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EFFECT OF RAW MATERIAL FORMULATION ON BASIC COMPOSITION AND RHEOLOGICAL PROPERTIES OF A MODEL PRODUCT OF MORTADELLA TYPE

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Abstract. A fragment of a study on the effect of raw material formulation on basic composition and rheological properties of model products is presented. The research material consisted of 14 model samples of mortadella, differing in raw material formulations. In the final product, the following determinations were carried out: the content of water, protein, fat, NaCl, total phosphorus, carbohydrates and collagen. The so-called non-variable indices – Feder number, i.e. water content / total protein content ratio (WC/PC), fat content / protein content ratio (FC/PC) and collagen / protein content ratio (CC/PC), were calculated. Rheological properties of the products were examined by the CASRA method. From the 14 examined model products with differentiated raw material formulations, six satisfied chemical requirements for "bologna mortadella". Correlation calculations between the parameters of the examined products and raw material formulation–modelling factors showed that factor A2, i.e. participation of pork stomachs in the composition of raw materials, was best correlated with the mentioned discriminants. Pork stomachs which were characterized by the highest water content (83.3%) and the lowest total protein (13.3%) and fat (2.8%) content in relation to the remaining raw meat materials had more distinct modifying effect on chemical and rheological characteristics of the examined products as compared to the addition of lean shoulder (A1) and tendinous beef (A3), the basic compositions of which are considerably less differentiated. Factor A2 affected most of the examined parameters and it was the most important moderator of chemical and rheological properties of the examined model products.

Keywords: mortadella, recipe, rheological and chemical characteristics, PCA

INTRODUCTION

In the Mediterranean countries, especially in Italy, traditional homogenous meat products, called mortadella and manufactured according to specific formulations, are very popular. Mortadella is habitually called "bologna" sausage as it originated in the capital city of Emilia Romano – Bologna. It is also produced in

Lombardy, Venice, Toscana and Marche. Speaking about "Mortadella Bologna" we mean the product which is subject to protection of geographic site (PGI 1998, PGI 2007), specified and described in detail in the standard (UNI 1996) and produced by Associazone Industriali Della Carni – ASS I.C.A. in accordance with the specification of the product.

Mortadella undergoes thermal treatment and fine comminuted with pieces of backfat. It has a light-pink to pink colour, with distinctly marked eyes of backfat. It is characterised by a delicate, slightly herbal smell and full, slightly sweet-salty taste. Typical mortadella is produced from selected pork and beef meats, mainly pork one, coming i.e. from lean shoulder and fine meat, mixed with emulsified fat, with the addition of backfat cubes, offals and other functional additives and seasonings (Novell *et al*. 1998, Zanardi *et al.* 1999, Osburn and Mandingo 1998). The discussed products are refined by the addition of garlic, pepper, grains of pistachio and some of them, even of wine. Mortadella should be cut very finely directly before consumption. In such a way the full aroma of the product is released (according to information of PAVONIQUE company – Jewels of Italian Kitchen (Information 2005).

At present, mortadella is also produced as a big-dimensional bloc product. Its characteristic feature, apart from dimensions (diameter of baton is equal to about 30cm) and weight of the batons, is a long period of shelf-life. The shelf-life period of mortadella is longer than 3 months. Mortadella must, therefore, meet strict requirements concerning raw material composition, which is directly expressed in the following limit values of chemical requirements: total protein content ≥ 13.5%; collagen content / total protein content ratio ≤ 0.20; water content / total protein content ration (Feder number) ≤ 4.10 and fat content / total protein content ratio ≤ 2.0.

According to Cantoni and Cattaneo (2001) mortadella meets the requirements of a product with long shelf-life period (Shelf Stable Product - SSP) as it is subjected to long heat treatment and contains indispensable addition of nitrites, its PH value is equal to 5.6-6.2 and water activity a_w is contained between 0.91 and 0.95; NaCl content is about 3% and after consideration of solids-not-fat only the effective NaCl concentration is about 4%.

Products of "mortadella bologna" type have been recently the subject of interest of specialists from the Meat and Fats Research Institute, due to their higher stability as compared to products manufactured in Poland, mainly according to formulas similar to those in the requirements of BN-84/8014-05 – "Unstable finely comminuted sausages – Mortadela" (1988). The attempt has been, therefore, undertaken with the aim to elaborate the product, similar to Italian-type mortadella in respect of sensory quality and rheological characteristics.

