

Color changes in frankfurters manufactured with or without sodium nitrite and sodium ascorbate

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Abstract— The aim of this trial was to evaluate color changes in refrigerated frankfurters manufactured with or without sodium nitrite and sodium ascorbate. Frankfurters were produced using meat and fat from Iberian pigs, and there was two experimental treatments: control frankfurters (CF) were those manufactured with sodium nitrite (100 ppm) and sodium ascorbate (500 ppm), and experimental frankfurters (EF) were those manufactured without sodium nitrite and sodium ascorbate. Instrumental color (CIE L*a*b*) of surface and inner area of the frankfurters were measured at 0, 15 and 30 d post-manufacturing by using a Minolta CR-300 colorimeter. Inner a* value of the EF was greater than CF at day 0, and no significant differences were found between treatments for surface color. At 15 d post-manufacturing, EF showed less L* but higher b* values than CF in both inner and surface of frankfurters. At the end of the trial (30 d), EF had less L* but greater a* and b* values than CF in the inner area. However, no significant differences were found between treatments for surface color. In conclusion, the addition of sodium nitrite and sodium ascorbate to Iberian frankfurters did not affect surface color, but increased the a* and b* values of the inner layer.

Keywords— Frankfurters, sodium nitrite, color.

I. INTRODUCTION

Color of meat or meat products is an important quality attribute that influences consumer acceptance of the meat. In the manufacturing of cooked sausages, nitrate and/or nitrite are commonly added to the sausage mince, which are used to stabilize the pink curing color, among other functions as enhancing the flavor and texture, and acting as an antioxidant and a microbiological preservative [1].

However, the principal concern with the use of nitrite in cured meat products is the eventual formation

of carcinogenic N-nitrosamines due to its reaction with secondary amines and amino acids in muscle proteins [2]. Furthermore, residual nitrite in cured meats may form N-nitrosamines in the gastrointestinal tract [3]. Thus, the meat industry continues to search for alternative methods to produce nitrite-free meats that maintain the color characteristics of nitrite meat products.

Many scientific papers have written about the effect of nitrite or nitrate alone. Regarding sausage manufacture, comparisons are usually made between samples manufactured with nitrite with those manufactured with both nitrite and nitrate or just samples manufactured with spices and without nitrogenous salts. Only a handful of researchers have produced sausages with only nitrite or nitrate in their formulation thus allowing differentiation between the effects of one or the other [4]. However, to the present no study has been reported on the effect of nitrite alone in frankfurters manufactured with meat and fat from Iberian pigs.

The aim of this paper was to evaluate the color changes in refrigerated Iberian frankfurters, manufactured with or without sodium nitrite and ascorbate.

II. MATERIALS AND METHODS

A. Sample preparation

Frankfurters were produced using meat and fat from Iberian pigs provided by Consorcio de Jabugo, S.A. There were two experimental treatments: control frankfurters (CF) were those manufactured with sodium nitrite (100 ppm) and sodium ascorbate (500 ppm), and experimental frankfurters (EF) were those manufactured without sodium nitrite and sodium ascorbate. All frankfurters were manufactured in two

batches (1 kg for each treatment per batch) in the pilot plant of Food Technology Department at Faculty of Veterinary (University of Extremadura) with the following standard formulation: 700 g/kg Iberian meat (with 22% of intramuscular fat), 275 g/kg distilled water, 20 g/kg NaCl, and 5 g/kg tri-phosphates (all from ANVISA, Madrid, Spain). In the experimental batch, sodium nitrite and sodium ascorbate replaced the equivalent volume of water in the formula.

Firstly, the meat was chopped into small cubes (1 cm³) and mixed with the sodium chloride, sodium nitrite and sodium ascorbate in order to allow the nitrification of the samples 2 h before the manufacture. Then, the meat was minced in a cutter Foss Tecator Homogenizer (mod. 2094, Höganäs, Sweden) for 6 min without the temperature of the mixture exceeded 7 °C until a homogeneous raw batter was obtained. Finally, the mixture was vacuum stuffed into 20 mm diameter cellulose casings, handlinked at 10 cm intervals and given the thermal treatment in a hot water bath for 30 min (65 °C).

In order to allow the development of color changes, the frankfurters were refrigerated stored (+4 °C) in the darkness for 30 days.

