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FOOD AND ENVIRONMENT SAFETY

DEVELOPMENT OF MATHEMATIC MODEL OF SPICED SOUR-MILK PASTAS QUALITY

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Abstract: *Comprehensive assessment effectiveness and food products quality forecast was substantiated using organoleptic estimation, profiles construction and usage of differential equations. The pastas with spices based on soft diet cottage cheese produced of variable recipes quality was selected as an object of the study.In the pastas composition such spices as allspice, black pepper, ginger, cinnamon, anise, cloves, cardamom, fenugreek and nutmeg were used in amount of 0.27…1.1%. Profiles of square area quality and differential equation for solving and analyzing by a computer program with usage of «Maple» pack were developed based on mathematical model in order to assess the quality of these dairy products.The analytical research results on product quality were obtained from organoleptic parameters and content of biologically active substances (tannin, catechin, and rutin) with usage of symbolic computer mathematics and graphic images methods.*

Keywords: *nutritious system condition, comprehensive evaluation of quality, mathematic model, differential equation, sour-milk pasta, spices*

1. Introduction

Nowadays consumer's demands for food products quality have changed dramatically. Food products have to be not only tasty and of appearance attractive, but also safe for consumption and serve as a source of nutritious and biologically active substances. Thus, the assessment of food products quality, including dairy products, comes to solving of complex criterial tasks. The question of complex criterial tasks of food products is considered in the works of such scientists as Bazarnova, Burova, Ishevsky, & Zyukano, 2004 [1].
The most important product characteristics, which are of interest for consumers, are the following criteria: organoleptic properties, content of the main nutrients (proteins, fats and carbohydrates), biologically active substances, etc.

The comparison of the quality indicators of the studied product between the basic sample – the closest to the analogue properties or "ideal" ones gives an opportunity to evaluate effectiveness of the solutions proposed in the scientific research: improvement of recipe composition, introduction of new processing methods, technological parameters refinement, etc.
These products have sticky pasty consistency and are intended for direct consumption [2]. The main feature that determines the high nutritional value of the base for pastas – cottage cheese, is the high content of proteins – 10…16 % compared to whole milk (3.2±0.5) % [3]. Sour-milk pastas have better protein and fat digestibility compared to similar dairy products produced without fermentation [4]. Introduction of natural components to products composition allows additional

enrichment by a complex of nutrients and biologically active substances [5].

It is known [3], that spices are characterized by high content of biologically active substances; they are used in products' composition in small amounts, faster food's digestibility by increasing body's metabolism, have bactericidal and antioxidant properties, so that they are able to stabilize nutrition products' quality during storage. Combining of natural spices in the new types of sour-milk pastas' technologies will allow enriching them by a complex of biologically active substances and provide products with original taste and flavoring properties.

One of the most important consumer characteristics of sour-milk pastas, as they are products of multiple raw material components is the organoleptic estimation, since organoleptic products characteristics such as appearance, taste, smell, color and consistency provide consumers with general idea of product quality [6].

Thus through compilation of recipes of such products complex approach based on sensory analysis methods with the elements of mathematical modeling and analysis of material system state should be applied.

2. Materials and methods

The study subject is the quality of sour-milk pastas with addition of spices obtained by using different recipes.

The subject of research is food products quality profiles, computer program and mathematic models, based on differential equations.

The research objective was to develop a method of computer simulation for complex evaluation and forecast quality of sour-milk pastas with spices obtained using different recipes. As sour milk base soft diet fat-extracted soft curd (moisture content 80 %, acidity – 150°T) was used. Spices are to be dispensed in dry ground form with particles size no bigger than 0,4 mm; common salt "extra" (extra class) – in amount 0.4 %. The paste with dry garlic concentrate was used as control one.

The compositions include spices as allspice, black pepper, ginger, cinnamon, anise, cloves, cardamom, fenugreek and nutmeg. The desired content of spice compositions was determined – from 0.27 to 1.1 %. To make harmonious products of taste characteristics, an insertion of common salt of 0.4 % is provided.

In scientific studies for assessing quality of dairy products identification methods are commonly used. A numerical score is usually included in. It allows setting the level of partial (by individual indicators) or general (by a complex of indicators) quality of the evaluated products and express its numerical value [7]. Such approach to products quality evaluation does not always give an objective assessment, therefore a new recipe usage of profiles square area quality and differential equations is proposed to forecast and determine the quality of food products.

