Sensory Interactions of Formulations to Mask Potassium Chloride Flavor Using Morton Lite Salt Mixture in White Pan Breads[1]

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ABSTRACT

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White pan breads containing three soy-based ingredients (milk replacer, dough conditioner, and oil) were compared with nonsoy containing breads to determine the effect of soy on the atypical flavor notes when using Morton Lite Salt, a mixture of sodium chloride and potassium chloride. Use of Lite Salt in bread shortened proof time and significantly decreased the sodium:potassium ratio. Soy ingredients had no effect on sensory bread softness or gumminess and did not intensify astringent mouthfeel or bitterness of breads containing Lite Salt; to the contrary, soy dough conditioner seemed to have some masking effect on bitterness. Also, breads containing soy ingredients were significantly less firm according to instrumental assessments and had greater volume than the nonsoy-containing breads. In the second part of the study, white pan breads with two levels of sucrose and Lite Salt and varied combinations of autolyzed yeast, milk solids, or butter (as a spread) did not differ significantly from the standard bread with sodium chloride.

Although a causal relationship between dietary sodium (Na) and hypertension has not been established, there is evidence that excessive intake of Na contributes to the increasing incidence of hypertension in the U.S. (Dahl 1972, Weber and Laragh 1978, Morgan et al 1978). Consumers continue to place pressure on the food industry to reduce the level of Na-containing ingredients currently included in processed food. Although bread is not considered a high-Na food, three slices per day contribute 400 mg, or approximately 7 to 10% of our estimated average daily Na intake (Vetter 1982). Efforts to reduce the Na level in white pan bread have included the use of potassium chloride (KCl) and sodium chloride (NaCl) mixtures as salt substitutes.

Kulp et al (1982) studied the effect of Morton Lite Salt Mixture, a 1:1 blend of KCl and NaCl, in white pan bread. They reported no significant differences between the effect of NaCl and Lite Salt on starch pasting, specific volume, or crumb firmness. However, the time required to reach minimum mobility was shorter in doughs containing Lite Salt than in doughs containing NaCl. Danno and Hoseney (1982), among others, found an increase in mixing time and in width and height of the mixograph curve as NaCl concentration increased. Lite Salt inhibited yeast growth much less than NaCl, thus decreasing proof time. In a similar study, Salovaara (1982a) reported that no essential technological problems are likely to be met when as much as 40% of NaCl normally present in bread is replaced with equivalent amounts of KCl.

Sensory studies have shown that at some levels KCl imparts a bitter flavor and astringent mouthfeel to breads. Wyatt and Ronan (1982), using an untrained panel of 40 judges and a hedonic scale, rated breads containing a 1% flour weight basis (fwb) mixture of 1:1 KCl-NaCl as not significantly different from the NaCl-containing breads. Salovaara (1982b), using triangle testing and 12–15 experienced judges, reported that flavor and aroma of breads containing KCl at the 20% replacement level (2% fwb) did not differ from breads containing only NaCl. At the 40% replacement level a significant bitter flavor was reported. Breads rated acceptable in the Wyatt and Ronan study (1% fwb at 50% replacement) had similar KCl content to breads rated acceptable in the Salovaara report (2% at 20% replacement). In contrast, Kulp et al (1982) characterized breads containing the Morton Lite Salt Mixture as having questionable consumer acceptability. A five-member panel experienced in bread profiling reported that the breads made with Lite Salt had atypical flavor profiles at both the 1.5 and 2.2% (fwb) levels. Atypical notes decreased in intensity with aging but by day four were detectable in both bread and toast.

The objective of this study was to assess formulation changes to mask undesirable KCl flavors in yeast breads. Preliminary work indicated a seemingly more intense KCl bitterness when soy oil was used instead of cottonseed or corn oil. The first part of the study was designed to determine if atypical flavor notes resulted from an interaction of soy ingredients with KCl rather than KCl alone. The follow-up study tested the effects of autolyzed yeast, milk solids, and butter as a spread on the perception of bitterness and astringency in white pan breads with two levels of sucrose and of Lite Salt.

