OPTIMIZATION OF THE GRINDING PROCESS DURING PRODUCTION OF COOKED SAUSAGES FROM POULTRY MEAT AND LACTIC PROTEIN CONCENTRATE

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INTRODUCTION

Due to the increased production and consumption of poultry meat throughout the world, the possibility to offer part of it in the form of processed meat products has gained considerable importance. This tendency has been further increased by the introduction of mechanical techniques for deboning of poultry carcasses (1,2,3). The major part of the mechanically deboned finely cut poutry meat is used for the production of cooked sausages and frankfurters. Recently there has been growing interest towards the production of cooked poultry sausages with different additives - mainly proteinaceous preparations of animal and vegetable origin. Thus, on one hand, there is the possibility to better utilize protein resources, and, on the other, said meat products more fully answer the requirements of physiological nutrition in relation to contemporary changes in the social and living conditions.

On the ground of the above considerations we developed a new kind of cooked sausage (frankfurter) from poultry meat and lactic protein concentrate. In the present work we set the objective to study the influence of certain factors on the process of grinding of the raw materials, and to optimize said process in order to establish the most favourable conditions that will give meat emulsion with satisfactory stability.

MATERIALS AND METHODS

Poultry meat and proteine concentrate, obtained by heat denaturation of rennet whey, were used as raw materials in the experiment. During the grinding process salt and spices were added. The following materials were used for the preparation of the filling mass: 65% poultry (mechanically deboned); 25% chicken necks (mechanically deboned); 10% goose meat from fatted geese; 2% salt; 0,2% black pepper; 0,04% nutmeg; 0,005% potassium nitrite.

The protein concentrate used in the experiments had the following chemical composition: 76-78% water; 13-15% proteins; 4-5% fats; 0,3-0,5% mineral substances. Five to 15% of the protein concentrate was added to the meat depending on the purpose of the experiment. The materials were processed using a laboratory grinder, MTZ-20, at 3000 min^{-1} rotation speed of the bladed roller.

First of all, the influences of the amount of added water and lactic protein concentrate, and processing (cutting) time were studied by single factor experiments (4,5). The influence of each factor on the studied process was evaluated according to the meat emulsion stability determined by Kozin's method (6) by measuring the volume of centrifugally separated liquid phase.

The influence of each factor was studied at three levels. The added water and lactic protein concentrate levels were 5%, 10%, and 15%, respectively, in relation to the amount of meat, while processing (cutting time was 3, 5, 8 min, respectively. To evaluate each factor, the other two were taken with their average values. After the preparation of the filling mass 20 g samples were taken out and were centrifuged in a laboratory centriguge "Janetzki-T23" at a rotation speed of 3000 min^{-1}. The samples were double centrifuged, initially without heating, and after that by preheating to an internal temperature of 72°C.

The single factor experiments carried out allowed us to determine the influence of the above-mentioned factors on meat emulsion stability, and made it easy for us to choose a test center when programming the experiment.

In order to find the optimal values for the studied factors, resulting in stable emulsion, we carried out experiment programming and optimization of the grinding (emulsifying) process using Box-Wilson's method (7,8)

Processing of the experimental data was preceded by verification of the type of distribution of a given random value - the volume of centrifugally separated liquid phase. The verification was made in accordance to the empirical criterion (5) and the distribution was found to be normal. With single factor analyses we checked the dispersions in advance according to Kochren's criterion (5).

RESULTS AND DISCUSSION

1. Effect of the added water level - As pointed out above, the effect of this factor was studied at three levels: 5, 10 and 15%. The remaining two factors were as follows: added protein concentrate 10%, processing (grinding) time 5 min. The results obtained are given in Table 1.