Development and further usage of mathematic models, different in their complexity and functional purpose, allows not only an objective evaluation of the product, but also forecasting the dynamics of a complex indicator of its quality under varying conditions [8].

Analytical studies of analysis methods of material system state in determining quality of food products indicate that objective mathematic models shall be considered the ones built on differential equations. They give opportunity to describe a state of a product by main predefined quality indicators, when chemical, biological, structural changes and other various by their nature transformations happen [9].

Therefore, the development of computer programs with usage of mathematic modeling for objective evaluation and forecast behavior of nutrition systems under varying conditions is a relevant objective scientific study.

The sour-milk pastas recipe composition with spices was developed by authors through previous studies (Table 1). Sour-milk pastas are produced from soft curd and/or sour cream with addition of flavoring fillers and additives; the pastas are a source of highly digestible complete dairy proteins and they are characterized by a certain content of fats, vitamins, minerals etc. [10].

Table 1

The recipes of sour-milk pastas with spices

Raw material	Norm, kg for 1000 kg without losses					
	Basic recipe (control)	Recipe, №				
		1	2	3	4	5
Soft diet cottage cheese (fat-extracted), moisture content no higher than 80 %	487.0	993.0	993.3	992.25	992.0	992.0
Sour cream, fat content no lower than 20 %	500.0	-	-	-	-	-
Common salt, dry solids weight ratio 99 %	5.0	4.0	4.0	4.0	4.0	4.0
Spices:						
Allspice:ginger:cinnamon=1:1:1	-	3.0	-	-	-	-
Cloves:allspice:ginger=0.8:1:1	-	-	2.8	-	-	-
Anise:cloves:ginger:black pepper =1:0.8:1:1	-	-	-	3.75	-	-
Allspice:ginger:cardamom: fenugreek=1:1:0.8:1.2	-	-	-	-	4.0	-
Anise:ginger:nutmeg:black pepper =1:1:1:1	-	-	-	-	-	4.0
Dry garlic concentrate	3.0	-	-	-	-	-
Xanthum gum	5.0	-	-	-	-	-
Total	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

Into a mixing container a calculated amount of soft diet fat-extracted curd cottage cheese, spices and common salt were added. The mixture was stirred for (5±1) min until homogenous consistency was obtained. After that, the paste was packed in 100 g glass jars, which were covered by lids and placed in a refrigerator, where the paste cooled down to a temperature (4±2)°C.

For analysis of quality of sour-milk pastas with spices compositions, the authors have proposed to apply a mathematic model in the form of a differential equation [1, 9]:

$$\frac{dy(c)}{dc} - ky(c)^n = 0, \quad (1)$$

where y – general index of product quality (numerical score); c – estimated variable characteristic functionally linked to a product recipe; n – ratio of area of product quality profile polygon, taken for the ideal area of product quality profile of each of the studied products; k – area of quality profile of ideal product at the selected coding level for individual metrics.

Equation (1) contains main indicators of sour-milk pastas quality. In order to obtain an adequate result usage of the equation (1) for sour-milk pastas quality forecast by determining the value of the general index was proposed.

Comprehensive evaluation was made by 6 indicators (descriptors), using a 30-point rating scale. Nomenclature of quality indicators and coefficients of significance of each indicator were defined by an expert commission taking into account their importance for consumer's assessment of sour-milk pastas with spices.

Determination of tannin, rutin, catechin content in spices was made by water suspension titration method chopped to particle size no bigger than 0.4 mm of spices by solution KM_nO_4 with concentration0.1 mole /dm^3. The content of the relevant biologically active substances in sour-milk pastas with spices was defined by computational method taking into account their recipe composition.

To determine general index of sour-milk pastas with spices quality and forecast quality of the same pastas, but prepared by using different recipes, a computer program was developed. It allows determining the general index of quality under organoleptic (assessment in points) or natural estimation of individual indicators, when their numerical values are brought to dimensionless view.

The computer program allows: calculating areas of individual of so called quality profiles, which may be obtained both for specific sour-milk pastas recipes (recipe-1, recipe-2, recipe-3, recipe-4, recipe-5), and for individual quality indicators (consistence, taste, scent, color, appearance etc.). Using a system of computer mathematics "Maple", for differential equations solving we calculated the value of general index of product quality under selected mathematic model in a form of first order differential equation, perform its analytical research and we presented the results graphically [11].

