The Use of Complex Quality Criterion for Optimization of Meat Products Formulations

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SUMMARY: Calculation method for development of optimal meat products formulations, based on integrational principle of linear programming and on method of complex quality evaluation was proposed. This method includes: plotting of scales of desirable quality parameters; calculations of formulations on the basis of simplex-method; calculation and evaluation of quality indices of the product, not accounted during determination of limits; calculation of complex quality index of formulation; maximization of complex criterion through purposeful change of limitations of individual quality indices of product and/or ingredients.

INTRODUCTION: The aim of optimization of meat products formulations is determination of composition, as close to ideal one as possible. At this, the task is formulated for determination of extreme point of some linear function (nutritive value, calories, content,cost, etc.) during establishment of limits on content of individual ingredients and elements of chemical composition (moisture, fat, protein, aminoacids, etc.) in a formulation mix (Ivashov et al.,1989).

However, during resolution of the given task, certain difficulties arise: 1. The whole complex of limitations of final product properties is contradictory. 2. Only limited number of requirements is taken into account, and for that reason the obtained formulation may not correspond to initial reuqirements by parameters, not included into limits.

For depicting of products quality, characterized by a number of properties, it is worth using complex criterion, being function of integral and/or individual indices:

$$K_0=f(K_1, K_2,\dots,Kn),$$

where K_o - is complex criterion of products quality;

$K_1,K_2,\dots,K_n$ - individual and/or integral quality indices.

Integral indices are calculated as compared to individual ones, and they allow to control quality of the product by its components: protein, fat, moisture, microelements,etc. Integral indices include functional properties, ratio of protein balance, ratio of polyunsaturated and saturated fatty acids, etc. Values of such indices may be obtained only after calculation of formulation and computer processing of separate indices values. For that reason their requirements cannot be introduced as limitations as it is done for individual indices, their values should be controlled separately.

MATERIAL AND METHODS: We propose a method for calculation of optimal formulations based on integrational principles of linear programming and calculation methods for complex quality criterion.

In the proposed method product quality is depicted with the use of multiplication model, based on generalized Harrington function of desirability (Ivashov V .I. et al., 1990).

Method includes several stages:1. Purpose of new product criterion is formulated and requirements to it are listed(medico-biological, technological, economical,etc.). Then purposeful function to optimization of formulation is chosen; the main requirement for this function being possibility of its measurement(quantitative expression) for each individual ingredient and final product.

A widely spread optimization method is presented, based on criterion of least cost of raw material: $C = \sum_{j=1}^{k} y_j x_j \rightarrow min$

where C - is cost of raw material in roubles;

Y_j-actual(normative price of j ingredient, roub.;

x_j-weight of j ingredient (value to be determined),kg;

k -amount of ingredients in formulation.

2. List of ingredients is determined, suitable for manufacture of a concrete product, according to initial requirements. For this purpose additional experiments are performed, during which purpose of product developments are considered, as well as requirements to products quality and rational use of raw material, and a range of other conditions.

3. Limitations on ingredients are chosen with the account of effect of certain ingredients and their chemical composition on quality of a product, and possibility of their quantitative interchangeability.

4. Considering initial requirements to the product, scales of desirability are plotted for each quality parameter(Kalinina E.K. et al.,1989).

5. Limitations for individual indices of product quality are selected (those that could be introduced as limits) according to plotted scales of desirability and approachable level of the appropriate quality of the new product. For that, upper and lower limits of desirability scale are determined.

For example, if purposes of product development assume, that values of protein content could be assessed as "satisfactory", then the folowing scale limit could be selected: d=0.37 $9.5 \leq P \leq 13.5$(g/100g).

However, if importance of this index is higher than importance of other indices, more strict: limits could be established: $10.5 \leq P \leq 12.5$(g/100g).

6. Initial data are introduced,simplex table formed and computed, resulting formulation is printed, as well as value of purpose function and values of individual quality indices of the product, which are predicted during its manufacture.

