Pigment formation in non-comminuted meats under different conditions of ripening

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Abstract

The dynamics of nitroso-myoglobin formation in the ripening of beef delicacies was followed. Experimental variants were made differing in the levels of added nitrates and nitrites, the temperature of ripening (12 or 20°C), and the addition of bacterial preparations.
Peak values of nitroso-myoglobin percentages were obtained at 48 hours in the products with added nitrites and a bacterial preparation. For the variants ripening at 12°C, they are 51,5% in the periphery and 55,6% in the core, and at 20°C., 59,2% in the periphery and 57,7% in the core. During drying and ripening, these values diminished, and finished products with added nitrite turned out to be with a lower pigment % than the ones prepared with 40 mg% of nitrate and a bacterial preparation.

The introduction of nitrates and nitrites, a possible source of cancerogenic N-nitroso-compounds, in the preservation of meat and meat products, and also the development of accelerated technologies for the manufacture of raw-dried meats, predetermine the interest of researchers in the mechanism of nitroso-myoglobin formation.
Research work is reduced to the search for such conditions in which, with a reduced nitrate level, an efficient nitrate metabolism could be ensured providing normal colour formation and building-up of the technological qualities of the product. This is achieved most frequently by the addition of different bacterial starters or reducing substances (Gerhardt and Böhm, 1980; Winter, 1981; Sippach et al., 1982).
The amounts of 800 mg/kg and 1000 mg/kg of nitrate required by the technologies applied for raw-dried products specific to this country, are unjustifiably high, since high residual nitrates occur (Dineva et al., 1981), which are not used upon long storage and are of a rather small import for colour stability. According to Wirth's (1980) results, nitrate in unstable raw hams of high pH-values serves as an easily accessible nitrogen source to proteolytic bacteria, which accelerates spoilage. The author is of the opinion that the high residual nitrates in the products have no essential technological or microbiological function.
The possibility to regulate the processes of ripening by the introduction of additional microflora determined the objective of the present work: to follow the effects of complex micro-

bial preparations on the dynamics of pigment formation in products made of non-comminuted beef using reduced levels of added nitrates or nitrites and different ripening temperatures.

Materials and Methods

Raw-dried products were made from non-comminuted beef by the accelerated technology of Chakarov (1979) in three experimental series. Chilled semitendinosus muscles were used, and samples from both sides of animals were used in parallel for initial ripening at two different temperatures. The following variants originate from left sides:

No. 1. Corresponding to technology: 800 mg/kg of potassium nitrate (100%).
No. 2. Addition of 100% of potassium nitrate (800 mg/kg) + Preparation I (P-I), containing lactobacilli and micrococci.
No. 3. Addition of 50% of the potassium nitrate used in the technology (400 mg/kg) + Preparation I containing lactobacilli and micrococci.
No. 4. Addition of 50% of the dose used in the technology (400 mg/kg) + Preparation II (P-II) containing lactobacilli, micrococci and yeasts.
No. 5. Addition of nitrite (100 mg/kg) + Preparation II.

Their ripening during the first 48 hours took place at 12°C. Correspondingly, variants 6, 7, 8, 9, and 10 were prepared from right sides and were ripened at 20°C. After 48 hours of ripening, the samples were put into a drying chamber at 10-12°C for 25 days.

Nitroso-myoglobin, % of total pigment, was determined by the method of Mirna and Schütz (1972). On definite days of the process of ripening and drying, samples were taken from the core and the periphery of the meats.

Results and Discussion

The formation of nitroso-myoglobin expressed in terms of % total pigment, was followed in the core and the periphery of meats (Fig. 1 and Fig. 2). The dynamics of pigment formation shows certain differences in the different variants and temperatures of ripening. The data on the nitroso-myoglobin levels formed in the processes of ripening and drying of the products from beef semitendinosus muscles in their peripheries are shown in Table 1.

The most dynamic nitroso-myoglobin formation is observed in the products cured with nitrite, with both ripening temperatures. Already on day 2, a level of 51,5% is found with a ripening temperature of 12°C, and 59,2% at 20°C. This is probably related to the absence of the first stage of nitrate reduction into nitrites. The presence of yeasts in preparation II, variants 4 and 5, determines also a rapid pigment formation. However, the pigment formed in those variants is unstable and on day 14, all the products ripening at 12°C during the first 48 hours demonstrate approximately equal nitroso-myoglobin levels.

On day 26, the highest nitroso-myoglobin percentage was found in the products cured with 50% of potassium nitrate and P-I, 39%.