3. Results and Discussion

The analysis was made and sequence of mathematic model (1) usage in pack with computer program "Maple", of sour-milk pastas quality analysis was considered. The equation (1) solving in a generic form will be:

$$y(c) = (kc - kcn + C_1)^{\frac{1}{1-n}} \qquad (2)$$

The constant of integration C_1 we shall find having accepted the initial condition, which corresponds to the maximum point value of the general index of quality of conditionally ideal product.

The initial condition needed for solving of differential equation in an analytical form will be: y(1)=y1, for different dairy products Y1=5; 15; 30 is accepted. Then we shall write down the final equation (2) solving:

$$y(c) = \frac{1}{(kc-kcn+e^{(-n\ln(y_1))}y_1-k+kn)^{\left(\frac{1}{n-1}\right)}} \qquad (3)$$

The equation (2) is multipurpose. When it is necessary to make a comparative analysis of product quality not only to ideal, but also to, for example, control sample, or between samples, different values of coefficient k are selected, which equals area of quality profile of selected sample.

We shall consider the example sour-milk pastas obtained on the bases of cottage cheese (Table 1) sequence of determination and analysis of general index of quality as compared with conditionally ideal product.

By using single point coding of quality organoleptic estimation results the following indicators were obtained: consistence, color, scent, taste, appearance, content of biologically active substances; the results are shown in Table 2.

Table 2

The results of organoleptic estimation of sour-milk pastas with spices

Indicator	Ideal	Control	Recipe-1	Recipe-2	Recipe-3	Recipe-4	Recipe-5
У1-Consistence	1	1	1	0.95	0.92	1	0.9
У2-Color	1	0.8	0.9	0.95	0.91	0.9	0.9
У3-Scent	1	0.9	0.95	0.85	0.89	0.92	0.82
У4-Taste	1	0.85	0.9	0.92	0.9	0.85	0.9
У5-Appearance	1	0.84	0.91	0.9	0.91	0.92	0.92
У6- CBAS	1	0.6	0.92	1	0.94	0.91	0.89

The results of organoleptic estimation of products in coded form transfer into interface pattern of the computer program (Table 3). It is obligatory to fill in boxes "Maximum score" and "Amount of indicators".Then, one should pass the mouse to the box "calculate areas" and give a command "calculate".

Table 3

An interface pattern of the computer program with inserted experimental data

Indicator	Ideal	Control	Recipe-1	Recipe-2	Recipe-3	Recipe-4	Recipe-5	
Consistence	1	1	1	0.95	0.92	1	0.9	
Color	1	0.8	0.9	0.95	0.91	0.9	0.9	
Scent	1	0.9	0.95	0.85	0.89	0.92	0.82	
Taste	1	0.85	0.9	0.92	0.9	0.85	0.9	
Appearance	1	0.84	0.91	0.9	0.91	0.92	0.92	
CBAS	1	0.6	0.92	1	0.94	0.91	0.89	S
k	S1	S2	S3	S4	S5	S6	S7	
	2.60	1.78	2.25	2.24	2.16	2.18	2.05	2.60
	Ideal	Control	Recipe -1	Recipe -2	Recipe -3	Recipe -4	Recipe -5	
S_i/S	1.00	0.68	0.86	0.86	0.83	0.84	0.79	c
S/S_1	1	1.46	1.16	1.16	1.2	1.19	1.27	n
Maximum score							1	
Amount of indicators							6	

At the end we shall receive k, n, c of equation. They are needed to complete the calculations for differential equation (2). The program calculates the polygons area. S_1=2.60; S_2=1.78; S_3=2.25; S_4=2.24; S_5=2.16; S_6=2.18; S_7=2.05 and values of characteristics k=2.60; c=1; c_0=0.68; c_1=0.86; c_2=0.86; c_3=0.83; c_4=0.84; c_5=0.79 та n=1; n_0=1.46; n_1=1.16; n_2=1.16; n_3=1.2; n_4=1.19; n_5=1.27.

The automatic mode displays graphic images on the monitor. The products' quality profiles by organoleptic

characteristics: consistence, color, taste, scent, appearance, content of biologically active substances are shown in the figure 1, and the quality profiles of products conditionally ideal, controled and obtained by using different recipes are shown in the figure 2.

