Evaluation of a Comminuted Meat Product Containing a Solid Metal Contaminant

H. W. OCKERMAN* and B. BOESEL

Department of Animal Science, The Ohio State University, Columbus, Ohio 43210, and the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691

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ABSTRACT

Frankfurters containing a solid metal object (nail) were subjectively evaluated on the basis of emulsion color change adjacent to the metal, insertion channel development, and molding of the meat around the object. Frankfurters contaminated during the processing phase of production, whether boiled or not boiled, showed significantly greater color change than did frankfurters contaminated during the distribution or consumer phase. However, these same frankfurters had significantly less distinct insertion channels. No channel could be observed in frankfurters which were contaminated before processing and before cooking/smoking. Molding of the meat around the object did not provide distinguishable evidence for time of insertion.

The food industry is periodically presented with the problem of unintentional or intentional contamination of a food item with foreign objects. The comminuted meat industry must also periodically determine the source or origin of the contamination from a quality control standpoint so that causes can be corrected. Some processing plants have installed metal detectors to inspect for metal as late in the emulsion process as is possible (1).

To date, no method for precise determination of the origin of metal contamination has been developed. Controversy arises when a contaminant is discovered by a consumer.

Color change due to oxidation of the meat surrounding the metal, channels or pathways created by the object upon entering the product, and molding of the meat around the object are characteristics of metal contamination that can be evaluated and may vary depending upon when the metal object was incorporated into the product.

The objective of this research was to evaluate an emulsion type product into which a nail has been inserted at various stages of production, product distribution, and/or consumer preparation for clues that could be used as an aid in determining whether the object entered the product while it was in the care of the processor, distributor or consumer.

MATERIALS AND METHODS

A standard formulation and processing procedure for frankfurters was used in this research. The non-meat ingredients, including spices (white pepper, coriander, and mace), salt, sodium erythorbate, sodium nitrite, and water, were combined with ground regular pork trim (50% fat) and ground lean beef trim (20% fat) to provide 4 replicate batches of frankfurters consisting of approximately 30% fat. Each batch was prepared and processed separately. All frankfurters (2.2 cm diameter, 12.7 cm long) were cooked to an internal temperature of 73°C and cooled (given a cold shower) to an internal temperature of 28°C. Each batch yielded approximately 70 frankfurters which were held in storage at 3°C.

To simulate the effect of either accidental or intentional contamination of a product with a metal object, 1 1/2 in. (3.8 cm), 1.6 mm diameter, mild steel (maximum 0.1% C) finishing nails were inserted into individual frankfurters at various stages of production, distribution, and consumer handling (Table 1). The nails were inserted longitudinally from one end of the frankfurter, using another 1 1/2 in. (3.8 cm) finishing nail as a probe to place the embedded nail 3.8 cm from the end of the frankfurter. Only one nail was inserted into each individual frankfurter. See Table 1 for additional information. Treatment 1 --a control. Treatment 2 --these frankfurters were stuffed separately and hand tied after insertion of the nail into the emulsion. Treatment 3 --nails were inserted into hot frankfurters. Treatment 4 --nails were inserted into cooled frankfurters. Treatment 5 --nails were inserted after storage for 6 d at 3°C. Treatment 6 --nails were inserted after boiling. Treatment 7 --nails were inserted after boiling and cooling.

To compare frankfurters with nails inserted during the consumer phase (following boiling) with those in which nails were inserted during the processing or distribution phases, yet not discovered until after boiling during the consumer phase, half of the frankfurters in Treatment groups 1 through 5 were boiled along with Treatments 6 and 7.

All frankfurters were coded and evaluated (after boiling or not boiling, see Table 1) one week after processing. Each frankfurter (5 duplicates per treatment group) was carefully

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sliced longitudinally along the surface of the embedded nail to the point of insertion to expose any channel created during entry. Evaluation of each batch of frankfurters consisted of subjective observations by a 3-member panel trained in preliminary testing of procedures and aided with color photographs of contaminated samples. Franks were scored with regard to: (a) estimated average distance of emulsion color change (oxidation) surrounding the nail, (b) presence of a clear and distinct channel, or pathway, created from insertion of the nail, and (c) distinctness of the molding, or impression created by the nail, in the meat. The frankfurters were scored individually for each of the above characteristics. A 10-point rating scale was used with 1 representing no emulsion color change, no channel present, and no molding impression, 5 representing an average of approximately 0.1 cm color change, ragged but continuous channel, and ragged but continuous impression, and 10 representing an average of greater than 0.2 cm of color change surrounding the nail, a clear and distinct channel present, and a distinct molding impression.

A total of three separate analyses using the General Linear Models program for significance of variables (color, channel, and molding) and Fisher's least-significant difference test for mean separation (2) were completed for (a) all treatments (1 through 7), (b) processing phase treatments (1 through 5), including boiled and non-boiled treatments, and (c) consumer phase treatments (6 and 7).

