DIETARY MEAT PRODUCTS WITH OPTIMIZED COMPOSITIONS

STEFAN DRAGOEV[1], MARIA POPIVANOVA[1], STEFAN DANCHEV[1], KOSTADIN WASSILEV[1] and BLAGOI JORDANOV[2]

[1]Higher Institute of Food and Flavour Technologies, 26 Lenin Blvd., 4002 Plovdiv, Bulgaria.
[2]Institute of Meat Industry, 65 Cherni Vruh Blvd., 1407 Sofia, Bulgaria.

SUMMARY: The objective of the present work was to develop dietary meat products (sausages) with improved protein and fat compositions that would meet definite medico-biological, organoleptic and technological requirements.

The products were developed by the method of mathematical modeling describing their amino acid and fatty acid compositions. The optimum formulations were found by a computer. The following raw materials were used: veal from the hindquarter, poultry meat from broilers (mechanically deboned), wheat gluten, sour buttermilk protein concentrate (Simov et al., 1980), powder defatted milk, and sunflower oil.

The results from the study indicated that the new dietary sausages had statistically meaningful higher total protein percentage from the total mass (20.53±1.55 and 18.30±0.84 in dietary sausages, and 13.69±0.86 in control samples) at a relatively balanced essential amino acid composition that was close to the one recommended by FAO.

The dietary sausage varieties had significantly lower fat level of the total mass (10.49±0.53 and 11.71±0.96 for dietary sausages, and 19.77±0.41 for control samples). The level of unsaturated fatty acids was higher in the optimized dietary sausages. The latter were with low salt content - 1% and 1.46% respectively, and there were no traces of resudual nitrites.

The results obtained indicated that the applied approach of modeling and optimization of the amino acid and fatty acid compositions could be successfully used in working out formulations for dietary meat products that correspond to the requirements for dietary and prophylactic nutrition of differentiated groups of people.

INTRODUCTION: The analysis of the nutrition habits of various groups of the population in this country (Balabanski et al., 1981; Goranov et al., 1983) and abroad (Leniger, 1985; Rogov, 1988) indicates that foods consumed today not only fully supply, but with some people considerably exceed, their energy needs. At the same time, the needs for animal proteins are satisfied as much as 80%.

There has been noted an excessive use of animal fats with unbalanced fatty acid composition (Rogov et al., 1988; Derby et al., 1980; Enser, 1983; Spritz et al., 1969).

All facts mentioned above result in an increased number of patients suffering from the so called socially important diseases (Rogov et al., 1988). Therefore, there is a need for a thoroughly new approach in formulating new meat products that will respond to the latest requirements as to their compositions, nutritive value, technological and organoleptic properties.

One of the ways to carry out such an approach is the optimization of the protein and fat compositions by mathematical modeling and computer programming to receive dietary meat products with optimized compositions that can become part of the differentiated diet of strictly defined groups of people.

MATERIALS AND METHODS: The dietary sausages were prepared from the following raw materials: veal from the hindquarter, poultry meat from broilers (mechanically deboned), wheat gluten, sour buttermilk protein concentrate (Simov et al., 1980), powder defatted milk, and sunflower oil.

The formulations of the dietary sausages were received after mathematical modeling of the amino acid and fatty acid compositions of the stuffing mass with consideration paid to FAO (WHO) recommendations for the amino acid composition of the "ideal" protein, and the corresponding medico-biological requirements for the fatty acid composition. For this purpose we used the method of linear programming (Glas, 1961) followed by computer optimization using simplex-method linear optimization programs (Vuchkov et al., 1986).

The characteristics of the optimized dietary sausages were compared to those of control samples from traditionally produced sausage of the same variety.

