A. E. WASSERMAN and F. TALLEY
USDA Eastern Regional Research Lab.
Eastern Marketing & Nutrition Research Div., ARS, Philadelphia, PA 19118

THE EFFECT OF SODIUM NITRITE ON THE FLAVOR OF FRANKFURTERS

INTRODUCTION

THE CURING OF MEAT and comminuted meat products with salt and an alkali nitrate salt is an ancient process originally intended as a method of preservation. Changes in the color and appearance of the product occur in the process. In 1891 Polenski demonstrated that the nitrate in the cure was reduced to nitrite as a result of bacterial action. The red color of the product, which was considered a characteristic of cured meat, was found by Isskalt (1899) to be formed in the presence of nitrite. Kerr and co-workers (1926) established the limits of sodium nitrite concentration in the cure that would yield a satisfactory product, and these limits are part of the legal requirements for cured meats in use today. The work of Kerr et al. (1926), however, was primarily directed toward the development of the cured color in the product. They noted that the flavor and quality of the products were equivalent to those prepared in the customary fashion, i.e., with nitrate only, but there was no investigation of the effect of the nitrite ion on the flavor of the product.

The relationship of nitrite to flavor was first described by Brooks et al. (1940) in a study of the use of nitrite in the cure of bacon and ham. Although they presented no taste panel data, these authors stated that the panel showed a preference for meat cured with nitrite. (It must be noted, however, that in a number of experiments very little differences in flavor were found among the variously treated bacons.) Barnett et al. (1965) reported on an extensive study of the factors affecting cured ham flavor. In a study on the concentration of nitrite in the pumping pickle, they found the panel had an equal preference for hams pumped with pickle containing the usual nitrite concentration (1.5g sodium nitrite per liter) and those in which pickle with 0.1g sodium nitrite per liter had been used. Recently Cho and Bratzler (1970) studied the effect of nitrite and smoke on the flavor of cured pork roasts, reaching the conclusion that more cured flavor was present in the roasts cured with nitrite.

The effect of nitrite on the flavor of frankfurters, a comminuted product of beef, pork and various spices, is reported in this paper.

MATERIALS & METHODS

FRANKFURTERS were prepared by a standard procedure according to the following formulation: lean beef–45%; pork (50% lean)–55%; and ice–25% of total beef and pork weight. The cure salts were added in the following quantities per pound of total meat: salt–11.4g; sugar–9g; commercial spice preparation–2.4g; sodium ascorbate–0.24g; sodium nitrate–0.574g; and sodium nitrite (when added)–0.070g. The frankfurters were cooked in a Dry-Sys smokehouse, using a 90-min program of increasing heat and controlled humidity. When smoking was desired, smoke, generated in a Mepaco apparatus from commercial hickory sawdust, was led into the smokehouse for the entire 90-min cooking period.

The frankfurters were stored at 5°C overnight and submitted to a taste panel for evaluation. The panel consisted of 23 judges who had been testing frankfurter flavor for several years. Frankfurters were heated for 5 min in water that had been brought to a boil, cut into ½-in. pieces and kept warm in a double boiler over hot water. Judging was carried out in individual booths under low intensity green light. While red light did cover up differences in color among the frankfurters, it was still possible to distinguish among them by the intensity of the dark color visible. This was alleviated to some extent by the use of the green light.

Types of tests used

Triangle test. The two samples to be compared were given as the odd sample an approximately equal number of times in a random fashion and were positioned randomly in the triangle to prevent sample or positional bias. Statistical significance of the results of these tests was determined from the table in the book by Amerine et al. (1965).

Scoring test. The panelists were presented with a standard of untreated frankfurter having a given value of "0" for poor flavor and were asked to score test samples for "frankfurter" flavor, on a scale of 0 to 10, compared to the standard. A duplicate of the standard was included as a hidden control. Analysis of variance was carried out as described in Steel and Torrie (1960).

