THE EFFECT OF FAT CONTENT AND FLAVOR ENHANCERS ON THE PERCEIVED SALTINESS OF COOKED 'BOLOGNA-TYPE' SAUSAGES

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ABSTRACT

The objective of this study was to evaluate the saltiness perception of cooked sausage changes the fat content of sausages was varied. The effect of varying fat content (8, 12, 16, 20, 24 and 28%) on sausage perceived saltiness was studied using two different formulations, each with 1.2 and 2.0% NaCl. The formulations were made either by varying the proportions of lean pork and pork fat (Series 1) or by replacing water with pork fat on an equal weight basis (Series 2). The replacement of lean pork with pork fat increased the perceived saltiness of the sausages. When water was replaced with pork fat on an equal weight basis the perceived saltiness of the sausage, however, did not change. There was a strong negative correlation ($p<0.01$) between perceived saltiness and protein content thus suggesting a causative link between these factors. The flavor-enhancing properties of monosodium glutamate (MSG) and Ribotide (monosodium glutamate and 5'-ribonucleotides IMP and GMP) were also studied. MSG only slightly improved the sensory properties of the cooked sausages. In addition, the effect weakened during storage.

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INTRODUCTION

Emulsified sausage products in the USA contain up to 30% fat and over 2% salt. A typical Finnish cooked 'bologna-type' sausage contains 18% fat and 1.7% NaCl, with added phosphate. Sodium chloride partly extracts myofibrillar proteins allowing the formation of a water-binding protein matrix. In cooked sausages, sodium chloride is dissolved in the water phase, but obviously the fat phase can also influence the perception of saltiness. Fat also influences binding and structural properties in finely comminuted meat products, such as frankfurters (Claus *et al*. 1989, Matulis *et al*. 1994).

The saltiness perception of NaCl is produced by Na^+ cations. The flavor intensity of frankfurters is influenced by salt concentration. As salt increases, flavor intensity also increases (Matulis *et al.* 1995). These results may be related to flavor enhancement (Gillette 1985). Fat and salt together contribute to many of the sensory properties that are characteristic of cooked sausages. Matulis *et al.* (1994) pointed out that the saltiness of frankfurters correlated positively with fat content. In sausages, fat affects the perceived saltiness differently at different concentrations of salt and fat. According to Hammer (1981), in lean meat products the threshold of recognition of a salty flavour is lower than in fatty products. When the salt level is raised it is more noticeable in fatty products than in lean ones. A variation in added salt is most evident in the flavour of cooked sausages with high fat content and least evident in lean, finely minced dry sausage and lean liver sausage. In contrast, Hughes *et al*. (1997) showed that decreasing fat level from 30% to 5% increased the saltiness of frankfurters. Other researchers have also reported an increase in spice flavor in low-fat frankfurters (Yang *et al* 1995) and in low-fat varieties of sausage (Solheim 1992)

compared with the full-fat controls.

The dietary guidelines of many industrial countries recommend a reduction in salt intake (eg. U.S Department of Agriculture 1995). The salt content of Finnish cooked sausages has been reduced from 2.3 to 1.7% over last 20 years. Reducing the salt content of sausages too greatly may make them tasteless. Therefore, it is important to know whether flavor enhancers increase the perceived saltiness, flavor intensity and palatability of sausages. Monosodium glutamate (MSG) is very often used in meat products as a flavor enhancer. It has been suggested that MSG compensates for low sodium chloride concentrations (Yamaguchi and Takahashi 1984). MSG alone or Ribotide (monosodium glutamate and 5'-ribonucleotides IMP and GMP) appear to increase the palatability of foods by intensifying their flavor profiles (Kemp and Beauchamp 1994).

Reducing the fat content of meat products leads to a number of difficulties in terms of flavor and texture (Hughes *et al.* 1997, Crehan *et al.* 2000). Both fat content and water-binding capacity of the sausage can affect perceived saltiness. When the water-binding capacity is poor, brine in the sausages is more loosely bound and may seem more. To resolve the controversy concerning the effects of fat level on the perceived saltiness of cooked sausage, this question was studied in cooked sausage by using different formulations with varying fat contents.