The finished new product was analyzed for the following characteristics: total protein (by Kjeldahl's method); fats (by Soxlett's method); assimilable protein (by W. Diemayer's method); unassimilable protein (calculated as the difference between the total and assimilable protein); water content (by drying of samples to a constant weight); salt content (by silver nitrate titration of an acqueous extract); residual nitrites (by photometric measurement of the colour intensity of dinitrous compounds received from the reaction of nitrites with nitrous acid, alpha-naphtylamine, sulfonic and acetic acids); organoleptic analysis by the 9-grade scale of the All-Union Research Institute of Meat Processing (Authors' panel, 1974). The amino acid composition was determined by a KLA-5 "Hitachi" automatic amino acid analyzer by the method of Spakman, Stain and Moore (Spakman et al., 1980). The fatty acid composition was determined on a SIGMA-10 gas chromatograph by Williams' method (Williams, 1980). The experimental data were processed according to the method of mathematical statistics with 0.05 confidence level and 0.89-0.98 criterium power (Georgieva et al., 1987).

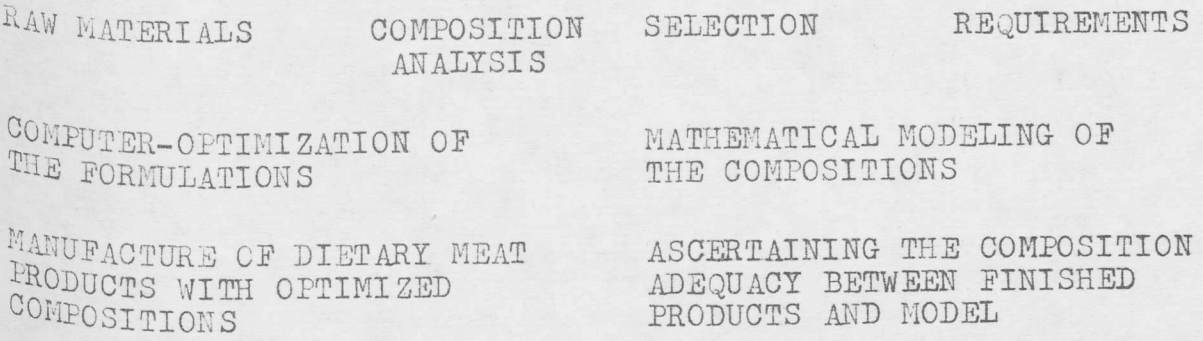
RESULTS AND DISCUSSION: Figure 1 shows the schematic diagram of the approach used in the development of dietary sausages with optimized compositions.

The computer-optimized mathematical models were used to work out the following formulations;

- Dietary frankfurters: veal from the hindquarter - 51.46%; poultry meat from broilers (mechanically deboned) - 38.84%; wheat gluten - 4.85%; sunflower oil - 2.91%; sour buttermilk protein concentrate - 1.94%.
- Dietary sausage: veal from the hindquarter - 83.33%; powder defatted milk - 6.41%; sunflower oil - 10.26%.

The new meat products with the above formulations were manufactured according to the traditional methods for cooked non-durable sausages.

Fig.1. Schematic diagram of the preparation of meat products with optimized compositions.



The results for the total physico-chemical compositions of test and control samples are given in Table 1.

Table 1. Total physico-chemical compositions of the test and control samples.

Characteristic	Dietary Frankfurters	Dietary Sausage	Control Samples
Total protein (% of total mass)	20.53±1.55	18.30±0.84	13.69±0.86
Protein (% dry matter)	60.51±0.93	54.51±0.87	36.44±0.89
Assimilable protein (% of total mass)	19.50±0.97	16.74±0.82	11.54±0.85
Unassimil. protein (%)	1.03±0.58	1.56±0.48	2.15±0.54
Fats (% of total mass)	10.49±0.53	11.71±0.96	19.77±0.41
Fats (% of dry matter)	30.92±0.64	34.88±0.99	52.63±1.01
Water content (% of total mass)	66.07±1.12	66.43±1.21	62.48±1.32
Salt (% of total mass)	1 ± 0.09	1.46±0.05	1.76±0.20
Nitrites (mg/100 g product)	-	-	0.038±0.006

After the results were statistically processed we established that the total protein in the test samples was significantly higher than that of the controls while there was no difference between the two dietary products.