MATERIALS AND METHODS

Formulation and Baking Procedures

The flour selected for this study was a composite of many hard wheat varieties harvested throughout the Great Plains in 1979. Moisture (13.0%) and protein content (11.7% N × 5.7, 14% moisture basis, mb) were determined by AACC approved methods 44-15A (1975) and 46-11 (1976), respectively. The breadmaking method included mixing for 4 min to reach minimum mobility (optimum). The standard bread formula with NaCl required 60.5 ml of water (optimum), 50 ppm ascorbic acid, 6.0 g of sugar, 2.0 g of NaCl, 3.0 g of oil, 5.3 g ± 0.2 g of compressed yeast, 0.25 g of barley malt (52 dextrinizing units per gram), 4.0 g of milk replacer, and 1.25 g of dough conditioner per 100 g of flour (14% mb). All possible combinations of soy and nonsoy dough conditioners, milk replacers, and oils were tested with this formula and with Lite Salt in place of NaCl.

In the second part of the study, neither dough conditioner nor milk replacer was used. The standard bread was prepared with 2.0 g NaCl, and the control bread was prepared with 2.0 g Lite Salt. The randomized complete block design tested two levels of Lite Salt (1.0 and 2.0%, fwb) and two levels of sucrose (6.0 and 8.0%, fwb) in all combinations with or without 0.75% autolyzed yeast or 4.0% milk solids as ingredients, or butter, used as a spread.

Straight doughs were fermented 52 min to first punch, 77 min to second punch, and 90 min to pan, and were proofed 32 ± 1 min (the time required to proof controls to 7.8 cm) at 30° C. Baking time was 24 min at 215°C. Loaf volume was determined by rapeseed displacement immediately upon removal from the oven. All loaves were labeled and frozen (−10° C) for an equal time before sensory evaluation. Preliminary triangle testing, comparing freshly baked breads held 24 hr to breads frozen and held up to six weeks, indicated no differences in the flavor notes studied.

Physical Measurements

The Instron universal testing instrument (IUTM) (Instron Corp., Canton, MA, model 1122) was used to determine crumb

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compressibility. Three 50 × 50 × 25 mm crustless samples from the midsection of each loaf were evaluated. A 5-cm^2 compression anvil, Instron model A372-17, was used with a 10-kg load cell at a crosshead speed of 100 mm/min. The upper limit was set at 18 mm and depth of penetration at 10 mm. Peak height of the curve, graphed at a chart speed of 100 mm/min, was measured as representative of the resistance of the crumb to compression.

Breads were analyzed for Na and K content using emission spectrographic methods 49.001–49.007 (AOAC 1980); then the ratio of Na to K (g) was determined for each treatment.

TABLE I
Sensory Characteristics and Scale Anchors for Characteristics of White Pan Breads

Characteristics	Scale Anchor and Score	Standard[a]
Softness	1 = Very soft 14 = Very firm	2.0
Gumminess	1 = No gumminess 14 = Very gummy	1.0
KCl bitterness	1 = None 14 = Intense	1.0
Astringent mouthfeel	1 = None 14 = Intense	1.0

[a]Bread prepared with sodium chloride with assigned values that were designated on a score card in the first part of this study.

TABLE II
Least Squares Means for Volume of Breads Containing Salt (NaCl) or Morton Lite Salt Mixture and Soy or Nonsoy Dough Conditioner, Milk Replacer, and Oil

Ingredient	Volume[a] (cc)
Salt	
NaCl	936.3
Lite	977.00***[b]
Dough conditioner	
Soy	961.9
Nonsoy	946.4***
Milk replacer	
Soy	957.0
Nonsoy	950.3*
Oil	
Soy	959.5
Nonsoy	948.8**

[a]Three replications.
[b]Level of significance is indicated as follows: *, $P \leq 0.05$; **, $P \leq 0.01$; ***, $P \leq 0.001$.

Sensory Evaluation of Breads

Sample preparation. The loaves were allowed to thaw one hour before sensory analysis. Crusts were removed before cutting 2.54 cm cubes, which were placed on white, odor-free plates. Samples were coded with three-digit random numbers and presented in random order to panelists to minimize biases from carryover or aftertaste of bitterness and astringency.

Sensory analysis. Potential panelists were tested for their sensitivity to bitterness. Panelists selected represented a range of sensitivities as might be encountered in a normal population. For the first study, 10 panelists were familiarized with sensory test procedures, standard bread characteristics, and the scoring method to be used. Panelists determined the characteristics pertinent for this study: they evaluated bread softness, gumminess, KCl bitterness, and astringent mouthfeel on a 15-cm unstructured line intensity scale, anchored at the extremes (Table I). The standard bread (prepared with NaCl and no soy ingredients) was evaluated by the panelists during the training sessions, and scores were assigned for each characteristic and designated on the score card. This standard bread was served at each session and identified for the panelists as a reference point. Four midmorning sessions per week, with four samples evaluated at each session, allowed all treatment combinations to be evaluated within a week.