Table 1–Triangle test evaluation of the flavor of frankfurters prepared with cure in which sodium nitrite was either present or absent

Experiment	Conditions	No. correct/ No. judges
1	Cooked, no smoke; + NO_2 vs. no NO_2	15/22***
2	Cooked, no smoke; + NO_2 vs. no NO_2	28/36***
3	Cooked, no smoke; + NO_2 vs. no NO_2	18/24***
4	Cooked, smoke; + NO_2 vs. no NO_2	11/17**
5	Cooked, smoke; + NO_2 vs. no NO_2	13/24*
6	Cooked, smoke; 50% NO_2 vs. no NO_2	12/17**
7	Cooked, smoke; 50% NO_2 100% NO_2	9/17NS

*p = .05; **p = .01; ***p = .001; NS = not significant

RESULTS & DISCUSSION

FRANKFURTERS prepared without sodium nitrite in the cure, and cooked but not smoked had an unpleasant grey color. Comments were made by the judges that

Table 2—Scaling test evaluation of the flavor of cooked or smoked frankfurters prepared with cure in which sodium nitrite was either absent or present

		Nitrite	
		No	Yes
Smoke	No	0.65[a]	3.85
	Yes	5.05	4.65

Analysis of Variance

Sources	df	SS	MS	F
Total	79	679.8		
Judges	19	155.3	8.17	1.63[NS]
Treatment	3	239.2	79.73	15.93**
Smoke vs. no smoke	1		135.20	27.01**
Nitrite vs. no nitrite	1		39.20	7.83**
Smoke × nitrite	1		64.80	12.95**
Error	57	285.3	5.00	

[a]Averages of scores of judges on a scale of 0 = no hot dog flavor, to 10 = excellent hot dog flavor

**Significant at p = .01; NS = not significant

Table 3—Scaling test evaluation of the flavor of cooked or smoked frankfurters prepared with cure containing various concentrations of sodium nitrite

		Nitrite		
		0	50%	100%
Smoke	No	1.18[a]	4.33	–
	Yes	5.25	5.59	5.02

Analysis of Variance

Sources	df	SS	MS	F
Total	84	472.92		
Judges	16	29.32	1.83	NS
Treatments	4	217.97	54.49	15.40**
Cooked vs. smoked	1		130.73	37.14**
0 vs. 50% NO_2 (cooked)	1		84.47	24.00**
Nitrite in smoked franks				
Linear	1		0.43	NS
Quadratic	1		2.36	NS
Error	64	225.61	3.52	

[a]Averages of scores of judges on a scale of 0 = no hot dog flavor, to 10 = excellent hot dog flavor

**Significant at p = .01; NS = not significant

this type of preparation had an unappetizing cooked pork flavor. When the frankfurters without sodium nitrite were smoked as well as cooked, the surface was brown (the intensity varying with degree of smoke applied) as a result of the deposition of smoke components. The interior of such franks, however, was still grey in color. The hardened, denatured protein skin of the franks could be removed easily. A red pigment was noted on the surface of the grey, underlying meat, which on analysis with the Cary Spectrophotometer was identified as nitrosomyoglobin. Smoke appears to contain sufficient oxides of nitrogen to penetrate the sausage casing into which the meat is stuffed and to react with myoglobin to form the nitrosated pigment.

A change in frankfurter flavor noticeable to the judges was brought about by eliminating sodium nitrite from the cure. Experiments 1 to 5 in Table 1 show that a statistically significant number of judges could distinguish between the flavors of franks prepared with or without sodium nitrite. While this was particularly true with the franks that were cooked only (Experiments 1–3) smoke did not prevent the selection of the correct odd sample, although the number of correct responses was somewhat lower (Experiments 4–6).

To quantitate the differences in frankfurter flavor indicated by the triangle test, a scoring procedure was applied. Frankfurters were prepared with and without sodium nitrite. One half of each batch was cooked only and the other half smoked as well. The results of triangle tests to detect differences in flavor among the samples are shown in Experiments 3 and 5 in Table 1. Table 2 shows the scores and analysis of variance for the flavors of the four preparations compared to a control sample of no nitrite–no smoke–treated frankfurter with a value of "0" for frankfurter flavor. In the absence of smoke there was a highly significant difference in flavor produced on the addition of nitrite. When the frankfurters were smoked, however, there was essentially no difference in the scores of the untreated and nitrite-treated franks. The analysis of variance demonstrated the statistically significant interaction between smoke and nitrite treatment.