MATERIALS AND METHODS

Two experiments were conducted. The objective of Experiment I was to evaluate the perceived saltiness of cooked sausage when the fat content of the sausage varies. The effect of varying fat content on sausage perceived saltiness was studied using two different sets of formulations (Series 1 and 2), each with 1.2 and 2.0% NaCl. In Experiment II, the flavor-

enhancing properties of MSG and Ribotide were evaluated for flavor intensity, perceived saltiness and palatability of the sausages as well as flavor stability and perceived saltiness during storage.

Experiment I

Twelve 'bologna-type' cooked sausages were made in Series 1 and Series 2. The target fat contents of the sausages were 8, 12, 16, 20, 24 and 28%. The salt contents in both Series were both 1.2 and 2.0%. All formulations contained 18% lean beef (fat content 22%), 5% pork skin, 4% potato flour, 1% sodium caseinate, sodiumphosphate (0.3 g/kg determined as P_2O_5), 0,012% $NaNO_2$ and 0.3% spice mixture. The water and fat contents in formulations were varied as shown below (Table 1). In Series 1, the formulations were made by varing the proportions of lean pork (12% fat) and pork fat (89% fat) and in Series 2, the formulations were made by replacing pork fat (89% fat) with water on an equal weight basis (Table1). For each series and each salt content, the cooking loss was determined by weighing all the sausages, before cooking and three hours after cooking.

Experiment II

Three different 'bologna-type' sausages were made. The salt content in each sausage was 1.5%. Sausage 1 was made without extra flavorings, Sausage 2 with 0.5% MSG and Sausage 3. with 0.5% monosodium glutamate and 0.2% 5'-ribonucleotides IMP and GMP (1:1) (Ribotide). The formulations contained 17.9% beef trimmings (fat content 22%), 23.4% pork trimmings (fat content 12%), 13.4% pork fat (fat content 89%). The amount of added water was 32.8%. In addition to the meat trimmings, the formulations contained 5% pork skin, 4%

potato flour, 1% sodium caseinate and 0.3% spice mixture. The fat content of the sausages was 16%.

In Experiment I and II, the sausages were stuffed into a casing (diameter 65 mm), smoked and cooked for 100 min at 76 ^{o}C to achieve an endpoint product temperature of 72 ^{o}C and cooled in a cold shower for 40 min. After cooling, the sausages were packed in vacuum and stored at 3 ^{o}C either 3 or 17 days.

Chemical Analyses

For each sausage, moisture, fat and protein were determined. Moisture content was determined by drying the sample at 104 ^{o}C for 16 h. Fat analysis was performed using the Gerber method (Krol and Meester 1963) and protein content was determined the Kjeldahl method (NMKL 1976). The NaCl concentration of the sausages was determining by analyzing their chloride-ion content (Corning 926 Chloride Analyzer, Corning Medical and Scientific Corning Limited, England). Sodium content was analyzed with an Na-selective electrode method according to Averill (1983) and Kühne (1988), modified by Kivikari (1996).

Sensory Evaluation

All fourteen panelists were familiar with the type of product and the range of variation. Before the experimental sessions, the panelists participated in two training sessions according to the ISO 8586-1 standard matching test (1993) both with salt solutions (0.1; 0.25; 0.4; 0.55 and 0.7% /w/v)) and with three sausages (salt content of 1.2; 1.6 and 2.0%). Prior to the experimental sessions, the panelists were trained to conduct the evaluation in one session.

In Experiment I, fourteen volunteers, either students or university staff members, served as judges (trained panel). They assessed each sausage in both series twice in a total of four sessions. In one session, the panelists received one slice of each of six sausages. Samples were fully randomized for each panelist. The saltiness was rated on a 9 point scale, end-anchored with 1=not salty, and 9=strongly salty.

In Experiment II, the same individuals as in Experiment 1 served as panelists. The panelists evaluated the flavor intensity and perceived saltiness of the sausages made with 1.5% NaCl under three sets of conditions: (i) without flavor enhancers, (ii) with MSG and (iii) with Ribotide.

In each session the assessors received one slice of all three sausages. The evaluations were made twice, once at three days and again at seventeen days after the preparation of the sausages. The flavor intensity and the saltiness of the sausages were evaluated on a 9 point scale, end-anchored with 1=no flavor at all, not salty, and 9=strong flavor, strongly salty.

In addition, thirty-five consumers evaluated the palatability and perceived saltiness of the three sausages made with 1.5% NaCl under three sets of conditions. The panelists were also either students or university staff members but they had no evaluation training. During the session, the assessors received one slice of each of the three sausages. The evaluation was done once, at three-five days after the sausage preparation. The saltiness and palatability of the sausages were evaluated on a 9 point scale, end-anchored with 1=not salty, not pleasant , and 9=strongly salty, strongly pleasant.

