FATE OF NITRITE AND COLOUR STABILITY IN BOLOGNA DURING DIFFERENT STORAGE CONDITIONS

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INTRODUCTION

Bologna sausage and other meat products are typically marketed either sliced and vacuum-packaged, for sale in display cases or whole, for slicing at the time of sale upon request by the consumer.

Colour is one of the main attributes affecting meat product acceptability. Colour fading varies in response to a number of factors, including product type and characteristics, storage conditions (exposure to air, time and intensity of exposure to light), etc. (Lin and Sebranek, 1979; Lin et al., 1980; Jiménez-Colmenero and Cassens, 1987; Yen et al., 1988; Andersen et al., 1988). Fading in the interior of cured products has been reported to take place at a much slower rate than at the surface (Acton et al., 1986). For this reason, plastic films with a low permeability to oxygen are not required to prevent fading in certain types of hams preserved in darkness prior to slicing at the time of sale (Terlizzi et al., 1984).

Furthermore, nitrite, a critical agent in meat curing processes, is known to be highly reactive, so that the amount of nitrite detectable falls rapidly, depending upon such parameters as product type and characteristics, processing methods, storage conditions, etc. (Cassens et al., 1979). Even within a given product, the decrease in residual nitrite varies with the location (centre or concentric outer layers) analyzed (Marinkov and Jovanov, 1984). Improving our understanding of the fate of nitrite for given conditions and storage periods is important in view of its capacity to react with amines and amides to form carcinogens.

The object of the present study was to determine the fate of nitrites (in the form of residual nitrite, nitrate, nitroso heme pigments, and protein-bound nitrite) and alterations in colour in bologna stored either whole or sliced and vacuum-packaged.

MATERIALS AND METHODS

Bologna sausages (diameter: 9 cm, moisture: 64.5 %, protein: 11.1 %, fat: 20.1 %, ash: 2.8 %, pH: 6.2) prepared from pork under commercial conditions and containing 120 ppm of added $NaNO_2$ but no ascorbate were randomly divided into two equal batches. The bolognas in one of the batches (W) were stored whole, whereas the bolognas in the other batch (S) were cut into slices approximately 1.5 mm thick (15 g) and vacuum-packaged five slices to a pack in Polyskin X plastic film with an oxygen permeability at 23 °C of 6-8 cc/m²/24 h/atm.

Both the whole bolognas (batch W) and the vacuum-packaged bologna slices (batch S) were stored in darkness at 0 °C (± 1 °C) for 45 days.

Product stability during storage was monitored by periodic controls carried out on three packages from batch S and on slices cut from the whole bolognas (batch W) no more than 2 h before analysis, after removal of the outer 7 cm at the end exposed to the air.

Objective colour measurements were performed using a Hunter-

Lab model D25-9 colourimeter standardized using a white standard (L = 91.6, a = -0.8, b = -1.3) at three different points on the top slice from each of the three packages in batch S. Readings for batch W were made in the same manner on three slices.

The other analyses described below employed bologna homogenates prepared by chopping and blending at least ten slices from each batch.

The total pigment and nitroso heme pigment contents were determined according to the method of Hornsey (1956). Residual nitrite and nitrate were ascertained following AFNOR standards (1974), and protein-bound nitrite was evaluated using the procedure of Mirna as modified by Olsman and Leeuwen (1977).

The degree of significance between means was calculated by two-way analysis of variance.

RESULTS AND DISCUSSION

Table 1 presents the alterations in colour taking place during storage. Changes in the colour parameters were slight in terms of the effect of both storage period and storage conditions. Small variations in colour in response to storage time were reported by Jiménez-Colmenero and Cassens (1987), Lozano and Cassens (1984), and Andersen et al. (1988) for sliced, vacuum-packaged products stored in darkness.

No significant differences ($P \leq 0.05$) in the total pigment and nitroso heme pigment contents with either sample type or storage time were detected. Overall mean values (in ppm) were 65.7 (± 5.3) for total pigments and 42.0 (± 4.8) for nitroso heme pigments, with a pigment conversion level of 63.9 %. The total pigment and nitroso heme pigment values were low, because the sausages were made from pork alone; this might also explain, in some measure, why the colour parameter (chiefly redness) values were lower than those for other products made of beef (Lozano and Cassens, 1984; Jiménez-Colmenero and Cassens, 1987) or even chicken (Acton et al., 1986). However, Jiménez-Colmenero and Cassens (1987) also reported that differing concentrations of nitroso heme pigments did not result in different redness values.

