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CONTRIBUTION OF FORCEMEAT COMPONENTS ON THE PRODUCING OF RAW-DRIED SALAMI WITH STARTER CULTURES

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Abstract. This work deals with the analysis of the influence of forcemeat composition (meat/lard ratio, dextrose, dietary fiber) on the producing of raw-dried salamis. The costs of study on an industrial scale were reduced using experiment in the linear approximation. A high level of meat/lard ratio directly and indirectly accelerates the drying process. A-posteriori was found that the optimal amounts of dextrose in the salami's recipe correspond to the center of the experimental matrix. A higher fiber content helps stabilize the pH value at the end of the fermentation process. Fibers directly accelerate the drying of the product and ultimately improve its quality.

Keywords: *dextrose, dietary fibers, meat/lard ratio, raw-drying, salami, starter cultures*

Introduction

Quite often, there is a need to modify the recipes of raw-dried and smoked salamis. These recipes are changed by "trial and error" method, using the knowledge and experience of technologists. Such an approach does not guarantee obtaining a product of a desired quality, especially when replacing at least some of the main ingredients. Technologists of a small enterprises should adapt "standard" recipes because of different quality indicators of entry raw materials, so that the obtained product meets the specified requirements [1]. Composition of forcemeat mixture represents best controlled input factor. Thereby, the quality of the products firstly is a function of the forcemeat composition, secondly, of the technological process parameters [2]. This work deals with study of influence of the forcemeat components on the physico-chemical characteristics of the fermented salami during the producing process.

Materials and methods

For the development of experimental and control samples of raw-dried salami, pork meat was used, which was obtained by intensive fattening technologies in pig breeding complexes in the Republic of Moldova. As a control (basic) formulation, the recipe of the raw-dried salami type "Kachchatori" was adopted. Its forcemeat recipes consisted of chilled low-fat pork (60%), frozen pork trimming (15%), frozen fat bacon (25%), nitrite salt, dextrose, skimmed milk powder, black and white pepper ground, food fibers Unicell WF 200. ("*InterFiber" Sp. z.o.o., Poland*).

To accelerate and regulate the fermentation process, as well as subsequent maturing and drying of salamis, the starting culture SM-194 (Chr. Hansen, Denmark) was used [3]. The starting culture included the following types of microorganisms: *Pediococcus Pentosaceus, Lactobacillus Sakei, Staphylococcus Xylosus, Staphylococcus Carnosus, Debaromyces Hansenii.* Preparation of experimental and control samples of raw-dried salamis was carried out in the production conditions. The technology included traditional operations: cutting, deboning, tendon removal, refrigeration (cooling, freezing), chopping, draining and compaction of crushed meat.

The forcemeat was made on the meat-cutter at a temperature from -5°C to -1°C in order to obtain a structure with the grains of 6-8mm in diameter, then other ingredients according to the recipe were added. Starting culture SM-194 in the amount of 10 grams per 100 kg of forcemeat was preliminarily diluted in 300 ml of cold water and introduced into the bowl of the cutter in the last turn. For the filling with forcemeat of a natural shell with a diameter of 44-46 mm special syringe was used. Fermentation, maturation and drying were performed in the Friulinox AS EN2 clime chamber (*"Friulinox"*, Italy) – Figure 1. The fermentation process began with tempering and shrinkage for 5-8 hours at a temperature of 22-24°C and relative humidity of 95-98%. Then followed, strictly speaking, fermentation process, which was carried out at 22-24°C and relative humidity of 85-90%, during 2-3 days until the pH of the forcemeat reached 4.8 - 4.9. The temperature and the humidity of the air in the climatic chamber were gradually reduced, respectively, to 18-20°C and to 82-84%.

Figure 1. Initial state of salami sticks

The final stage of drying was performed at relative humidity of air 72-74%, 13-14°C, and the speed of air movement equal to 0.1-0.2m/s. The total weight loss at the end of drying was 40-45%. Four experimental compositions and one control composition of raw-dried salamis were studied. In the finished product, water activity (a_w), humidity (W), pH and total fat content were determined by means of non-modified standard method [4].

Results and discussion

The formulations of the investigated raw-dried salamis were elaborated on the basis of the following considerations. The meat content was postulated as main factor influencing both the technological process and the consumer properties of the product. At the same time, the technology for producing raw-dried salamis assumes the use of lard, which, in turn, should lead to the introduction of an additional entry factor, respectively, to complication of study and increasing its cost. Therefore, the ratio of the meat mass to the lard mass in the recipe, $\mathbf{m_{Meat}/m_{Lard}}$, was introduced as the main factor of influence.