Statistical Analysis

The sausages were manufactured once but the sensory analysis with the trained panel was

performed twice and once with consumers. The differences in the perceived saltiness of different fat levels were tested using two-way analysis of variance with fat level and assessors as factors. Regression coefficients were calculated to test the effects of moisture, fat as well as protein content on the perceived saltiness of the sausages. Also, the differences in the flavor intensity, perceived saltiness and palatability between sausages without flavor enhancers, MSG and Ribotide sausages were analyzed with two-way analysis of variance with flavor enhancers and assessors as factors.

The data was analyzed using Statgraphics Plus for Windows -program 1994-1997, version 3 (Manugistics Inc., Rockville, Maryland, U.S.A).

RESULTS AND DISCUSSION

Experiment I

In each series, all the sausages in the same salt content group were weighed together so that it was not possible to determine whether the fat content has an effect on the cooking loss. The cooking loss was: in Series 1. (1.2% NaCl) 1.2%, (2.0% NaCl) 0.5%, in Series 2 (1.2% NaCl) 1.5% and (2.0% NaCl) 1.4 %. For sausages in Series 1 (2.0% NaCl) the cooking loss was less than in the other sausage series. This did not, however, cause any marked difference in the chemical composition of the sausages as can be seen in Table 2.

One of the major problems in reducing the fat level in meat products is the increase of the toughness and therefore lower acceptability (Sofos and Allen 1977). Whiting (1984) found that salt reduction (from 2.5% to 1.5%) resulted in increased water release from frankfurters, and an additional reduction to less than 1.3% resulted in incomplete protein extraction and water was released during cooking. In this study, a similar phenomenon was not observed.

There was no released water even in sausages made with 1.2% NaCl. Potato flour (4%) and sodium caseinate (1%) in the formulation may have stabilized sausages at low salt contents. This may be due to the fact that the addition of non-meat proteins e.g. sodium caseinate and potato starch is believed to partly compensate for the potential loss of water-binding properties by high water additions and salt reduction (Ellekjaer *et al*. 1996, Schelle 1995, Su *et al.* 2000).

As expected, increasing the salt content of the sausages from 1.2 to 2.0%, led to increased perceived saltiness in both series (Figures 1 and 2). When fat content was varied by replacing lean pork with pork fat, the perceived saltiness of the sausages also increased (Figure 1). This was observed for both salt levels. The difference in perceived saltiness in different fat contents was, however, not particularly large. For a salt content of 1.2%, the perceived saltiness ranged between 3.2 and 4.3, and for a salt content of 2.0%, between 5.9 and 7.1. For a salt content of 1.2% NaCl, only the difference in perceived saltiness between sausages containing 8 and 24 or 28% fat was significant ($p<0.05$). In sausages containing 2.0% NaCl, the differences in perceived saltiness between sausages containing 8 or 12 and 24 or 28 % fat were significant ($p<0.05$) (Figure 1).

When fat content was varied by replacing water with pork fat on an equal weight basis (Series 2), there was, however, no correlation between the perceived saltiness and fat content of the sausages (Figure 2). The overall differences in perceived saltiness between the sausages with different fat content were smaller than between the sausages in Series 1. For a salt content of 1.2% NaCl, the perceived saltiness ranged between 3.2 and 3.8, and for a salt content of 2.0%, between 5.3 and 5.6.

In Series 2, the water content of the sausages with 8% fat was higher (Table 3) than in corresponding sausages in Series 1 (Table 2). This may indicate that in Series 2, the water might have been bound more loosely in the low-fat sausage and thus caused the saltier taste

compared to sausage with high fat content at the same salt content. This could also explain why the difference in perceived saltiness between the sausages with low fat content and high fat content in Series 2 is lower than in Series 1 (Figures 1 and 2). Low water-holding, not necessarily high water content, may also increase perceived saltiness by releasing sodium (and chloride) to the water phase. In this study, this cannot be seen, because the sausages held practically all the water well. Unfortunately, no measurements of water binding in the sausages were performed. Further studies with decreased water-holding are needed to confirm this.