Table 1. Hunter-Lab colour readings during storage*

Parameter	Batch	Days in storage 0	15	30	45
L Lightness	W	59.47 (0.47)	59.26 (0.26)	59.89 (0.33)	59.77 (0.18)
	S	59.47 (0.47)	60.47 (0.49)	59.16 (0.50)	59.20 (0.37)
a Redness	W	6.65 (0.32)	7.30 (0.26)	7.12 (0.26)	7.22 (0.33)
	S	6.65 (0.32)	6.68 (0.21)	7.26 (0.42)	7.22 (0.15)
b Yellowness	W	7.86 (0.25)	7.70 (0.17)	7.79 (0.12)	7.95 (0.22)
	S	7.86 (0.25)	7.95 (0.11)	7.71 (0.13)	7.82 (0.11)

* Values are the means of nine determinations; brackets contain standard deviations

The residual nitrite content (Table 2) underwent similar decreases in both batches through the first 30 days in storage, after which time it fell much more steeply in the sliced, vacuum-packaged batch. Decreases in residual nitrite content under a variety of storage conditions have been reported by a number of workers (Olsman, 1973; Cassens et al., 1979; Lin et al., 1980; Jiménez-Colmenero and Cassens, 1987).

The behaviour of the nitrite converted to nitrate (Table 2) was similar in both batches and displayed a tendency to decrease with storage time. Nitrate levels amounted to around 18-25 % of the added nitrite, coinciding with the conversion rate indicated in the literature (Cassens et al., 1979), even though no ascorbate, which intensifies nitrate formation (Lee et al., 1978), was added.

The protein-bound nitrite content (Table 2) rose in both batches after 15 days in storage, thereafter remaining constant for the rest of the storage period. Olsman (1977) reported that, following an initial increase, protein-bound nitrite levels decreased with storage time in function of storage temperature, with variation very low at 0 °C. The levels recorded in the present experiment, representing from 5.5 to 10 % of the nitrite, were low in comparison with values given in the literature (Cassens et al., 1979), which were more than 20 % of the added nitrite.

Table 2. Concentration (in ppm) of residual nitrite (RN), nitrites converted to nitrate (NN), and protein-bound nitrite (PN) during storage*

Nitrite fraction	Batch	Days in storage 0	15	30	45
RN	W	78.6_{1}^{a}	$70.4_{1}^{a,b}$	65.9_{1}^{b}	61.2_{1}^{c}
	S	78.6_{1}^{a}	72.5_{1}^{a}	61.6_{1}^{b}	29.6_{2}^{c}
NN	W	30.1_{1}^{a}	30.8_{1}^{a}	27.4_{1}^{a}	25.0_{1}^{a}
	S	30.1_{1}^{a}	31.8_{1}^{a}	31.1_{1}^{a}	22.3_{1}^{b}
PN	W	6.7_{1}^{a}	11.0_{1}^{b}	11.3_{1}^{b}	12.3_{1}^{b}
	S	6.7_{1}^{a}	11.1_{1}^{b}	11.9_{1}^{b}	12.0_{1}^{b}

* Values are the means of four determinations; for each fraction, different letters in the same row and different numbers in the same column indicate significant differences ($P \leq 0.05$)

The total detectable nitrite from all the fractions studied, residual nitrite, nitrite converted to nitrate, protein-bound nitrite, and nitroso heme pigment nitrite [calculated on the basis of two nitrite molecules for each myoglobin molecule (Tarladgis, 1962; Lee and Cassens, 1976)], combined ranged between an initial value of 96.4 % of the added nitrite in both batches and end values of 82.3 % in batch W and 53.5 % in batch S. Thus, recovery of the added nitrite depended on storage time, mainly owing to the residual nitrite converted to compounds that were not quantifiable in the conditions of the experiment. Cassens et al. (1977) reported recovery levels ranging between 36 and 90 % of the added nitrite for the four fractions considered here, but they made no mention of any relationship with storage conditions or storage time.

Exposure to oxygen both increases colour fading (Lin and Sebranek, 1979; Lin et al., 1980; Acton et al., 1986; Yen et al., 1988) and lowers residual nitrite levels (Lin et al., 1980). This may explain why Marinkov and Jovanov (1984) found higher residual nitrite concentrations at the centre of sausages than in the surface layers. Bearing this in mind, the results suggest that the factors regulating the variations taking place in the parameters tested were similar up to 30 days in storage in both the whole bologna sausages and the sliced, vacuum-packaged bologna, since the response to the storage conditions was similar in the two batches.

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