Table 1

Formulation of control probe classical salami type "Kachchatori"

Basic ingredients	per 100kg
Pork meat (back)	60
Pork meat (low-fat trim)	15
Frozen lard	25
Sodium nitrite	2.4
Sugar	0.2
Black pepper	0.1
White pepper	0.1
Fiber Unicell WF 200	1
Skimmed-milk powder	1
Starter culture SM-194	0.02

The recipes of raw-dried salamis contain about 1% of milk powder, which in turn is half composed of milk sugar (lactose). Thus, even without additional dextrose administration, the starting content of lactose in all samples will be about 0.5 kg per 100 kg. Such a content of sugars, according to the data of some authors [5, 6], is insufficient to provide the necessary activity of starter cultures. At the same time, this amount of nutrient medium cannot be neglected when interpreting the results of the effect of sugars on the fermentation process. Therefore, planning the experiment, we assumed that the total amounts of sugar in the recipes, should differ by not less than 1.5 times, also taking into account lactose, introduced with skimmed milk powder. The content of the structure-forming food additive, dietary fiber "*Unicell WF 200*", was the third chosen *a priori* influencing factor. Since in the control sample the content of dietary fiber was 1%, we can to assume, what this value is equal to the geometric center of the experiment. The minimum and maximum levels of dietary fibers content in the experimental samples were set at 0.5 and 2.0 as in comparison with the control (Table 1).

Two-Level, Three Factor Fractional Experiment FFE 2^{3-1}, (which is a "half-reply" of complete three-factor experiment CFE 2^3) was realized for obtaining of quality product according to good production practices. Its realization presumes deducing the following equation:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \quad (1)$$

in which: Y – is measured parameter (response); β_0 –responce in the center of experiment; β_1, β_2, β_3 – influence coefficients of separated presumably independent factors X_1, X_2 and X_3 [7].

Table 2

Experiment-planning matrix in the encoded and real coordinates.

Factor 1		**Factor 2**		**Factor 3**	
x_1	**Meat / Lard**	**x_2**	**Dextrose (kg/100kg)**	**x_3**	**Fiber (kg/100kg)**
+	6…9	+	0.30…0.50	+	1.75…2.00
+	6…9	–	0.05…0.10	–	0.50…0.75
–	2…3	+	0.30…0.50	–	0.50…0.75
–	2…3	–	0.05…0.10	+	1.75…2.00

The kinetics of water activity in the salami samples were studied. Obtained data, interpreted as $W_A = f(\tau)$ corresponded well to the linear model (Figure 2), since the values of the credibility of the approximation, R^2, are very high for all samples: 0.948 for the control and 0.968...0.986 for experimental recipes.

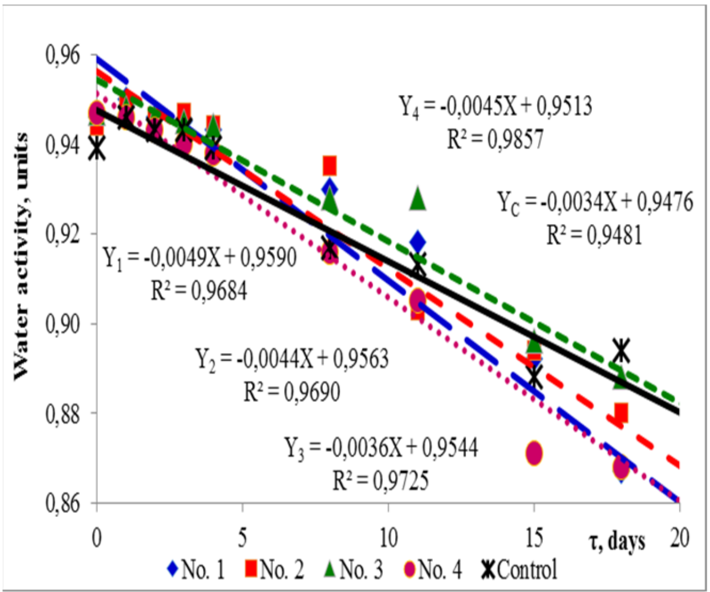

Figure 2. Changes in water activity, W_A, of the salami samples

The values of the coefficients at X show the steepness of the straight line $W_A = f(\tau)$, that is, the rate of drying of the salami is quantified by that coefficients. It is clearly seen that the steepest slopes have dependencies for the first and fourth samples, which corresponds to the upper level of factor X_3. Thus, the decrease in water activity in the sample of salamis during the fermentation process directly depends on the content of added dietary fiber. For the most reliable estimation, a regression equation (2) was obtained:

$$|\Delta W_A/\Delta\tau| = 0.00435 + 0.00030 \cdot X_1 - 0.00010 \cdot X_2 + 0.00035 \cdot X_3 \quad (2)$$