In Series 1, the protein content of the sausages decreased, when the lean pork was replaced with pork fat. The correlations between moisture, fat, protein and perceived saltiness (averages of sensory evaluations) were all high [>0.9] and significant ($p<0.02$) (Table 4). In Series 2, the protein content of the sausages was constant (Table 3). All the correlations were non-significant ($p>0.05$) (Table 5).

As shown above, there was a different effect when fat content was decreased by replacing it with water or with lean meat. This may indirectly show that neither fat nor water are the major factors, but lean meat or protein may have a relevant effect. The availability of different ions to taste receptors may explain this. In meat, chloride ions are bound more strongly to meat proteins than sodium ions (Hamm, 1972). Hamm also stresses that although sodium ions can be extracted with water, this does not mean that they do not interact with proteins. According to Hamm, ca 70% of sodium ions are (loosely) bound, especially to myosin. Consequently, it can be hypothezised that meat proteins may bind the salt to the extent that it reduces the perceived saltiness.

Experiment II

The chemical composition of the sausages in Experiment II is shown in Table 6. In practical terms, there were no marked differences between the sausages.

MSG appears to increase the palatability of foods by altering their flavor profiles (Kemp and Beauchamp 1994). In this study, the flavor intensity was stronger ($p<0.05$) for sausages with MSG or Ribotide than without (Table 7). The flavor intensity of MSG and Ribotide sausages decreased during the fourteen days for storage but the reduction was not significant ($p>0.05$). No differences in flavor intensity between the sausages without flavor enhancers, MSG and Ribotide sausages were seen 17 days after their preparation ($p>0.05$) (Table 7).

The perceived saltiness was greater when the sausages contained MSG than Ribotide or without flavor enhancers ($p<0.05$) (Table 8). The perceived saltiness of MSG and Ribotide sausages decreased during the fourteen days storage but the reduction was not significant ($p>0.05$). No difference in perceived saltiness between the sausages was seen 17 days after preparation ($p>0.05$) (Table 8).

The consumers rated the MSG sausages to be more palatable than the sausages without flavor enhancers or Ribotide sausages ($p<0.05$). No significant difference was found between the perceived saltiness of the three sausages (Table 9).

According to the trained panel, MSG and Ribotide had a minor effect on flavor intensity but only for a few days after preparation. The effect lessened during the storage. MSG increased the perceived saltiness of the sausages but the perceived saltiness decreased during the storage. In Finland, the given shelf life for these types of sausages is three-four weeks. Therefore, it is important to take into consideration flavor losses. Consumer tests showed that MSG also enhanced the palatability of the sausages (Table 9). Because the consumers did

not notice any difference in perceived saltiness between sausages without flavor enhancers, with MSG or Ribotide (Table 9), it may be concluded, that the effect of the flavor enhancers on sausage flavor was not very strong.

CONCLUSIONS

Fat content of cooked sausages affects the perceived saltiness in different ways depending on the composition of the formulation. By replacing lean pork with pork fat, thus increasing the fat content and simultaneously reducing the protein content, perceived saltiness of sausages increases. By replacing water with fat on an equal weight basis, the perceived saltiness of the sausage does not change. Therefore, the increase of protein content may have a reducing effect on perceived saltiness. Flavor enhancers only slightly improves the sensory properties of the cooked sausages, an effect which decreases during storage.

