AGRICULTURAL AND FOOD SCIENCE IN FINLAND

Vol. 10 (2001): 27–32.

Saltiness of coarsely ground cooked ham with reduced salt content

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When the salt content of food is reduced a lack of flavor is anticipated to be the greatest problem related to consumer acceptance. The aim of this study was to examine how much the salt content of cooked ham can be reduced without a significant effect on sensory saltiness. Hams made up of coarsely ground pork with added phosphate were prepared and the cooking loss was determined. The salt content of the hams were 1.1, 1.4, 1.7, 2.0, 2.3 and 2.6% NaCl. The saltiness intensity of cold hams was rated against a reference ham (1.7% NaCl) using a relative-to-standard scale. The cooking loss in ham made with 1.1% added salt was higher than in the other hams. The ham with 1.7% NaCl was rated as salty as the hams with 2.0 and 2.3% NaCl ($P>0.05$), but saltier than those with 1.1 and 1.4% ($P<0.05$). The ham with 2.6% NaCl was the saltiest, but it did not differ significantly from those with 2.0 or 2.3% ($P>0.05$). The results of this study suggest that based on saltiness evaluations it is possible to reduce the salt content of cooked ham to 1.7% NaCl.

Key words: meat products, ham, salt

Introduction

The number of health-conscious consumers is increasing. Therefore, the demand for a variety of low fat and low salt meat products has increased. The public has become more aware of the relationship between sodium and hypertension. The most important source of sodium is NaCl (Kolari 1980). Food processors are developing numerous low salt products to meet the demands of consumers. Developing low-salt meat products is, however, not straightforward. Salt plays an important role in meat products as

Manuscript received November 2000

a flavoring and preservative agent. It also has an important role in meat products, where it solubilizes meat proteins, which contribute to meat binding, moisture and fat retention, and the formation of a desirable gel texture upon cooking (Terrell 1983, Sofos 1984). Salt is also the most effective substance for lowering water activity in meat products and thus influences their shelf life (Sofos 1984).

Owing to its low-fat content, cooked ham is considered healthier than sausages. High-moisture hams are usually prepared by tumbling with the brine (water, salt, phosphate, nitrite and other ingredients) for extraction of salt-soluble protein and the meat pieces are bound together by subsequent thermal processing. The binding of muscle pieces results from gelation of salt-extracted myofibrillar proteins (Mcfarlane et al. 1977, Siegel and Schmidt 1979). The binding of ham muscle pieces and retained water are together responsible for the texture of the final product (Prabhu and Sebranek 1997).

In meat products, alkaline phosphates are generally used to enhance water-holding capacity and to improve cooking yield. This is brought about by an increase in the pH of the meat from its isoelectric point (Hamm 1960, Shults et al. 1972, Shahidi et al. 1994) and ionic strength (Seman et al. 1980). The combined effects of salt and phosphate on improving the water retention properties in processed meats are well known (Pepper and Schmidt 1975, Matlock et al. 1984a, b).

In many countries the salt content of cooked hams made using the wet-curing process either with meat pieces or coarsely ground meat, usually ranges from 2.0 to greater than 3.0% (Lin et al. 1991, Nute et al. 1987). Olson (1982) made sectioned and shaped massaged hams with salt levels of 2.5%, 2.0% and 1.5%. The sensory characteristics of these hams clearly showed that a small reduction in salt (2.0%) does not change the characteristics of the ham but reducing salt content by 40% (1.5% treatment) reduces the desirability of hams.

The salt contents of Finnish sausages and cooked hams have been greatly reduced over the last 20 years (Karanko and Puolanne 1996), and consumers have up to now accepted these products. However, the high salt content of hams, an average of 2.3% NaCl (Puolanne and Ruusunen 1997), is higher than the average salt content of cooked sausage, 1.7% NaCl (Karanko and Puolanne 1996).

The average ham consumption in Finland in 1997 was 5.5 kg per capita and consumption is constantly increasing due to its healthy image and reduced price. Manufacturers will continue to reduce the salt content of cooked hams. The aim of this study was to examine how much the salt content of cooked ham can be reduced without significant effects on its sensory saltiness.

