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Factors Affecting the Acceptability of Low-Nitrite Smoked, Cured Ham

CYNTHIA N. DuBOSE, ARMAND V. CARDELLO, and OWEN MALLER

ABSTRACT

Two experiments were conducted to evaluate the consumer acceptance of samples of cooked, smoked ham which varied in sodium nitrite concentration and to evaluate the importance of two factors hypothesized to affect their acceptability. The first experiment assessed the importance of color to the overall acceptability of smoked ham. Results indicated that satisfactory color in this product can significantly increase its acceptability, even when other attributes (e.g. flavor) of the product are inferior. The second experiment assessed the effect of a warning of the possible dangers of sodium nitrite on the acceptability of the products. Results showed that the warning had no effect on the consumers' acceptance of the product.

INTRODUCTION

CURRENT CONCERN over the use of nitrite in the curing of meat, fish, and poultry has been well publicized (Wall Street Journal, April 28, 1978; FDA Consumer, Feb., 1978) since it was discovered that nitrosamines, which are formed from nitrites in the presence of amines in food, may cause cancer in animals. The USDA is currently studying the risks and benefits associated with these additives.

Currently, the meat industry uses the USDA maximum of 156 ppm nitrite in the processing of most ham and other cured pork products. (The exception is bacon at 120 ppm.) Recently there has been an interest in reducing levels of nitrites in the curing process. However, it is known that, besides protecting against spoilage and growth of *Clostridium botulinum*, nitrites contribute to the characteristic flavor (Brooks et al., 1940; Cho and Bratzler, 1970) and red color (Bailey et al., 1964; Fox, 1967; Fiddler, 1972) of these cured products. Therefore, lowering of nitrite levels in these products may affect their acceptance by the consumer, an issue addressed by this paper.

Studies have indicated that the effects of nitrite reduction in the preparation of cured meat are product-dependent. For instance, one study of frankfurters (Sebranek et al., 1977) indicated that the acceptability of samples containing the maximum level of nitrite allowable (156 ppm) was significantly higher than that of samples containing 52 ppm, which, in turn, was significantly higher than that of samples containing either no nitrite of 25 ppm. Judgments of the color of the products indicated that there were significant differences among the 0, 25, 52, and 156 ppm nitrite samples, with the highest level having the most acceptable color. In addition, they found that the color imparted by nitrite seemed to have a significant effect on overall acceptability, even in samples with low levels of nitrite. Flavor judgments also were significantly different between samples having 156 ppm nitrite and those with reduced levels. Another study (Wasserman and Talley, 1972) showed significant differences in flavor between frankfurter samples prepared without nitrite and those prepared with 50% or 100% of the legal maximum of nitrite. Although there was a trend to distinguish between the 50% and 100% samples in triangle tests, the differences in flavor were not statistically significant. The study also noted that the presence of a commercial frankfurter-flavored spice in the cure was not sufficient to impart good frankfurter flavor in the absence of sodium nitrite.

In contrast to the frankfurter studies, studies of cooked, smoked ham (Wierbicki and Heiligman, 1973; Wierbicki et al., 1976) have reported that minimum amounts of nitrites (25 ppm) can be effectively used to produce cured ham with a characteristic color and flavor. Samples containing 25 ppm nitrite were reported to be highly acceptable in terms of color, flavor, texture, appearance, and general acceptance and were not significantly different from samples containing higher levels of nitrite.

The above studies indicate that nitrite reduction tends to produce distinguishable differences and inferior acceptability ratings in traditional frankfurter products, while in ham products, this effect is not evident. These studies also suggest that the effects of alterations of color and flavor on consumer acceptance are product-specific.

The following experiments were designed to evaluate consumer acceptance of cured ham samples prepared with varying levels of sodium nitrite and to examine two conditions believed to have an effect on the acceptability of the products: (1) a *color masking* condition, to assess the effect of color on the perceived acceptability of ham, and to compare these results with those found previously with frankfurters (Sebranek et al., 1977), and (2) a *warning* about the hazards of the nitrites used in the curing process, since consumers' concern about the presence of possible carcinogens in food is an important issue in the present controversy over nitrites.