Table 1

Added water (%)	5		10		15	
No	x_1	x_1^2	x_2	x_2^2	x_3	x_3^2
1	1,9	3,61	3,6	12,96	5,8	33,64
2	2,1	4,41	3,4	13,66	5,6	31,36
3	1,9	3,61	3,6	12,96	5,6	31,36
4	2,1	4,41	3,4	13,66	5,8	33,64
R_j	8		14		22,8	
P_j		16,04		53,30		130
R_j^2	64		196		519,84	

$\sum R_j = 44,8$; $\sum P_j = 199,34$; $\sum R_j^2 = 779,84$

p = number of factors

q = number of dublicate tests

α = confidence level

$$SS = \sum_{j=1}^{p} P_j - \frac{1}{p.q} \left(\sum_{j=1}^{p} R_j \right)^2 = 32,09$$

$$SS_B = \frac{1}{q} \sum_{j=1}^{p} R_j^2 - \frac{1}{p.q} \left(\sum_{j=1}^{p} R_j \right)^2 =$$

$$= 27,71$$

$$SS_W = \sum_{j=1}^{p} P_j - \frac{1}{q} \sum_{q=1}^{p} R_j^{\,2} = 4,38$$

$$MS_B = \frac{SS_B}{p-1} = 13,85$$

$$MS_W = \frac{SS_W}{p(q-1)} = 0,48$$

$$F_H = \frac{MS_B}{MS_W} = 28,63$$

$$F_{cr} / \alpha, p-1, p(q-1) / = 4,26$$

$F_H > F_{cr}$, i.e the factor studied has an effect on the grinding (emulsifying) process. Next we checked the effect of this factor between different levels according to Duncan, Newman and Kols's criterion (5).

$\bar{x}_1 = 2$; $\bar{x}_2 = 3,5$; $\bar{x}_3 = 5,7$;

$$S_x = \sqrt{\frac{MS_W}{q}} = 0,348$$

$Q_\nu / (p-1)(q-1), \nu / = 3,2$;

$R_\nu = Q_\nu \cdot S_x = 1,23$

$x_1 - x_2 = 1,5 > R_\nu$;

$x_2 - x_3 = 2,2 > R_\nu$.

The check for each level confirmed the factor's influence.

2. Effect of the added protein concentrate level - This was also studied at three levels: 5,10 and 15%. The remaining two factors were: added water 10%, processing (grinding) time 5 min. The results obtained are given in Table 2.

Table 2

Protein concentrate added (%)	5	10	15
No	x_1	x_2	x_3
1	2,1	3,6	5,4
2	1,9	3,4	5,2
3	2,1	3,6	5,4
4	1,9	3,4	5,2

$F_H = 26,14 > F_{cr} = 4,6$, i.e.

the factor has an effect on the process.

$\bar{x}_1 - \bar{x}_2 = 1,5 > R_\nu = 1,23$,

$\bar{x}_2 - \bar{x}_3 = 1,8 > R_\nu$

indicating that the factor has an effect on each level studied.

3. Effect of processing (grinding time) - It was studied for 3,5 and 8 min grinding time, and the other two factors were 10% each. The results obtained are given in Table 3.

Table 3

Grinding time (min)	3	5	8
No	x_1	x_2	x_3
1	2,6	3,6	5,2
2	2,6	3,4	5,2
3	2,4	3,6	5,0
4	2,4	3,4	5,0

$F_H = 14,6 > F_{cr} = 4,6$ i.e. at a confidence level $\alpha = 0,05$ this factor also has an effect on the process.

$\bar{x}_1 - \bar{x}_2 = 1,0 < R_\nu = 1,23;$

$\bar{x}_2 - \bar{x}_3 = 1,6 > R_\nu$

The verification of this factor on the process at different levels indicated that the effect was significant for 3 and 5 min levels. 3/5 min grinding did not lead to statisticall significant results in relation to the centrifugally separated liquid phase.

<u>Full Factor Experiment and Process Optimization</u>.

As a center for the experiment programming we selected a point with the following parameters: added water 10%; added protein concentrate 10%; processing (grinding) time 5 min.

x_1 denotes the amount of added water, x_2 - the amount of added protein concentrate, x_3 - grinding time, the variation intervals are x_1=5%, x_2=5%, x_3=3 min respectively.