In the second study, the standard bread, prepared with 2% NaCl and 6% sugar, was included in each test series but was not identified for the six panelists. Samples to be buttered were spread by the panelists with ⅛ teaspoon unsalted butter (Land O'Lakes). Apple slices and a water rinse were provided for panelists to use between samples.

Statistical design and analysis. A randomized complete block design with 16 treatment combinations was used for each study. Each experiment was repeated three times with all treatment combinations. When significant differences were found for treatments or treatment combinations after analyses of variance, least significant differences were used to compare means (SAS Institute 1982).

TABLE III
Analysis of Variance for Physical, Chemical, and Sensory Data[a] of White Pan Breads Containing Sodium Chloride (NaCl) or Morton Lite Salt Mixture (NaCl:KCl) with Soy and Nonsoy Ingredients

		F Value and Level of Significance[b]						
Ingredient	DF	Volume	Compressibility[c]	Na:K ratio	Softness[d]	Gumminess[d]	KCl Bitterness[d]	Astringent[d] Mouthfeel
Salt (S)	1	86.03***	0.45	4,542.72***	2.68	0.00	64.90***	58.01***
Dough conditioner (DC)	1	16.15***	2.20	24.66***	0.09	0.03	3.48	0.49
Milk replacer (MR)	1	3.96*	4.93*	23.54***	0.10	1.65	0.26	1.59
Oil (O)	1	7.89**	0.15	1.52	0.00	0.39	0.02	0.11
S + DC	1	0.01	1.91	16.42***	0.54	0.60	3.97[e]	0.63
S + MR	1	0.64	0.22	3.50	0.44	0.00	0.50	0.51
S + O	1	0.00	0.07	55.24*	0.21	0.09	0.02	0.25
DC + MR	1	0.13	5.87*	5.53*	0.30	5.52*	0.19	0.12
DC + O	1	0 .00	0.64	119.87***	0.51	0.01	0.04	0.22
MR + O	1	0.33	2.85	50.39***	3.63	0.45	0.02	0.34
DC + MR + S	1	1.59	0.00	7.39*	0.00	0.00	0.20	0.56
DC + MR + O	1	0.14	0.72	20.48***	0.00	0.20	1.79	0.02
DC + S + O	1	0.02	0.03	75.07***	1.07	0.22	0.69	0.28
MR + S + O	1	0.03	2.43	56.61***	0.01	0.03	0.29	0.77
DC + MR + S + O	1	0.02	1.16	13.86**	0.08	0.08	0.05	0.72

[a]Three replications.
[b]F = variance ratio. Values without an asterisk are not significantly different. Level of significance is indicated as follows: *, $P \leq 0.05$; **, $P \leq 0.01$; ***, $P \leq 0.001$.
[c]Instron universal testing machine measurement.
[d]Sensory assessment.
[e]Level of significance: $P \leq 0.056$.

RESULTS AND DISCUSSION

Physical Measurements

Volume. Loaf volumes were significantly higher ($P \leqslant 0.001$) for all breads containing Lite Salt (Table II). Gassing power studies have shown that Lite Salt inhibited yeast fermentation to a lesser extent than NaCl (Kulp 1982, Salovaara 1982a). Since breads in this study were proofed to time rather than to height, breads containing Lite Salt would be expected to have higher volumes.

Slightly higher volumes also were significant (Table III) for soy-containing milk replacer ($P \leqslant 0.05$), dough conditioner ($P \leqslant 0.001$), and oil ($P \leqslant 0.01$). The enhancement of volume by soy milk replacer and dough conditioner could be attributed to the effects soy flour has on gluten protein. Adding small amounts of nonwheat flours dilutes the gluten content, and the dough becomes slightly more extensible (Ofelt et al 1952, Finney 1984). Oil makes a dough softer and more extensible and may increase volume. No studies comparing the effect of soy and nonsoy oil were found to account for the higher volumes in breads containing soy oil.