The levels of fats, unassimilable proteins and salt in the test samples was significantly lower than those in the controls, and the water content and assimilable proteins levels were higher; there were no residual nitrites..

Table 2 contains a comparison between the protein and fat levels of the finished products and of the model calculated values.

Table 2. Total proteins and fats in the new dietary sausages compared to model values.

Characteristic	Dietary Frankfurters		Dietary Sausage		Norm
	Model	Test	Model	Test	
Total proteins (% of total mass)	22.89	20.53	19.74	18.30	above 18
Total fats (% of total mass)	10.32	10.49	11.59	11.71	10 to 12

The comparison in Table 2 indicates that the test results are very close to the model values.

The amino acid and fatty acid compositions of the dietary meat products are given in Tables 3 and 4, respectively.

Table 3. Amino acid composition of the test samples compared to FAO (WHO) recommendations.

Amino Acid	Levels, g / 100 g of protein		
	Dietary Frankfrt.	Dietary Sausage	Ideal Protein
Valine	4.43±0.19	4.26±0.43	5.00
Isoleucine	3.96±0.16	4.19±0.31	4.00
Leucine	8.23±0.37	8.37±0.25	7.00
Lysine	7.98±0.41	9.44±0.97	5.50
Methionine	2.46±0.33	2.59±0.42	3.50+Cystine
Cystine	1.10±0.26	0.67±0.19	
Threonine	4.13±0.22	4.52±0.53	4.00
Tryptophan	0.65±0.35	0.60±0.37	1.00
Phenylalanine	4.26±0.18	4.07±0.25	6.00+Tyrosine
Tyrosine	3.60±0.20	3.70±0.20	
Alanine	5.40±0.33	5.57±0.48	
Arginine	6.05±0.55	6.80±0.99	
Aspergillic acid	8.45±0.57	9.16±0.85	
Glycine	4.60±0.24	4.19±0.40	
Glutamic acid	21.68±1.08	16.69±1.13	
Proline	5.53±0.56	4.14±0.83	
Serine	4.04±0.31	4.36±0.26	
Hydroxyproline	0.48±0.11	2.28±0.54	
Histidine	2.96±0.65	4.38±0.51	

The statistic processing of the results from Table 3 shows that there are no significant differences in relation to the amino acid levels of the new dietary products and the amino acid composition of the "ideal" protein recommended by FAO (WHO).

Table 4. Fatty acid composition of the new dietary products compared to the model composition and the medico-biological requirements.

Fatty Acid Groups	Levels, % of fats				
	Dietary Frankfurters Model	Test	Dietary Sausage Model	Test	Norms
Linolic acid	28.23	18.82±0.96	45.16	35.74±0.85	16.00
Linolenic acid	1.13	0.52±0.13	0.28	traces	1.60
Other poly-unsaturated acids	1.39	1.3 ±0.45	1.32	1.02±0.51	2.40
Monounsaturated fatty acids	41.70	42.45±0.98	33.42	33.50±0.76	50.00
Short- and medium-chain saturated fatty acids	0.10	2.66±0.34	0.04	5.83±0.67	6.00
Long-chain saturated fatty acids	27.45	34.06±0.89	19.78	23.86±0.85	24.00
Polyunsaturated: Monounsaturated: Saturated Ratio	31:42:27	20:43:37	47:33:20	37:33:30	20:50:30

The statistic analysis of the above data gave no indication of significant differences between the theoretical and experimental levels of the monounsaturated fatty acids. In all other cases there were observed such differences. The results in Table 4 indicate that the level of the polyunsaturated fatty acids decreases as compared to the theoretic value by approximately 10% while the level of the saturated fatty acids increases also with 10% compared to the theoretic values. That is probably due to a certain saturation of the double bonds and disruption of the longer carbon chains as a result of the technological processing method. It was established that the ratio of the separate fatty acid groups in the dietary frankfurters was closer to the recommended values than that in the dietary sausage; in the dietary sausage, however, there was observed a higher level of the polyunsaturated fatty acids and the linolic acid in particular.

