EFFECT OF THE LEVEL OF RESIDUAL NITRITE AND PACKAGING CONDITIONS ON COLOR STABILITY IN COOKED HAM

R. GOUTEFONGEA

Institut National de la Recherche Agronomique, Theix, 63110 BEAUMONT, France

INTRODUCTION

Although potassium nitrate (salpeter) has been used for meat curing for many hundreds of years, its role has been understood only since the end of the XIXth century. The studies of POLENSKI (1891), LEHMAN (1899) and HALDANE (1901) established that nitrite must be reduced to nitrite bacteriologically before reaction occurs with myoglobin to give the characteristic color of cured meat products. Later, KERR et al. (1926) established proper levels of usage for nitrite in meat curing. Then, BROOKS et al. (1940) and TARR (1941) offered the first proof that Nitrite is the agent responsible for cured flavor and has an antimicrobian function.

Further studies corroborated these findings and, simultaneously, showed that some of the added nitrite disappeared during processing storage and distribution (FOX and THOMSON, 1963 ; CHO and BRATZLER, 1970 ; GREENBERG, 1972 ; NORDIN, 1969 ; HERRING, 1973).

Now, three potential problems currently associated with nitrite and cured meat have to be dealt with : firstly, the possible presence of preformed nitrosamines in the product ; secondly, the presence of residual nitrite (whose consumption increases the total body burden of nitrite and can produce nitrosamine formation in the consumer's stomach), and, thirdly, concern about the unknown.

If the improvement of our knowledge about the third point is the aim of a lot of researchers, the outcome of the first two is a modification of the regulation in many countries, in order to lower the level of residual nitrite as near 0 as possible in cured meats. But, as nitrosamine formation is to be prevented and the amount of nitrite ingested by consumers decreased, cured meat products need to have a good shelflife. Therefore, this work was undertaken to study the effects of residual nitrite and vacuum degree on the color stability of cooked ham during storage under commercial conditions.

EXPERIMENTAL

Twenty-four hours after slaughter, four hams, chosen for being similar in color and pH, were purchased from a local slaughterhouse. The next day, they were derinded, defatted, deboned and injected (stitch pumping) with brine (15 % of their weight after trimming).

Two brines were used. Both contained 15 % Sodium chlorode but brine A contained 330 mg of Sodium nitrite per kg and brine B 1000 mg of sodium nitrite per kg. So, hams 1 and 2, injected with brine A, received 50 ppm of nitrite ; hams 3 and 4, injected with brine B, received 150 ppm of it. Hams were then soaked for 48 hours in their respective brine, drained for 4 hours, put in moulds and cooked in a steam oven until the internal temperature reached 68° C. After cooking, they were pressed under 2200 pascals and stored at + 2° C for 2 days in a chilling room. Afterwards, they were taken out of the moulds, all the lean parts were carefully dissected with complete removal of fat and connective tissue, and finely ground. Aliquots weighing about 50 g were packaged in plastic pouches under different vacuum levels and stored in a room at + 10° C, either in light (daylight + fluorescent light) or kept in the dark. The distribution of the samples between the different storage conditions is given in table 1.

Vacuum level	Number of pouches in light	Number of pouches in the dark
5 mm Hg	3	3
10 mm Hg	3	
20 mm Hg	3	
30 mm Hg	3	
40 mm Hg	3	3
60 mm Hg	3	
80 mm Hg	3	
100 mm Hg	3	3

Table 1 : DISTRIBUTION OF THE SAMPLE FOR EACH HAM

The oxygen transmission rate of the pouches was 10 $cm^3/m^2/24$ h.

Reflectance spectroscopy measurement was performed on each ham under each storage condition, after the 1st and 4th hours, 1st, 2nd, 4th, 7th, 10th, 14th and 18th days, and residual nitrite and pigment determinations were made on the 18th day.

The two other samples were used for residual nitrite and pigment determinations, 5 hours and 7 days respectively, after packaging.