The present paper presents a fragment of greater work, dedicated to mortadella production technology under development, dealing with studies on the effect of raw material formulation on the basic composition and rheological properties of the model product.

RESEARCH MATERIAL AND METHODOLOGY OF STUDIES

The research material included 14 model samples of mortadella, differing in raw material composition, produced on half-technical scale at the Institute. The basic raw materials employed in the particular variants included: lean shoulder (5-40%), pork stomachs (0-30%), hard fat in cubes (15-25%), trimming fat (0-10%), water-fat-protein emulsion (5:5:1) (always 10%) and tendinous beef meat (0-45%). The percentage contents of the basic raw materials of experimental formulations are given in Table 1. Table 2 shows the basic chemical composition of fundamental components of the formulations.

Table 1. Percentage of main components in raw material recipe

Variant	Lean shoulder (%)	Porcine stomach (%)	Back fat cubes (%)	Trimming fat (%)	Fat-protein emulsion (%)	Tendoneus beef (%)	Sum of components (%)
W-1	40	25	25	0	10	0	100
W-2	30	25	25	0	10	10	100
W-3	20	25	25	0	10	20	100
W-4	40	20	25	0	10	5	100
W-5	30	30	20	0	10	10	100
W-6	40	25	15	10	10	0	100
W-7	40	25	15	10	10	0	100
W-8	40	12.5	15	10	10	12.5	100
W-9	40	0	15	10	10	25	100
W-11	40	25	15	10	10	0	100
W-4K	18	14	20	0	10	38	100
W-5K	5	20	20	0	10	45	100
W-6K	13	32	20	0	10	25	100
W-7K	17	26	20	0	10	27	100

In all experimental variants the following set of ingredients and seasonings was used: curing mixture (2.15%), saccharose (1.28%), sodium caseinate (1.00%) or skimmed milk powder (2.00%), polyphosphates (0.30%), sodium ascorbate (0.10%), sodium glutaminate (0.10%), black pepper (0.10%), white pepper (0.03%), garlic (0.02%), nutmeg (0.02%) and nutmeg mace (0.025%).

Table 2. Chemical composition of main raw materials for bologna type sausage

Raw material	Water content (%)	Total protein content (%)	Fat content (%)	$NaNO_2$ and $NaNO_3$ as $NaNO_2$ ($mgkg^{-1}$)	Collagen content (%)	Ash content (%)
Porcine meat from shoulder	63.8	16.4	17.8	–	1.60	0.9
Beef meat tendinous	67.2	18.0	12.2	–	2.60	0.8
Porcine stomach	83.3	13.3	2.8	8.3	3.06	0.5
Back fat	9.0	3.9	82.6	–	3.65	–
Trimming fat	16.9	4.7	76.8	–	1.65	–

Well cooled (temp. from +1 to – 1°C) materials for production were subjected to passage comminution in a grinder, successively on grids of Ø20, Ø10 and Ø5, returning the comminuted raw material to the cooling room after each passage. After repeated cooling down, the comminuted raw materials were subjected to chopping which was conducted till obtaining batter temperature equal to 15°C. The batter was filled in cases of ϕ170, wrapped with butcher's yarn and subjected to long heat treatment till obtaining the temperature of 72°C in the centre of the baton. Then the ready sausages were cooled down to room temperature and placed in the cooling room.

It should be stressed that in the production of Italian type mortadella, technological water in the form of ice is not added to batter during chopping. The water, which participates during the chopping of batter, comes from the water-fat-protein emulsion and from the minced raw materials only.

<u>The following determinations were conducted in the studied mortadellas:</u>

- water content (WC) – by the drier method acc. to PN-ISO 1442:2000;
- total protein content (PC) – by Kjeldahl method acc. to PN 75/A-04018;
- fat content (FC) – by Soxhlet method acc. to PN-ISO 1444:2000;
- NaCl content (NC) – by potentiometric method acc. to PN-ISO 1841-2:2002;
- total phosphorus content (PhC) – by the method in accordance with PN-A-82060:1999;

- carbohydrates content (CaC) – according to PN-85/A-82059
- collagen content (CC) – by the method of hydroxyproline determination acc. to PN-ISO 3496:2000.

For the studied products, the so-called non-variable indices were calculated: Feder number, i.e. water content / total protein content ratio (WC/PC), fat content / protein content ration (FC/PC) and collagen content / protein content ratio (CC/PC).