MATERIALS & METHODS

FOR EACH EXPERIMENT, four lots of cooked, smoked ham were prepared, containing 0, 25, 75, and 156 ppm sodium nitrite. The lots each contained 2.4% salt, 0.3% NaTPP, and 550 ppm Na ascorbate and Na erythorbate (1:1). No nitrate was used in any of the samples. The method of curing and processing was the same as described by Wierbicki et al. (1976). The resulting ham rolls were refrigerated at 1–2°C for 3 days before testing. Immediately before the test session, samples were prepared by cutting the ham rolls into 1/2" slices, removing the casing and quartering the slices. All samples were heated to 150°F (65°C), placed in stainless steel pans prior to testing and held in a water bath.

The subjects were members of a consumer taste panel and had extensive experience judging food samples and using labelled category scales. The panel consisted of volunteer employees of the laboratory, a diverse group of professionals and nonprofessionals, with and without food science experience.

The first experiment was conducted to determine whether the color of nitrite-added and nitrite-free ham samples affected their acceptability. Each of the 96 subjects participating in this session tasted each of the four samples varying in nitrite concentration and rated each for "overall acceptability" and "acceptability of flavor." The ratings were made on 9-point labelled hedonic scales, ranging from 1 = dislike extremely to 9 = like extremely. Half of the sub-

Authors DuBose, Cardello, and Maller are affiliated with the Food Sciences Laboratory, US Army Natick Research & Development Command, Natick, MA 91760.

jects judged the samples under normal (white fluorescent) lighting conditions. The other half judged them under color-masking conditions (red fluorescent lighting).

The second experiment was conducted to determine if a warning about the safety of nitrite-added ham products would affect the acceptability of the products. Eighty-two subjects tasted and rated each of four samples on four attributes: "overall acceptability," "acceptability of the flavor," "acceptability of the color," and "color rating." The three acceptability ratings used 9-point hedonic scales, as described previously. The "color rating" was a 9-point labelled scale which ranged from 1 = extremely gray to 9 = extremely pink. All evaluations were made under normal lighting conditions (white fluorescent). Half of the subjects were given standard instructions before the test session, while the other half were given a warning which was printed in bold-face type at the bottom of the instruction sheet and is presented below:

> "These products contain varying levels of sodium nitrite, a compound traditionally used to preserve many meats. It is presently thought by some researchers to be a health hazard because during heating and cooking it can be converted into nitrosamines, which have been shown to cause cancer in laboratory animals."

RESULTS

ANALYSES OF VARIANCE (Myers, 1971) performed on the data obtained from the first experiment indicated that overall acceptability was significantly affected by nitrite level ($F = 50.0$, $df = 3,282$, $p < 0.01$) with an interaction between nitrite level and lighting condition ($F = 4.93$, $df = 3,282$ $p < 0.01$). Acceptability of flavor was also significantly affected by nitrite level ($F = 32.46$, $df = 3,282$, $p < 0.01$) with an interaction between nitrite level and lighting condition ($F = 2.70$, $df = 3,282$, $p < 0.05$). These effects are shown in Figures 1 and 2, respectively.

The main effect of nitrite level was further analyzed by Scheffé multiple comparison tests (Ferguson, 1966). These tests indicated that the overall acceptability, as well as the acceptability of the flavor, of the 0 ppm nitrite samples was significantly lower ($p < 0.01$) than those of the other samples. The ratings of the nitrite-added samples did not differ. With regard to the significant interactions, it can be seen from the figures that there are monotonic increases in acceptability with increasing levels of nitrite under the color-masking condition, whereas all the nitrite-added samples (25, 75, and 156 ppm) were rated equally under normal viewing conditions. This was observed to be the case for both overall acceptability and flavor acceptability.