Table 4 shows 8 variants of the operating matrix used in programming, and the experimental data (cm3 liquid phase from the emulsion centrifugation) obtained from the actual experiment carried out twice (y_1,y_2).

$N=8$; $m=2$; $\sum S_i^2 = 0,14$; $\sum S_o^2 = 0,0175$

$S_i max = 0,02$

$G_H = 0,344 < G_{cr}/0,05;2;8/ = 0,517$

i.e. there is equality of dispersions.

By means of the results obtained we calculated the following regression coefficienta:
$b_o=4,5$; $b_1=0,85$; $b_2=0,55$; $b_3=0,67$; $b_{12}=-0,2$; $b_{23}=-1,25$; $b_{13}=-0,4$; $b_{123}=0,025$

After we established the experiment dispersion, we checked the coefficients' significance. The verification indicated that all coefficients are significant except b_{123}. Thus we determined the following model for the "y" function (centrifugally separated liquid phase volume):

$$y=4,5+0,85x_1+0,55x_2+0,67x_3 - 0,2x_1x_2-1,25x_2x_3-0,4x_1x_3$$

The model's adequacy was then confirmed by verification.

Table 4

Added water (%)	Added prot.con. (%)	Process time (min)	y_1	y_2	$\bar{y}$	S_i^2	$\sum(y_i-\bar{y}_i)^2$
15	15	8	5,9	6,1	6,0	0,01	0,02
5	15	8	5,3	5,1	5,2	0,01	0,02
15	5	8	5,7	5,3	5,5	0,04	0,08
5	5	8	4,1	3,9	4,0	0,01	0,02
15	15	3	5,5	5,3	5,4	0,01	0,02
5	15	3	3,8	3,4	3,6	0,04	0,08
15	5	3	4,6	4,4	4,5	0,01	0,02
5	5	3	1,9	1,7	1,8	0,01	0,02
	5	3					

Further, we proceeded with the process optimization, where x_1 was a basic factor with step H_{bf}=5%. The respective steps of the other factors can be calculated from the basic factor step.

The results from the imaginary experiments are given in Table 5.

Table 5

n	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	y (min)	c_1 (%)	c_2 (%)	c_3 (min)
0	0	0	0	0	0	0	4,50	10	10	5
1	-1	-0,65	-0,75	0,65	0,75	0,48	1,59	5	6,8	3,5
2	-2	-1,29	-1,50	2,58	3,00	1,90	-2,20	0	3,5	2

It can be seen from the results that after the second step "y" becomes negative. Because of that it was necessary to carry out additional imaginary experiments between the first and second steps with a new step $h_{xi}=\frac{h.xi}{5}$. The results from these experiments are given in Table 6.

Table 6

n	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	y (min)	c_1 (%)	c_2 (%)	c_3 (min)
1	-1,2	0,78	-0,9	0,94	1,0	0,70	0,3	3,8	5,98	3,24
2	-1,4	-0,90	-1,05	1,26	1,5	0,94	-0,9	3,6	5,82	3,10

Obviously, we have the best meat emulsion stability with the following factor values: c_1=3,8%; c_2=5,98%; c_3=3,24 min. For these values the result from the grinding process is most favourable, i.e. it corresponds to minimum liquid phase volume (0,3 cm3) separated during centrifugation of the ready meat emulsion.

The subsequent actual experiments confirmed these values to be optimal in relation to the desirable outcome of the grinding process.

CONCLUSIONS

1. Based on a full factor experiment (x_1: added water level; x_2: level of added protein concentrate from rennet whey; x_3: material processing (grinding) time), we established the following relationship between the volume of unbound liquid phase (y, cm3), separated during centrifugation of poultry meat emulsion, and lactic protein concentrate:

$$y=4,5+0,85x_1+0,55x_2+0,67x_3-0,2x_1x_2-1,25x_2x_3-0,4x_1x_3$$

2. The optimal values for the studied factors resulting in stable meat emulsion are: added water level - 3,8%; added protein concentrate level - 6%; material processing (grinding) time - 3,2 min.

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