IMPROVEMENT OF THE METHOD OF DESIGNING BIOLOGICAL VALUE OF FOODSTUFFS

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Fundamental research in the field of mathematical designing of foodstuffs, and especially their biological value, by I. A. Rogov and N. N. Lipatov (Jr) are associated with formalization of qualitative and quantitative conception about rational utilization of essential aminoacids as contained in proteins of these foods (1,2). In their publications these scientists persist that all the logic constructions as used for such formalization are made with the assumption that the proteins of foodstuffs are subjected to full proteolysis in gastrointerstinal tract.
Ideal character of such conception is corrected for with the help of experimental determination of theoretical calculation of proteins digestibility of the foodstuffs designed.
In the present article an attempt has been made to combine mathematical methods of amino acid composition calculation and digestibility of total protein of multi-component mixes (I. A. Rogov, N. N. Lipatov (Jr) with the participation of S. B. Yudina).
There is an apriori information about digestibility and aminoacids composition of proteins that are contained in i-th kinds of raw materials, as used for the production of multicomponent food products (3). The digestibility of this protein is characterized by numerical index π_i, as measured in mg tyrosine/g protein.
According to works of (4,5), the characteristic of protein digestibility of i-th component can be calculated according to the following formula:

$$k_i = \frac{\pi_i}{10 \cdot T_i}, \qquad (1)$$

where T_i - mass fraction of tyrosine in protein of the i-th component (g/100 g protein)
10 - dimensionless coefficient of proportionality.
The equivalent of digestibility of total protein of multicomponent mixture can be determined from the following balance equation:

$$\sum_i^n x_i k_i p_i = k_p \sum_i^n x_i p_i \text{ , where} \qquad (2)$$

x_i - mass fraction of i-th component in mixture, fract. unit;
p_i - mass fraction of protein in i-th component, % or fract. unit;
k_p - equivalent of digestibility of total protein of multicomponent mixture, fract. unit;
n - number of components relating to k_p.
When solving this equation one can easily obtain:

$$k_p = \frac{\sum_i^n x_i k_i p_i}{\sum_i^n x_i p_i} \qquad (3)$$

Total mass fraction A_j of j-th aminoacid in digested protein of the multicomponent mixture can be found by the following formula:

$$A_j = \frac{\sum_i^n x_i k_i p_i a_{ij}}{\sum_i^n x_i k_i p_i}, \text{ g/100 g of protein} \qquad (4)$$

where a_{ij} - mass fraction of j-th aminoacid in protein of i-th component, g/100 g protein.
For the theoretical analysis of conversion of j-th aminoacids in protein of multicomponent mixture as a result of its digestibility a modernized version of formula (4) can be interesting:

$$A_j = \frac{\sum_i^n x_i k_i p_i a_{ij}}{\sum_i^n x_i p_i}, \text{ g/100 g of protein} \qquad (5)$$

which numerically characterizes a total mass of j-th aminoacid contained in digested protein related to initial protein. Similarly with the equivalent of digestibility of the total protein of multicomponent mixture a conception of the equivalent of "digestibility" of its j-the acid can be introduced. The formula for the calculation of this

equivalent can be derived from the following equation mathematically describing the material balance:

$$A_j = \frac{\sum_i^n x_i k_i p_i a_{ij}}{\sum_i^n x_i k_i p_i} = k_j \frac{\sum_i^n x_i p_i a_{ij}}{\sum_i^n x_i p_i}, \quad (6)$$

where k_j - equivalent of digestibility of j-th acid, fract. unit.
Elementary algebraic transformations suggest the following solution of this equation:

$$k_j = \frac{\sum_i^n x_i k_i p_i a_{ij}}{\sum_i^n x_i p_i a_{ij}} \cdot \frac{\sum_i^n x_i p_i}{\sum_i^n x_i p_i k_i} \quad (7)$$

Analysing the formula (7) taking into account the formula (3) one can notice that correlation of right cofactors of its denominator and numerator is nothing more than k_p.
This thing will make it possible to suggest one more formula for the calculation of digestibility equivalent of j-th acid:

$$k_j = \frac{\sum_i^n x_i k_i p_i a_{ij}}{k_p \sum_i^n x_i p_i a_{ij}} \quad (8)$$

Analysis of this formula will permit to make a qualitative conclusion (completely not evident from the speculations) that the equivalent of digestibility of j-acid of total protein of the mixture is proportional to the individual digestibility of protein of its j-th components and inversely proportional to the equivalent of digestibility of its total protein.
Developing further the idea about necessity of taking into account individual digestibility of every component of multicomponent mixture during designing its biological value, realized step-by-step in mathematical relationships (4-8) the authors propose the following formula for modelling the influence of correlation of protein-containing components and their digestibility on amino acid composition of total protein:

$$A_j = \frac{\sum_{i=l+1}^{n} x_i \sum_{i=1}^{l} x_i k_i p_i a_{ij} + \left(\sum_{i=l+1}^{n} x_i - Y\right) \sum_{i=l+1}^{n} x_i k_i p_i a_{ij} + y \sum_{i=l+1}^{n} x_i \sum_{i=m+1}^{n} x_i k_i p_i a_{ij}}{\sum_{i=l+1}^{n} x_i \sum_{i=1}^{l} x_i k_i p_i + \left(\sum_{i=l+1}^{n} x_i - Y\right) \sum_{i=l+1}^{n} x_i k_i p_i + y \sum_{i=l+1}^{n} x_i \sum_{i=m+1}^{n} x_i k_i p_i}, \text{where} \quad (9)$$

n - total number of ingredients, entering the recipe;
l - number of ingredients, that are not variable during modelling;
m-l - number of ingredients, that are variable (changeable) during modelling;
n-m - number of ingredients, that act as changing ingredients during modelling:

$$\sum_{i=1}^{l} x_i = 1; \qquad \sum_{i=m+1}^{n} x_i = 1;$$

Y - total mass fraction in the recipe of ingredients variable during modelling:

$$Y \leqslant \sum_{i=l+1}^{n} x_i$$

The rest of the designations are the same as in formulae (1-4).
The qualitative concepts as stated above about the influence of digestibility of individual ingredients of multicomponent food mixtures on potential utilization of their total protein and essential aminoacids contained in them make it possible in a quite a new manner to interpret a balance approach to quantitative determination "in vitro" of their biological value. In accordance with this interpretation biological value of protein of a multicomponent food mixture should be characterized by the information about mass fractions of essential aminoacids in potentially digestible part of this protein.

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