Material

The formulations of the cooked hams are given in Table 1. The added salt concentrations were 1.1, 1.4, 1.7, 2.0, 2.3 and 2.6%. For each formulation 5 kg of coarsely ground (Ø 13 mm plate) lean hams (taken from *M. semimembranosus*, *M. adductor*, *M. gluteus medius* and *M. superficialis*) were used. The brine solution for each formulation was prepared by dissolving a commercial phosphate mixture (58% P_2O_5), followed by ascorbic acid, sodium nitrite and sodium chloride in tap water (2ºC). The brine was added to the ground ham in a vacuum tumbler. The hams were massaged continuously for an hour (14 rpm, 3ºC) in a vacuum and kept overnight at 3ºC. Next day the hams were stuffed into a casing (Ø 90 mm). For each formulation, four hams (1.4 kg), were obtained. The hams were thermally processed (Vemag, Vemag Verdener Maschinen- und Apparatebau GMBH, Germany) to a meat-core temperature of 72ºC by using a stepwise thermal-processing schedule (drying: 10 min at 55ºC, 12 min at 60ºC and 12 min at 65ºC, smoking: 12 min at 68ºC, cooking: 50 min at 72ºC and 100 min at 77ºC and cooling 59 min in a cold shower). The hams were made once but the sensory evaluations were done twice.

Vol. 10 (2001): 27–32.

Table 1. Formulations of the cooked hams.

	Formulations, % NaCl					
	1.1	1.4	1.7	2.0	2.3	2.6
Pork, g	5000	5000	5000	5000	5000	5000
Water, g	830	830	830	830	830	830
Phosphate mixture, g	25.5	25.6	25.7	25.7	25.8	25.9
$NaNO_2$, g	0.7	0.7	0.7	0.7	0.7	0.7
Ascorbic acid, g	3.6	3.6	3.6	3.6	3.6	3.6
Added NaCl, g	65.2	83.3	101.5	119.7	138.1	156.6

Methods

Cooking loss

The cooking loss was determined by weighing all the hams with the same salt content together before cooking and three hours after cooking.

Chemical analysis

Moisture content was determined by drying the sample at 104°C for 16 h. Protein content was determined by the Kjeldal method (NMKL 1976). The NaCl concentration of the hams was determined by analyzing their chloride-ion content (Corning 926 Chloride Analyzer, Corning Medical and Scientific Corning Limited, England). The sodium content was analyzed with an Na-selective electrode (Ross™ sodium electrode, Orion Research, Inc.) (Kivikari 1996). The Na-selective electrode method was a modification of Averill's (1983) and Kühne's (1988) methods. In this study the analyte addition method was used contrary to the studies of Averill (1983) and Kühne (1988), where the known addition method was used.

Sensory evaluation

Nineteen assessors, all trained to evaluate meat products, evaluated the hams. The hams were prepared once, but the sensory evaluations were done twice. A relative-to-standard scale was used for rating the saltiness of the hams (Fig. 1) (Tunaley et al. 1987, Ruusunen et al. 1999). At each session, the saltiness intensity of cold ham samples of six different salt concentrations was rated against a reference sample which contained 1.7% salt. The reference sample was also hidden among the samples without informing the assessors. Each assessor was given samples in a different randomized order. The reference sample was tasted immediately before tasting each of the other ham samples. The assessors rinsed their mouths with water between each sample. Saltiness intensity rating were recorded by marking the appropriate point on a 100 mm continuous line scale (Fig. 1). The assessors were informed beforehand that the mid-point of the scale (marked 'standard') represented the saltiness intensity of the reference sample.

Statistical analysis

The data was analyzed statistically using the SAS program (SAS Institute Inc. 1989). All saltiness values were corrected according to Powers et al. (1977) by multiplying the saltiness values of each assessor by w (weight coefficient). The

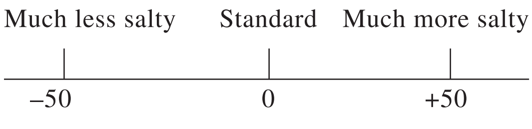

Fig. 1. Relative-to-standard scale used for rating saltiness.