Rheological properties of the product bloc were tested by the continuously alternating stress and relaxation method (Continuously Alternating Stress-Relaxation Analysis – CASRA), using UTM Zwick 1445 MOPS (Tyszkiewicz *et al.* 1997) and determining the following parameters:

- plasticity (*P*) – parameter which determines force necessary for destruction of the material structure of the tested object;
- elasticity (*E*) – parameter which informs about susceptibility of material to reversible changes in shape of the tested object;
- fluidity (*F*) – parameter which informs about susceptibility of material to irreversible changes in shape of the tested object.

In the studies, a mandrel with rectangular cross-section (2 x 20 mm) with cross-section area $S = 4.0 \cdot 10^{-5}$ m^2 with unit tension $\sigma_1 = 1.25 \cdot 10^4$ N m^{-2} was employed.

The results of the tests, constituting mean values from three repetitions, were subjected to linear regression analysis, multiple regression analysis, variance analysis and analysis of the principal component (PCA – Principal Component Analysis) using statistical package Statgraphics for Windows ver.3.

RESULTS

As it was already mentioned at the beginning, "Bologna mortadella" must satisfy strict chemical requirements: total protein content $\geq$ 13.5%, water content / total protein content ratio (Feder's number) $\leq$ 4.10, fat content / total protein content ratio $\leq$ 2.0 and collagen content / total protein content ratio $\leq$ 0.20. Diagrams 1-4 show the consistence or deviation from the above mentioned limit values in the form of differences between the determined (calculated) values minus limited values. In the case of total protein content in the product, in 9 products (from 14 tested ones) the discussed content was correct, above the limit value ($\leq$ 13.5%) and in 5 cases it was found on the approved level (Fig. 1). Value of Feder's number of the tested products were disqualifying in 7 cases above the limit value ($\leq$ 4.10) and in 7 cases it was found on the approved level (Fig. 2). On the other hand, the non-variable indices: fat content / protein content ratio (FC/PC $\leq$ 2.0; Fig. 3) and collagen/protein ratio (CC/PC $\leq$ 0.2; Fig. 4), except for one case (W-2, Fig. 3), possessed values consistent with the requirements below the limiting boundary values.

The abovementioned review of limit values, obtained by the model products in relation to the normative restrictions, indicates that it is not easy to formulate the raw material composition so as the final product meets all the requirements of the standard. Only the following products: W-8, W-9, W-11, W-4K, W-5K and W-7K were found within the limits of the required chemical standard values for “mortadella bologna”.

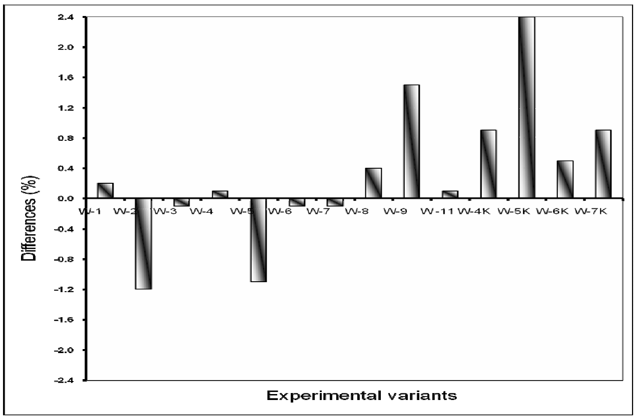

Fig. 1. Protein content (PC) – differences between experimental values and limit value (≥ 13.5%)

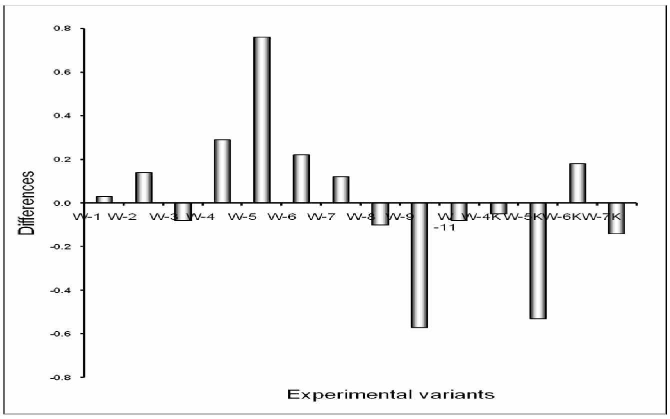

Fig. 2. Water content / Protein content ratio (WC/PC) – differences between experimental values and limit value (≤ 4.10)