Na:K ratio. Comparison of mean values of Na:K are given in Table IV. As expected, breads containing Lite Salt had significantly lower Na:K ratios than breads containing NaCl. A significant difference was found between the two milk replacers and dough conditioners with the soy ingredients giving the higher Na:K ratio. Analyses of variance (Table III) indicated a four-way interaction of milk replacer, dough conditioner, oil, and salt with no apparent pattern to the differences among the means (Table IV).

Compressibility. The dough conditioner–milk replacer interaction for IUTM compressibility was significant ($P \leqslant 0.05$). The nonsoy milk replacer with the nonsoy dough conditioner gave the bread with the firmest crumb ($P < 0.05$). Those least squares means are shown in Table V. The softer crumb of breads containing soy flour has been attributed to the water-holding capacity of soy flour (Stellar and Bailey 1937, Ying and Geddes 1948, Turro and Sipos 1970). Furthermore, the greater loaf volume noted in soy-containing breads also might contribute to crumb softness.

Softness. No significant differences in sensory softness were found among treatments (Table IV).

Gumminess. Least squares means for gumminess are reported in Table V. A significant difference ($P \leqslant 0.05$) in gumminess for the dough conditioner and milk replacer interaction was noted; the bread containing the nonsoy dough conditioner and nonsoy milk replacer was rated the most gummy compared to breads containing any of the soy counterparts. The bread evaluated as most firm by IUTM measurement also contained this treatment combination. Possibly, the attribute panelists referred to as gumminess was related to the characteristic of firmness evaluated by IUTM measurement. Further work would need to be done to confirm this observation. No significant difference in gumminess was attributed to salt or oil.

Astringent mouthfeel. Significant differences in astringency ($P \leqslant 0.001$) were noted for type of salt, as given in Table III. Breads containing Morton Lite Salt Mixture were given a significantly higher mean rating (5.2) for astringent mouthfeel than the breads containing NaCl (3.4). Kulp and co-workers (1982) reported similar astringency in breads containing Lite Salt at both the 1.5 and 2.2% (fwb) levels. Neither milk replacer, dough conditioner, nor oil (soy and nonsoy) had a significant effect on astringent mouthfeel.

KCl bitterness. Least squares means for KCl bitterness were higher ($P \leqslant 0.001$) for the Lite Salt mixture (5.1) than for NaCl (3.3). Similar results had been reported in studies evaluating 50% replacement of NaCl (2% level) with KCl (Kulp et al 1982, Salovaara 1982a). However, in this study the mean score for KCl bitterness in breads containing Lite Salt with all treatments pooled was only 5.1 on a scale having 15.0 as the highest point.

The interaction of dough conditioner and salt was significant for bitterness at the $P \leqslant 0.056$ level. When the Lite Salt was used with soy dough conditioner, scores for bitterness were lower (4.6) than when nonsoy dough conditioner was used (5.5). Bitterness scores with soy or nonsoy dough conditioner and NaCl were 3.3 in each instance. Therefore, some masking potential by the very low levels of soy dough conditioner is indicated.

In this portion of the study, the use of Morton Lite Salt Mixture in white pan breads shortened proof time and significantly decreased the Na:K ratio. Breads containing Lite Salt consistently were rated mildly bitter and had an astringent mouthfeel. Bitterness was not increased significantly with soy ingredients, although the breads rated most bitter did contain soy oil. Soy dough conditioner appeared to have a slight masking effect on bitterness. Breads containing soy ingredients were significantly less firm and had greater volumes than breads with nonsoy ingredients.

Ingredients as Masking Agents

The treatments in this portion of the study were designated as follows: A) the control bread, with 2% Lite Salt (fwb), 6% sucrose (fwb); B) 2% Lite Salt, 8% sucrose; C) 1.5% Lite Salt, 6% sucrose; and D) 1.5% Lite Salt, 8% sucrose. Each of these treatment combinations was tested and evaluated with milk solids, autolyzed yeast, and spread with butter.