Table 2. Cooking loss (%), moisture (%) and protein (%) as well as NaCl (%) and sodium (g Na/100 g) content of cooked hams.

Added NaCl, %	Cooking loss, %	Moisture, %	Protein, %	NaCl, %	Sodium, g 100 g^{-1}
1.1	5.5	74.5	20.3	1.1	0.51
1.4	3.6	76.5	18.5	1.4	0.67
1.7	3.7	76.5	18.5	1.7	0.82
2.0	3.7	76.3	18.5	2.0	0.90
2.3	3.5	76.1	18.7	2.3	1.04
2.6	3.8	75.5	18.3	2.6	1.14

The moisture, protein, NaCl and sodium content have been analyzed of one ham per each salt content. The cooking loss was determined by weighing all the hams with the same salt content together before cooking and three hours after cooking.

weight coefficient (w) was calculated using the following formula:

$w = 10/(10 + x_k - x_u)$,

where $x_k = 0$ is the score the assessor should give to the reference sample (standard sample) and x_u is the score s/he gave to the hidden reference sample. If both x_k and x_u were zero, the weight (w) attached to the judgment was taken as 1. If the assessor makes a misjudgment the weighting was less than 1.

The differences in saltiness among the hams with different salt content were studied using two-way analysis of variance. The two factors were assessors (the subjectivity of the assessors) and added NaCl (%). A t-test with a significance level of P=0.05 was used to locate the differences.

Results and discussion

Cooking loss

In this study the cooking loss was higher in hams made with 1.1% added salt when compared to all other treatments (Table 2). The moisture content was lower and the protein content higher than in the other hams for the ham made with 1.1% added salt (Table 2). Müller (1991) has also pointed out that reducing the salt content of cooked ham by reducing the brine strength whilst otherwise leaving the manufacturing technology unchanged led to a clear increase in cooking loss. In products with low salt content and a high amount of added water is necessary to add extra protein or other ingredients e.g. carrageenan or starch to increase the yield (Prabhu and Sebranek 1997). Starch addition (2%) has been reported to improve surface appearance, sliceability and the texture of hams containing 0.5% carrageenan. The surface of products with carrageenan alone appeared to be jelly-like and wet (Trudso 1985).

Chemical composition

In this study one of the hams with middle salt content, 1.7%, was chosen to be the reference sample. The analyzed NaCl and sodium contents are given in Table 2. The NaCl content of the reference ham was 1.7% and the sodium content was 0.82 g Na/100g (Table 2).

Sensory evaluation

In the sensory evaluations, a reference sample was also among the samples (hidden reference).

Vol. 10 (2001): 27–32.

The hidden reference was, however, rated differently than the reference when evaluating the saltiness (Fig. 2). All saltiness values were corrected according to Powers et al. (1977) by multiplying the saltiness values of each assessor by w (the weight coefficient). It has also to be noted that the saltiness of the reference ham is not known and the scale is based on a comparison with the reference (1.7% NaCl).

The assessors' evaluations of saltiness corresponded to the actual salt content (Fig. 2). The ham with 1.7% NaCl was rated as salty as hams with 2.0 and 2.3% NaCl ($P>0.05$), but saltier than those with 1.1 and 1.4% ($P<0.05$). The ham with 2.6% NaCl was the saltiest, but it did not differ significantly from those with 2.0 or 2.3% ($P>0.05$). The average salt content of Finnish cooked hams is 2.3% NaCl (Puolanne and Ruusunen 1997). Based on this study, it can be concluded that the lowest ham salt content which is as salty as a normal cooked ham in Finland is 1.7% added salt. On the basis of these results, it is hard to say if the findings would have been the same if the cooked ham with 2.0% NaCl would have been chosen for the reference.

The simplest way to decrease the amount of salt people obtain from meat products is to reduce the salt content of meat products with the highest salt content to average values of similar products on the market. This reduction is possible without any technological or taste problems.