The effect of nitrite concentration was explored by preparing frankfurters with no nitrite, with the full amount of sodium nitrite normally used (100% nitrite), and with half this concentration of sodium nitrite (50% nitrite). Half of each batch was cooked, the other half was cooked and smoked. Triangle tests showed that the judges could distinguish between the flavors of the franks with no nitrite and 50% nitrite, but although there was a trend to distinguish between the flavors of the franks treated with 50% and 100% nitrite concentration, the values were not significant at the 5% level (Table 1, Experiments 6 and 7). The frankfurters used in these tests were smoked; triangle tests with the franks that had been cooked only were not carried out since, on the basis of the previous tests, there was very little difficulty in distinguishing between untreated and nitrite-treated franks.

The scores of scaling tests of the flavors of these preparations, and the analysis of variance in the data, are shown in Table 3. In the absence of smoke there was a significant difference in the values assigned to the untreated and 50% nitrite-treated franks. (Although the 100% nitrite-treated, cooked-only franks were not tested it is anticipated that there would not be a significant difference between this preparation and the 50% nitrite-treated franks.) The presence of smoke resulted in similar scores (no significant difference) for the franks receiving no nitrite and those prepared with the two levels of sodium nitrite. The high significant statistical difference among treatments was analyzed into single degree-of-freedom contrasts. The difference in scores between the cooked-only and the cooked and smoked samples is statistically significant. The scores of the flavors of the smoked franks treated with the various concentrations of nitrite were not significantly different but there appears to be a trend that suggests their relationship can be described by a quadratic expression, indicating the presence of a point of maximum flavor.

A consumer-type test was carried out on a group of visitors to the laboratory consisting of children and adults, male and female. They were requested to indicate their preference between a pair of smoked frankfurters prepared with and without nitrite in the cure; 44 out of 55 of those participating preferred the flavor of the frankfurter with nitrite.

It is interesting to note that in triangle Experiments 4–6 (Table 1) in which the frankfurters were smoked, and in the experiments with cured pork described by Cho and Bratzler (1970), the judges were able to detect the effect of nitrite on the flavor of the product; the application of smoke apparently did not affect the flavor. However, when the frankfurters were subjected to a scaling test (Experiment 3, Tables 1 and 2; Experiment 6, Tables 1 and 3), the flavors of the smoked products were judged approx-

imately the same whether or not sodium nitrite had been used in the cure. The triangle test is purely a difference test, indicating in this case that an effect—some effect—differentiates the two samples. The scaling procedure requires a value judgement of the flavor, taking into account all factors, psychic and physical, that enter into such a judgement. Thus, while it is of interest to know that a difference can be detected, it would appear to be of greater importance that the judges found no significant difference in the flavor of smoked frankfurters in the presence or absence of sodium nitrite.

It is also of interest to note that the presence of a commercial frankfurter spice formulation was not sufficient to impart a good frankfurter flavor in the absence of sodium nitrite in the cure.

REFERENCES

Amerine, M.A., Pangborn, R.M. and Roessler, E.B. 1965. "Principles of Sensory Evaluation of Food." Academic Press, New York.

Barnett, H.W., Nordin, H.R., Bird, H.D. and Rubin, L.J. 1965. A study of factors affecting the flavour of cured ham. 11th European Meeting of Meat Research Workers.

Brooks, J., Haines, R.B., Moran, T. and Pace, J. 1940. The function of nitrate, nitrite and bacteria in the curing of bacon and hams. Food Investigation Special Report No. 49. H.M. Stationery Office, London.

Cho, L.C. and Bratzler, L.J. 1970. Effect of sodium nitrite on flavor of cured pork. J. Food Sci. 35: 668.

Kerr, R.H., Marsh, C.T.N., Schroeder, W.F. and Boyer, E.A. 1926. The use of sodium nitrite in the curing of meat. J. Agr. Res. 33: 541.

Kisskalt, K. 1899. Beitrage zur Kenntnis der Ursachen des Rötwerdens des Fleisches beim Kochen nebst einigen Versuchen über die Wirkung der schwefligen Sanve auf die Fleischfarbe. Arch f. Hyg. Bd. 35: S-11.

Polenski, E. 1891. Uber den Verlust, welchen das Rinkfleisch und Nahrwert durch das Pokeln erleidet, sowie uber die Veranderungen sulpeterhaltiger Pokellaken. Arb. a.d. Kaiserlichen Gesundheitsamt Bd. 7. S. 471.

Steel, R.G.D. and Torrie, J.H. 1960. "Principles and Procedures of Statistics." McGraw-Hill Book Co., New York.

Ms received 8/20/71; revised 4/21/72; accepted 5/1/72.