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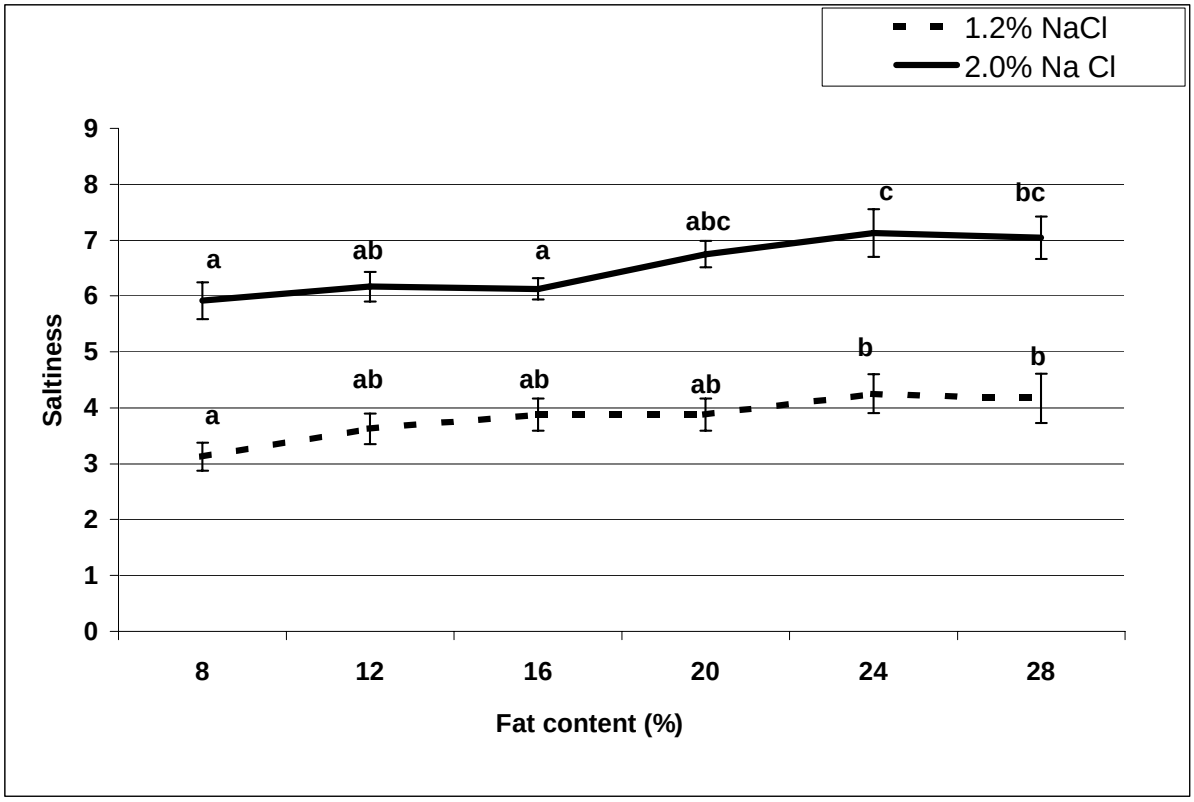

[abc] the same letter for the average saltiness value means that the difference in sausage perceived saltiness between fat contents is not significant ($p>0.05$)

FIG. 1. THE EFFECT OF FAT CONTENT ON THE PERCEIVED SALTINESS OF 'BOLOGNA-TYPE' COOKED SAUSAGES
Fat content varied by replacing lean pork with pork fat

