CALCULATION OF THE NUTRIENT BALANCE OF MULTI-COMPONENT MEAT PRODUCTS USING INFORMATION TECHNOLOGIES

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Abstract – This paper is devoted to the computer system for assessment of protein quality and balance. Protein substances are a plastic material that ensures construction of organelle structures. Protein deficiency in the body leads to impairment of its normal functions: memory loss, a decline in the intellectual abilities and reduced resistance to environmental external factors. Efficiency of protein utilization by the human body is conditioned by two main parameters: its balance by the essential amino acid content with regard to the FAO/WHO reference protein and efficiency of its participation in metabolism and protein utilization by human organs, tissues and cellular structures. Deficiency or absence of the essential amino acids in food causes the development of the negative nitrogen balance, dysfunction of the nervous system, stunt and, in the most severe clinical conditions, the development of avitaminosis. Deficiency of only one essential amino acid can lead to incomplete intake of others. This regularity is subjected to the law of Liebig. The developed computer system allows targeted and rapid assessment of products by the amino acid balance.

Key Words – meat products, protein quality assessment, amino acid score, biological value.

I. INTRODUCTION

Nowadays, information technologies occupy new spheres of human activities and adopt novel developments in the field of physics, chemistry, biology and mathematics. Today, no comprehensive research can be carried out without the use of information technologies: work of a scientist (user) in the mode of data manipulation; end-to-end information support at all stages of information processing using databases; interactive (dialog) mode of task solving with broad possibilities; possibility of collective document execution based on a group of personal computers linked by communication means. The concept of new information technology is based on three main principles: integration, flexibility and interactivity.

Information technologies have been increasingly introduced into the meat industry. These are the multitask robots that manage the production process, program complexes that allow optimizing business processes and one-task programs intended for solving specific objectives.

The main task of the study was to use information technologies (or programming) to develop multi-component products balanced by amino acid composition according to the requirements of the human body and to improve their quality while reducing production expenses.

II. MATERIALS AND METHODS

The computer program "Calculation of nutrient adequacy of multicomponent meat products" was developed in the software development environment Embarcadero Delphi 2010. The program was tested on a personal computer with the Microsoft Windows 7 64-bit Operating System. The work with the program (Fig. 1) begins after launching the executable file dFoodstuff.exe.

The developed program with a database will ensure computer-based solving of such tasks as calculation of quantitative and qualitative indicators of a food product, calculation of the total chemical composition and nutritive, biological and energy values.

Based on current regulatory documents and according to the requirements for the physico-chemical composition of meat products, the program allows calculating the recipes with consideration for a high number of assessment factors. To this end, a computer technology for maintaining a constantly expanding bank of knowledge about products and their characteristics was developed.

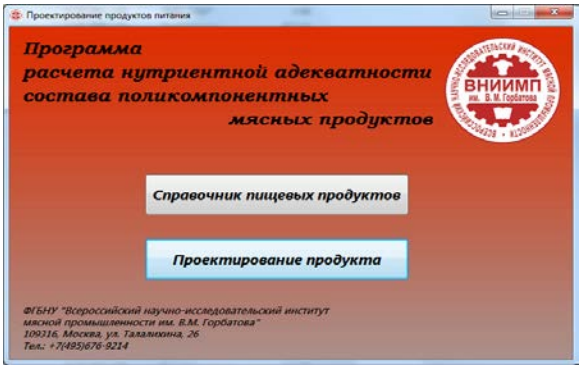

Figure 1. Program interface at launching

When developing databases, we used a component of the object-oriented environment Delphi 7 – Database Desktop, which allows creating tables, changing table structures and editing data. When designing the database, we used the relational model, which, so far, has been the most common and is well suited for solving set tasks. The advantages of this model are simplicity, structural flexibility and convenience of its use.

The database contains information about the chemical composition of meat raw material and ingredients used in designing combined meat products.

The program database includes "Reference book of food chemical composition" for meat product manufacture:

- The database of amino acid composition contains information about quantitative content of the essential and non-essential amino acids;
- the database of fatty acid composition includes the data on the presence and content of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA);
- the database of carbohydrate composition includes the data on monosaccharides, disaccharides, hydrolysable and non-hydrolysable polysaccharides;
- the database of vitamins contains the data on water soluble vitamins including vitamin C (ascorbic acid), B_1 (thiamine), B_2 (riboflavin), B_4 (choline), B_5 (pantothenic acid), B_6, B_9 (folic acid), B_{12} (cobalamine), PP (niacin), N (biotin) and fatty acid vitamins A,D,E.
- the database of minerals includes information about mass fractions of macro- and microelements.

Another method of biological value determination consists in determination of an essential amino acid (EAA) index. The method is a modification of the method of chemical score (Oser, [2]) and allows taking into account the amount of all essential amino acids.

In the program "Calculation of nutrient adequacy of multicomponent meat products", the qualitative composition of the protein component is determined using the coefficient of comparable redundancy (G), coefficient of amino acid score differences (KRAS), utility and biological value. The amino acid score establishes a maximally possible level of using nitrogen of this kind of protein for the plasticity purposes. An excess of other amino acids in a protein composition will be used either as a source of non-specific nitrogen or for energy requirements of the body [3].

The coefficient of amino acid composition utility (U) quite fully reflects a balance of the essential amino acids (EAA) with regard to the ideal (reference) protein.

III. RESULTS AND DISCUSSION

Let us examine a qualitative assessment of amino acid balance in an emulsified meat product as an example of system operation. The initial data presented in Table 1 were taken from the methodology guidelines [4].