In the second experiment, analyses of variance showed that the ratings of overall acceptability ($F = 91.66$, $df = 3,240$, $p < 0.01$) and acceptability of flavor ($F = 44.16$, $df = 3,240$, $p < 0.01$) were significantly affected by nitrite

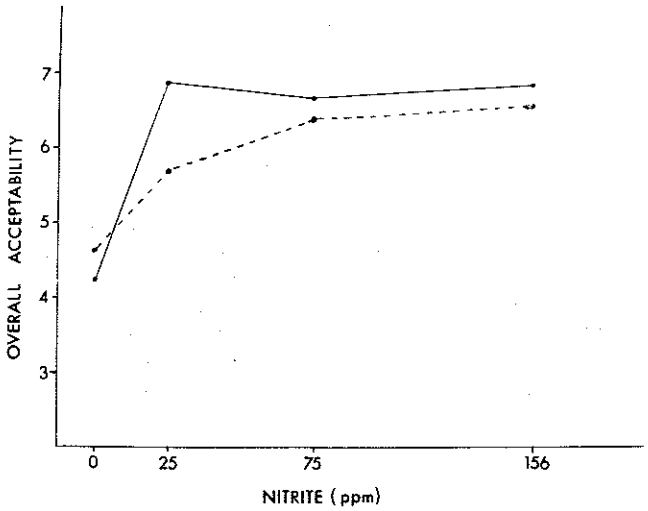

Fig. 1—Overall acceptability of samples of ham varying in levels of added sodium nitrite. Solid line connects ratings made under normal lighting conditions. Dashed line connects ratings made under color-masking lighting conditions. 48 Ss were run under each condition.

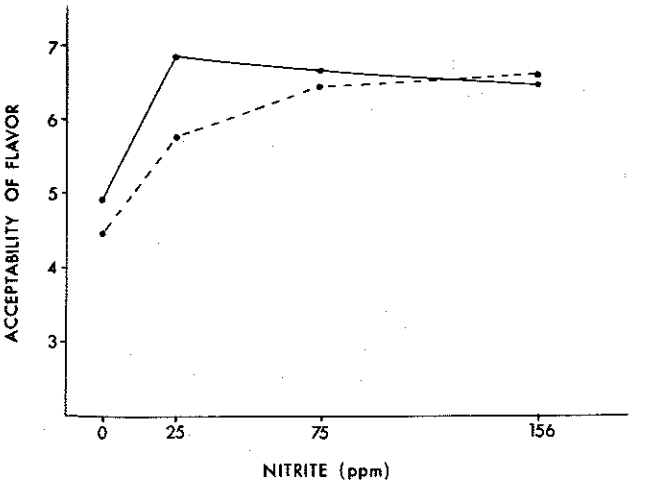

Fig. 2—Acceptability of flavor of ham samples. Solid and dashed lines have same meanings as in Fig. 1.

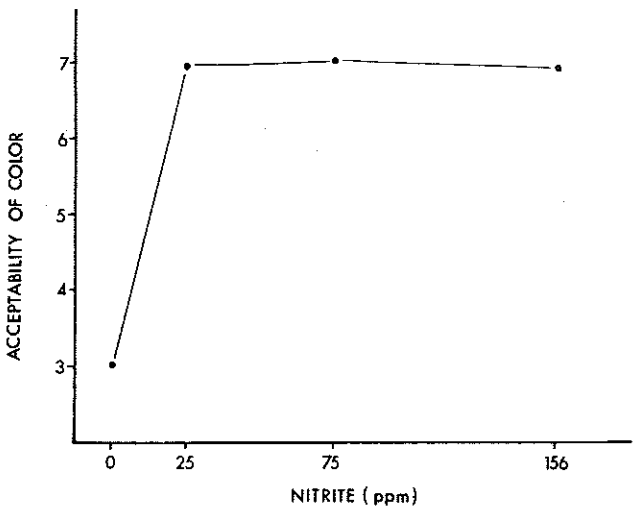

Fig. 3—Acceptability of color of four samples of ham. N = 82.