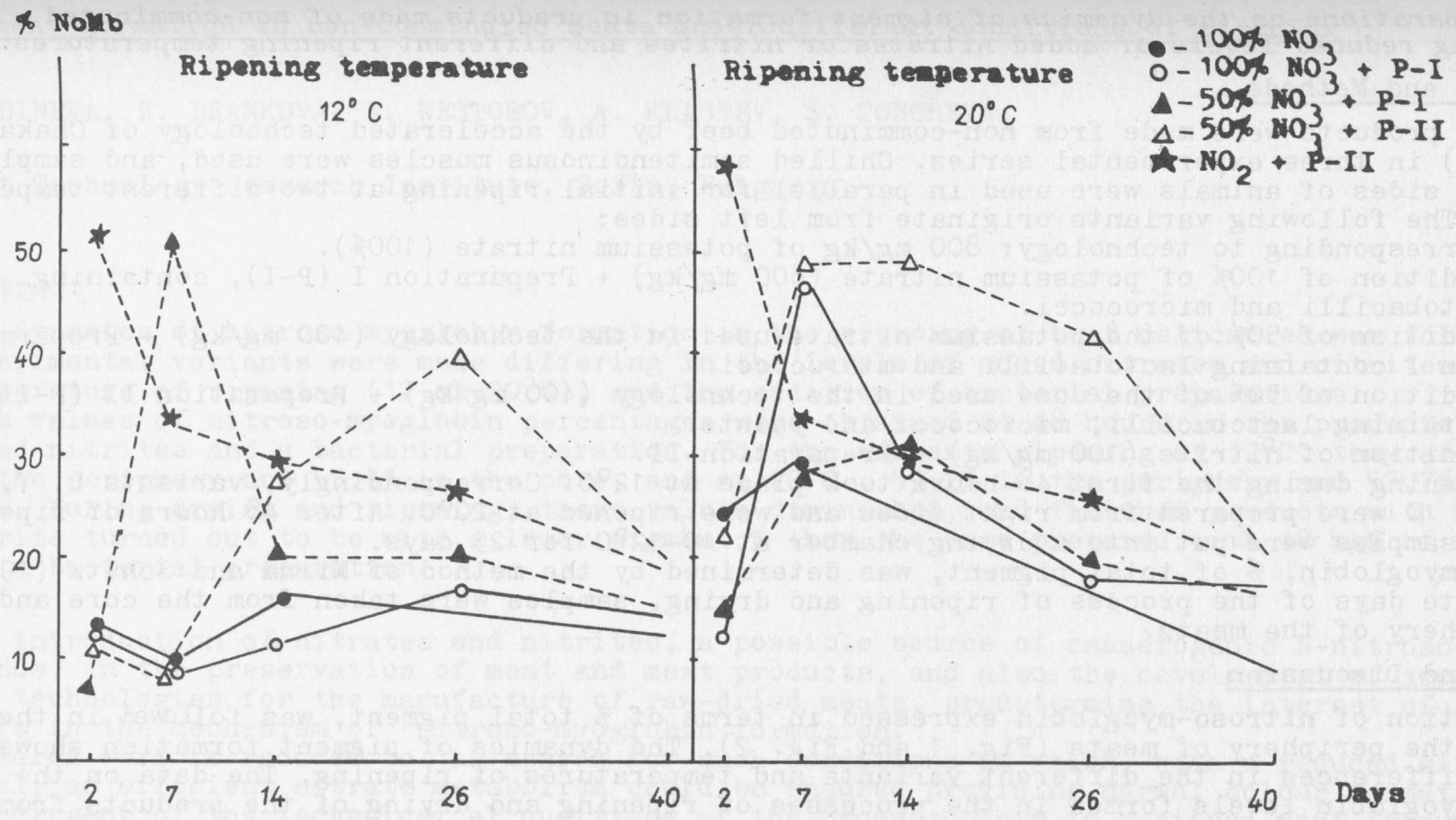

Fig. 1. Pigment formation during the ripening and drying of raw-dried non-comminuted meats (periphery)

Table 1. Dynamics of pigment formation during the ripening and drying of raw-dried non-comminuted meats (periphery)

Ripening and drying period, days	Nitroso-myoglobin, % of total pigment				
	100% nitrate	100% nitrate + P-I	50% nitrate + P-I	50% nitrate + P-II	Nitrite + P-II
12°C	1	2	3	4	5
2	11,9	12,0	11,6	7,7	51,5
7	8,5	10,2	9,0	50,7	32,5
14	11,0	15,6	27,8	20,0	20,3
26	16,8	-	39,3	20,0	22,0
40	14,0	9,0	19,0	15,0	17,0
20°C	6	7	8	9	10
2	12,3	24,7	24,7	14,9	59,2
7	46,6	29,0	49,2	29,4	33,5
14	29,0	-	49,0	31,2	29,2
26	17,7	-	41,6	20,0	26,2
40	17,0	9,0	19,8	17,0	18,0

All results are means of 9 replicas.

