BIOTECHNOLOGICAL MODIFICATION OF RAW MEAT MATERIALS, RICH IN CONNECTIVE TISSUE, IN THE MANUFACTURE OF MEAT PRODUCTS OF ENSURED QUALITY

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A brief analysis of the factors which limit a wide application of raw meat materials rich in connective tissue in the manufacture of meat products of ensured biological value and organoleptical qualities, is given.

Prospective ways of solving this problem have been outlined: biotechnoligcal (viz., enzymic) modification of such materials and computerised formulation of products balanced in macronutrient ratios.

Experimental data are reported, which illustrate, as a complex, the enzymic effect on the composition, physico-chemical, biochemical properties and microstructure of modified materials. Methods are disclosed, the results of the computerised development of formulations being balanced by their proximate composition and the ratio of essential amino acids are reported.

Technological difficulties of processing raw materials rich in connective tissue are due, first of all, to an increased mechanical strength of the connective tissue, its poor WHC and a low pieso-conductivity to curing ingredients. Altogether, it causes high energy consumption in sausage meat preparation and a considerable prolongation of the curing process in cured meats production. Certain difficulties arise at the stage of thermal treatment of collagen-containing materials, too. A higher resistance of collagen and elastin fibres to heat disaggregation predetermine a number of defects of finished products, which are due to the fact that, at the main structural background provided by muscle proteins, connective tissue inclusions are perceived as hardly chewable, foreign and affecting product consistency. More tough conditions of heating, which contribute to connective tissue tenderisation, cause extreme thermohydrolysis of the muscle protein elements of the meat structure, this also affecting product consistency. Both factors predetermine difficulties in selling finished meat products.

Medico-biological problems are connected with the danger of lowering the biological value of the total protein of a meat product in case of a high content of connective tissue.

A widely commercially used method which reduces the "risk factor" of the occurrence of the above negative effects, when raw meat of a high connective tissue content is included into formulations, is desinewing. It cannot be considered as promoting the elimination of the problem of wasteless processing since during desinewing the connective tissue is separated and not used for processing together with the desinewed meat.

The summation of the experimental results allowed to suggest that, as a alternative to desinewing, may be biotechnological modification of meat rich in connective tissue by means of its treatment with proteolytic enzymes having collagenase and elastase activities.

Tables 1 and 2 show averaged experimental data (as exemplified with beef trimmings), characterising the influence of the enzymic modification of the raw materials on their proximate analysis, macro- and microelemental and amino acid compositions. Table 1 demonstrates that beef trimmings treatment with proteolytic enzymes is not accompanied with significant changes in meat composition. Raw meat enzymic treatment to replace desinewing renders it possible to preserve more that 1.5% of meat proteins in the product.

Table 1

Characteristics	Beef trimmings		
	non-desinewed	desinewed	non-desinewed enzyme-treated
Mass fraction(%) of:			
water	67.3	67.7	67.8
fat	14.3	16.6	14.2
protein	17.2	15.3	17.0
ash	1.1	1.0	0.9
Macroelements, mg/g of d.s.:			
Ca	0.53	0.41	0.49
P	6.07	6.31	6.15
K	17.52	15.09	16.89
Cl	1.80	1.91	2.53
S	4.82	5.03	4.61
Mg	2.81	2.47	2.71
Microelements, mcg/g of d.s.:			
Fe	89.06	92.13	87.11
Cu	3.09	2.91	2.73
Zn	18.76	21.51	19.16
Mn	3.18	2.75	2.94
Si	0.63	0.78	0.71
Ni	1.31	1.59	1.45

The data in Table 2 justify a suggestion that, despite an increase in the total essential amino acids in desinewed meat trimmings, the enzyme-treated non-desinewed meat is characterised with practically the same coefficient of the rationality of protein utilisation.

Table 3 shows the experimental results on the effect of meat trimmings enzymic treatment with animal proteases on the physioco-chemical indices of the treated materials. The information on the structuro-mechanical properties of desinewed and non-desinewed beef trimmings are derived with the INSTRON 1122 machine.

It is clear from Table 3 that the enzymic treatment lowers the integral strength characteristics of non-desinewed meat trimmings by more than 15%. A differential evaluation of proteolysis effect on the shear force of the muscle tissue across and along meat fibres demonstrated that the shear values went down, on the average, by 5%. Thus, a more than 10% decrease of toughness of the non-heated raw meat rich in connective tissue, treated with pepsin is due to protease tenderizing effect on collagen and elastin.