**RESULTS AND DISCUSSION**

An interaction between treatment (time of metal insertion) and preparation (boiling 12 min) was significant (p<0.01) for all variables measured, indicating that preparation of the frankfurters did have an effect in combination with treatments on the resulting scores.

The color scores for all treatments, boiled and not boiled, are illustrated in Fig. 1, with higher scores indicating larger average distance of color change. Frankfurters that were contaminated during processing (Treatments 2, 3, and 4) and boiled had significantly more emulsion color change than those contaminated during processing but not boiled. However, all of the frankfurters in these processing treatment groups, both boiled and not boiled, exhibited more than twice the average distance of color change that was observed in the frankfurters contaminated after storage (Treatment 5), either boiled or not boiled, and frankfurters contaminated during the consumer phase, either hot or cold. The catalytic effect of the metal combined with the increased temperature during boiling probably caused an increased rate of oxidation, which resulted in significantly more color change in frankfurters that were boiled, regardless of time of insertion of the nail. Time, in combination with processing...
temperature, was probably the factor which caused the increased amount of emulsion color change in the frankfurters contaminated during the processing phase. At the time of evaluation, nails had been in contact with the cooked emulsion tissue in the processing phase treatments for 7 d while nails had been in place in the distribution phase treatment and consumer phase treatments for only 1 d. The longer the nails were in place, the greater

the amount of time available for the oxidation reaction to develop a color change. Consequently, a color change greater than an average score of 3 would suggest contamination during processing and before storage, provided the product was examined during the time frame of this research. Based upon the results of this study, a product with this type of metal in place for 7 d would have an average emulsion color score between 5.4 and 6.7. Be-

![Figure 1. Least squares means and standard errors for frankfurter sensory color scores (boiled vs. not boiled) at the top, channel scores (boiled vs. not boiled) in the center, and molding scores (boiled vs. not boiled) at the bottom.](http://meridian.allenpress.com/jfp/article-pdf/49/1/14/1655828/0362-028x-49_1_14.pdf)
cause of the low color scores developed in 1 d in the
non-boiled frankfurters of Treatment 5 (score 2.20), and
only slightly higher scores (2.75) in the boiled frankfur-
ters of Treatment 5 and the consumer phase frankfurters
of Treatments 6 and 7, a product with little or no emul-
sion color change surrounding the metal object, whether
boiled or not boiled, would probably have been contami-
nated within a 24-h period before detection.

The channel scores for all treatments, both boiled and
not boiled, are also illustrated in Fig. 1. Channel scores
in the processing phase treatments were not affected by
boiling. The fact that the channel scores in the processing
groups, both boiled and not boiled, were observed to be
significantly lower than those in the distribution treatment
(5) (less distinct channels), both boiled and not boiled,
and in the consumer treatments (6 and 7) was expected
because partial coagulation of protein was still occurring
during the manufacturing process and tended to obscure
the entrance pathways. Boiled and non-boiled frankfurters
in Treatment 2, in which nails were inserted into the un-
cooked emulsion immediately after stuffing, were not signi-
ficantly different from the control frankfurters, which
obviously exhibited no channels. This result was expected
since the channel had ample opportunity to reseal before
cooking. More distinct channels were formed when the
nails were inserted into fully-cooked meat. In the distri-
bution phase treatment (5), boiled frankfurters had sig-
nificantly less distinct channels than did the non-boiled
frankfurters, however, they still scored higher (clearer
channels) than any of the other treatments. Consequently,
the presence of a clear and distinct channel would indi-
cate contamination after processing was completed, re-
gardless of boiling by the consumer.

Molding of the meat around the nail or the impression
left by the nail in the meat after the nail was removed,
for both boiled and non-boiled franks, was the observed
characteristic showing the least difference with all scores
(except controls) ranging between 8.25 and 9.00 (Fig. 1).
This indicates that fairly distinct impressions were formed
regardless of treatment.

Results of this study suggest that, in conjunction with
dates of processing, distribution, and purchase for con-
sumption, clues obtained from evaluation of the emulsion
color change and channel development in a contaminated
product could aid in determining the time of contamina-
tion. A frankfurter, boiled or not boiled, showing an av-
erage of approximately 0.2 cm of emulsion color change
around the object suggests contamination during process-
ing or possibly the metal object has been embedded for
a number of days if the frankfurter has been stored longer
than 7 d. A frankfurter, boiled or not boiled, showing
little or no color change around the object suggests con-
tamination for less than 24 h, probably occurring at the
distribution or consumer level. A contaminated frankfur-
ter showing no channel probably resulted from incorpora-
tion of the object before process cooking. Significantly
clearer channels were formed when objects were inserted
into fully-cooked meat and suggests consumer phase or
distribution phase contamination. Molding of the meat
around the object did not provide clear evidence to distin-
guish between processing phase or consumer phase con-
tamination.

Smaller metal objects may require different evaluation
techniques, i.e., microscopic structural alterations to de-
termine contamination pre- and post-processing. With
small objects visual evaluation probably would not be
sufficient.

REFERENCES

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