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# THE INFLUENCE OF THE CURING PROCESS ON THE CONVERSION OF THE MEAT PIGMENTS TO NITROSO-COMPOUNDS

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## S u m m a r y

Basing on the results of an carlier work the author tested and confirmed the validity of the mathematical formulas for the conversion ratio of meat pigments to nitroso - compounds in cured hams. The performed experiments indicated that there is the optimum hams curing time. From the obtained results the author concludes that the proposod formulas allow to programme the ham curing process.

## Z u s a m m e n s e t z u n g

Der Verfasser prüfte und bestätigte im gepökelten Schinken die Gültigkeit der mathematischen Formeln für die Konversion von Fleischpigmenten zur Nitrosoverbindungen, die in einer seiner früheren Publikationen ausgearbeitet ~~gewesen~~ worden sind.

Die ausgeführten Versuche ~~erzeigten~~ beweisen, dass es eine optimale Pökleungszeit gibt. Auf Grund der Versuche kommt der Verfasser zu der Folgerung, dass diese Formeln eine Rationalisierung des Schinkenpökelnprozesses ermöglichen.

Adam BORYS

## 1. Introduction

The meat curing is one of the elder methods used for the purpose of its preservation /7/. In the case of pasteurized canned hams production this procedure lost its original character as a preservation method and it is used now for the improvement the sensoric features and among them one of the most important is colour of the cured meat.

It is well proved in the available research literature that the nitrosopigments of cured meat or nitrosohemochrome after denaturation are the components of the colour. Zatočil and Gilka /15/ published the latest review of that literature. In fact there is still lack of unanimity in explanation of mechanism of the formation of nitrosopigments /2,8,13,15/, but the majority of authors are unamimous that one of the fazes of this process are reduction reactions. Moreover it is well known /14/ that in the presence of surplus nitrite the nitrosopigments or nitrosohemochrome undergo oxidation to metpigments and further to oxidized porphyrins.

Basing on these informations author in one of his previous research works /3/ proved, that the conversion ratio expressed in % of nitroso compounds to total pigments in case of nitrite or nitrite plus nitrate curing one can describe by equation:

$$p/\%/ = 100 \cdot \frac{R_o}{MPG} \left(1-e^{-a \cdot t}\right) \cdot e^{-q' \cdot t} \qquad \text{.......... 1}$$

where:

$R_o$ - meat reducing power before curing determined by the use of Kajita's method modified by Ando /1/.

MPG - quantity of total meat pigments determined by Hornsay's method /10/

a - factor of the decrease rate of reducing power.

$q'$ - $q.NO_2' \cdot 10^{3,4-pH}$ - factor of oxidation rate of nitroso-compounds or nitrosohemochrome to met-compounds or oxidized porphyrins

- $NO_2'$ - concentration of $NO_2'$ in cured meat.

t - time in hours

The above equation 1 has a maximum for the value $t = t_m$ which is

$$t_m = \frac{1}{a} \cdot \ln\left(1 + \frac{a}{q'}\right) \qquad \text{............ 2}$$

The value of $t_m$ denotes the curing time corresponding to maximal conversion ratio of meat pigments /$p_m$/ and therefore denotes the optimum curing /wet curing and draining included/. It means that under defined conditions of curing process i.e. at defined meat reducing power and pH as well as defined concetrations of curing ingredients, there is such curing time which is the most favourable on account on the conversion ratio of meat pigments to nitroso- compounds. So the shorter or longer curing time from that optimum one will effect in lower conversion ratio. Since the actually obligatory curing instructions are worked out empirically, it seamed worthwhile to verify suitability of presented equations for programmed ham curing process and at least to define the optimum curing time value.

The determination of the decrease of meat reducing power in the equation 1 is of great importance. The actual level of reducing power, as it was proved in the above mentioned author's work /3/ is expressed in equation:

$$R = R_o \cdot e^{-a.t} \qquad \text{............} \quad 3$$

The equations 1 to 3 are traced back to model research experiments. To verify the drawn equations with experiment standard error of estimate /S/ was introduced /6/ as well as the mean error of the method of determination /$\bar{B}$/. Thus the criterion of conformity of the drawn equations with the experiments will be the comparison of S with $\bar{B}$.