7. Particular d-functions for individual indices were evaluated for formulation obtained on stage 6.

8. Calculations of integral quality parameters of the product, depending on separate indices, were performed.

9. Limitations of calculated indices are checked. If values of calculated indices satisfy the specified $P_j > P_{ja}$ condition then it is possible to proceed to calculation of complex D-criterion (stage 10). If values of calculated indices do not comply with the specified condition, it is necessary to change limitations of indices. This procedure is valid for those individual indices which are included in calculated ones. Change of limitations is completed when the specified condition is fulfilled, or when limits of all indices are changed. After that we can proceed to stage 10.

10. Complex index is calculated, according to formula: $D= \sqrt[n]{d_1 \cdot d_2 \dots d_n}$,

where D - is a complex criterion of quality;

$d_1, d_2, \ldots d_n$ - particular functions of desirability for individual and integral indices.

11. Value of complex D-index is checked, wether it satisfies $D_{i+1} - D_i \geq \Delta$spec, condition, where D_{i+1}, D_i - is complex quality index on i and (i+1) step of calculation of formulation. (At step 1 D_i is taken by analogue of developed formulation); Δspec - specified superiority level by quality of the developed product. Δspec value is chosen, depending on purposes of product creation (for example, product for mass production, dietetic produc) and according to desirable level of quality.

Obviously, if lower limit on scale of desirability D is, as a rule, not lower than 0.37, for complex criterion this limit must be situated a bit higher. For created product is should be not lower than 0.5. In case of specialized products(dietetic food) limit is o.63 and higher.

Thus, Δspec must be established by professionals-manufactures.

If complex criterion value satisfies specified condition, then calculated variant of formulation is adopted and it is possible to proceed to stage 12.

If value of complex criterion (irrespective of limits change) stays low and does not satisfy specified condition, further improvement of quality becomes possible,if: limitations are changed into individual indices, not influencing values of calculation indices; ingredient limitations and list of ingredients are changed.

Change of limits on indices is organised in the following way: procedure starts from those indices for which d-values are close to $d_{min.}$ and goes on until complex index satisfies the required condition.

If in course of calculations limitation changes of all indices were introduced, and values of calculated indices do not satisfy specified requirements, then it is necessary to start change of limitations of content of ingredients and their list, which might influence level of indices. If all possible changes of ingredients are done and further change is not possible, we should proceed to stage 12.

12. Resolution about accomplishment of calculations is taken, after that the following information is printed: alternative variants of formulation (from the most acceptable); value of purpose function; values of final product characteristics, which are predicted during its manufacture by those variants of formulation; values of particular d-functions, of calculated indices and complex D criterion of quality.

CONCLUSION: The proposed method enables a technologist, using personal computer in a dialogue regime, to aobtain different variants of new products formulations, compare them and purposefully approach the developed product to the "Ideal" one.

Among the advantages of this method one can list: possibility of account of greater amount of limitations individual and integral(calculated) quality indices; use of nondimensional non-linear scales of desirability, reflecting correspondance of individual indices to initial requirements and easily interpreted in terms of usefulness; introduction of complex criterion in multiplication form, allowing to depict general correspondance of formula-tion to initial requirements.