Fig. 1 and Table 1 show the dynamics of pigment formation in the peripheries of products ripening at 20°C during the first 48 hours. The higher temperature was found to stimulate the faster and higher per cent pigment formation. The value of the latter is perceptibly higher, already on day 2, in all the variants, compared to the ones at 12°C. Here, peak values occur already on day 7, after which, a reduction in pigment level is observed. On day 26, irrespective of the experimental variant, a temperature of 20°C has a positive effect on pigment stability. A 40-day drying period proved too long for all the variants studied in view of both colour and the remaining quality indices.

The results of the comparative data on nitroso-myoglobin percentage in the core are shown in Table 2 and Fig. 2. Ripening at 20°C contributes to the much faster pigment formation in the core of the product. Already on the seventh day, peak values can be observed, while for the variants ripening at 12°C, that happens on day 14. On day 2, positive and rather high results are observed in the variants prepared using sodium nitrite and preparation II (as also in the periphery) in both temperatures studied: at 20°C, 57,7% nitroso-myoglobin, and at 12°C, 55,6% nitroso-myoglobin.

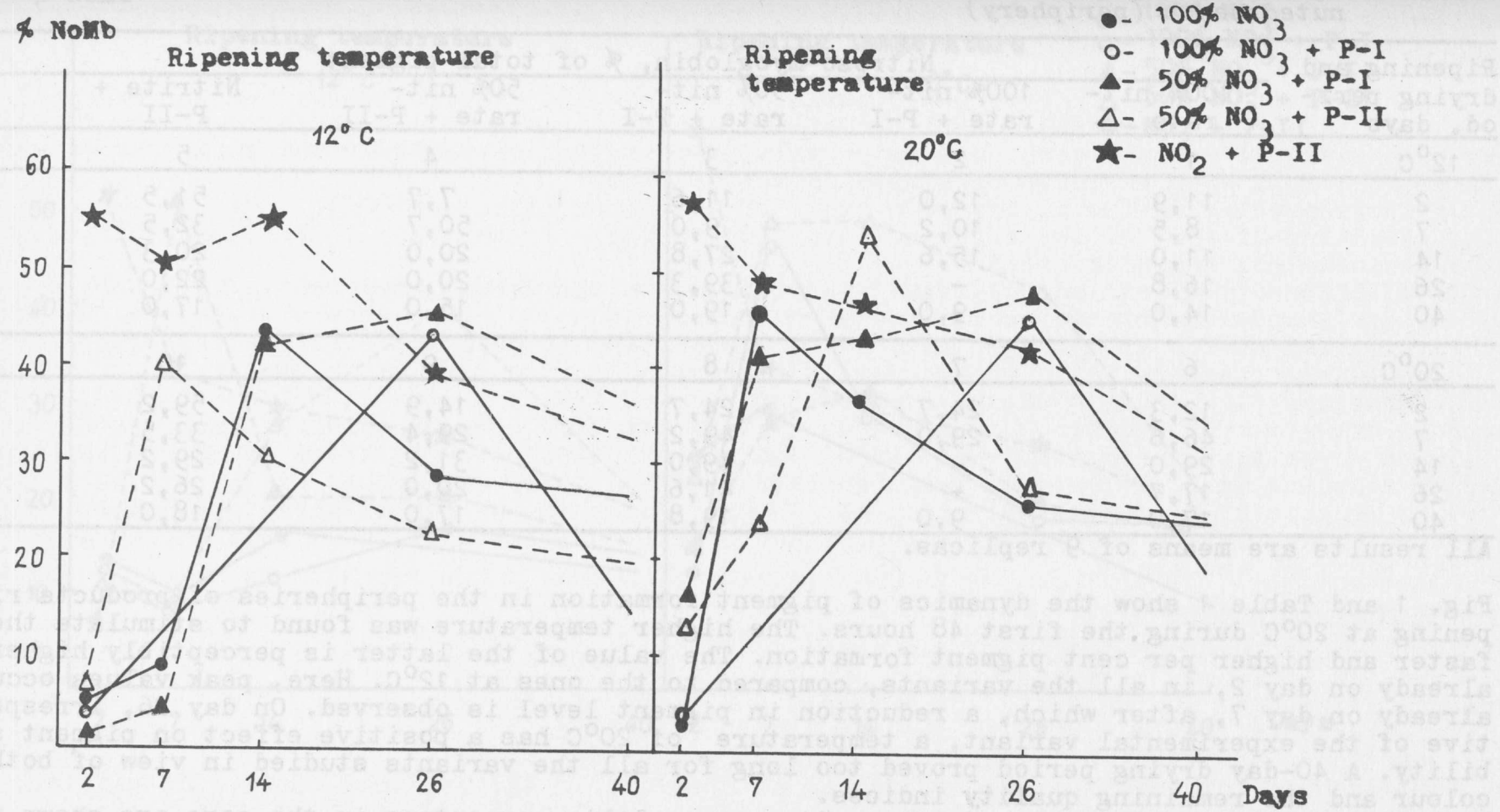

Fig. 2. Pigment formation in the core of raw-dried non-comminuted meats during ripening and drying