Equation (2) shows that the drying rate in the product actually grows most noticeably with an increase in the content of dietary fiber (X_3) and for a larger value of relationship m_{Meat}/m_{Lard} (X_1) too. The addition of dextrose to the forcemeat formulation contributes to a slight slowing down of the drying process (since the coefficient at X_2 has a negative value). Analysis of the kinetics of moisture reduction in samples of forcemeat (Figure 3) showed that the dependencies $H_R = f(\tau)$ have very high values of the credibility of the linear approximation. Reducing the humidity of all experimental samples is faster than in the control.

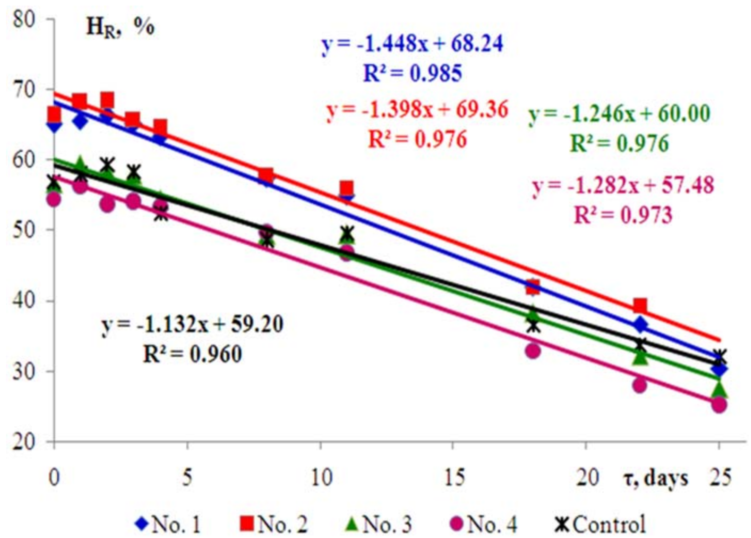

Figure 3. Linear kinetics of humidity changes

The regression equation (3) estimates influence of factors on the rate of humidity decrease:

$$\Delta H_R/\Delta\tau| = 1.344 + 0.080 \cdot X_1 + 0.004 \cdot X_2 + 0.022 \cdot X_3 \quad (3)$$

Eq. (3) shows that the factor X_1, and to a lesser extent factor X_3, contribute to the decrease in humidity. The influence of factor X_2 is least significant, which also agrees with Eq. (2). The kinetics of fat content both in the samples under study and in the control sample obey linear dependences (Figure 4). Attention is drawn to the fact that the kinetics of samples with low fat (No. 1 and No. 2) are characterized by very high values of the credibility of approximation (0.982 and 0.990). This speaks for the higher reproducibility of analysis of the samples with a lower fat content.