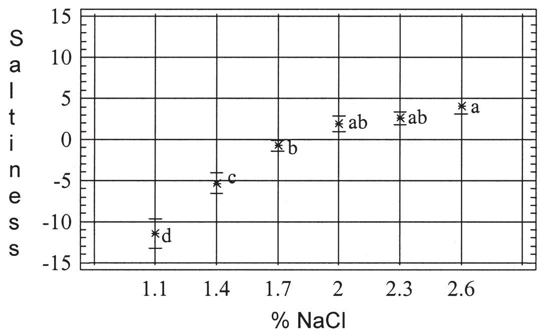

Fig. 2. Saltiness of the cooked hams. A different letter [a, b, c] or [d] at each average saltiness value means a significant difference in saltiness between the hams.

Products like these are now being produced and consumers have accepted them.

Conclusions

The results of this study suggest that it would be possible to reduce the salt content of cooked ham to 1.7% NaCl, while still maintaining the normal sensory saltiness of cooked ham.

Acknowledgements. This study was funded by the Ministry of Social Affairs and Health. We would like to thank all the assessors who took part in the sensory evaluations.

References

Averill, W. 1983. Ion-selective electrode system measures sodium content of foods. *Food Technology* 37: 44–52, 56

Hamm, R. 1960. Biochemistry of meat hydration. *Advances in Food Research* 10:355–463.

Karanko, E. & Puolanne, E. 1996. Chemical composition of Finnish sausages in 1973–95. Meat Day 1996. *University of Helsinki, Department of Meat Technology, reports from meat technology* Nr. 536. p. 49–55. (in Finnish).

Kivikari, R. 1996. Analysis of sodium in meat products using an Na-selective electrode. Meat Day 1996. *University of Helsinki, Department of Meat Technology, reports from meat technology* Nr. 536. p. 64–66. (in Finnish).

Kolari, O. 1980. Salt dietary concerns. In: *Proceedings of the Meat Industry Research Conference*. American Meat Institute Foundation, Chicago, Illinois. p. 89–100.

Kühne, D. 1988. Analysis of common salt and sodium in meat products. *Fleischwirtschaft* 68: 1007–1010.

Lin, G., Mittal, G. & Barbut, S. 1991. Optimization of tumbling and KCl substitution in low sodium restructured hams. *Journal of Muscle Foods* 2: 71–91.

Matlock, R., Terrell, R., Savell, L., Rhee, K. & Dutson, T. 1984a. Factors affecting properties of raw-frozen pork sausage patties made with various NaCl/phosphate combinations. *Journal of Food Science* 49: 1363–1366.

– , Terrell, R., Savell, L., Rhee, K. & Dutson, T. 1984b.