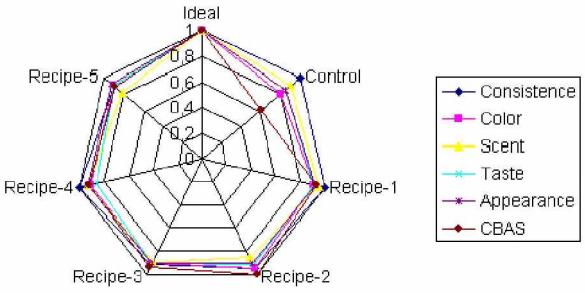

Fig. 1. Products quality profiles by organoleptic characteristics and content of biologically active substances

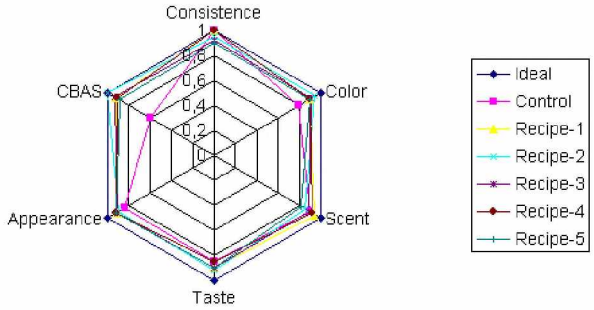

Fig. 2. Quality profiles of products conditionally ideal, control and obtained using different recipes

The developed computer program also allows, besides quality profiles, which characterize the quality of the product according to area of polygon, comparative assessment card of quality of conditionally ideal, control and obtained using different recipes products (Figure 3). The results of calculations allow visual performing of a comparative analysis of product quality obtained by using different recipes as compared to conditionally ideal, control and between themselves by the values of polygon areas (S_1, S_2…S_7) and through the card analysis (Figure 3). With the help of this program it is possible to calculate areas of quality profiles of sour-milk pastas obtained using different recipes at different point scores, at 1, which is used in technology of dairy products. When comparing sour-milk pastas obtained using different recipes to conditionally ideal product we adopt: k=2.6, to compare to control k=1.78. Where k – area of polygon with single coding, y1=5 – indicator of ideal product quality with selected five-point score.

These values are automatically entered as fixed into the corresponding program line of the "Maple" system, which was used for solving and analyzing differential equation (1).

We shall consider an example of practical use of the mathematical model analysis program for analysis of sour-milk pastas with spices quality using a 30-point evaluation system, when k=2.60; y1=30; c=0.86; n=1.16. Having used an equation, we shall find a value of general index of quality. It equals y=16.5. The result was obtained after substitution of data into the equation, derivatives k; y1; c; n.

$$y(c) = \frac{1}{(0{,}058+30e^{-1{,}16\ln 30})^{6{,}25}} = 16.5 \quad (4)$$

The calculations by using a mathematic model (1) values of general index of quality with different point scores (y1=30; 15; 5) are listed in the Table 4.

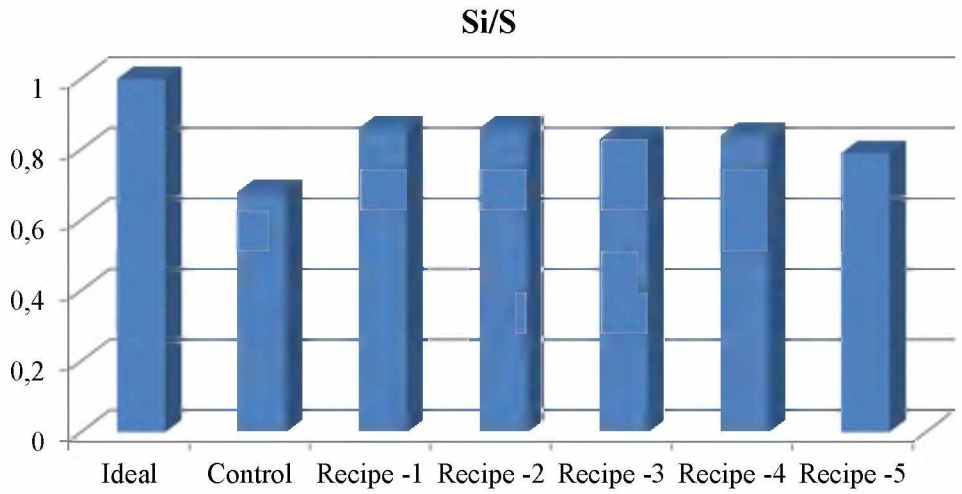

Fig. 3. Comparative assessment card of sour-milk pastas quality obtained using different recipes and conditionally ideal product