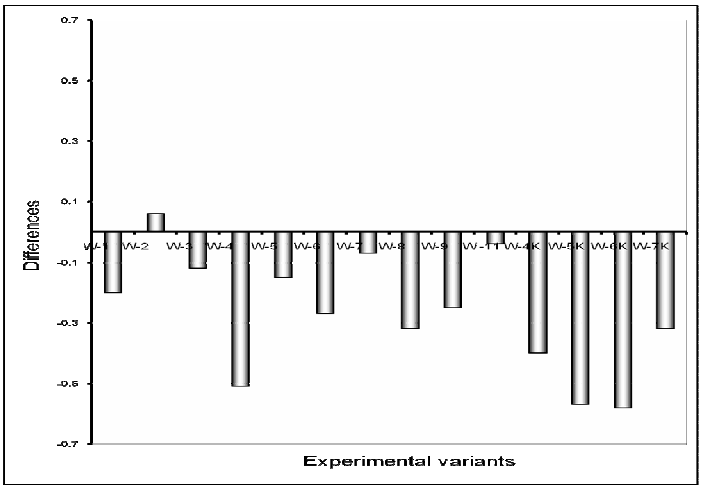

Fig. 3. Fat content / Protein content ratio (FC/PC) – differences between experimental values and limit value (≤ 2.00)

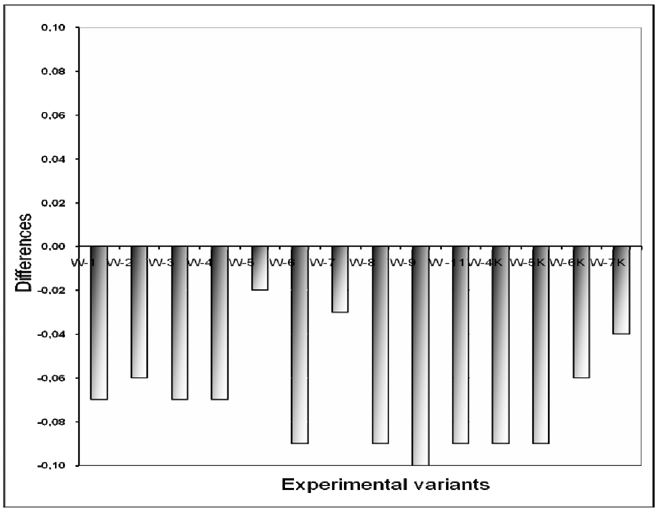

Fig. 4. Collagen content / Protein content ratio (CC/PC) – differences between experimental values and limit value (≤ 0.20)

On the ground of the data submitted in Table 1, the main factors modifying raw material formulation were specified. They consisted of the percentage participation of the following components: percentage of lean shoulder (factor A1), percentage of pork stomachs (factor A2) and percentage of tendinous beef meat (factor A3). The conducted analysis of linear regression, as shown in Table 3, revealed that only the content of carbohydrates (r = 0.667*) was significantly correlated with factor A1.

Table 3. Correlations between main raw material parameters and tested variables

Variable	A1	A2	A3
A1	–		
A2	–0.242 ns	–	
A3	–0.843 ***	–0.310 ns	–
Plasticity (P)	0.051 ns	–0.701 **	0.298 ns
Elasticity (E)	0.190 ns	0.787 ***	–0.590 *
Fluidity (F)	0.126 ns	0.399 ns	–0.320 ns
Water / Protein ratio (WC/PC)	0.235 ns	0.644 *	–0.544 *
Fat / Protein ratio (FC/PC)	0.492 ns	0.131 ns	–0.577 *
Collagen / Protein ratio (C/P)	–0.078 ns	0.639 *	–0.241 ns
Phosphorus cont. (PhC)	0.088 ns	–0.617 *	0.252 ns
NaCl cont. (NC)	0.014 ns	0.154 ns	–0.125 ns
Carbohydrates cont. (CaC)	0. 667 **	–0.388 ns	–0.438 ns

Significance level: *** = P≤ 0.001, ** = P≤ 0.01, * = P≤ 0.05, ns not significant,
A1 – percentage of lean shoulder, A2 – percentage of porcine stomach, A3 – percentage of tendon beef.