Factors affecting properties of raw-frozen pork sausage patties made with various NaCl/phosphate combinations. *Journal of Food Science* 49: 1372–1375.
Mcfarlane, J., Schmidt, G. & Turner, R. 1977. Binding of meat pieces: a comparison of myosin, actomyosin and sarcoplasmic proteins as binding agents. *Journal of Food Science* 42: 1603–1605.
Müller, W.-D. 1991. Cooked cured products. Influence of manufacturing technology. *Fleischwirtschaft* 71: 544–550.
NMKL 1976. *Nitrogen determination in foods and feeds according to Kjeldahl.* Nordic Committee on Food Analysis No 6, 3rd ed.
Nute, G., Jones, R., Dransfield, E. & Whelehan, O. 1987. Sensory characteristics of ham and their relationships with composition, visco-elasticity and strength. *International Journal of Food Science and Technology* 22: 461–476.
Olson, D. 1982. Salt for processing probably can be cut by only one quarter. *The National Provisioner* 7–10.
Pepper, F. & Schmidt, G. 1975. Effects of blending time, salt, phosphate and hot-boned beef on binding strength and cook yield of beef rolls. *Journal of Food Science* 40: 227–230.
Powers, J., Godwin, D. & Bargmann, R. 1977. Relations between sensory and objective measurements for quality evaluation of green beans. *ACS Symposium series* 51: 51–70.
Prabhu, G. & Sebranek, J. 1997. Quality characteristics of ham formulated with modified corn starch and kappa-carrageenan. *Journal of Food Science* 62: 198–202.
Puolanne, E. & Ruusunen, M. 1997. Lämpökäsiteltyjen kinkkutuotteiden laatuluokituksen kehittäminen. Development of quality classification for cooked hams. *University of Helsinki, Department of Meat Technology, reports from meat technology* Nr. 561.
Ruusunen, M., Särkkä-Tirkkonen, M. & Puolanne, E. 1999. The effect of salt reduction on taste pleasantness in cooked 'Bologna-type' sausages. *Journal of Sensory Studies* 14: 263–270.
SAS Institute Inc. 1989. *SAS/STAT User's Guide*. Version 6 Fourth edition, Vol. 2. Gary, NC. 846 p.
Seman, D., Olson, D. & Mandigo, R. 1980. Effect of reduction and partial replacement of sodium on bologna characteristics and acceptability. *Journal of Food Science* 45: 1116–1121.
Shahidi, F., Synowiecki, J. & Balejko, J. 1994. Proteolytic hydrolysis of muscle proteins of harp seal. *Journal of Agriculture and Food Chemistry* 42: 2634–2638.
Shults, G., Russell, D. & Wierbicki, E. 1972. Effects of condensed phosphates on pH, swelling and water-holding capacity of beef. *Journal of Food Science* 37: 860–864.
Siegel, D. & Schmidt, G. 1979. Ionic, pH and temperature effects on the binding of myosin. *Journal of Food Science* 44: 1686–1689.
Sofos, J. 1984. Antimicrobial effects of sodium and other ions in foods: A review. *Journal of Food Safety* 6: 45–78.
Terrell, R. 1983. Reducing the sodium content of processed meats. *Food Technology* 37: 66–71.
Trudso, J. 1985. Increasing yields with carrageenan. *Meat Processing* 24: 37–42.
Tunaley, A., Thomson, D. & McEwan, J. 1987. Determination of equi-sweet concentrations of nine sweeteners using a relative rating technique. *International Journal of Food Science and Technology* 22: 627–635.

SELOSTUS

Suolapitoisuuden pienentämisen vaikutus kinkkuleikkeen aistittuun suolaisuuteen

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Tutkimuksen tarkoituksena oli selvittää kuinka paljon kinkkuleikkeen suolapitoisuutta voi alentaa ilman vaikutusta tuotteen aistittavaan suolaisuuteen. Kinkkuleikkeet valmistettiin karkeaksi hienonnetusta sianlihasta. Suolapitoisuudet olivat 1,1, 1,4, 1,7, 2,0, 2,3 ja 2,6 % ja valmistuksessa käytettiin fosfaattia. Tutkimuksessa määritettiin painotappio kypsennyksen aikana. Kinkkuleikkeiden suolaisuus suhteessa referenssikinkkuleikkeeseen arvioitiin aistinvaraisesti käyttäen graafista jana-asteikkoa (välimatka-asteikko). Referenssikinkkuleikkeen suolapitoisuus oli 1,7 %.

Painotappio oli 1,1 %:n suolalisällä valmistetussa kinkkuleikkeessä suurempi kuin muissa kinkkuleikkeissä. Kinkkuleike, jossa oli 1,7 % suolaa arvioitiin yhtä suolaiseksi kuin kinkkuleikkeet, joissa oli 2,0 ja 2,3 % suolaa, mutta suolaisemmaksi kuin kinkkuleikkeet, joissa oli 1,1 ja 1,4 % suolaa. Kinkkuleike, jossa oli 2,6 % suolaa oli suolaisin, mutta ei eronnut merkitsevästi kinkkuleikkeistä, joissa oli 2,0 tai 2,3 % suolaa. Tämän tutkimuksen tulokset osoittavat, että kinkkuleikkeen suolapitoisuuden voi alentaa 1,7 %:iin ilman, että aistittu suolaisuus oleellisesti heikkenee.