Reflectance spectroscopy measurements were carried out on a spectrophotometer Beckman DBGT fitted with an integrating sphere, a 10-inch recorder and a tape punch attachment. The reflectance spectra were recorded between 700 and 400 nm and the values of the reflectance percentage were recorded at 5 nm intervals on a punched tape. The tapes were thereafter treated on an H.P. 9825 calculator fitted with a tape reader and a platter to obtain color characteristics. We considered mainly the Luminance Y, the dominant wavelength λd ant the excitation purity P.e. Furthermore, we determined ΔE, which is a global assessment of color difference, between the initial time and the different times at which reflectance measurements were made. The residual nitrite was determined in duplicate on samples weighing 10 grams, homogeneized in warm water (60°) buffered with borax (5 % pH, 9.0) and then heated at 100° C for half an hour. After cooling, the solutions were clarified by ARREZ solutions I and II, adjusted in volume and filtered. Nitrite was determined by diazotation with sulfanilamide-Hcl and coupling with α naphtylethylene diaminie. The resulting chromophore was measured spectrophotometrically at 540 nm. Total pigment and nitrosopigment were quantified (HORNSEY, 1956) by Hcl-Acetone-Water extraction for total pigment and Acetone-Water for nitrosopigment. Spectrophotometric measurements were made at 512 and 540 nm respectively.

RESULTS AND DISCUSSION

Hams 1 and 2, on the one hand, hams 3 and 4, on the other hand, are considered to be replicates and each value presented is the mean of both. Results concerning residual nitrite and pigments are presented in table 2.

We observed that the amount of residual nitrite is about 50 % of the initially added when determined just after processing.

During storage, there is a depletion of residual nitrite which amounts to 33 % of initially added after 7 days, and decreases up to 17 % after 18 days on hams receiving 50 ppm. In the hams receiving 150 ppm, these depletion percentages are 24 % and 11 %. No effect of vacuum pressure on the depletion of nitrite was noted. A slight effect of the dark exposure, in contrast to light, was observed. So, after 7 days, the average amount of residual nitrite in hams 1 and 2 was 31 % of the initially added in samples stored in light and 38 % in samples kept in the dark. After 18 days, the results were less different : 17 and 19 %. For hams 3 and 4, these percentages were 23 % and 27 % after 7 days, then 10.5 % and 14 % after 18 days.

Our results are in agreement with these obtained by several authors (NORDIN, 1969 ; OLSMAN and KROL, 1972 ; OLSMAN, 1974) on the depletion of residual nitrite during storage.

As for pigment conversion, the percentage is about the same, at the beginning of the experiment, with the two levels of added nitrite. We noticed a decrease in the conversion, similar in both cases, after 7 days of storage, then a more pronounced increase between the 7th and 18th days in hams receiving 150 ppm of nitrite. We can explain these changes by assuming that there is : firstly, an oxydation of the pigment and secondly, a nitrosation of it, by reaction with residual nitrite. This reaction would be more complete in samples containing the highest level of nitrite. We did not notice any effect of vacuum pressure on the percentage of pigment conversion, but, as for nitrite, is seems that the dark provides better storage conditions with regards to nitrosopigment.

To avoid presenting several very boring tables of data about the effect of vacuum degree and residual nitrite on color characteristics, we have presented only the most significant of them in figures. Figures 1, 2, 3 and 4 are about samples with the low level of residual nitrite (Hams 1 and 2). They show the evolution of the four color characteristics considered during storage. For each figure, we selected five storage conditions :

- Dark : 5 and 100 mm Hg
- Light : 5, 20 and 100 mm Hg

Figures 5, 6, 7 and 8 are the same about samples with a higher level of nitrite (hams 3 and 4).

Obviously, for the different levels of residual nitrite and the different vacuum degrees, the dark is the best storage condition.

In light, with a low level of residual nitrite, only a very good vacuum is able to maintain color characteristics almost as satisfactorily as in the dark. We observed a progressive degradation of the color which becomes grey-brown. This change in color is faster and larger when the vacuum degree is lower.

With a higher level of residual nitrite, and a high vacuum degree (5 mm Hg) the color degradation is slower but as great as with low nitrite. With higher vacuum pressure (20 mm Hg), very fast discoloration (between 1 and 4 hours) and a recovery of good color occured after 1 or 2 days. This was already mentionned by ROY, 1973. The evolution was then similar to that observed at 5 mm Hg.
With very low vacuum pressure (100 mm Hg), the reversible color change is greater but the recovery is less complete than in the former, and color becomes unsatisfactory very rapidly. An interesting point to consider is the reversibility of the color change. The exact biochemical reactions occuring would be useful to know. We could assume that oxydation was followed by a nitrosation, but we do not know if the pigment in question is the originally nitrosated or non nitrosated part of it.