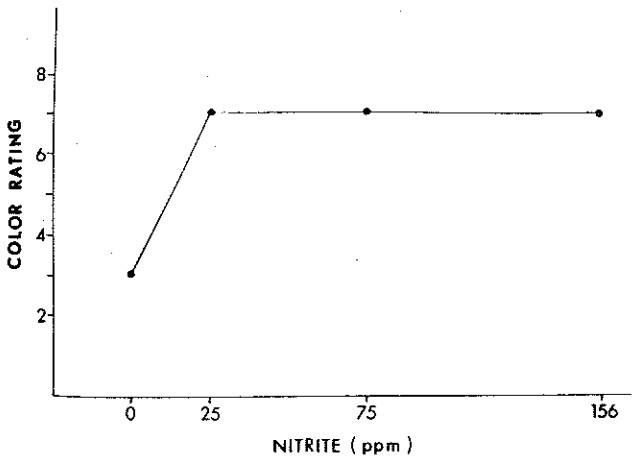

Fig. 4—Ratings of the color of four samples of ham. Scale ranged from 1 = extremely gray to 9 = extremely pink.

level, replicating the results of the first experiment. In addition, acceptability of color ($F = 162.02$, $df = 3,240$, $p < 0.01$) and color rating ($F = 278.60$, $df = 3,240$, $p < 0.01$) were significantly affected by nitrite levels. Scheffé multiple comparison tests indicated that, for each of the four attributes, the 0 ppm nitrite sample was rated significantly lower ($p < 0.01$) than the other three samples, but there were no significant differences among the 25 ppm, 75 ppm, and 156 ppm nitrite samples. The color ratings and color acceptability curves are shown in Figures 3 and 4.

The warning condition had no effect on overall acceptability, flavor acceptability, or color acceptability, but did alter the judgment of the color rating of the samples. The mean rating of the color under the warning condition was significantly *lower* (i.e. more gray) ($F = 5.62$, $df = 1,80$, $p < 0.05$) than under the no-warning condition. The result is contrary to the expectation that subjects given the warning (i.e. the *information* that the products contained added nitrites) would rate the products to be more pink, as might be predicted if the notion that "people know the red color means another preservative" (Wall Street Journal, Sept. 12, 1978) is true. Rather, it appears that information in the form of a warning, that a health-risk additive has been added to the product, evokes a perception of the product as being less wholesome-looking or less natural.

DISCUSSION & CONCLUSIONS

THE RESULTS of these experiments are consistent with those of Wierbicki (1976); consumer acceptance of ham products cured in the absence of sodium nitrite is lower than it is for products cured with added nitrite, but samples cured with varying reduced levels of nitrite are as acceptable in terms of flavor, color, and overall acceptability as products prepared with the present maximum nitrite concentration. Since the color ratings of the 25 ppm, 75 ppm, and 156 ppm nitrite samples were judged to be the same ("moderately pink," Fig. 4) in the second experiment and also to be equally acceptable (Fig. 3) in both the normal lighting conditions of experiments 1 and 2, yet monotonic increases in flavor and overall acceptability were observed in the "color-masked" condition of the first experiment, it can be concluded that the color of the three nitrite-added samples is an important and overriding attribute affecting judgements of these products. These results are consistent with those found by Sebranek et al. (1977) for frankfurters, showing the important role of the color, contributed by even reduced amounts of nitrite, to the acceptability of these products.

While these findings ignore the potential microbial consequences of reducing nitrite in the curing process, they reconfirm the important effects that nitrites have on the sensory characteristics of the products.

The effects of a warning on the consumers' perception of the products are curious, in that they show a warning to increase the perceived "grayness" of the meat. A variety of hypotheses could be put forward to explain these results. One such hypothesis, suggested in the previous section, is that this information results in the perception of a less-wholesome or less-natural product, which, in the present case, was manifested in the ratings of color. Other explanations are possible. The important aspect of these findings, however, is that such information had no effect on the acceptability of the product. These results are consistent with a previous study conducted in this laboratory (DuBose et al., 1980) showing the negligible effects of a colorant safety warning on the acceptance of beverages and cakes containing artificial colorants.

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