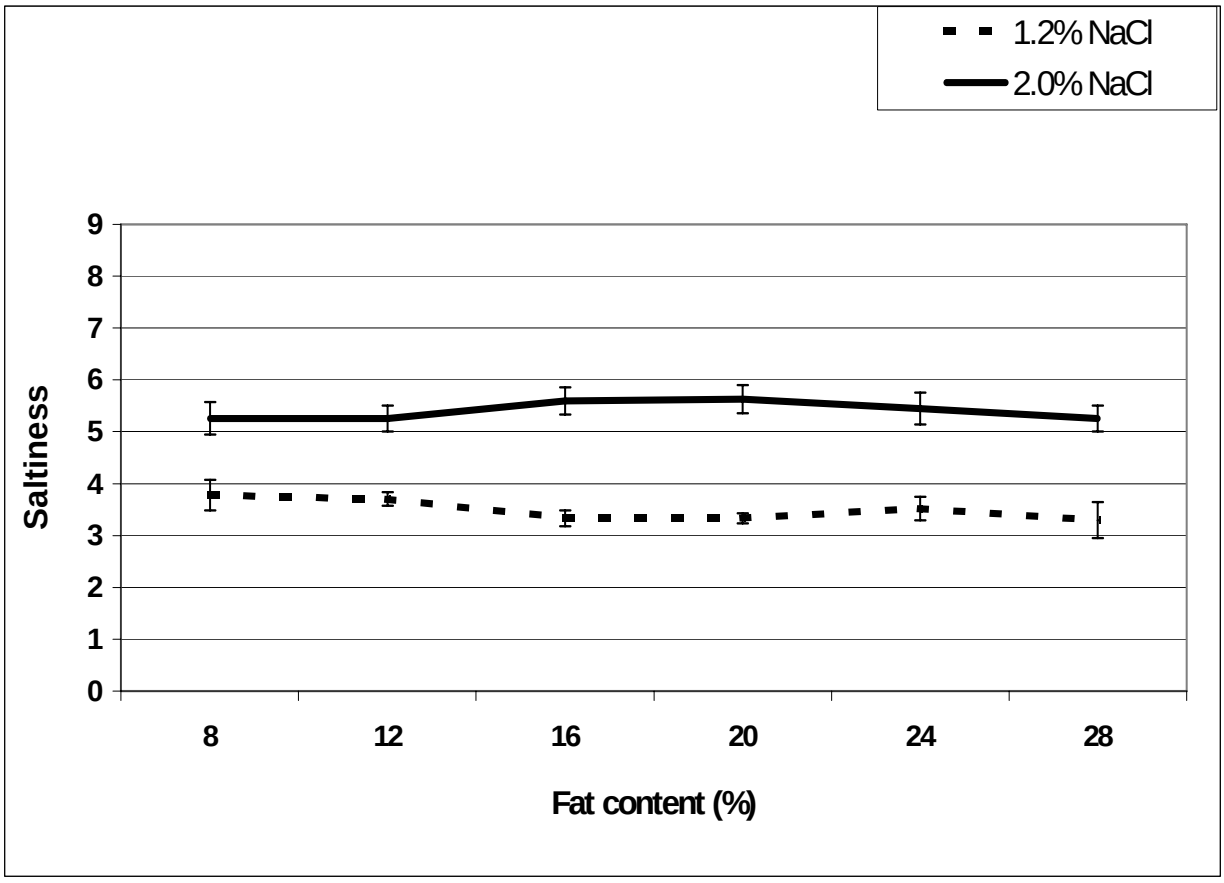

FIG. 2. THE EFFECT OF FAT CONTENT ON THE PERCEIVED SALTINESS OF BOLOGNA-TYPE COOKED SAUSAGES
Fat content varied by replacing water with pork fat on an equal weight basis

TABLE 1.
PORK, PORK FAT AND ADDED WATER CONTENTS (%) IN THE FORMULATIONS BOTH IN SERIES 1 AND SERIES 2

		Target fat content (%)					
		8	12	16	20	24	28
				(%)			
Series 1	pork[1)]	35.8	30.7	25.6	20.5	15.4	10.3
	pork fat[2)]	0	5.1	10.2	15.3	20.5	25.6
	Water	34.1	34.1	34.1	34.1	34.1	34.1
Series 2	pork[1)]	24.8	24.3	23.7	23.2	22.7	22.2
	pork fat[2)]	1.2	6.1	11	16	20.9	25.8
	Water	43.9	39.6	35.2	30.8	26.3	22

[1)]lean pork, fat content 12%; [2)]pork fat, fat content 89%,

TABLE 2.
MOISTURE-, PROTEIN-, FAT[1)] AND SALT CONTENT AS WELL AS SODIUM CONTENT

Sausage	Moisture (%)	Fat (%)	Protein (%)	NaCl (%)	Sodium (g/100 g)
1	72.5	8.5	12.7	1.1	0.6
2	70.7	11.8	12.1	1.2	0.6
3	67.6	15.2	11.2	1.2	0.6
4	64.4	19.6	10.8	1.2	0.6
5	62.3	23.0	9.5	1.2	0.6
6	59.3	26.4	8.9	1.2	0.6
7	71.6	9.3	12.7	1.9	0.9
8	69.2	12.8	11.6	1.9	0.9
9	65.9	17.1	11.1	2.0	0.9
10	63.4	21.0	10.1	1.9	0.9
11	60.3	24.3	9.3	1.9	0.9
12	56.3	28.8	8.4	1.9	0.9

[1)]Fat content varied by replacing lean pork with pork fat

TABLE 3.
MOISTURE-, PROTEIN-, FAT[1)] AND SALT CONTENT AS WELL AS SODIUM CONTENT

Sausage	Moisture (%)	Fat (%)	Protein (%)	NaCl (%)	Sodium (g/100 g)
1	74.2	7.6	11.4	1.2	0.5
2	70.9	12.0	11.2	1.2	0.6
3	66.4	16.3	11.4	1.2	0.6
4	62.0	20.2	11.1	1.2	0.6
5	57.3	24.3	11.2	1.2	0.6
6	54.0	28.0	11.4	1.2	0.6
7	74.5	8.1	11.4	1.8	0.9
8	68.9	11.9	10.9	1.8	0.9
9	65.9	15.9	10.9	1.8	0.9
10	61.9	19.8	10.8	1.8	0.9
11	59.0	23.9	11.0	1.8	0.9
12	53.8	28.3	11.1	1.9	0.9

[1)]Fat content varied by replacing pork fat with water on an equal weight basis.