A relationship between results on pigment conversion and on color changes is difficult to set up ; the former is determined on the whole sample, while the latter is observed only on sample surface.

CONCLUSION

Our results agree mostly with those of SEBRANEK (1979) who studied a large selection of different films. Our conclusion is the same. If we wish meat products with a low level or residual nitrite, we must use a very high vacuum degree and keep the products in the dark when possible to have a satisfactory shelflife.

Fundamentally, understanding the biochemical pattern of reversible color change could be noticeably improve our knowledge about conditions for maintaining color stability in cured meat products.

ACKNOWLEDGEMENTS

We are grateful to Nicole VIZET, M. PELISSIER, J.-F. GARDETTE anc R. DAUZAT for their contribution to the experimental work.

REFERENCES

BROOKS, J., HAINES, R.B., MORAN, T. and PACE, J., 1940. Food. Invest. Bd. Special Report n° 49. London.

CHO, I.C. and BRATZLER L.J., 1970. J. Food. Sci., 35. 668.

FOX, J.B. Jr. and THOMSON, J., 1963. J. Biochemistry, 2. 465.

GREENBERG, R.A., 1972. Proc. Meat Ind. Res. Conf. p. 25.

HALDANE, J., 1901. J. Hygiene, 1. 115.

HERRING, H.K., 1973. Proc. Meat Ind. Res. Conf. p. 47.

HORNSEY, H.G., 1956. J. Sci. Food Agric., 7.534.

KERR, R.H., MARSH, T.N., SCHROEDER, W.F. and BOYER, E.A., 1926. J. Agr. Res. 33.541.

LEHMAN, K.B., 1899. Sitzt. Physikol. Med. Ges. Wurzburg. 4. 57

LIN, H.S. and SEBRANEK, J.G., 1979. J. Food Sci. 44. 1451.

NORDIN, H.R., 1969. Can. Inst. Food Technol. J. 2. 79.

OLSMAN, W.J. and KROL, B., 1972. 18th EMMRW. GUELPH. CANADA. V.2. 409.

OLSMAN, W.J., 1974. Proc. Int. Symp. Nitrite in Meat products. B. KROL and B.J. TINBERGEN (ed.). PUDOC. Wageningen

POLENSKI, E., 1891. Arb. Kais. Gesundh. 7 : 471.

ROY C., 1973. Thesis CNAM. Paris.

TARR, H.L.A., 1941. Nature 147 : 417.