The correlation between A1 and A3 is obvious (r = –0.843*), as in the experiment the raw material formulations were created according to the following principle: if the participation of lean shoulder was decreasing, the participation of tendinous beef meat increased and vice versa, and their percentage shares were summing up. Elasticity (E) was very highly significantly positively correlated (r = 0.787***) with the percentage participation of pork stomachs in the formulation (factor A2); plasticity (P) was correlated highly significantly but negatively; collagen content/total protein content ratio (CC/PC) was correlated significantly positively (0.639*) and phosphorus content (PhC) was negatively correlated (–0.614*) with the discussed factor. On the other hand, elasticity (r = –0.590*), Feder number – WC/PC (–0.544*) and fat content/protein content ratio – FC/PC (–0.577*) were negatively correlated with factor A3 (percentage participation of tendinous beef meat). The remaining variables did not show any correlations with the studied factors.

As follows from the above discussed analysis, the greatest number of correlations with the studied discriminants of final product, including the correlations with non-variable parameters: WC/PC and CC/PC, were revealed by factor A2, that is percentage participation of pork stomachs in the formulation of the product. This may be explained by the fact that pork stomachs are characterised by the highest water content (83.3%) and the lowest total protein content (13.3%) and fat content (2.8%) in relation to the remaining meat components (apart from backfat and trimming fat) used in the creation of the formulations in the present experiment. Due to this fact, they affect more distinctly the modification of chemical and rheological characteristics of the tested products than the addition of lean shoulder (A1) and of tendinous beef meat (A3), the basic compositions of which are considerably less differentiated (Tab. 2).

Table 4 contains a presentation of the results of one-way ANOVA's analysis of the effect of factors A1, A2 and A3 on the evaluated rheological parameters (*P*, *E*, *F*) and on characteristics of chemical composition of the model products. The increase of the participation of shoulder (factor A1) in raw material formulation caused the increase of plasticity (*P*) and lowering of elasticity (*E*), CC/PC ratio and phosphorus content (PhC). Similar effect on the studied parameters was revealed by the increasing percentage participation of tendinous beef (factor A3). On the other hand, increased participation of pork stomachs in the formulation caused a decline of plasticity (*P*) and phosphorus content (PhC) and increase of elasticity (*E*), Feder number and CC/PC ratio in the final product.

Table 4. Multifactor ANOVA of rheological and chemical characteristics

Factors		Rheological traits			Chemical traits				
Component	Value	Plasticity (P)	Elasticity (E)	Fluidity (F)	WC/PC ratio	FC/PC ratio	CC/PC ratio	Phosphorus (PhC)	Carbohydrates (CaC)
A1	1	3.005 [ab]	8.329 [ab]	2.656	3.91 [a]	1.34 [a]	0,11	4.47 [b]	0.92
	2	2.585 [a]	8.594 [b]	2.426	4.42 [b]	1.70 [ab]	0.15	3.69 [a]	0.79
	3	3.134 [b]	7.462 [a]	2.168	4.08 [a]	1.83 [b]	0.13	3,86 [a]	1.42
	LSD	0.414	1.061	1.194	0.27	0.33	0.05	0.58	1.06
A2	1	3.250 [b]	7.428	2.311	3.80 [a]	1.51	0.10 [a]	4.54 [b]	1.48
	2	2.918 [ab]	8.179	2.359	3.95 [a]	1.68	0.13 [a]	3.95 [a]	0.76
	3	2.553 [a]	8.778	2.581	4.66 [b]	1.68	0.17 [b]	3.54 [a]	0.88
	LSD	0.568	1.452	1.194	0.23	0.39	0.05	0.58	1.06
A3	1	2.635 [a]	9.221 [b]	2.779	4.45 [b]	1.57	0.13	4.11	1.24
	2	3.290 [b]	7.587 [a]	2.110	3.92 [a]	1.65	0.13	4.02	1.03
	3	2.797 [ab]	7.577 [a]	2.362	4.04 [a]	1.65	0.13	3.89	0.86
	LSD	0.381	1.379	1.132	0.23	0.37	0.04	0.55	1.00

[a, b,] – means with different index in columns are significantly different ($P \leq 0.05$),
A1 – lean shoulder: 1 – 5-13%, 2 – 18-20%, 3 – 30-40%,
A2 – porcine stomach: 1 – 0-14%, 2 – 20-25%, 3 – 30-32%,
A3 – tendon beef: 1 – 0-10%, 2 – 20-25%, 3 – 38-45%.