Table 2

Amino acids, g/100 g of protein	Beef trimmings		
	non-desinewed	desinewed	non-desinewed enzyme-treated
Essential			
iso-leucine	4.22	5.14	4.34
leucine	8.02	8.21	9.14
lysine	8.41	8.81	6.65
methionine+cystine	3.38	3.74	3.68
phenyl-alanine+tyrosine	6.87	7.47	7.03
threonine	4.94	5.17	4.97
tryptophane	0.92	1.09	0.91
valine	6.02	5.83	5.72
Total essential amino acids	42.81	45.46	42.44
Rationality coefficient of the amino acid composition	0.774	0.791	0.780
Non-essential			
alanine	5.58	4.82	4.97
arginine	7.48	7.59	6.72
asparagine	9.36	9.81	9.97
histidine	2.96	2.65	2.47
glutamic acid	16.93	16.17	16.92
glycine	4.39	4.11	5.74
proline	4.81	4.07	5.27
serine	4.36	4.21	4.12
hydroxyproline	1.74	1.58	1.71
Protein quality index	0.53	0.69	0.53

It is also interesting to note an approximate 7.2% increase of the WHC of non-desinewed beef trimming after enzymic treatment.

The above conclusions are vividly confirmed with scanning electron microscopy of the microstructure of connective and muscle tissue and with electrophoretic fractionation of the proteins of non-desinewed trimmings prior to and post enzymic treatment.

Analysing the results obtained, the authors suggested naturally that the enzymic treatment of raw meat rich in connective tissue should contribute to a faster rate of diffusion-filtration distribution of curing ingredients during pickling. The performed tests allowed to prove experimentally a more uniform sodium chloride distribution when using proteolytic enzymes to treat raw meat materials. To develop meats formulations providing for the utilisation of collagen-containing raw meat and balanced by their amino acid profile of the total protein, computerised modelling was applied, based on the mathematical relation described in detail in earlier papers.

$$A_j = \frac{\sum_{i=l+1}^{m} X_i \sum_{i=1}^{l} X_i P_i A_{ij} + \left(\sum_{i=l+1}^{m} X_i - y\right)\sum_{i=l+1}^{m} X_i P_i A_{ij} + y \sum_{i=l+1}^{m} X_i \sum_{i=m+1}^{n} X_i P_i A_{ij}}{\sum_{i=l+1}^{m} X_i \sum_{i=1}^{l} X_i P_i + \left(\sum_{i=l+1}^{m} X_i - y\right)\sum_{i=l+1}^{m} X_i P_i + y \sum_{i=l+1}^{m} X_i \sum_{i=m+1}^{n} X_i P_i},$$

Table 3

Physico-chemical characteristics	Beef trimmings		
	non-desinnewed	desinewed	non-desinewed enzyme-treated
pH	5.67-5.87	5.78-5.84	5.79-5.95
WHC, % of the total water	76.9-79.7	81.4-85.3	82.3-83.5
Integral shear force*, $\sigma \cdot 10^{-5}$ N/m	7.28-8.12	5.71-6.32	6.74-7.13
Integral shear work, $A \cdot 10^{-3}$ J/m^2	4.16-4.78	3.31-4.11	3.97-4.91
Shear force:			
across the fibers**	12.61-13.11	12.54-13.96	11.81-12.97
along the fibers	11.09-12.31	10.97-12.14	10.64-11.78

* a measuring cell "Kramer Shear Press"

** a measuring cell "Warner-Bratzler"

where A_j is a mass fraction of the j-th amino acid of the total protein of a meat product to be formulated (g/100 g of protein);

X_i is the level of the i-th component in minced meat (fraction of a unit);

P_i is the protein level in the i-th component (%);

A_{ij} is a mass fraction of the j-th amino acid in the i-th component (g/100 g of protein);

y is a mass fraction of the basic replaced component in a formulation (fraction of a unit); $\sum_{i=1}^{m} X_i = 1$, $\sum_{i=m+1}^{n} X_i = 1$

l is the number of the basic (no replaced) components in a formulation (units);

n is the number of replacers (units).

As a result of modelling the amino acid composition of a multi-component meat product containing raw meats rich in connective tissue, it is not difficult to derive a formulation close to an optimum one by essential/non-essential amino acid balance as compared to the FAO/WHO reference. e.g., a similar formulation for such a set of ingredients as non-desinewed enzyme-treated beef trimmings, Grade 2 beef, Grade 1 beef, high-fat pork and semi-lean pork, elimiantes the use of one of them and will be as follows:

beef trimmings 50%, Grade 2 beef 30%, Grade 1 beef 6%, high-fat pork 14%. The amino acid composition of the protein in such a formulation, in case of protein mass fraction being 17.01'%, is as follows: iso-leucine 3.38, leucine 8.67, lysin 7.38, methionine+cystine 3.69, phenyl-alanine 7.30, threonine 4.76, tryptophane 1.00, valine 5.66, U = 0.855, R = 0.840.

The analyses of these data evidence a high balance of essential and non-essential amino acids with some dominance of the mass fraction of each of them over the value of the FAO/WHO reference.