EFFICIENCY OF PRODUCTION OF ECOLOGICALLY PURE FOODS

N.N. LIPATOV, Z.M. TSNITISHVILI, L.N. LIPATOVA

The Moscow Academy of Applied Biotechnology

Talalikhina 31, Moscow 109316, Russia

A.B. LISITSYN

The All-Russian Scientific Research Institute of Meat Industry

Talalikhina 26, Moscow 109316, Russia

The research work is dedicated to the choice, grounds and systemic analysis of dominant factors influencing the complex quality of technological processes and the effective production of a new generation of the ecologically pure food for rationalizing the dietary structure of determined groups of population. Classification of dominant factors ranged on two hierarchical levels as well as corresponding mathematical criteria for computer operating those factors are proposed. The concept of the complex quality of technological process carried out on different stages of the food production is introduced and necessary mathematical criteria are given. Ways of approach are stated and a criterion of evaluating the integral quality of ecologically pure food is proposed. In the given research, we used some new concepts concerning different aspects of the food production which are not popularized in special technical research, patent and advertising literature and differ to a certain extent from generally accepted notions. However, necessary wording and explanations are given in each concrete case. Thus, "Dominant Factors" term is used for limiting the multiplicity of moving forces created in technological processes or influenced on the course of causes to those, quantitatively definable changes of which, leads to a commensurable or even greater change of "the complex quality" of these processes. Moreover "the complex quality" notion includes also technologically functional properties of the processed raw material as well as consumers' properties of ready products. It does not contradict the statement that a most modern (from technical positions) process is not so perfect by its complex quality as traditional technologies if foods prepared by means of modern processes have worse consumers' characteristics. The same statement relates to the food production effectiveness on the whole.

Considering these positions, subsequent choice and system analysis of dominant factors influenced on the complex quality of technological processes and effectiveness of ecologically pure production of the new generation of foods are carried out. As a result the classification of dominant factors ranged them on two hierarchical levels.

Classification of dominant factors influenced on the production effectiveness of the ecologically pure foods (classification of the first hierarchical level) is shown in the diagram (Fig. 1). In spite of the fact that the proposed diagram is limited by two stages, in fact it is quite reasonable to attribute it to a three-stage one according to modern notions of the theory of classification (Kedrov B.M., 1961-1965).

The first stage of this classification includes general classes of factors reflected functional and economic interaction between industrial enterprise-processor of the food raw material and its producers on the one hand and commercial organizations realized the ready production on the other hand. These classes include storing, production and commercial factors. The second stage includes nine groups of factors detailed the above mentioned classes.

So far as raw-material, organizational, technical, and technological groups of factors will be detailed in the classification of the second hierarchical level, only five groups remained are considered.

The group of transport factors related to the storing and commercial classes includes such factors of the third stage as route, volume, temporal, and sanitary-ecological ones.

The group of price - estimating factors related to the storing and commercial classes includes the following factors: the level of purchase prices, structure of purchases, level of wholesale prices.

Fuel and power factors are marked out as an independent group in the class of production factors. This group envelops factors influenced upon the effective functioning of such important production subunits as boiler-house, compressors' house, water supply and power supply and in any case each of them are used practically in all technological cycles. This group includes structures, temporal, climatic and other factors.

Sanitary and ecological factors predetermine not only the potentiality for realizing as any production processes as the functioning of the whole production, but its prosperity and the possibility of existence as for producers and for consumers (Lipatov N.N., Lipatova L.N., Antonian A.A., 1990). The Chernobyl tragedy may be the example of the above said. The diagram given in Fig. 2 reflects to a certain degree the classification of sanitary and ecological factors. While considering the group of sanitary and ecological factors as a whole class according to this diagram, we may determine three main subclasses which envelope in its turn fourteen groups of factors. Each factor may be quantitatively characterized. This class of factors is wrongly ignored by researchers, specialists of this branch of industry, financial and inspection bodies by evaluating the effectiveness of the food production. In spite of the fact that nowadays we have a number of interpretations for the notion of effectiveness as well as a lot of numeral criteria for its evaluation, we use exclusively economic factors and indices. To fill up the gap, a fundamentally new criterion is offered. This criterion lets quantitatively link economic indices with sanitary and ecological prosperity of the production:

$$EI = \left\{ \frac{SP}{SP_f} \cdot \left(\prod_{i}^{n} \frac{SPol_{if}}{SPoli} \right) \left(\prod_{i}^{m} \frac{aP_{if}}{aPi} \right) \times \left(\prod_{i}^{k} \frac{SMBC_{if}}{SMBC_i} \right) \right\}^{\frac{1}{n+m+k+1}} \quad (1)$$

where $SP = \frac{VCO - PC}{VRM}$ is specific profit for a definite period of time, Rb/tons; VCO is volume of commodity output for a definite period of time in terms of money, Rb; PC is prime cost of the commodity, Rb; VRM is volume of stored raw material spent for the commodity output, tons; SP_i is "i" factor from the subclass of the sewage pollution, %; aP_i is "i" factor from the subclass of the airborne pollution, %; $SMBC_i$ is "i" factor from the subclass of the sanitary and microbiologic contamination expressed in corresponding measurement units. "f" index in the denominator or numerator means that given indices and factors are related to the fundamental version and are average statistical ones on the basis of a republic, region or country.

Factors of other eight subclasses shown in Fig. 2 are not used in the formula (1) but they are dominant because of their direct influence upon values of such economic indices as the profit and prime cost.

Classification of dominant factors influenced on the complex quality of technological processes (classification of the second hierarchial level) is shown in diagram (Fig. 3). In this case "complex quality of technological process" means:

- the quantitative characteristic enveloped groups of integral indices concerning expenses of material carriers, power, and raw material spent by the realization of fundamental and comparable process;
- groups of integral indices concerning functional and technological properties of the raw material treated by means of these processes;
- group of integral indices concerning consumer properties of a ready product made by means of them.

This classification has four general stages and does not require any additional comments. It permitted to advance in realizing the potentiality of quantitative evaluating the technological processes.

Elaboration of factors classification grounded on and arisen from its analysis occurred to be an important stage in this trend, if to take into account that above mentioned factors exert influence on the complex quality and classification of corresponding indices contained (Fig. 4).

Hence, as appears from the above formulated notion of the complex quality, the first stage classification contained complex quality indices and as a separate subclass envelops indices related to consumer properties of ready products. Their detailed analysis is carried out on the second stage included three main groups. As a result this subclass occurs to be practically exhausted in full. While indices related to organoleptic and sanitary groups appear to be quite usual for specialists, indices related to the group of medico-biological factors are to be detailed. Since the protein and fat (Howard Roberts, 1986; Belenkiy N.G.,1989; Lipatov N.N., 1988; Emmanuel N.M., Zaiko G.E., 1986) are the most valuable nutrients of food products (in particular, made of the animal raw material), then the protein digestion in vitro, rationality of its aminoacid composition and adequate correlation between saturated, mono- and polyunsaturated fatty acids (Lipatov N.N., 1985; Lipatov N.N., Zharicova S.B., 1990) may be used as generalized indices of the medico-biological adequacy. These indices will be used then in the offered numeral criterion of the complex quality. In a symbolic mathematical form this criterion reflects the essence of conclusion made as a result of the comparison between two classifications described above: the more stable is the technological process in relation to the negative change of dominant factors, the higher is its complex quality. Using a computer or calculator, the quantitative calculation may be carried out by the formula:

$$K_\sigma = \left\{ \left(\prod_i^{\alpha} \frac{\Delta OXC_i}{\Delta OXC_{i\sigma}} \right) \left(\prod_i^{\beta} \frac{\Delta \Phi T_i}{\Delta \Phi T_{i\sigma}} \right) \left(\prod_i^{\gamma} \frac{maxC\text{Э}_i}{maxC\text{Э}_{i\sigma}} \right) \left(\frac{KO_\sigma \cdot \Gamma_\sigma \cdot \text{Э}_\sigma \cdot M_\sigma}{KO \cdot \Gamma \cdot \text{Э} \cdot M} \right) \times \right.$$