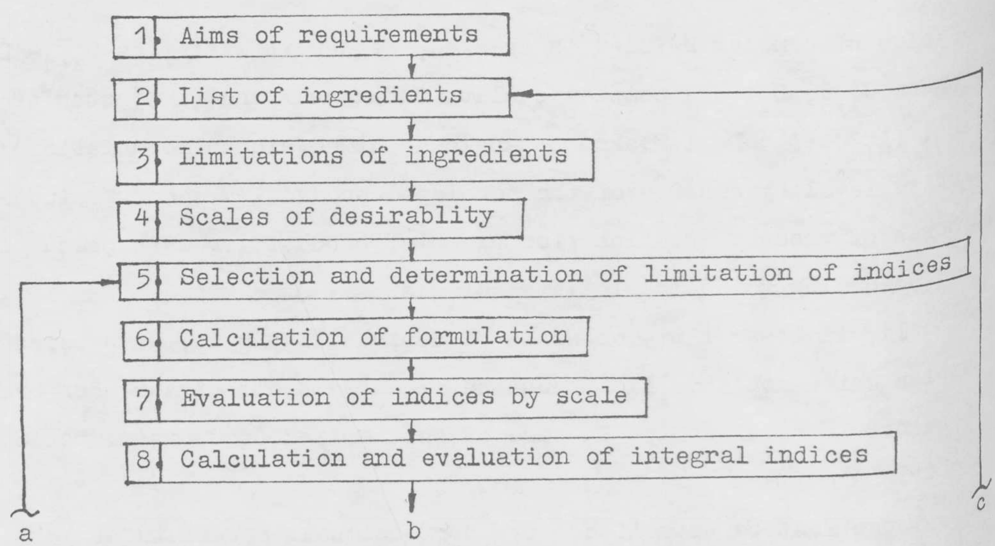

Fig. Algorythm of calculation of formulation

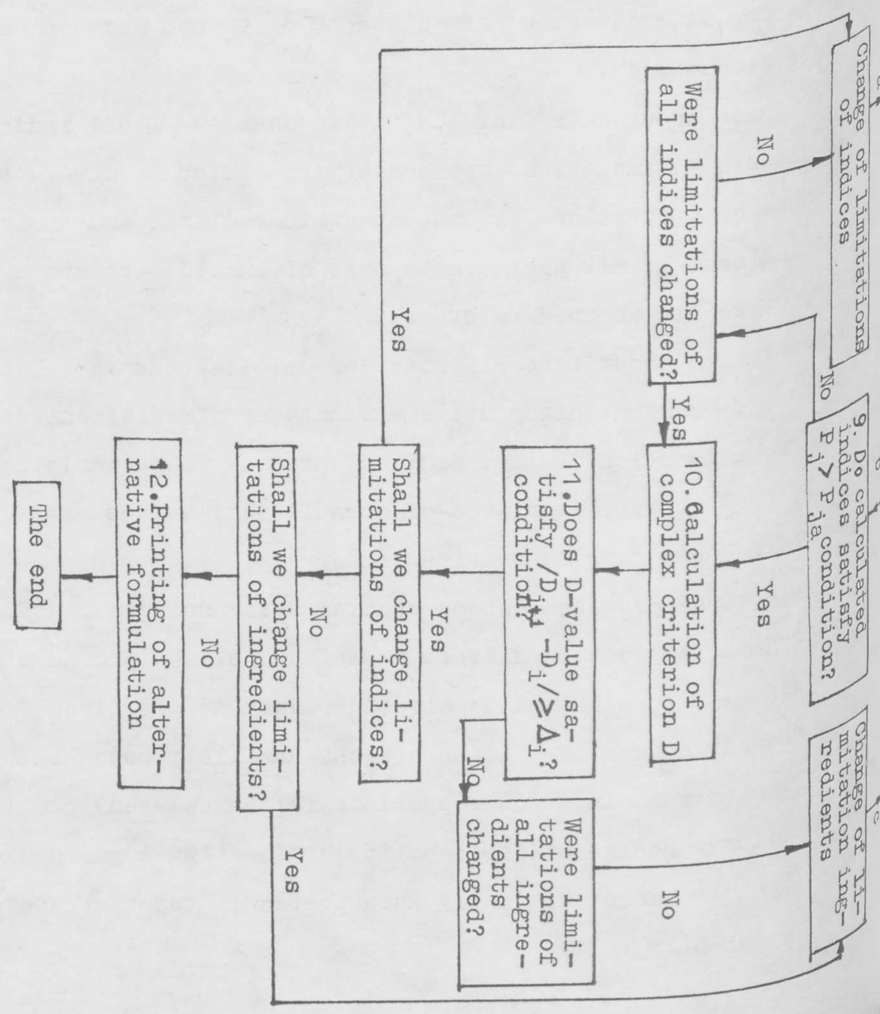

Fig. 2. Algorythm of calculation of formulation (continuation).

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