B. Color analysis

Instrumental color of surface and internal area of the frankfurters was measured in triplicate at 0, 15 and 30 days post-manufacturing by using a Minolta CR-300 colorimeter (Minolta Camera Corp., Meter Division, Ramsey, NJ) with illuminant D65 and 0° standard observer with a D65 illuminant. CIELAB L*, a* and b* values [5] were determined as indicators of lightness, redness and yellowness, respectively.

A numerical total color difference (ΔE) between 0 and 30 days of trial was calculated by:

$$\Delta E = [(L - L_{ref})^2 + (a - a_{ref})^2 + (b - b_{ref})^2]^{1/2}$$

C. Statistical analysis

Statistical analysis was performed using Statistical Package for Social Science (SPSS, Windows version 17.0, SPSS Inc., Chicago, IL, USA). General Lineal Model (GLM) was done to determine the significance

of the main effect. Significant differences ($P < 0.05$) between means were identified using Least Significant Difference procedures.

III. RESULTS AND DISCUSSION

As it was expected, no significance differences were found between treatments for the surface color of the frankfurters at day 0 (Table 1). After 15 days of refrigerated storage, EF showed lower L-value and higher b-value than CF, which means that EF were darker than that CF. At the end of the trial (day 30), the addition of sodium nitrite and ascorbate did not affect the instrumental color of the frankfurters.

Table 1. Effect of sodium nitrite and ascorbate on surface color of Iberian frankfurters.

	EF	CF	SEM ^a	P
Day 0				
L	61.67	62.87	0.84	NS
a	8.34	8.56	0.10	NS
b	9.83	9.52	0.14	NS
Day 15				
L	63.69	65.47	0.41	0.023
a	11.35	11.48	0.30	NS
b	11.45	9.49	0.17	<0.001
Day 30				
L	61.44	61.28	0.89	NS
a	13.24	13.29	0.49	NS
b	10.20	10.04	0.29	NS

^a SEM, standard error of the mean (n=4).

The effects of sodium nitrite and ascorbate on internal color of Iberian frankfurters are presented in Table 2. At the beginning of the trial, EF showed higher a-value than CF, without significant differences between treatments for L and b-values. After 15 days of refrigerated storage, EF had lower L-value and higher b-value than CF. These results are agree with the previous data obtained for the surface color, which means that EF were darker than that CF. At the end of the trial (day 30), EF showed lower L-value and higher a and b-values than CF. In contrast with other reports [6], there is no decrease in the a-value in treatments with nitrites due to the oxidative action of nitrites. The addition of nitrites during processing of the batter involves an initial oxidation of red,

oxygenated myoglobin (MbO₂) to brown metmyoglobin (MMb) with reduction of nitrite to nitric oxide (NO), which is then oxidized to nitrate and other products in slower and more complex reactions.

Table 2. Effect of sodium nitrite and ascorbate on internal color of Iberian frankfurters.

	EF	CF	SEM ^a	P
Day 0				
L*	64.81	64.46	0.23	NS
a*	9.22	8.32	0.24	0.036
b*	11.92	11.62	0.17	NS
Day 15				
L*	61.84	63.22	0.29	0.009
a*	12.48	12.06	0.18	NS
b*	12.71	11.95	0.14	0.004
Day 30				
L*	58.76	60.32	0.44	0.047
a*	14.77	13.58	0.23	0.011
b*	13.39	12.28	0.18	0.005

^a SEM, standard error of the mean (n=4).

Numerically calculated total color difference (ΔE) in Iberian frankfurters indicated that there is no significant difference between treatments for the surface color. However, regarding the inner color, EF tended to increase the numerical total color difference with respect CF. Therefore, it can be concluded that the extent of color change by addition of sodium nitrite and ascorbate to frankfurters was smaller than that without additives.

Table 3. Numerical total color difference (ΔE) in frankfurters manufactured with or without sodium nitrite and ascorbate during storage.

	EF	CF	SEM ^a	P
SURFACE	5.57	5.22	0.78	NS
INNER	8.41	6.74	0.57	<i>0.085</i>

^a SEM, standard error of the mean (n=4).

IV. CONCLUSIONS

The addition of sodium nitrite and sodium ascorbate to Iberian frankfurters did not affect surface color, but increased the a* and b* values of the inner layer.

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