$$\times \left(\frac{\text{УА} \cdot \text{УМ}}{\text{УА}_\sigma \cdot \text{УМ}_\sigma} \right) \frac{G}{G_\sigma} \left(\prod_i^{r} \frac{\Phi T_1}{\Phi T_{i\sigma}} \right) \left(\prod_i^{\varepsilon} \frac{M_{i\sigma}}{M_i} \right) \left(\prod_i^{f} \frac{O_i}{O_{i\sigma}} \right) \times$$

$$\left. \times \left(\prod_i^{\varepsilon} \frac{M\text{Б}_{i\sigma}}{M\text{Б}_i} \right) \cdot \left(\frac{\pi \cdot R^P \cdot R^L}{\pi_\sigma \cdot R^P{}_\sigma \cdot R^L{}_\sigma} \right) \right\}^{\frac{1}{\alpha+\beta+\gamma+r+\varepsilon+f+\xi+10}} \quad (2)$$

where: $\Delta\ OXC_i$ is permissible scatter of a mass quota of the fat, protein, carbohydrates, moisture in the original raw material, % of mass quota;

$\Delta\ \Phi T_i$ is permissible scatter of values defined functional and technological properties of the raw material (e.c. pH, water holding ability, dissolvability, etc), % to the absolute value;

$max\ C\text{Э}_i$ is maximum permissible level of contamination of the original raw material by "i" species substances microorganisms in the course of the technological process, % (or any other measurement unit);

KO is number of the service personnel necessary for carrying out the technological process, units/tons of the general raw material;

Γ are measurements of apparatus and devices required for carrying out the technological process, m/tons of the general raw material;

$\text{Э} = \sum_i^{w} \text{Э}_i$ is summary power expenditure of "i" kinds, MJ/tons of the general raw material;

$M = \sum_{i}^{k} M_i$ is summary expenditure (losses) of power carriers and water, tons/tons of the general raw material;

УА, УМ is the level of automation and mechanization of the technological process, %; G is the output, tons of the general raw material per hour;

$ФТ_i$ is the value of a determinant functional and technological property acquired by the raw material (half - finished product) in the course of the technological process (measurement unit correspondent to "i" property);

O_i is "i" index of organoleptic properties determined by the way of experts evaluation, scores';

$МБ_i$ is "i" index of the sanitary and microbiological contamination of ready product (half - finished product);

P is protein digestion in vitro of the ready product prepared by the use of any concrete technological process, % to the initial tyrosine;

R^P is the rationality coefficient of this protein aminoacid composition, unit quota; R^L is adequancy coefficient of the fattyacid composition of the product, unit quota (values of R^P and R^L may be calculated by means of formulas offered by Lipatov N.N., junior).

Integral criterion of the food products quality. Comparing the quality of food products (e.c. meat products), the consumer evaluates usually its appearance and state on the cut, consistency, juiciness, flavour and aroma. This method seems to be simple and natural. However it does not envelope inner properties concerning the biologocal value of the food product, and their correspondence to the metabolism specificity, their harmless state, etc, which appeared to be even more important than organoleptic properties.

As regards the quantitative evaluation of the commodity output, M.D.Burtein (Burtein M.D., 1083) offered a formula made out on basis of the heuristic analysis and destined for calculating a numeral index for the integral quality of the production estimated.

$$Q = (Q_1^{\alpha 1} \cdot Q_2^{\alpha 2} \cdot \ \ldots \ \cdot Q_n^{\alpha n})^{0,5n} \cdot (Q^{\alpha}_{min})^{0,5} , \qquad (3)$$

where Q_1 is numeral quality characteristic of "i" parameter, unit quota; $0 \leq Q \leq 1$; α_1 is index of quality importance of "i" parameter, unit quota, $0 \leq \alpha \leq 1$; Q_{min} is minimum of numeral quality characteristics of all unit parameters, unit quota; "n" is number of unit parameters which are used for evaluating the quality.

Mathematic and statistical sense of the formula (3) lies in the fact that it is the quadratic mean of weighted medio-harmonic quality of all parameters concerning the evaluating production.