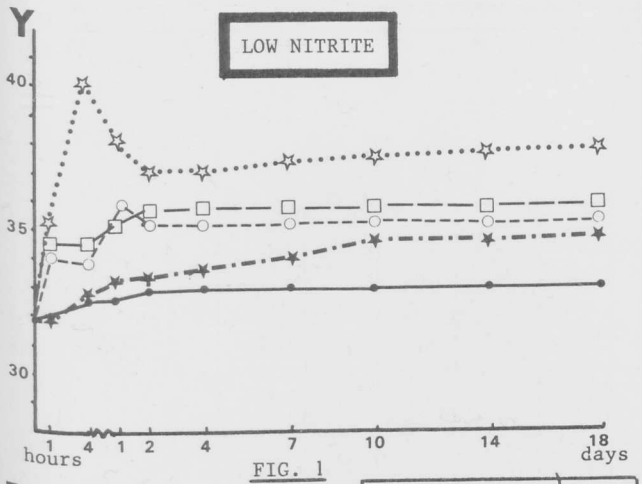

FIG. 1

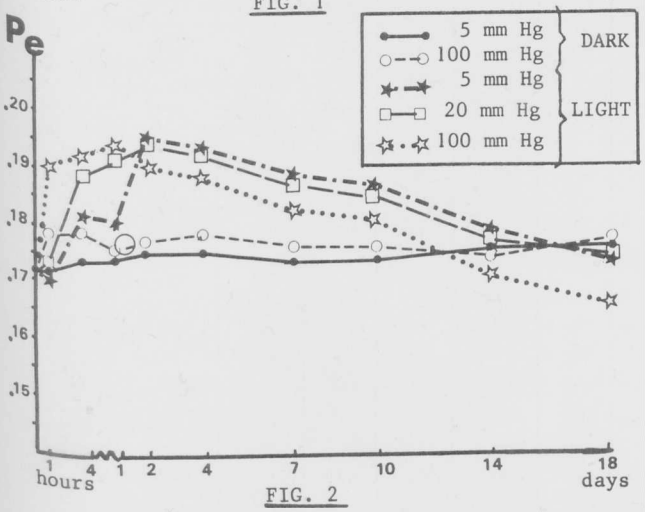

FIG. 2

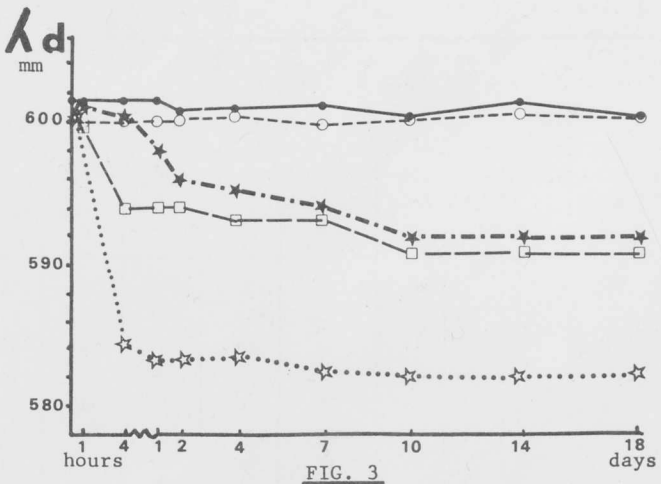

FIG. 3

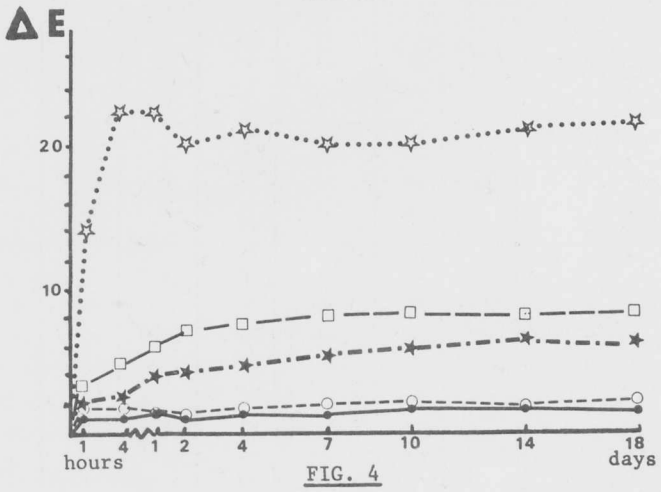

FIG. 4

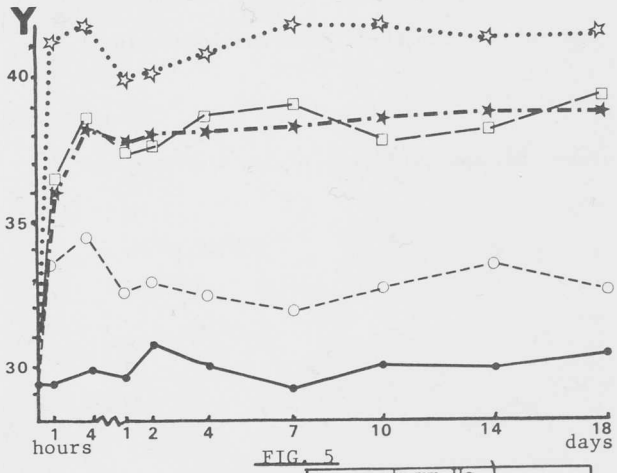

FIG. 5

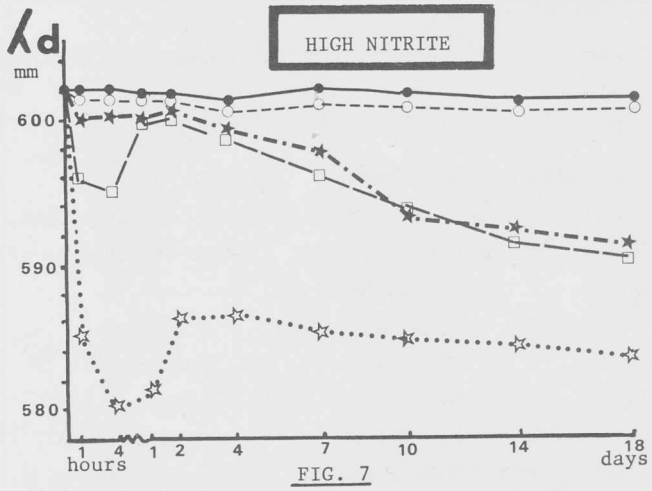

FIG. 7

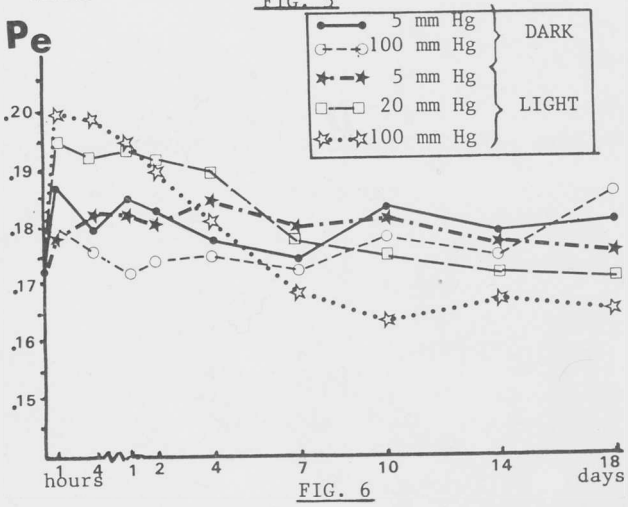

FIG. 6

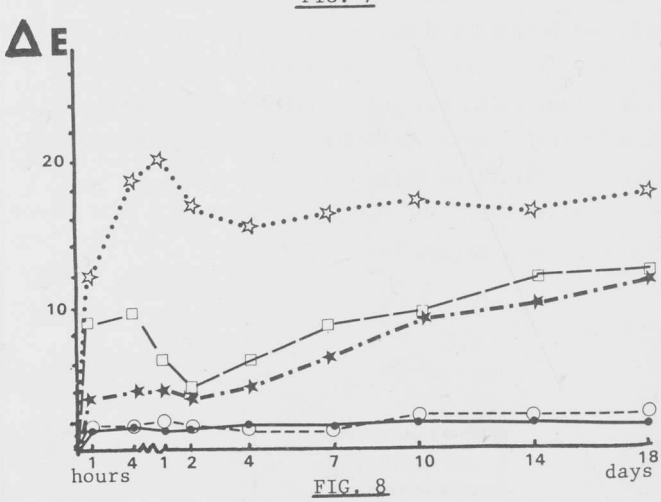

FIG. 8

Storage conditions			Light								Dark		
mm Hg			5	10	20	30	40	60	80	100	5	40	100
5 hours	Low NO_2^-	NO_2^-	26	26	26	26	26	25	25	25	26	26	25
		PT	92	84	87	82	82	85	82	88	92	92	86
		PN	52	40	45	38	41	45	47	50	55	55	49
	High NO_2^-	NO_2^-	80	79	79	76	76	73	77	72	84	76	75
		PT	109	104	109	104	111	98	109	96	85	112	116
		PN	47	49	46	59	60	59	59	58	49	52	49
7 days	Low NO_2^-	NO_2^-	15	17	16	16	13	12	18	18	18	19	20
		PT	95	99	85	92	99	78	82	89	99	99	102
		PN	35	31	34	35	39	27	46	30	36	44	42
	High NO_2^-	NO_2^-	69	70	58	51	54	63	58	60	63	63	67
		PT	88	85	85	87	76	79	75	73	90	89	92
		PN	45	42	38	42	48	34	37	30	41	43	48
18 days	Low NO_2^-	NO_2^-	9	10	9	2	8	7	9	8	8	10	10
		PT	85	86	88	86	81	79	78	82	107	89	92
		PN	44	36	29	42	36	33	34	34	46	95	42
	High NO_2^-	NO_2^-	19	13	15	17	16	14	17	16	18	21	25
		PT	75	85	88	85	80	73	78	102	108	79	79
		PN	52	49	60	59	58	53	56	63	55	72	78

Table 2 : EVOLUTION OF RESIDUAL NITRITE (ppm) AND PIGMENTS (ppm hematin) DURING STORAGE
(Total Pigment : PT and Nitroso Pigment : PN)