Treatments B, C, and D were not found to be different from the treatment A bread used as the control for Lite Salt (Table VI). This seems to indicate no effect of the level of sucrose in masking bitterness or astringency. Nor did the addition of milk solids result in any significant differences from the control bread in either bitterness or astringency. On the other hand, neither treatments A nor D were considered to be different from the standard bread made with NaCl. None of the breads in this part of the study, which were prepared with cottonseed oil instead of soy oil, had bitterness or astringency scores that would be considered high, ranking 2.7 or

TABLE IV
Mean Values for Sodium to Potassium Ratios (Na:K) in White Pan Breads Made with Sodium Chloride (NaCl) or Morton Lite Salt Mixture and Soy or Nonsoy Dough Conditioner, Milk Replacer, or Oil

Ingredients Combined				
Dough Conditioner	Milk Replacer	Salt	Oil	Na:K (mean[a])
Nonsoy	Nonsoy	Lite	Nonsoy	0.63 abe
Nonsoy	Nonsoy	Lite	Soy	0.73 abe
Nonsoy	Nonsoy	NaCl	Nonsoy	2.78 c
Nonsoy	Nonsoy	NaCl	Soy	2.55 dg
Nonsoy	Soy	Lite	Nonsoy	0.71 bef
Nonsoy	Soy	Lite	Soy	0.83 abef
Nonsoy	Soy	NaCl	Nonsoy	2.41 dg
Nonsoy	Soy	NaCl	Soy	3.72 h
Soy	Nonsoy	Lite	Nonsoy	0.70 abef
Soy	Nonsoy	Lite	Soy	0.70 abef
Soy	Nonsoy	NaCl	Nonsoy	3.64 hi
Soy	Nonsoy	NaCl	Soy	2.64 cd
Soy	Soy	Lite	Nonsoy	0.86 bef
Soy	Soy	Lite	Nonsoy	0.77 abef
Soy	Soy	NaCl	Nonsoy	3.48 i
Soy	Soy	NaCl	Soy	2.92 c

[a]Two replications. Means followed by the same letter are not significantly different ($P \leqslant 0.05$).

TABLE V
Least Squares Means[a] for Sensory Gumminess[b] and Instron Universal Testing Machine (IUTM) Compressibility of Breads Containing Soy or Nonsoy Milk Replacer and Dough Conditioner

Ingredient Combination	Sensory Gumminess	IUTM Compressibility
Soy milk replacer		
Soy dough conditioner	3.7 ab	0.66 a
Nonsoy dough conditioner	3.1 a	0.65 a
Nonsoy milk replacer		
Soy dough conditioner	3.5 ab	0.63 a
Nonsoy dough conditioner	4.0 b	0.78 b

[a]Three replications.
[b]Mean values in a column followed by the same letters are not significantly different ($P < 0.05$). Scores ranged from 1 = no gumminess to 14 = very gummy.

3.8 on a 15-point sensory scale. Breads A and B made with autolyzed yeast also were considered not to differ significantly from the control bread without autolyzed yeast or from the standard bread using NaCl.

Butter as a spread had a masking effect when used on bread with 8% sucrose and 2% Lite Salt (B), but the buttered bread with 8% sucrose and 1.5% Lite Salt (D) was not different from the NaCl standard bread. Since bitterness was lessened by some combinations of ingredients but not by any one ingredient alone, the effectiveness of sucrose, milk solids, autolyzed yeast, or butter used as a spread for masking bitterness cannot be stated conclusively.

Effects of Ingredients on Other Characteristics

Mean scores for volume, IUTM firmness, and sensory gumminess, and comparisons of those scores to the Lite Salt control and the NaCl standard breads are given in Table VII. The bread with 6% sucrose and 1.5% Lite Salt with milk solids was the most firm

TABLE VI
Mean Scores[a] for Bitterness and Astringency Ranked and Compared to the Sodium Chloride (NaCl) Standard and Lite Salt Control Breads

KCl Bitterness				Astringency			
		Level of Difference from				Level of Difference from	
Treatment[b]	Mean Score	Lite Salt Control	NaCl Standard	Treatment	Mean Score	Lite Salt Control	NaCl Standard
BWB	1.38	0.03	NS[c]	AWB	2.19	NS	NS
STD	1.40	0.0	···	CWB	2.64	NS	NS
B	1.68	NS	NS	STD	2.82	NS	···
C	1.84	NS	NS	AAY	3.06	NS	NS
BAY	1.97	NS	NS	A	3.13	···	NS
DMS	1.98	NS	NS	BWB	3.21	NS	NS
AMS	1.99	NS	NS	BMS	3.25	NS	NS
AAY	2.00	NS	NS	CMS	3.28	NS	NS
DWB	2.001	NS	NS	DWB	3.31	NS	NS
D	2.09	NS	0.06	D	3.43	NS	NS
CWB	2.10	NS	0.06	CAY	3.53	NS	NS
CMS	2.18	NS	0.04	DMS	3.57	NS	NS
A	2.18	···	0.04	B	3.66	NS	NS
AWB	2.34	NS	0.010	C	3.67	NS	NS
BMS	2.41	NS	0.008	AMS	3.69	NS	NS
DAY	2.65	NS	0.001	BAY	3.75	NS	NS
CAY	2.72	NS	0.0008	DAY	3.82	NS	NS