The above relations might be explained in the following way: increase of percentage participation of pork (A1) or beef (A3) meat with relatively low water content and high total protein content in the raw material formulation caused strengthening of structure and consistency of the tested products whereas increase of the percentage content of pork stomachs (A2) with a high water content and low total protein content in the raw material formula caused weakening of the structure of the model products.

Table 5 shows the results of multiple regression (Multiple Regression Analysis). They demonstrate the mutual participation of factors A1, A2 and A3 (connected with modelling of raw material formulations) in shaping the studied rheological and chemical discriminants of the experimental products. The calculated correlation coefficients indicate that these relationships have a significant (FC/PC, CC/PC PhC and CaC), highly significant (P, WC/PC) or very highly significant (E) character. Only in the case of two parameters (F and NC), correlation coefficients turned out to be insignificant. Special attention should be paid to factor A2 – percentage participation of pork stomachs in the raw material formulation; the mentioned factor is modelling most of the studied parameters: plasticity (*P*), elasticity (*E*), Feder number (WC/PC), collagen content/protein content ratio (CC/PC), phosphorus content (PhC) and NaCl content (NC). The above data indicate also that factor A2 is the most important moderator of the chemical and rheological properties of the studied model products.

Table 5. Parameters of Multiple Regression Analysis

Parameters	Multiple regression $Y_i = C + aX_1 + bX_2 + cX_3$	Correlation coefficient
Plasticity (P) ($\cdot 10^5$ N m^{-2})	P = 3.62 – 0.03(A2)	0.707 **
Elasticity (E) ($\cdot 10^{-7}$ m^2 N^{-1})	E = 5.28 + 0.03(A1) + 0.10(A2)	0.879 ***
Fluidity (F) ($\cdot 10^{-8}$ m^2 (N s)$^{-1}$	F = –3.19 + 0.09(A1) + 0.09(A2) + 0.07(A3)	0.505 ^{ns}
Feder number (WC/PC)	WC/PC = –2.47 + 0.10(A1) + 0.11(A2) + 0.08(A3)	0.837 **
Fat/Protein ratio (FC/PC)	FC/PC = 1.85 – 0.01(A3)	0,577 *
Collagen/Protein ratio (CC/PC)	CC/PC = 0.09 + 0.002(A2)	0.639 *
Phosphorus cont. (PhC)	PhC = 4.53 – 0.03(A2)	0.620 *
NaCl cont. (NC)	NC = 5.70 – 0.06(A1) – 0.05(A2) – 0.06(A3)	0.315 ^{ns}
Carbohydrates cont. (CaC)	CaC = 0.23 + 0.03(A1)	0.666 *

Significance level: *** = P≤ 0.001, ** = P≤ 0.01, * = P≤ 0.05, ^{ns} not significant,
X_1 = A1 – percentage of lean shoulder, X_2 = A2 – percentage of porcine stomach,
X_3 = A3 – percentage of tendon beef.

The conducted analysis of the principal components (PCA) of the studied products (Tab. 6) showed that the first principal component PC1 covered 40.47% of the total variability and the second principal component PC2 accounted for another 22.96% of variability. It was found that the following variables were important for PC1: factor A2, plasticity (*P*), elasticity (*E*), Feder number (WC/PC), phosphorus content (PhC) and collagen content/protein content ratio (CC/PC). For PC2, the following variables were most important: factors A1 and A2, fat / protein ratio (FC/PC) and carbohydrate content (CaC).

Table 6. Coefficient of Eigenvalue (loadings) for two First Components (PC 1 and PC 2)

Variables	PC 1		PC 2	
	Weight	(%)	Weight	(%)
A1	0.09	2.87	0.55	19.66 *
A2	0.40	12.76 *	–0.23	8.26
A3	–0.29	9.46	–0.42	14.97 *
Plasticity (*P*)	–0.38	12.09 *	0.13	4.61
Elasticity (*E*)	0.43	13.70 *	–0.01	0.50
Fluidity (*F*)	0.23	7.31	0.11	3.90
Water / Protein ratio (WC/P)	0.40	12.78 *	0.05	1.83
Fat / Protein ratio (FC/PC)	0.18	5.81	0.30	10.89 *
Collagen / Protein ratio (CC/PC)	0.24	7.86	–0.25	8.88
Phosphorus cont. (PhC)	–0.33	10.58 *	0.17	6.10
NaCl cont. (NC)	0.12	3.73	0.06	2.26
Carbohydrate cont. (CaC)	–0.03	1.06	0.51	18.13 *
Sum of /loadings/	3.11	100.00	2.79	100.00

where: A1 – percentage of lean shoulder, A2 – percentage of porcine stomach, A3 – percentage of tendon beef, * Variables with loading ≥ 10% of the sum absolute loading (Σ/loadings/).

Figure 5 shows the distribution (in two-dimensional space) of the studied discriminants (principal components): rheological (*P*, *E*, *F*), chemical (WC/PC, CC/PC, FC/PC, NC, PhC and CaC), and of factors differentiating raw material formulations (A1, A2 and A3) in relation to the system of coordinates determined by axes of the principal components: PC1 and PC2. The distribution of the studied principal components is a graphic representation of their mutual linear correlations, as can be seen in Table 3.

The development of Figure 5 is shown in the so-called “biplot” (Fig. 6) on which, apart from the principal components, points representing the studied products have been additionally marked in the dimensional space. The mentioned diagram shows, more precisely, mutual relationships between the studied variables (vectors coming from the beginning of the system) and the distribution of the products (points) in space, resulting from the mentioned relationships and dependent on the percentage participation of factors A1, A2 and A3 in the raw material formulation and the resulting basic composition of the final model products, and on rheological characteristics connected with the basic composition.

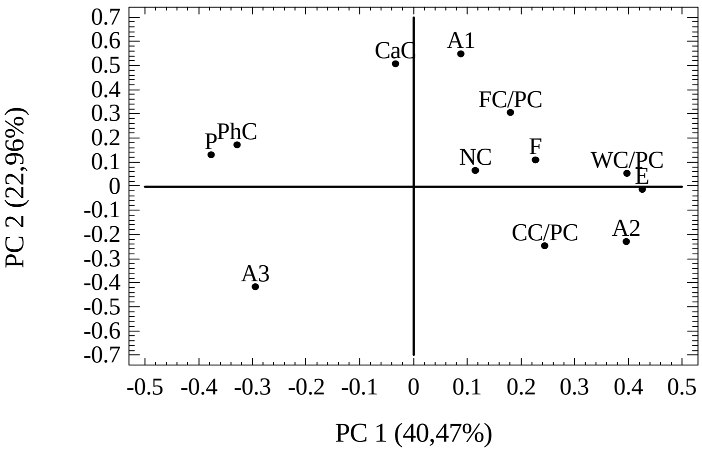

Fig. 5. Plot of Component Weights

The main vectors of factors A1, A2 and A3, depending on the percentage participation of the raw materials, appoint the places of the products in the "biplot". A big role is also played by such discriminants as WC/PC, CC/PC, and FC/PC, and by rheological parameters (*P*, *E* and *F*). The remaining indices have rather a small effect on the distribution of the particular model products in biplot space. Alongside A3 vector, commencing from K-5 sample with the highest percentage participation of beef meat in raw material formulation (45%), the products with decreasing participation of the mentioned raw material are distributed: K-4 (38%), W-3 (28%) and W-1 and W-11 with zero participation of beef. Products K-6 (25%) and K-7 (27%) are distinctly shifted towards the right side of the diagram due to considerable participation of pork stomachs (32 and 26%, respectively). Product W-5, with the highest participation of pork stomachs (30%) and the highest Feder's number (4.9), exceeding the limit value, is situated utmost to the right. Products W-1, W-2, W-4, W-6, W-7 and W-11, characterised by a high participation of pork meat (30-40%) and pork stomachs (20-35%) in the raw material formulation, are situated near A1 vector. On the other hand, products W-9 and W-8, in spite of

40% beef participation but due to zero (W-9) and 12.5% (W-8) participation of pork stomachs, are located at the edge of the diagram, in its upper left corner.

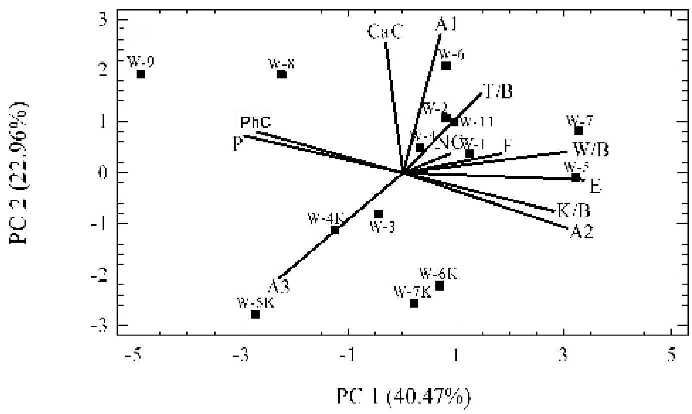

Fig. 6. Biplot in two-dimensional space

CONCLUSIONS

1. From 14 examined model products with different raw material formulations, 6 products met the chemical requirements for “bologna mortadella”.
2. The conducted correlation calculus between the discriminants of the examined products and factors modelling raw material formulation showed that factor A2, i.e. participation of pork stomachs in the raw material formulation, was best correlated with the chemical and rheological parameters. The two remaining factors (A1 and A3) did not show such good linear correlations with the examined parameters.
3. Pork stomachs (A2), as being characterised by the highest water content (83.3%) and the lowest total protein (13.3%) and fat (2.8%) content in relation to the remaining raw meat components, had a more distinct modifying effect on the chemical and rheological characteristics of the examined products in comparison to the addition of lean shoulder (A1) and tendinous beef (A3), the basic compositions of which are considerably less differentiated.
4. Factor A2, i.e. the percentage participation of pork stomachs in the raw material formulation, had an effect on most of the examined parameters: plasticity (*P*), elasticity (E), Feder number (WC/PC), collagen content/protein content ratio (CC/PC), phosphorus content (PhC) and NaCl content; it was the most important moderator of the chemical and rheological properties of the examined model products.

5. Increase of the percentage participation of pork (A1) or beef (A3) meat with relatively low water content and high total protein content resulted in strengthening of the structure and consistency of the examined products, whereas increase of the percentage participation of pork stomachs (A2) with high water content and low total protein content in the raw material formulation caused weakening of the structure of model products

6. The above correlations and interactions between the examined factors modelling raw material formulation, rheological parameters and basic composition of the examined products are well presented in the "biplot" being the result of conducted principal component analysis (PCA). It allows understanding of the mutual relationships between the chemical composition of the product and parameters of the rheological characteristics as affected by differentiated raw material formulations.

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WPŁYW RECEPTURY SUROWCOWEJ NA SKŁAD PODSTAWOWY I WŁAŚCIWOŚCI REOLOGICZNE MODELOWEGO PRODUKTU TYPU MORTADELLA

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S t r e s z c z e n i e. Zaprezentowano fragment badań poświęcony ocenie wpływu receptury surowcowej na skład podstawowy i właściwości reologiczne modelowego produktu. Materiał badawczy stanowiło 14 prób modelowych mortadelli różniących się recepturami surowcowymi. W gotowym produkcie oznaczano: zawartość wody, białka ogólnego, tłuszczu, NaCl, fosforu całkowitego, węglowodanów i kolagenu. Wyliczano tak zwane niezmienniki: liczbę Federa – stosunek zawartości wody do zawartości białka ogólnego (WC/PC), stosunek zawartości tłuszczu do zawartości białka (FC/PC) oraz stosunek zawartości kolagenu do zawartości białka (CC/PC). Właściwości reologiczne bloku wędliny badano metodą CASRA. Z 14 badanych produktów modelowych o zróżnicowanych recepturach surowcowych 6 spełniło wymagania chemiczne dla „mortadelli bologna”. Przeprowadzony rachunek korelacyjny pomiędzy wyróżnikami badanych produktów a czynnikami modelującymi recepturę surowcowa wykazał, że najlepiej skorelowany z wyróżnikami był czynnik A2 – udział w recepturze surowcowej żołądków wieprzowych. Żołądki wieprzowe charakteryzujące się najwyższą zawartością wody (83,3%) oraz najniższą zawartością białka ogólnego (13,3%) i tłuszczu (2,8%) dużo wyraźniej wpływały modyfikująco na charakterystykę chemiczną i reologiczną badanych produktów niż dodatek chudej łopatki (A1) i ścięgnistej wołowiny (A3). Czynnik A2 oddziaływał na większość badanych wyróżników i był najważniejszym moderatorem właściwości chemicznych i reologicznych badanych produktów modelowych.

S ł o w a k l u c z o w e: mortadella, receptura, charakterystyka reologiczna i chemiczna, PCA