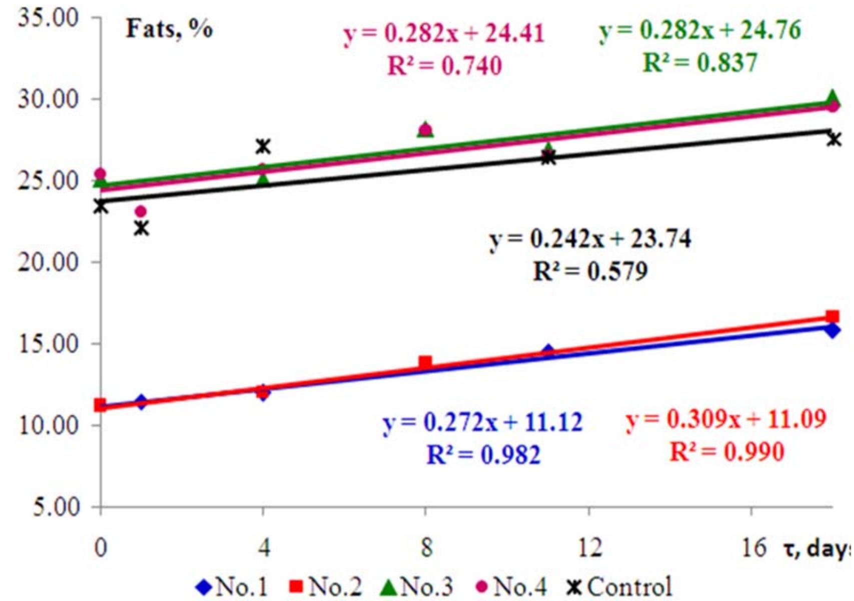

Figure 4. Variation of fats in linear correlation

Kinetics of the pH contain the sections that correspond to the processes of formation of low-molecular acids and their subsequent consumption during the fermentation process. The sharpest decrease in pH is observed for samples Nr.1 and Nr.3, which corresponds to high values of dextrose (X2), and indicates more intensive fermentation processes in these samples (Figure 5). At the end of the process, on the 25-th day, the pH values are even more significantly different from the sample to the sample. Thus, the dextrose added to forcemeat affects the physicochemical characteristics of the product throughout the entire process.

To adequately assess the effects on pH changes, the corresponding models were obtained at the extremes of the function pH = f (τ):

$$pH_{3rd\_day} = 4.95 + 0.01 \cdot X_1 - 0.11 \cdot X_2 + 0.04 \cdot X_3 \quad (4)$$

$$pH_{25th\_day} = 6.33 + 0.35 \cdot X_1 + 0.07 \cdot X_2 - 0.25 \cdot X_3 \quad (5)$$

From equations (4) and (5) it is obvious that increasing the meat / lard ratio (X_1) increases pH_{3rd_day} and pH_{25th_day}. Moreover, if at the beginning of the process the influence of factor X_1 is insignificant, then on the 25th day it is, on the contrary, the largest. Probably, the influence of relationship meat/lard on the product's pH is indirect. This is presumably being a consequence of the influence of this factor on drying speed. And already drying speed directly influence the process of fermentation and the pH values.

Dextrose has the strongest, lowering effect on pH on the third day and contribute to a very slight increase of this index in the 25th day. The presence of dietary fiber slightly increases the pH on the third day of drying, in fact during active fermentation, and on the 25th day it significantly reduces it. In general, dietary fibers inhibit the growth of pH throughout the fermentation process.

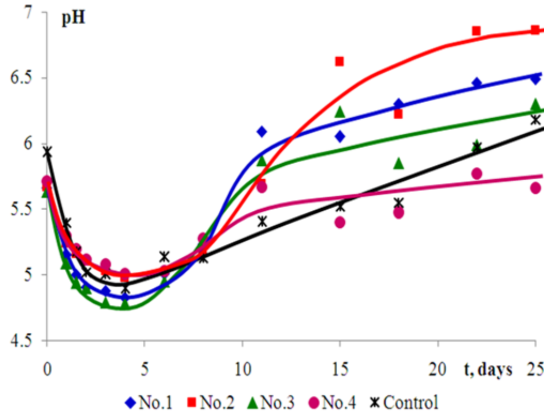

Figure 5. Changes of pH - during the raw-drying

Figure 6. Three weeks' age raw-dried salamis

3. Conclusions

1. Application of the FFE 2^{3-1} method allows quantifying the effect of the mince composition and the accompanying factors (fond) on the physicochemical and technological parameters of the raw-dried salamis in the process of manufacturing.
2. The use as an influencing factor of the ratio of the mass of meat to the mass of lard significantly simplifies the study without reducing the information content. High values of this factor directly and indirectly accelerates the drying.
3. Dextrose has a weak direct effect on the physicochemical parameters of the process of obtaining the product. Its effect on the pH of the samples, strong at the beginning of the fermentation process, almost does not manifest itself to the end of the drying process.
4. The low effect of dextrose on all responses of studied system allows to state that the amount of sugars in the center of the experiment corresponds to the optimal value, necessary in the production conditions.
5. The greater content of fibers contributes to the stabilization of pH values in the final product, and also directly accelerates its drying. Thus, the increased content of dietary fibers (about 2%) contributes to the acceleration of the producing process and the production of better quality raw-dried salamis.

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