[a]Three replications. Bitterness and astringency were scored from 1 = none to 14 = intense.
[b]Codes used were: STD = 6% sucrose, 2% NaCl; A = 6% sucrose, 2% Lite Salt; B = 8% sucrose, 2% Lite Salt; C = 6% sucrose, 1.5% Lite Salt; D = 8% sucrose, 1.5% Lite Salt; AY = 0.75% autolyzed yeast; MS = 4% milk solids; WB = with butter.
[c]NS = Not significant.

TABLE VII
Mean Scores[a] of Breads Ranked and Compared to Lite Salt Control and Sodium Chloride (NaCl) Standard Breads for Volume, Firmness, and Sensory Gumminess

Volume (cc)				Firmness (kg)[b]				Gumminess[c]			
		Level of Difference from				Level of Difference from				Level of Difference from	
Treatment[d]	Mean Score	Lite Salt Control	NaCl Standard	Treatment[d]	Mean Score	Lite Salt Control	NaCl Standard	Treatment[d]	Mean Score	Lite Salt Control	NaCl Standard
CMS	938	0.05	NS[e]	D	0.399	0.01	0.03	DWB	4.10	0.001	0.01
STD	942	0.02	···	BAY	0.414	NS	NS	BWB	4.49	0.01	0.095
B	953	NS	NS	AAY	0.416	NS	NS	D	4.89	0.09	NS
A	958	···	0.02	BMS	0.419	NS	NS	DAY	4.92	NS	NS
DMS	962	NS	0.03	CAY	0.420	NS	NS	CWB	5.01	NS	NS
C	966	NS	0.0011	A	0.420	···	NS	AWB	5.06	NS	NS
AMS	970	NS	0.003	DAY	0.425	NS	NS	C	5.09	NS	NS
AAY	989	0.003	0.0001	C	0.426	NS	NS	CAY	5.21	NS	NS
D	994	0.0001	0.0001	AMS	0.428	NS	0.02	CMS	5.24	NS	NS
CAY	995	0.0006	0.0001	STD	0.436	NS	NS	STD	5.25	NS	···
BAY	996	0.0004	0.0001	B	0.442	NS	NS	BAY	5.26	NS	NS
DAY	997	0.0003	0.0001	DMS	0.459	0.09	NS	A	5.66	···	NS
BMS	999	0.0002	0.0001	CMS	0.479	NS	NS	AMS	5.83	NS	NS
								BMS	5.87	NS	NS
								AAY	5.96	NS	NS
								DMS	6.19	NS	0.04
								B	6.20	NS	0.04

[a]Three replications.
[b]Force on Instron universal testing machine, 0.1 kg load cell, required to compress bread sample, 25-cm thick, with crust.
[c]Scored from 1 = no gumminess to 14 = very gummy.
[d]Codes used were: STD = 6% sucrose, 2% NaCl; A = 6% sucrose, 2% Lite Salt; B = 8% sucrose, 2% Lite Salt; C = 6% sucrose, 1.5% Lite Salt; D = 8% sucrose, 1.5% Lite Salt; AY = 0.75% autolyzed yeast; MS = 4% milk solids; WB = with butter.
[e]NS = Not significant.

and had the lowest volume of the breads tested in this study, and the bread with 8% sucrose and 2% Lite Salt had a low firmness score and a high volume.

Summary

Sensory product optimization means identifying the best possible or most favorable product (in this case, white pan bread) from a sensory perspective. These studies indicate that each of the ingredients studied has some impact on lessening bitterness of KCl when used in product formulations. Additional levels of sucrose, Lite Salt, milk solids and milk replacers, soy oils, and dough conditioners should be studied by response surface methodology or similar approaches to optimize bread formulations with respect to bitterness. Results from the second part of this study are promising, since ratings for bitterness in bread formulas used were low.

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