## 2. Materials and procedure

Forty five minutes after slaughter hams were cut from the carcass, deboned, defatened and chilled in 6 hours to 6°C. They were pumped with multineedle equipment and wrapped with muslin stockinets. The needles were spaced 20 m/m. Five experiments were carried cut each in four replicae. In experimente 1,2,3,5 nitrite brine /for 1000 ml: NaCl-143 g, $NaNO_2$ - 1,8 g, sugar - 2,8 g, Hamine - 40 g/ and in experiment 4 nitrite + nitrite brine /for 1000 ml: NaCl - 137 g, $NaNO_2$ - 0,65 g, $KNO_3$ - 1,3 g, sugar -2,4 g, Hamine - 38,3 g/ were applied. The curing process began 36 hours after slaughter. The hams were pumped with brine in the amount of 10 % of their weight. The curing and draining was carried in 5°C. The pumped hams were covered with pumping brine. The wet curing time lasted in experiments 1,2,3,5 - 24 hours and in experiment 4 - 48 hours. The draining time lasted in experiments 1,2,3,5 - 108 hours and in experiment 4 - 84 hours.

The regular sampling of each ham was carried on throughout the whole period of curing and $NO_2$, $NO_3$, pH, reducing power and conversion ratio were determined. The sampling was so performed that the slices were cut from each group of muscles along its long axis. In each sample the amount of meat cut from each group of muscles was proportionate to their percentage share in the whole ham. The samples were diminuted and carefully mixed to secure the representation of the mean composition of ham muscles.

- the meat pH was determined with pH - meter LBS-61; the determinations was performed on watery suspension of diminuted meat; the ratio of distilled water to meat was 1:1,
- the conversion ratio of meat pigments to nitroso-compounds was calculated from the data obtained by determination of nitrosocompounds and meat pigments by modified Hornsay´s method /10/
- the nitrites and nitrates were determined by the use of Griess-Ilosvay´s method in the modification og Grau-Mirna /9/
- the meat reducing power was determined by the use of a modification of the method of Kajita /1/.

The mean error of reducing power determination was ± 4% and that of conversion ratio determination was ± 9%.

## 3. Results and discussion

Basing on the obtained results the parameters of the equation 3 were calculated by the use of the method of least squares after transforming it to linear form in the coordinates system y,t where y = ln R. The calculated values are given in table 1.

Table 1.

The Parameters of the equation 3

| HAM Nr | $R_o$/mg%/ | a/hour$^{-1}$ |
|---|---|---|
| 1 | 64,18 | 0,00060 |
| 2 | 64,01 | 0,00130 |
| 3 | 64,28 | 0,00120 |
| 4 | 60,87 | 0,00080 |
| 5 | 63,75 | 0,00125 |
| 6 | 63,46 | 0,00150 |
| 7 | 63,40 | 0,00114 |
| 8 | 63,84 | 0,00130 |
| 9 | 65,17 | 0,00126 |
| 10 | 64,67 | 0,00133 |
| 11 | 64,04 | 0,00099 |
| 12 | 63,11 | 0,00098 |
| 13 | 61,47 | 0,00122 |
| 14 | 62,61 | 0,00157 |
| 15 | 66,23 | 0,00178 |
| 16 | 65,54 | 0,00140 |
| 17 | 64,74 | 0,00133 |
| 18 | 62,04 | 0,00147 |
| 19 | 61,90 | 0,00093 |

The changes of reducing power are shown on the figure 1 seperately for nitrites and nitrite plus nitrate brines. The curves present the mean values of following equations:

- experiments 1, 2, 3, 5:

$$R = 63{,}56 \cdot e^{-0{,}00116 \cdot t} \qquad \ldots\ldots\ldots\ldots\ 4$$

- experiment 4:

$$R = 63{,}96 \cdot e^{-0{,}00149 \cdot t} \qquad \ldots\ldots\ldots\ldots\ 5$$

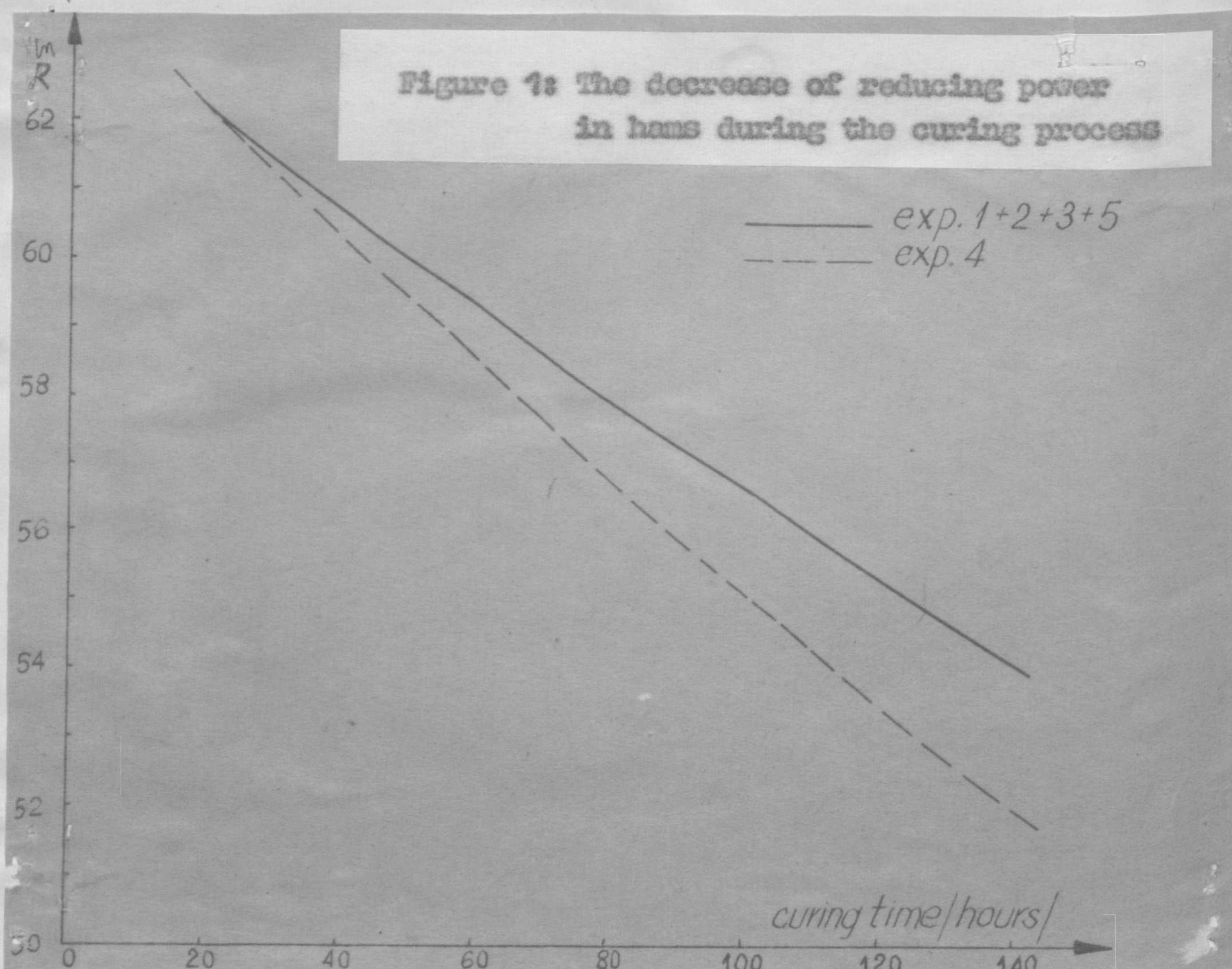



Figure 1: The decrease of reducing power in hams during the curing process

/Fig. 1/

Standard error of estimate for equations 4 and 5:

$S_4 = \pm 4{,}98$  $S_5 = \pm 5{,}63$

and mean error of the method of determination

$\bar{B}_4 = \pm 5{,}09$  $\bar{B}_5 = \pm 5{,}10$

This is the proof that equation 3 is suitable to describe the changes of the meat reducing power during the curing process conformable with the experiment in the limits of method error.

