0% protein, 2.6% total nitrogen (w/w), with a final pH of 5.40–5.47.

2.2. Bread formulation and manufacture

The formulations used for the bread samples to study the effect of NFE in salty taste perception in bread are shown in Table 1. The treatments contained either table salt or NFE as the only significant source of added sodium, with the control containing 3.42 g of sodium and five treatments with 10%, 20%, 30%, 40%, and 50% sodium reduction.

The formulations used to evaluate the effect of NFE on the volume, color and consumer perception are also shown in Table 1. The control treatment contained table salt as the only significant source of added sodium (3.42 g of sodium), and three treatments where the salt source would be substituted by 25%, 50%, and 100% using NFE. Bread loaves were manufactured in triplicate for sensory analysis and in quadruplicate for all other analyses.

The ingredients of each formulation were mixed, kneaded, proofed, and baked using an automatic bread maker (Panasonic SD-YD250, Panasonic Consumer Electronics Company, Secaucus, New Jersey, USA) using the settings for basic bread, medium crust color, and extra-large loaf. After baking, the breads were cooled at room temperature for 1 h and packaged in paper bags. Samples for sensory evaluation were manufactured in triplicate. Samples for compositional and functionality analyses were manufactured in quadruplicate. Samples underwent sensory evaluation within 24 h of manufacture, compositional and loaf volume analyses were done within 1 week of manufacture.

2.3. Sensory analysis

2.3.1. Descriptive evaluation

Bread samples were cut into crust-less, 1 cm^3 cubes and given in a randomized monadic sequential presentation to a group of thirteen panelists experienced in descriptive evaluation using Spectrum® methodology (Meilgaard et al., 2006b). Panelists were asked to evaluate the salty taste intensity of each bread sample by using a 0–15 scale with anchored references of NaCl solutions in different concentrations (0.25% = 1; 0.50% = 3; 0.75% = 5.5; 1.00% = 9; 1.50% = 14).

Table 1
Formulations of bread samples first four rows are the formulations used to determine bread color, volume and consumer acceptability. Last twelve rows are the formulations used for descriptive sensory analysis.

Treatment	Sodium reduction	Flour (g)	Water (g)	Table salt (g)	NFE (g)	Yeast (g)
Control	–	500	350	8.7	0	10
NFE25	–	500	350	6.5	10	10
NFE50	–	500	350	4.5	20	10
NFE100	–	500	350	0	40	10
NaCl 0%	0%	500	350	8.7	–	10
NaCl 10%	10%	500	350	7.8	–	10
NaCl 20%	20%	500	350	6.9	–	10
NaCl 30%	30%	500	350	6.1	–	10
NaCl 40%	40%	500	350	5.2	–	10
NaCl 50%	50%	500	350	4.3	–	10
NFE 0%	0%	500	350	–	38.4	10
NFE 10%	10%	500	350	–	34.6	10
NFE 20%	20%	500	350	–	30.7	10
NFE 30%	30%	500	350	–	26.9	10
NFE 40%	40%	500	350	–	23.0	10
NFE50%	50%	500	350	–	19.1	10

2.3.2. Consumer acceptability

Consumer sensory analysis was conducted at the University of Wisconsin–Madison, Consumer Sensory Analysis Laboratory. Bread samples were given to 94 white bread consumers in a randomized sequential monadic presentation.

For sample preparation, the breads were cut in 1 cm thick slices, then each slice was cut into four pieces. Samples were assigned random three digit codes for identification. The selected consumers were asked to evaluate their overall liking of each sample on a 9-point hedonic scale, appearance liking, texture liking, aroma liking, and flavor liking of each sample on a 7-point hedonic scale, and the crust and crumb color, crust and crumb flavor, and crust and crumb texture on a 5-point just-about-right scale. Panelists were also asked to answer their purchase intent on a 5-point scale and to rank the samples from the most liked to the least liked.

2.4. Bread color and volume

Sample color was determined using a colorimeter (Minolta Chroma Meter CR-300, Minolta Corporation, Ramsey, New Jersey, USA) by recording the CIELAB values at 4 points of the crumb and 6 points of the crust. The volume of the loaves was determined by rapeseed displacement (AACC method 10-05, AACC, 2000).

2.5. Sodium content

Bread samples were prepared for analysis according to AACC method 62-05 (AACC, 2000) for compositional analysis for sodium content (AOAC method 2006.03).

2.6. Statistics

Statistical analysis was performed using statistical analysis software (JMP Pro 10, SAS Institute Inc. Cary, North Carolina, USA). Sodium levels, loaf volume, loaf color, and descriptive analysis data were evaluated with one-way ANOVA. Hedonic consumer data was evaluated for differences with one-way ANOVA. Just-about-right (JAR) data was evaluated using the Cochran-Mantle-Haenszel (CMH) method to determine if the JAR score distributions were similar among products and, when significant differences were found, the CMH method was used to find differences among pairs of products (Fritz, 2009). Ranked data was evaluated for significant differences using Friedman statistic and a nonparametric LSD (Meilgaard et al., 2006a). Significance levels were determined at $\alpha < 0.05$.

3. Results and discussion

3.1. Sodium reduction

Results from the descriptive sensory analysis showed that using NFE as a source of sodium resulted in an increase in perceived saltiness (Fig. 1). Treatments containing NFE had a significant increase in the perceived salty taste intensity compared to the bread made with table salt in 0% (no reduction), 10%, 30%, and 40% reductions.

Compared to bread containing table salt with no sodium reduction, there were no differences in saltiness in NFE bread with