Modeling the recipe composition of food products and recommendations for their use in individual nutrition

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Abstract. To determine the body type of an individual according to the input parameters (age, gender, height and weight), a model is developed based on the statistical module classification trees. Based on the analysis of body type, labor intensity, gender, weight and nutritional structure for various categories of citizens, a neural network design of an algorithm for calculating the daily intake of protein, fat, dietary fiber and energy is carried out. The obtained data can serve as the basis for drawing up an individual nutritional diet. Taking into account the amino acid composition, organoleptic and economic indicators, a database is developed that allows to determine the optimal recipe of a meat product for individual nutrition. A structural-parametric model consisting of three stages (establishing the body type; determination of calorie content and requirements for protein and fat of animal origin; calculation of the energy value of the daily diet) is created in the Data Mining module to design a products composition for individual nutrition.

1. Introduction
The individual diet should be based on the principles of adequate nutrition. The development of a diet is carried out in accordance with individual consumption norms for the main components of food. It is necessary to take into account age, gender, body type, nature of work and other factors and individual characteristics of the human body. For healthy people of normal body type, the quantitative ratio of carbohydrates, fats and proteins in the daily diet should be equal to 1 : 1 : 4 [1–4].

For people underweight more than 5%, the recommended ratio by weight of the main components is 2–2.25 : 1 : 4 (protein : fat : carbohydrates).

The digestive activity in an elderly person body is reduced. Therefore, the proportion of meat proteins in the diet should be no more than 30% (of the total amount of protein intake) [5–10].

It is recommended to increase the amount of dietary fiber in the diet to 5–10% of the total amount of carbohydrates. The use of dietary fiber in the diet reduces the absorption of glucose in the intestine [11–16].
2. Research methods
To create the original database, mathematical planning of the Statistica v. 10 was used. The planning matrices were imported from the Industrial Statistics & Six Sigma block. Matrix forms were filled out in Excel. Neural network processing of the results was carried out using the Statistic Neural Networks v. 4.0e. The algorithmic language Pascal was used to compose the data arrays of the input variables. The structural-parametric model was developed in the Data Mining block.

3. Results and discussion
In everyday life, it is difficult to draw up the diet structure, since the amount and type of food consumed depends on many factors due to the individual characteristics of the human body. Let's compose a structural-parametric model (SPM) of the diet. At the initial stage, the body type is determined (variable “y”). The input variables in the neural network module are age (x₁), gender (x₂), height (x₃) and weight (x₄) (table 1).

| Variant No. | Age (x₁), years | Gender (x₂) | Height (x₃), cm | Weight (x₄), kg | Body type (y) |
|-------------|-----------------|-------------|-----------------|----------------|--------------|
| 1           | 20              | male        | 155             | 53             | normal       |
| 2           | 21              | male        | 152             | 51             | normal       |
| 6298        | 67              | female      | 180             | 77             | slim         |
| 10539       | 38              | female      | 160             | 69             | obesity 1 degree |
| 18900       | 69              | female      | 170             | 148            | obesity 3 degree |

To establish the body type, a database was created in the algorithmic Pascal language in accordance with the initial indicators shown in table 1 [2, 3, 4].

Interactive classification based on regression and simple extended trees is an effective means of establishing an individual's body type. (Statistica Data Mining Boosted Tree) (figure 1).

According to the input variables (age, gender, height and weight), the body type is established: normal, slim, obesity 1 degree (fat 1), obesity 2, 3 degree (fat 2, 3). When moving along the branches of the tree, one should answer questions in the nodes starting at the root.

Input variables marked with the letter “X” and a certain body type (table 1, figure 1) are used for neural network determination of daily requirements for energy (calories), protein (animal), fat and dietary fiber (figure 2). The obtained results and recommendations of nutritionists are used to determine the optimal recipes for meat products in an individual diet.
Figure 1. Determination of body type by the classification method.

The compositions optimal in terms of chemical and amino acid composition in the data array were determined in the neural network application sorting the output variable (in descending order) by the proportion of essential amino acids used for anabolic purposes.

The recipes of cooked sausages were developed and their main quality characteristics were investigated. The analysis of the developed formulations efficiency was carried out.

Figure 2. Determining the energy value of the need for protein and fat in individual diet.