Table 2. Dynamics of the nitroso-myoglobin formation during the ripening and drying of raw-dried non-comminuted meats (core)

Ripening & drying period, days	Nitroso-myoglobin, % of total pigment				
	100 % nitrate	100% nitrate + P-I	50% nitrate + P-I	50% nitrate + P-II	10 mg% nitrite + P-II
12°C	1	2	3	4	5
2	4,8	3,6	2,6	6,6	55,6
7	8,9	-	3,8	40,0	50,1
14	43,5	-	43,2	31,2	55,6
26	28,2	43,0	46,2	23,3	39,3
40	26,0	16,0	36,0	21,0	33,0
20°C	6	7	8	9	10
2	3,5	4,0	17,1	14,6	57,7
7	46,6	-	41,1	25,0	49,5
14	37,9	-	43,7	54,8	48,1
26	27,2	45,5	48,5	28,0	43,2
40	25,3	20,0	36,5	25,1	34,1

On day 7, the pigment values in the nitrite-cured variants remain the highest, but a rapid rise occurs also in those of control variants at 20°C, of the lots with 50% added nitrate and P-I at 20°C, and of the variants with 50% added nitrate and P-II at 12°C. The pigment formation using preparation II at 12°C, which is better than at 20°C, is probably due to the synergism observed between yeasts and lactobacilli which is favoured by lower temperatures.
The high per cent pigment on using nitrite is reduced gradually, being preserved comparatively high till day 26: 39% at 12°C and 43% nitroso-myoglobin in the lots with initial ripening at 20°C. On the same day, the best results are observed in the lots with 50% added nitrate and P-I in both ripening temperatures studied: at 12°C, 46,2% nitroso-myoglobin, and at 20°C, 48,5%. The most stable, in view of colour in the core of the product, on day 40 proved to be the variants cured with 50% nitrate and P-I at both temperatures studied (36% of nitroso-myoglobin), and also the ones cured with nitrite (33-34% of nitroso-myoglobin). In the control variants (1, 2, 6, and 7) and in variant 3, nitroso-myoglobin level on day 2 is higher in the periphery than in the core, after which an equalizing takes place towards day 7. In the remaining variants, that equalizing can be observed already on day 2. After day 7, nitroso-myoglobin percentage is higher in the core than in the periphery in almost all the variants.

Nitroso-myoglobin formation in variants 4,8, and 9 is more dynamic. Already on day 7, its level constitutes from 25% to 41% of total pigment. In general, it can be noted that, in those variants, nitroso-myoglobin percentage is considerably higher, compared to the other variants cured with nitrate, and also its formation is at a higher rate. This can be explained by the presence of bacterial preparations accelerating the first stage of nitrate reduction into nitrite (Schiffner, 1975), and also by the higher ripening temperature in variants 8 and 9. According to Puolanne (1977), nitrate reduction is enhanced with temperature rise up to 44°C.

The highest nitroso-myoglobin values were obtained using nitrites: 59% in the periphery and 57% in the core on day 2 in a product with initial ripening at 20°C. By day 7, a certain equalizing of data for the two temperatures takes place, core values (at 12°C and 20°C) being much higher than those in the periphery. On day 26, pigment values at 20°C are higher once again.

Conclusions

1. Peak nitroso-myoglobin values are obtained in the meat core on day 2 in ripening with nitrite at both temperatures studied, on day 7 in the products cured with nitrate and ripened initially at 20°C, and on day 14, at 12°C. After that, Nitroso-myoglobin level is gradually reduced in most cases.
2. In the beginning of the ripening period, nitroso-myoglobin percentage is higher in the periphery than in the core of the product. On day 7, an equalizing takes place of its values in the products cured with nitrate and ripened at 20°C. Using nitrite, this takes place already on day 2, after which pigment level in the core is higher in all the variants.
3. In the initial days of ripening, the highest nitroso-myoglobin levels are obtained upon curing with nitrite and starter cultures. In the finished product, however, the highest pigment percentage and with the greatest stability till day 40, is obtained on curing with 50% (400 mg/kg) of potassium nitrate and preparation I at both ripening temperatures.

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