Table 4

Values of general index of quality with different point scores (5; 15; 30) of sour-milk pastas quality (c; n; y1 – characteristic of the mathematic model of the product quality calculation)

Characteristics m.m.*	Ideal	Control	Recipe-1	Recipe-2	Recipe-3	Recipe-4	Recipe-5
c	1	0.68	0.86	0.86	0.83	0.84	0.79
n	1	1.46	1.16	1.16	1.20	1.19	1.27
	y1=30	3.13	16.50	16.50	13.42	14.32	9.36
y (c)	y1=15	2.38	8.80	8.80	7.40	7.80	5.58
	y1=5	1.39	3.18	3.18	2.80	2.9	2.34

*m.m. – mathematic model

The positive side of the food products quality modeling program is that if one needs to use other levels of point evaluation, the program gives an opportunity by changing the y1 parameter, get value of general index y (c) product quality and build 3d cards. Visually the results of calculations in the range of change n=1…1.5; c=1…0,5 using a 30-point evaluation system of product quality are presented graphically in the Figure 4. The use of various levels of point evaluation of dairy products quality is pictorially presented in Figures 5-6.

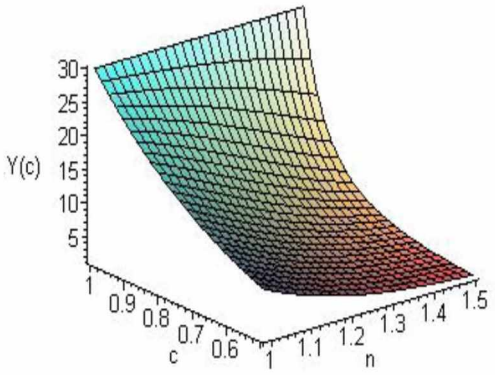

Fig. 4. 3d card of dependence of general index of quality y(c) using a 30-point evaluation system of product quality

When using a 15-point evaluation system of product quality in Figure 5.

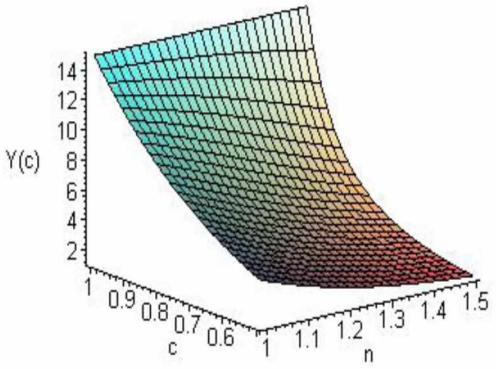

Fig. 5. 3d card of dependence of general index of quality y(c) using a 15-point evaluation system

When using a 5-point evaluation system of product quality on Figure 6.

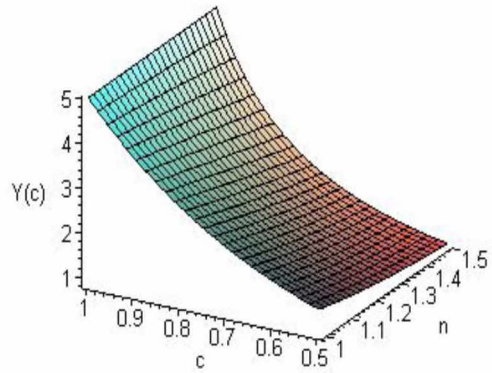

Fig. 6. 3d card of dependence of general index of quality y(c) using a 5-point evaluation system

Analysis of graphic dependencies shown in Figure 4-6 testifies that the smaller the area of quality profile of sour-milk pastas is, the lower point score on general indexes of quality the product has. With a decrease of value of the characteristic n of the mathematic model and accordingly an increase in the characteristic c , the product quality improves.

4. Conclusion

The proposed computer program allows determining and forecasting quality of sour-milk pastas with spices obtained by using different recipes based on their organoleptic estimation, quality profiles and usage of differential equations.
By using it we can build 3d cards and visually conduct analytical researches of product quality, forecast its quality for different content of biologically active substances, develop new products by improving both their recipes and technological modes of production.
The suitability of the computer program and its adequacy is confirmed by the development of new types of sour-milk pastas with spices.

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