To create a structural-parametric model, we used the resulting database (in our example, of 16 compositions), which made it possible to determine the optimal version of the meat product, its energy value and daily consumption rate, taking into account the individual characteristics of the human body (table 2).
Table 2. Calculation of the daily rate and energy value of meat products.

| Recipe variant No. | Need for animal proteins (x₁), g/day | Protein content (x₂), | Fat content (x₃), | Dimensionless indicator of efficiency | Energy value (y₁), kcal/100 g of product | Consumption norm (y₂), g/day | Energy value of the consumption rate (y₃), kcal/day |
|--------------------|--------------------------------------|------------------------|------------------|---------------------------------------|------------------------------------------|-----------------------------|-----------------------------------------------|
| 1                  | 44                                   | 15.7                   | 1.4              | 523.8                                 | 79.4                                     | 280                         | 222.3                                         |
| 2                  | 44                                   | 16.0                   | 1.0              | 573.3                                 | 77.0                                     | 275                         | 211.8                                         |
| 3                  | 44                                   | 15.7                   | 1.7              | 573.3                                 | 82.1                                     | 280                         | 229.9                                         |
| 4                  | 44                                   | 15.3                   | 2.1              | 543.6                                 | 84.1                                     | 288                         | 242.2                                         |
| 5                  | 44                                   | 15.5                   | 1.1              | 543.6                                 | 75.9                                     | 284                         | 215.6                                         |
| 6                  | 44                                   | 13.9                   | 2.7              | 517.2                                 | 83.9                                     | 317                         | 266.0                                         |
| 7                  | 44                                   | 13.6                   | 2.0              | 467.7                                 | 76.4                                     | 324                         | 247.5                                         |
| 8                  | 44                                   | 13.9                   | 2.2              | 467.7                                 | 79.4                                     | 317                         | 251.7                                         |
| 9                  | 44                                   | 13.8                   | 2.1              | 467.7                                 | 78.1                                     | 319                         | 249.1                                         |
| 10                 | 44                                   | 11.2                   | 2.1              | 350.0                                 | 67.7                                     | 393                         | 266.1                                         |
| 11                 | 44                                   | 14.3                   | 4.4              | 258.1                                 | 100.8                                    | 308                         | 310.5                                         |
| 12                 | 44                                   | 14.6                   | 14.7             | 380.0                                 | 194.7                                    | 301                         | 586.0                                         |
| 13                 | 44                                   | 11.8                   | 14.2             | 417.4                                 | 179.0                                    | 373                         | 667.7                                         |
| 14                 | 44                                   | 10.8                   | 12.6             | 258.1                                 | 160.6                                    | 407                         | 653.6                                         |
| 15                 | 44                                   | 11.6                   | 3.3              | 309.1                                 | 80.1                                     | 379                         | 303.6                                         |
| 16                 | 44                                   | 11.4                   | 13.4             | 414.0                                 | 170.2                                    | 386                         | 657.0                                         |
| 17                 | 44                                   | 11.7                   | 3.1              | 309.1                                 | 78.7                                     | 376                         | 295.9                                         |

The calculation results of table 2 were used as a database in the neural network module of the structural-parametric model. The factors or input parameters in the multilayer perceptron of the neural network were the consumption rate of animal protein (x₁), quantitative protein content (x₂) and fat (x₃) in the product used in the diet; the output parameters were the energy value (kcal) of 100 g of the product (y₁), daily consumption norm (y₂) and the energy value of the recommended consumption rate (y₃). The efficiency indicator in non-dimensional terms was used to identify the optimal formulation of the meat product.

To determine the most effective recipe option, consumption rates and the product energy value, it is recommended to use the modern Data Miner module, which includes artificial intelligence.

Figure 3 shows the developed structural-parametric model for food products composition design and the recommendations for their use in individual diets.

SPM structure includes three steps:
1 – to establish body type (classification method);
2 – to determine the need for protein, fat and calories of the daily diet (neural network modeling);
3 – to calculate the energy value and establish the daily consumption rate of the developed food product (neural network modeling).
Figure 3. Structural-parametric model for determining recommendations for meat products use in individual nutrition.

The output data obtained in the 1st step are the input variables of the 2nd step in the structural-parametric model; the output parameters of the 2nd step are used at the 3rd step for the development of recommendations for individual nutrition.

4. Conclusion
The food products recipe composition and recommendations for their use in individual nutrition can be determined in the following sequence.

- Using classification method, the body type of an individual is determined;
- Taking into account the body type, the nature of work, gender, weight and age, the need for animal protein, fat, and dietary fiber is established;
- Basing on calculations of need in essential ingredients and energy value, the optimal recipe and consumption rate of products is established;
- a structural-parametric model that allows to automatically develop recipes and recommendations for their use in individual nutrition is developed.

The proposed technique can be used to develop various types of food products for individual nutrition.

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