In conformity with food products, 21 differential parameter of quality indices are chosen and 12 of them are absolute ones (by evaluating the quality of a food product these parameters are not compared with similar indices of the standard sample), but other 9 of them are relative ones (by calculating these parameters we use several other parameters similar to the standard sample) (Lipatov N.N., Lipatova L.N., Antonian A.A., 1990):

$P_1 = P$ protein digestion in vitro unit quota to the initial tyrosin;

$P_{13} = \frac{P_x}{P_s}$ - protein

$P_{14} = \frac{L_x}{L_s}$ - fat

$P_2 = R$ rationality coefficient of the aminoacid composition, unit qiota;

$P_3 = C_{min}$ is minimum score, unit quota;

P_{4-9} is $\frac{OLP}{5}$, organoleptic scores;

fatty-acid composition:

P_{10} is $\frac{\Sigma SFA}{0.3}$

P_{11} is $\frac{\Sigma MUSFA}{0.6}$

P_{12} is $\frac{\Sigma PUSFA}{0.1}$

structural and mechanical:

$P_{15} = \frac{\Theta_x}{\Theta_s}$

$P_{16} = \frac{\tau_x}{\tau_s}$

$P_{17} = \frac{\Theta_{ssx}}{\Theta_{sss}}$

$P_{18} = \frac{A_{scx}}{A_{scs}}$

indices of harmless state:

$P_{19} = \frac{BC_s}{BC}$

$P_{20} = \frac{TC_s}{TC}$

$P_{21} = \frac{RAC_S}{RAC}$

Σ SFA is sum of saturated fatty acids, unit quota of the product fat;

Σ MUSFA is sum of monounsaturated fatty acids, unit quota of the product fat;

Σ PUSFA is sum of polyunsaturated fatty acids, unit quota of the product fat;

P_x, P_s is mass quota of protein in the compared sample and standard sample, correspondingly, %;

L_x, L_s is mass quota of fat in the compared sample and standard sample, correspondingly, %;

Θ_x, Θ_s is stress of standard penetration on compared sample and standard sample, correspoddingly, Pa;

τ_x, τ_s is period of stress realization of the standard penetration in compared sample and standard sample, correspondingly, s.;

Θssx, Θ_{sss} - shear stress (for solid products) of the compared sample and standard sample, correspondingly, Pa;

A_{scx}, A_{scs} is shear cut (for solid products) of the compared sample and standard sample, correspondingly, G/m^2;

BC, BC_s is biological count of the compared product sample and standard product sample in comparable measurement units;

TC, TC_s is contamination by toxic substances in comparable measurement units;

Taking into account all above mentioned, the formula (3) may be transformed (Lipatov N.N., Lipatova L.N., Antonian A.A., 1990):

$$K = \left\{ \prod_{i=1}^{n} P_1^{\alpha_1} \right\}^{0.5n} \cdot (P^{\alpha}_{min})^{0.5} \qquad (4)$$

In formula (4) P_i has the same meaning as Q_1 in formula (3). Because of earlier introduced limitation concerning the fact that Q values should be in the interval from 0 to 1, the following formula is offered for determining α_1 index:

$$\alpha_i = \beta \text{sign } (zn - ch), \qquad (5)$$

where "sign" is mark function; zn is denominator of P_{10-18} indices; ch is numerator of P_{10-18} indices.

The Central Research Institute of Information, Technical and Economic Investigations of the Meat and Dairy Industry drew some leading specialists and researchers in analysis the state of the industry and making prognosis of its further development till the year 2010. Values of coefficients $\beta_i(\alpha_i)$ were chosen as result of expert scores: $\beta_{1-2} = 1$, $\beta_{3-9.13} = 0.75$, $\beta_{10-12,14-18} = 0.5$, $\alpha_{19} = 0.25$, $\alpha_{20} = 0.75$, $\alpha_{21} = 1$.

In case if the level of the bioloical count, contamination by toxic substances and radioactive substance is higher than the level of ПДК:

α_{19}, α_{20}, α_{21} assume to be equal to $-\infty$.

The criterion (4) may be used as fundamental one for calculating the product quality, analysis, and ascertaining an objective level of retail and contractual prices for traditional and new food products. In case of fixing prices it permits to take into account not only the raw material value, but physico-chemical, medico-biological, and sanitary-ecological quality indices which are considerably more important for different groups of population concerning the provision with high quality food products.

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