The equation 1 was transformed to:

$$p/\%/ = A.R_0 \ /1-e^{-a.t}/ \ . \ e^{-q'.t} \qquad \ldots\ldots\ldots\ldots\ldots \ 6$$

to make the calculation easier.

The parameters of this equations were calculated analogously to equation 3 and the auxilliary system of coördinates was y,t where $y = \ln/-\frac{D}{\Delta R}-/$. The parameters of $R_0$ and a are identical with the ones shown in table 1 and the value of the other two were shown in table 2. Additionally the coefficients of determination $/r^2/$ for the linear form of equation 6 is listed in table 2.

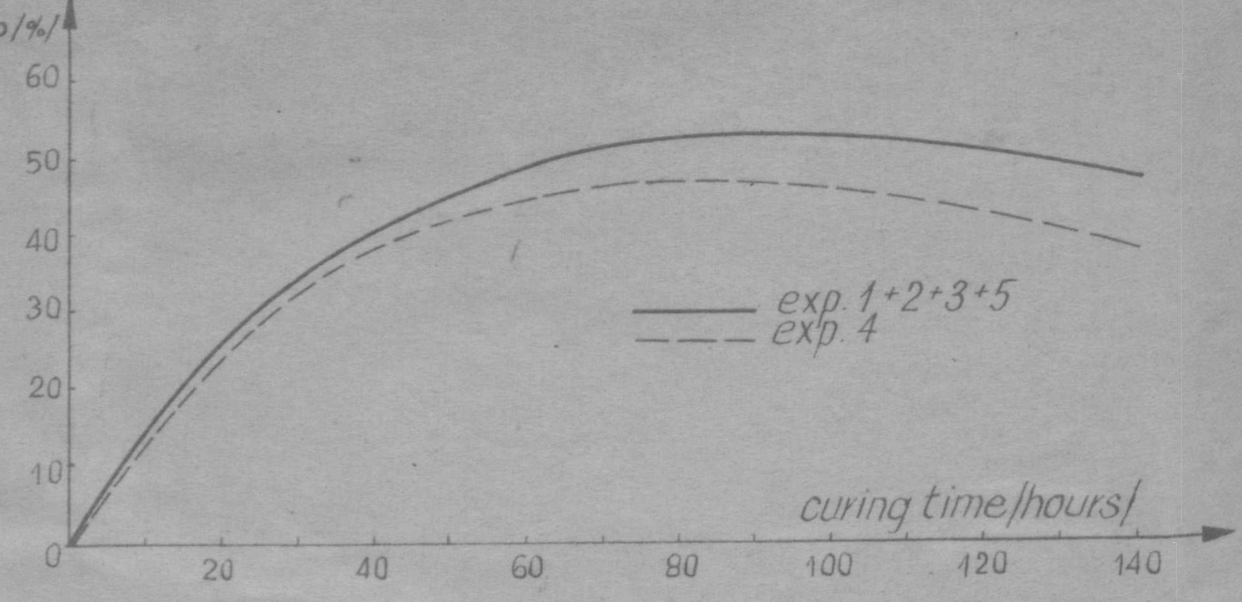
Tabele 2

Parameters of equation 6 and coefficients of determination $/r^2/$ of its linear form

| HAM Nr | $A/mg\%^{-1}/$ | $q_{\cdot}/hour^{-1}/$ | Coefficient of determination $r^2$ |
|---|---|---|---|
| 1 | 44,54 | 0,0123 | 0,958 |
| 2 | 21,01 | 0,0114 | 0,856 |
| 3 | 19,03 | 0,0097 | 0,906 |
| 4 | 33,20 | 0,0098 | 0,992 |
| 5 | 17,23 | 0,0083 | 0,941 |
| 6 | 19,00 | 0,0118 | 0,891 |
| 7 | 25,98 | 0,0150 | 0,674 |
| 8 | 14,55 | 0,0081 | 0,797 |
| 9 | 15,86 | 0,0098 | 0,835 |
| 10 | 18,41 | 0,0110 | 0,848 |
| 11 | 16,87 | 0,0069 | 0,803 |
| 12 | 15,85 | 0,0069 | 0,740 |
| 13 | 28,58 | 0,0146 | 0,966 |
| 14 | 13,64 | 0,0107 | 0,856 |
| 15 | 10,07 | 0,0119 | 0,878 |
| 16 | 13,49 | 0,0090 | 0,810 |
| 17 | 19,59 | 0,0125 | 0,885 |
| 18 | 12,09 | 0,0102 | 0,799 |
| 19 | 24,60 | 0,0110 | 0,709 |

The mean values of obtained parameters were figured out jointly for experiments 1,2,3,5 and seperately for experiment 4. On this basis the curves of conversion ratio were drawn and shown on figure 2.

Figure 2: Changes in the conversion ratio in hams during the curing process




/Fig. 2/

The following equations correspond to those curves:

- The curve for experiments 1,2,3,5:

$$p/\%/ = 1344{,}91/1-e^{-0{,}00115.t}/.e^{-0{,}0105.t} \quad \ldots\ldots\ldots\ldots \quad 7$$

- The curve for experiment 4:

$$p/\%/ = 1040{,}22/1-e^{-0{,}00149.t}/.e^{-0{,}01155.t} \quad \ldots\ldots\ldots\ldots \quad 8$$

Standard error of estimate for equations 7 and 8:

$S_7 = \pm 8{,}97$ $\qquad$ $S_8 = \pm 8{,}43$

and mean error of the method of determination:

$\bar{B}_7 = \pm 9{,}08$ $\qquad$ $\bar{B} = \pm 8{,}42$

From the obove the conclusion is drawn that equation 1/or equivalent equation 6/ describes reliably the changes of the conversion ratio with the precision within the limits of the error of the method.

As an additional criterion of the correctness of the application of equations 1 or 6 the coefficients of determination $/r^2/$ of the linear form given in table 2 can be used.

On the basis of the proved correctness of equation 6 and parameters shown in the table 2, the optimum curing time and maximal conversion ratio for each ham were calculated. The results were shown in the table 3.

Table 3

The optimum curing time and maximal conversion ratio

| HAM Nr | $t_m$ /hour/ | $P_m$ /%/ |
|---|---|---|
| 1 | 79,45 | 50,03 |
| 2 | 82,91 | 53,51 |
| 3 | 97,30 | 52,41 |
| 4 | 98,45 | 58,11 |
| 5 | 112,57 | 56,48 |
| 6 | 79,68 | 53,12 |
| 7 | 64,44 | 44,25 |
| 8 | 114,97 | 50,61 |
| 9 | 39,80 | 47,82 |
| 10 | 85,89 | 48,50 |
| 11 | 135,31 | 53,80 |
| 12 | 134,50 | 49,69 |
| 13 | 65,35 | 52,05 |
| 14 | 87,43 | 42,87 |
| 15 | 78,53 | 34,25 |
| 16 | 103,64 | 46,79 |
| 17 | 75,67 | 47,40 |
| 18 | 51,49 | 37,40 |
| 19 | 87,91 | 45,08 |

## 4. Conclusions

The experimental results enable to say that the equations 1,2 and 3 may be used to describe the changes in conversion of meat pigments to nitroso-compounds during curing process of hams. The figure 2 shows clearly that there is optimum ham curing time which in accordance with the results shown in tabele 3 amounts to 88 hours for the hams with pH 5,4 to 5,9. On this basis it can be stated that there is a possibility to programme the ham curing process by the use of equation 1.

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