TABLE 4.
CORRELATION COEFFICIENTS BETWEEN COMPOSITIONAL CONSTITUENTS[1)] AND THE AVERAGE PERCEIVED SALTINESS OF THE SAUSAGES (SERIES 1)

	1.2% added NaCl			2.0% added NaCl		
	R^2	Correlation coefficient	p	R^2	Correlation coefficient	p
Moisture	0.821	-0.91	0.013	0.858	-0.93	0.008
Fat	0.847	0.92	0.009	0.875	0.94	0.006
Protein	0.859	-0.93	0.008	0.902	-0.95	0.004

[1)]Fat content varied by replacing lean pork with pork fat, N=6

TABLE 5.
CORRELATION COEFFICIENTS BETWEEN COMPOSITIONAL CONSTITUENTS[1)] AND THE AVERAGE PERCEIVED SALTINESS OF THE SAUSAGES (SERIES 2)

	1.2% added NaCl			2.0% added NaCl		
	R^2	Correlation coefficient	p	R^2	Correlation coefficient	P
Moisture	0.028	-0.17	0.752	0.560	0.75	0.087
Fat	0.028	0.14	0.757	0.593	-0.77	0.073
Protein	0.434	-0.66	0.155	0.000	0.00	0.987

[1)]Fat content varied by replacing pork fat with water on an equal weight basis. N=6.

TABLE 6.
MOISTURE-, PROTEIN-, FAT, SALT AND SODIUM CONTENT OF THE SAUSAGES

	No flavor enhancers[1)]	MSG[2)]	Ribotide[3)]
Moisture (%)	67.5	68.1	67.8
Fat (%)	15.9	16.2	15.8
Protein (%)	10.9	10.7	11.1
NaCl (%)	1.5	1.5	1.5
Sodium (g/100 g)	0.7	0.7	0.7

[1)]No flavor enhancers; sausage was made without extra flavorings
[2)]MSG; sausage was made with 0.5% monosodium glutamate
[3)]Ribotide; sausage was made with 0.5% monosodium glutamate and 0.2% 5'-ribonucleotides IMP and GMP (1:1)

TABLE 7.
THE FLAVOR INTENSITY OF UNFLAVORED, MSG AND RIBOTIDE SAUSAGES RATED BY A TRAINED PANEL 3 AND 17 DAYS AFTER PREPARATION

	No flavorings	MSG	Ribotide
Flavor intensity 3 days after preparation	4.18 ± 0.18^{a}	5.39 ± 0.27^{b}	5.18 ± 0.22^{b}
Flavor intensity 17 days after preparation	4.5 ± 0.25^{a}	5.13 ± 0.2^{a}	4.83 ± 0.33^{a}

[a,b]the same letter on a row means the difference in flavor intensity between the sausages is not significant ($p>0.05$)

TABLE 8.
THE PERCEIVED SALTINESS OF UNFLAVORED, MSG AND RIBOTIDE SAUSAGES RATED BY A TRAINED PANEL 3 AND 17 DAYS AFTER PREPARATION

	No flavorings	MSG	Ribotide
Saltiness 3 days after preparation	4.18 ± 0.27^{a}	5.86 ± 0.24^{b}	4.61 ± 0.24^{a}
Saltiness 17 days after preparation	4.25 ± 0.24^{a}	4.46 ± 0.29^{a}	4.42 ± 0.33^{a}

[a,b]the same letter on a row means the difference in the saltiness between the sausages is not significant ($p>0.05$)

TABLE 9.
THE PALATABILITY AND THE PERCEIVED SALTINESS OF UNFLAVORED, MSG AND RIBOTIDE SAUSAGES RATED BY CONSUMERS

	No flavorings	MSG	Ribotide
Palatability	4.89 ± 0.11^{a}	5.60 ± 0.21^{b}	5.23 ± 0.19^{a}
Saltiness	4.48 ± 0.19^{a}	5.13 ± 0.24^{a}	4.86 ± 0.28^{a}

[a,b]the same letter on a row means the difference in the palatability or the perceived saltiness between the sausages is not significant ($p>0.05$)