Raw material and ingredients	Recipe, %	
	Control	Experiment
Trimmed beef, 2nd grade	48	35
Semi-fat pork	30	23
Trimmed fat pork	20	20
Starch	2	2
SUPRO-651	-	4
Water (for hydration)	-	16
Total	100	100

Table 1: The recipe of the combined emulsified meat product

An algorithm of the calculation module (Fig.2) of the computer system at the first stage allows a technologist to choose components from a database according to the following traits: a chemical composition, functional properties capable to significantly influence the balance of fat:protein upon their variation; structural and mechanical properties of the obtained system, and organoleptic indicators of a finished product. Then, it is necessary to indicate mass fractions of each component in a recipe of a combined meat product.

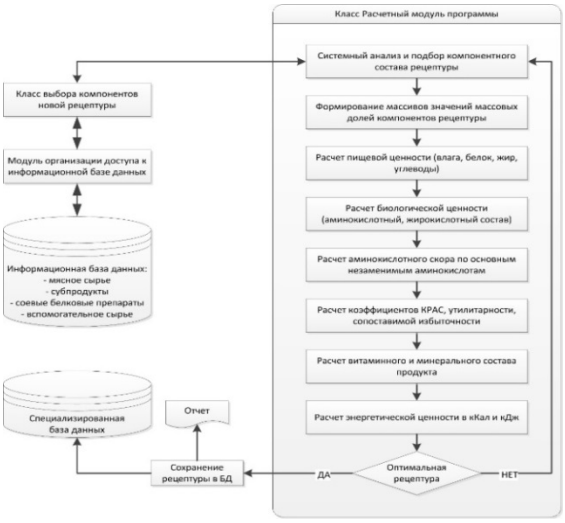

Figure 2: Functional scheme of the generalized algorithm of the calculation module

After launching the program calculation module, the window “Product design” opens (Fig. 3-4).

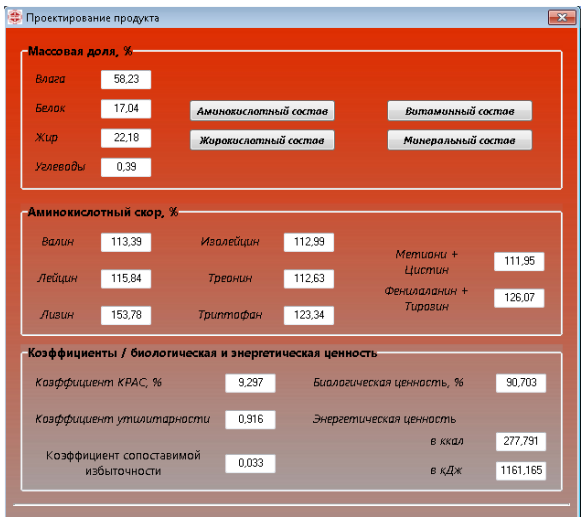

Figure 3: The window “Product design” (control)

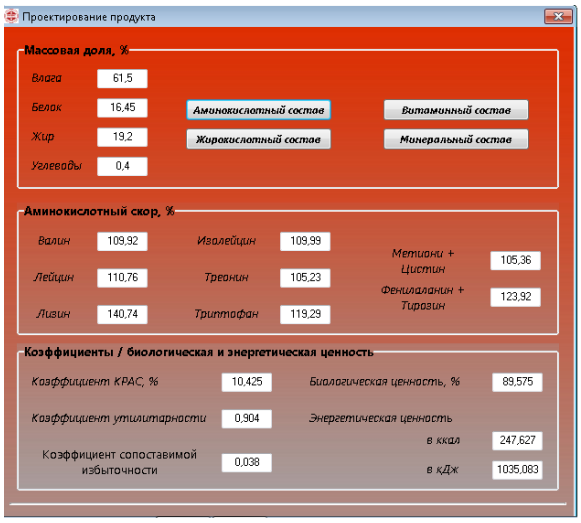

Figure 4: The window “Product design” (experiment)

As can be seen from Fig. 3 and 4, the display form presents mass fractions of moisture, protein, fat, carbohydrates, the amino acid score of the essential amino acids, coefficients of KRAS, utility, comparable redundancy, biological and energy value of a product under design (control and experiment). A technologist can also view an amino acid, fatty acid, vitamin and mineral composition of a product by clicking the corresponding buttons. Table 2 presents the amino acid composition of the combined meat product.

Indicators	Control	Experiment	Reference protein, FAO/WHO, % to protein
Essential amino acids, g/100 g protein			
Valine	5.67	5.50	**5.00**
Leucine	8.11	7.75	**7.00**
Lysine	8.46	7.74	**5.50**
Isoleucine	4.52	4.40	**4.00**
Threonine	4.51	4.21	**4.00**
Tryptophan	1.23	1.19	**1.00**
Methionine+ cystine	3.92	3.69	**3.50**
Phenylalanine+Tyrosine	7.56	7.44	**6.00**
Non-essential amino acids, g/100 g protein			
Alanine	5.66	4.55	
Arginine	5.71	4.62	
Histidine	3.76	3.04	
Glycine	5.00	4.02	
Proline	4.34	3.55	
Serine	4.31	3.47	
Oxyproline	1.51	1.21	
Glutamic acid	16.04	12.88	
Aspartic acid	9.33	7.49	

Table 2: Amino acid composition of the combined emulsified meat product

Based on the obtained data, a technologist or a person responsible for decision-making can come to a conclusion about an influence of soy protein components and collagen containing raw material that are incorporated into recipes on the total chemical composition, amino acid composition of a protein component and energy value of a finished product.

IV. CONCLUSION

Information technologies are meant to be assistants of specialists, in particular, those who work in the meat industry. Among these specialists, technologists play an important role. They are not required to have knowledge in the field of the computation technique and possess a good mathematical apparatus. Integration between technologists, information technologies and methods of mathematical and statistical analysis is necessary. Then, it will be possible to increase quality of manufacturing products, which have to correspond to the modern world level.

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