Table 5 shows a comparison between the fatty acid compositions of the test and control samples. The comparison is for groups of fatty acids.

After the statistic analysis we can assert that there are statistically significant differences in the levels of the linolic acid and the long-chain saturated fatty acids with all three samples. The highest is the level of the polyunsaturated fatty acids in the dietary sausage followed by the dietary frankfurters and the control sample. The level of the monounsaturated fatty acids is the lowest in the dietary sausage and is significantly different from that of the rest of samples. The levels of this group of acids in the dietary frankfurters and the control sample do not differ. There is also no difference between the levels of the linolenic acid and other polyunsaturated fatty acids for all three samples. The group of short- and medium-chain fatty acids is signifi-

The new dietary meat products with optimized compositions have high levels of total proteins, balanced amino acid composition, lowered levels of fats, and high levels of the biologically active linolic acid. The fatty acid composition of the dietary meat products is close to the medico-biological requirements. This is expressed best in the dietary frankfurters.

The new dietary sausages have better proteins:fats ratio compared to the control.

The physico-chemical as well as the amino acid and fatty acid compositions of the dietary products are very close to the theoretically calculated ones.

The finished dietary sausages have good organoleptic properties.

The new approach applied in the preparation of dietary meat products with optimized compositions can be successfully used for formulating new products in accordance with the requirements of the science of nutrition.

The new dietary meat products are suitable to be consumed by patients who suffer from atherosclerosis, cardiac ischemia, hypertonia, obesity and other diseases related to hyperlipemia, advanced-aged and healthy persons.

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cantly undiscernible in the dietary sausage and the control, and these acids are at the lowest in the dietary frankfurters.

Table 5. Fatty acid composition of the test and control samples.

Fatty Acid Groups	Levels, % of fat quantity		
	Dietary Frankfurters	Dietary Sausage	Control
Linolic acid	18.82±0.96	35.74±0.85	3.50±0.74
Linolenic acid	0.52±0.13	traces	0.80±0.12
Other polyunsaturated fatty acids	1.30±0.45	1.02±0.51	traces
Monounsaturated fatty acids	42.45±0.98	33.50±0.76	42.75±0.99
Short- and medium-chain saturated fatty acids	2.66±0.34	5.83±0.67	6.20±0.72
Long-chain saturated fatty acids	34.06±0.89	23.86±0.85	46.50±0.88
Polyunsaturated: Monounsaturated: Saturated Ratio	20:43:37	37:33:30	5:43:52

The explanation for these results lies in the introduction of vegetable oil in the dietary sausages, and also in the decrease of the total fats.

Table 6 presents the results from the organoleptic analysis of the new meat products with optimized compositions.

The results from the organoleptic analysis show that the new dietary sausages were evaluated by grades from 5.29 to 8.85.

Table 6. Organoleptic analysis of the test samples.

Characteristic	Dietary Frankfurters	Dietary Sausage
Outer appearance	7.31±0.56	7.43±0.57
Cutting surface colour	7.44±0.46	7.01±0.39
Flavour	8.23±0.41	7.05±0.73
Taste	7.29±0.36	6.86±0.35
Texture	8.43±0.42	8.58±0.34
Juiciness	5.29±0.58	7.72±0.42
Overall evaluation	7.57±0.37	7.14±0.63

The overall evaluation of the dietary frankfurters is 7.57 ±0.37, and 7.14±0.63 for the dietary sausage. We can draw the conclusion that these meat products are well accepted by the taste panel in relation to their organoleptic properties.

CONCLUSIONS: The results obtained and their analysis give us the ground to state the following: