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MODELLING FORMULAE OF STRAWBERRY WHEY DRINKS OF PROPHYLACTIC APPLICATION

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Abstract. Expediency of the development of formulae and innovative technologies for production of prophylactic application drinks possessing antioxidant, probiotic and hepatoprotective properties with the use of the secondary dairy product – whey, as well as the domestic vegetable raw materials having a high content of bioactive substances has been substantiated.

Formulation composition of the prophylactic drinks based on cheese whey, extract of *Tagetes patula* flowers and the berry filler “Strawberry” with the use of the response surface method has been developed. Bioactivity of the drinks and the complex quality indicator which accounts for the total influence of the bioactivity, organoleptic assessment and weight coefficients of the specified unit indicators were taken as the optimization criteria; as the independent factors that were varied in the course of the experiment, the mass fractions of the marigold flowers extract and the strawberries filler were selected. It is recommended that the mass fractions of the berry filler “Strawberry” and the extract of *Tagetes patula* flowers in the prophylactic drinks are set as 7 and 20 % of the finished product, accordingly. The practical mass fraction of the citric acid of 0.2 % was determined as it ensures high organoleptic characteristics of the finished drinks. Recommendations are given concerning development of innovative technologies of unfermented and fermented strawberry whey drinks of prophylactic application enriched with the extract of *Tagetes patula* flowers.

Key words: whey, strawberry filler, *Tagetes*, bioactivity, organoleptic assessment, complex quality index, optimization, response surface.

МОДЕЛЮВАННЯ РЕЦЕПТУР СИРОВАТКОВО-ПОЛУНИЧНИХ НАПОЇВ ПРОФІЛАКТИЧНОГО ПРИЗНАЧЕННЯ

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Анотація. Обґрунтовано доцільність розроблення рецептур та інноваційних технологій напоїв профілактичного призначення з антиоксидантними, пробіотичними та гепатопротекторними властивостями з використанням вторинної молочної сировини – сироватки, а також вітчизняної сировини рослинного походження з високим вмістом біологічно активних речовин.

Розроблено рецептурний склад напоїв профілактичного призначення на основі сирної сироватки, екстракту квітів *Tagetes patula* і ягідного наповнювача «Полуниця» з використанням методології поверхні відгуку. У якості критеріїв оптимізації обрано біологічну активність напоїв і комплексний показник якості, який враховує сукупний вплив біологічної активності, органолептичної оцінки і коефіцієнтів вагомості зазначених одиничних показників; незалежними факторами, які варіювалися, в експерименті – масові частки екстракту квітів чорнобривців і полуничного наповнювача. Рекомендовано масову частку ягідного наповнювача «Полуниця» та екстракту квітів *Tagetes patula* в напоях профілактичного призначення встановити 7 і 20 % від маси готового продукту відповідно. Визначено раціональну масову частку лимонної кислоти – 0,2 %, яка забезпечує високі органолептичні характеристики готових напоїв. Наведено рекомендації з розробки інноваційних технологій неферментованих і ферментованих сироватково-полуничних напоїв профілактичного призначення, збагачених екстрактом квітів *Tagetes patula*.

Ключові слова: сироватка, полуничний наповнювач, *Tagetes*, біологічна активність, органолептична оцінка, комплексний показник якості, оптимізація, поверхня відгуку.

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Introduction

Development of the dairy industry under current circumstances is inextricably connected with solution of innovative tasks concerning wise utilization of the secondary raw dairy products, primarily whey [1]. Unprocessed milk whey presents ecological hazard for the environment. Discharge of milk whey in the sewerage threatens with considerable fines, which lead to higher expenditure for the enterprise. In a number of instances the expenditure for sewage clean-up from milk whey is comparable with the costs required to arrange collection and industrial processing of milk whey. Besides, whey contains more than 50 % of dry matter, which is contained in the unskimmed milk. Under competitive conditions and a deficit of raw milk, the enterprise owners need that all milk components are fully used in the commercial output [1-3].

Nowadays in Ukraine, the whey processing problems have been solved in the majority of cheese factories where they make dry whey out of cheese whey while complete processing of cheese and casein whey is not organized at any dairy enterprise. During recent years, Ukraine has increased the lactic cheese production and reduced the production of casein. Therefore, organization of the industrial processing of cheese whey, including into premium-class foodstuffs, is topical. One of the ways to settle this problem can be to organize, at the existing milk processing factories, the shops for producing drinks with preset therapeutic or prophylactic properties. It is a pressing task to substantiate formulae of such drinks using the mathematical simulation and optimization on the basis of the domestic plant stock with due account of the medical and biological requirements to chemical composition, physical, chemical, microbiological and sanitary and hygienic parameters of prophylactic products having high organoleptic, probiotic and antioxidant characteristics.

Analysis of bibliography and problem statement

The range of products made out of milk whey includes: cream products, protein products, drinks, biologically treated foodstuffs, lactose, condensed and dry concentrates, ice-cream and cheeses [1]. From the viewpoint of biological value, proteins that do not contain limit amino acids. Almost all macro- and micro elements of milk, the greater part of lactose as well as water-soluble vitamins pass into milk whey. According to the range and absolute content of vitamins, milk whey is a biologically complete product.

In practice, two categories of milk whey are commonly dealt with – sweet whey and acid whey [1,3]. The whey, which is a by-product of hard cheese, semi-hard cheese, soft cheese and rennet casein is called sweet whey characterized by pH 5.9 – 6.6. When lactic cheese is produced, the acid whey is formed having pH 4.6 – 5.2; when producing precipitated with inorganic acids casein – the acid whey is obtained that has pH 4.3 – 4.6. Composition and properties of whey depend on the kind

of base product and peculiar technology of its production [2]. It is promising to organize production of combined drinks based on unclarified cheese whey (with whey proteins preserved) with the use of probiotic bacteria and domestic raw plant products, which are the sources of bioactive substances (BAS).

The authors propose to develop prophylactic drinks based on cheese whey that possess antioxidant, probiotic and hepatoprotective properties [4]. In order to ensure high probiotic and hepatoprotective properties of the product it is recommended to use the probiotic cultures of lactobacilli and/or bifidus bacteria [5]. So, as to strengthen antioxidant and hepatoprotective properties of the product which is a source of BAS, flowers of marigold wide spread in Ukraine and berry filler «Strawberry» were selected.

Marigold (Latin name *Tagetes*) possess anti-inflammatory, antiseptic, antiviral, hepatoprotective and invigorative properties, and are widely used in medicine, perfumery and cosmetic industries [6,7]. Known are 59 marigold species, including 3 species growing in Ukraine: African marigold (*Tagetes erecta*); French marigold (*Tagetes patula*); and Lemon marigold (*Tagetes tenuifolia*), the synonym being Signet marigold (*Tagetes signata*) [6-8].

Phytoncide properties of marigolds ensure their therapeutic and insecticide significance. The above-ground part of *Tagetes* is rich in ether oil having spice-floral aroma and fruit flavour which main component is ocytomen comprising nearly 50 %. The oil contains also sabinene, apinene, limonene, citral, myrcene, linalool, thymol, terpinene and other components that inhibit growth and development of pathogenic microorganisms and fungi [9-11]. Therapeutic drinks with the use of *Tagetes* boost immune system and help to get rid of respiratory diseases during their bursts [9,10].

Carotenoids, specifically lutein, that are found in marigold flowers possess anti-inflammatory properties, reduce the risk of cataract and facilitate restoration of visual acuity, particularly with people who permanently strain eyes [11,12]. Marigold flowers elixir assist in curing pancreas, particularly diabetes mellitus and pancreatitis, improve condition of blood vessels, have hepatoprotective influence and ease nervous system, particularly at depression, anxiety, neuroses, lack of self-trust and in stress situations [10,13].

Out of all natural compound groups identified in marigold flowers a special place is occupied by flavonoids that indirectly, via the enzyme systems, control the processes that determine, above all, the cell membrane condition and provide for hepatoprotective, antioxidant, anti-inflammatory and wound healing effects. Patuletin – the main flavonoid of *Tagetes* reduces permeability of capillaries, produces hypotensive and diuretic action, and reveals P-vitamin activity [8,14]. It is established that *Tagetes patula* flowers contain pectin substances that exhibit sorption properties, water-soluble polysaccharides, hemicellulose A and hemicellulose B: in the polysaccharide complex 16.26 % accounts for one part of water-

soluble polysaccharides, 11.87 % of pectin substances, 0.91 % of hemicellulose A and 0.55 % of hemicellulose B [15,16].

Despite useful properties of marigold, there are contraindications for their use. It is not recommended to use the plant for treatment in the first trimester of pregnancy, in lactation period, children below 3 years, people suffering from eczema, at idiosyncrasy and by those people who are allergy-predisposed [6-9].

Based on the literature data analysis, when producing prophylactic drinks on the basis of cheese whey with high antioxidant and hepatoprotective properties it is recommended to use, as a physiologically functional food ingredient, the extract of *Tagetes patula* flowers obtained in accordance with the parameters [17] recommended by the authors after removing ethyl alcohol by means of a convertor dryer from the extract.

With a view of imparting original organoleptic characteristics to dairy products and improving their food and physiological value, they are added with fruit-and-berry (or berry) fillers. Fruit and berry present an indispensable source of vitamins, pectins, fruit fibre and iron. Application of fillers in production of dairy products enables to enrich their range [3].

A manufacturer has an important advantage when he adds fruit-and-berry (or berry) fillers as they have a good taste and fresh flavour of the final product. Besides, presence of filler excludes a necessity to add flavouring agents, dyes and certain kinds of stabilizers [3].

The differences in production and storage technologies, consistence and properties of raw dairy products contribute to application of fruit-and-berry and berry fillers of various characteristics: category «FP» – fillers of homogeneous consistence: fruit or berry content – 35 %; category «F» – fillers with lumps of fruit or berry below 5 mm in size: fruit or berry content – 35 %; category «E» – fillers with lumps of fruit or berry below 10 mm in size: fruit or berry content 40 %, 70 %.

For producing prophylactic drinks having high food and physiological value and prepared on the basis of cheese whey the berry filler «Strawberry» of «FP» category was selected.

Objective and task of the research

The conducted research was aimed at performing mathematical modelling and optimization of formulae of the prophylactic drinks with the use of cheese whey, extract of *Tagetes patula* flowers and berry filler «Strawberry».

To achieve the set objective, it was required to accomplish the following tasks:

- to optimize components of the prophylactic drink based on cheese whey, extract of *Tagetes patula* flowers and berry filler «Strawberry»;
- to determine organoleptic characteristics of the when-and-plant mix consisting of raw components in their optimum ratio;
- to give recommendations as to scientific substantiation of the technology of unfermented and fermented whey-and-strawberry drinks with preset prophylactic properties based on the developed formulae.

Mathematical modelling and optimization of the formulae of the whey-and-strawberry prophylactic drinks

The formulae of the prophylactic drinks were based on: whey obtained when producing fat-free lactic cheese by the acid-rennet method at LLC «Gormolzavod No.1»; extract of marigold flowers (ME) obtained in laboratory conditions at the chair of technology of milk, fats and perfumery and cosmetic products in accordance with the method developed by the authors [17] and the berry filler «Strawberry» with the 50 % mass fraction of sugar produced at LLC «Agrana Frut» (SF).

The research was founded on a central composition rotatable design [18]. The levels and intervals of factor variation were selected on the basis of literary sources and results of previous research [3, 4]; the mass fraction of the marigold extract (ME) was varied within 15 – 20 %; the mass fraction of the berry filler «Strawberry» (SF) was within 4 – 7 %.

Optimization criteria were the following: biological activity and complex performance criterion (CPC) is an indicator that takes into account the aggregate influence of biological activity (BA, activity units), organoleptic assessment (OA, points) and rating coefficients (M_i of said single indicators). In the course of experiments use was made of variable independent factors – the mass fraction of SF (C_{SF} , %) and the mass fraction of ME (C_{ME} , %).

For the purpose of mathematical modelling and optimization, a response surface methodology was chosen [18]. This method presents an aggregate of mathematical and statistical techniques aimed at modelling processes and finding out combinations of the experimental series of predictors with a view of optimizing the response functions $\hat{y}(x, b)$ that are, generally, described by a polynomial (1):

$$\hat{y}(x, b) = b_0 + \sum_{l=1}^n b_l x_l + \sum_{k=1}^n b_k x_k^2 + \sum_{i=1}^{n-1} \sum_{j=i+1}^n b_{ij} x_i x_j, \quad (1)$$

where, $x \in R^n$ – vector of variables, b – vector of parameters.

In the studied process, a response function was selected of the form of the second degree polynomial for the biological activity (BA, activity units) and the complex performance criterion (CPC):

$$BA = b_0 + b_1 \cdot C_{ME} + b_{11} \cdot C_{ME}^2 + b_2 \cdot C_{SF} + b_{22} \cdot C_{SF}^2 + b_{12} \cdot C_{ME} \cdot C_{SF}, \quad (2)$$

$$CPC = b_0 + b_1 \cdot C_{ME} + b_{11} \cdot C_{ME}^2 + b_2 \cdot C_{SF} + b_{22} \cdot C_{SF}^2 + b_{12} \cdot C_{ME} \cdot C_{SF}, \quad (3)$$

where, BA – biological activity, activity units; CPC – complex performance criterion; b_0 – constant value; C_{SF} – mass fraction of berry filler «Strawberry» (SF), %; C_{ME} – mass fraction of marigold flowers extract (ME), %; $b_1, b_{11}, b_2, b_{22}, b_{12}$ – coefficients for each element of the polynomial.

In the course of research the formulae components were mixed in the required quantities, biological activity of the drinks was determined according to [19] and organoleptic assessment was made using 15-point scale. The planning matrix and experimental values of the response function are shown in Table 1.

Table 1 – Planning matrix and response function

Test No.	Mass fraction of ME, %		Mass fraction of SF, %		Biological activity, BA , act. units	Organoleptic assessment, OA , points
	Coded level	%	Coded level	%		
1	0	17.50	0	5.50	27.33	13.00
2	0	17.50	0	5.50	27.33	13.00
3	0	17.50	0	5.50	27.33	11.00
4	0	17.50	0	5.50	27.33	12.00
5	+1	19.27	-1	4.44	27.66	11.00
6	$+\sqrt{2}$	20.00	0	5.50	35.00	11.00
7	+1	19.27	+1	6.56	40.00	11.00
8	0	17.50	$+\sqrt{2}$	7.00	31.66	12.00
9	$-\sqrt{2}$	15.00	0	5.50	23.33	12.00
10	-1	15.73	-1	4.44	23.33	12.00
11	0	17.50	$-\sqrt{2}$	4.00	23.33	12.00
12	-1	15.73	+1	6.56	28.33	12.00

Modelling and processing of the experimental data were made with the aid of *Statistica 10 (StatSoft, Inc.)* package.

In order to check significance of the regression coefficients (2), the Pareto diagram was constructed which is shown in Fig. 1 (L – linear effect, Q – quadratic effect).

This Pareto diagram (Fig. 1) indicates the standardized coefficients ranked according to their absolute values. Analysis of the data proves that all coefficients are significant because the table column showing assessments of the recorded effects crosses the vertical line that represents 95% confidence level.

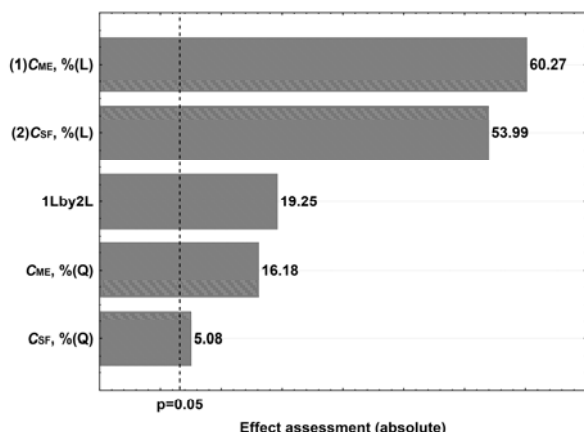


Fig. 1. Pareto chart

The obtained equation with the calculated coefficients is written as:

$$BA = 192.31 - 16.37 \cdot C_{ME} + 0.39 \cdot C_{ME}^2 - 17.43 \cdot C_{SF} + 0.34 \cdot C_{SF}^2 + 0.98 \cdot C_{ME} \cdot C_{SF} \quad (4)$$

Adequacy of the developed model (4) has been verified by the disperse analysis method and the obtained results prove that the obtained model adequately describes the response as the determination coefficients are close to unity ($R^2 = 0.968, R^2_{adj} = 0.942$).

The described polynomial (4) reflecting the aggregate influence of the mass fraction SF (C_{SF} , %) and the mass fraction of ME (C_{ME} , %) on the bioactivity of the revitalizing drink based on cheese whey, marigold extract and berry filler «Strawberry» is shown in the graphical form in Fig. 2.

Increase of the ME mass fraction (C_{ME}) and SF (C_{SF}) mass fraction in the revitalizing drink formula promotes biological activity of the target product (Fig. 2) which, possibly, is due to synergy of the whey components of the drink and biologically active substances of plant origin in the specified quantities (Fig. 2). The highest value of bioactivity equalling 45.22 activity units (Fig. 2) in the target product is achieved with the 20 % marigold extract mass fraction and 7 % of the berry filler «Strawberry» mass fraction, therefore the indicated parameters of the variation factors are optimum for the biological activity of the target product.

For optimization of the formula composition of the revitalizing whey drink and with due account of the performed organoleptic assessment (Table 1), a complex performance criterion (CPC), which was defined as the function of assessment of the individual quality indicators – biological activity (BA , activity units) and organoleptic assessments (OA , points) (Table 1) converted to the scaled values with due account of the weights of the individual indicators (M_i) [20]:

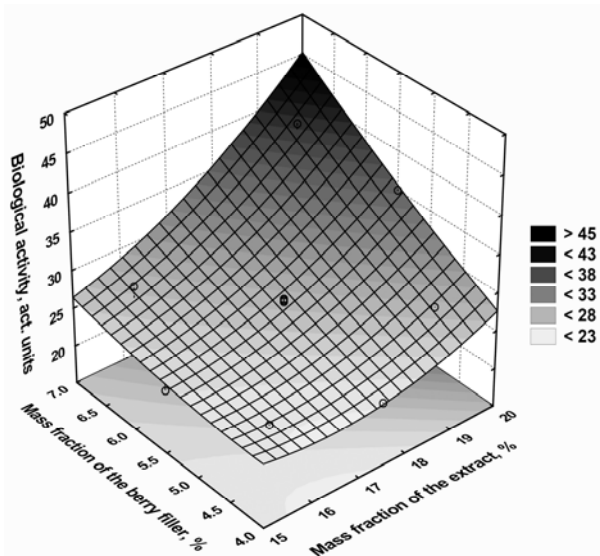


Fig. 2. BA of the prophylactic drink based on cheese whey, *Tugetes patula* flowers extract and berry filler “Strawberry” versus mass fractions of SF and ME

$$CPC = M_1 \cdot BA_{em} + M_2 \cdot OA_{em} \quad (5)$$

where BA_{em} , OA_{em} mean the biological activity and organoleptic assessment of the whey-and-strawberry prophylactic drink, accordingly, that have been converted

to scaled values; M_1 , M_2 mean weight coefficients of the individual indicators – bioactivity and organoleptic assessment, accordingly. At that

$$\sum_{i=1}^n M_i = 1.0 \quad (6)$$

For converting unit indicators to range [1,10], the output data shown in Table 1 have been scaled according to equation (7):

$$y = \frac{(y_{max} - y_{min}) \cdot (x - x_{min})}{x_{max} - x_{min}} + y_{min} \quad (7)$$

where, y – scaled data; x – output data contained in Table 1; x_{min} and x_{max} – the minimum and maximum values of the output data (for biological activity x_{min} and x_{max} were computed according to the model (4); for organoleptic assessment $x_{min}=3$ points, $x_{max}=15$ points (by 15-point scale); y_{min} and y_{max} – the minimum and maximum values of the new range (1 and 10, accordingly).

The scaled values of unit indicators computed with the aid of (7) and the complex performance criterion (CPC) computed according to formula (5) are shown in Table 2 (when CPC was computed, the following weight coefficient values were adopted (according to the expert commission recommendations) – $M_1=0,6$; $M_2=0,4$).

Table 2 – Scaled values of the unit indicators and the computed values of the complex performance criterion

Test No.	Scaled bioactivity (BA_{em})	Scaled organoleptic assessment (OA_{em})	Complex performance criterion (CPC)
1	1.13	8.50	4.08
2	1.13	8.50	4.08
3	2.89	7.00	4.53
4	5.86	7.75	6.62
5	7.89	7.00	7.53
6	4.51	7.00	5.50
7	3.16	7.00	4.70
8	1.13	7.75	3.78
9	2.75	7.75	4.75
10	3.23	7.75	5.04
11	2.92	7.75	4.85
12	3.17	7.75	5.00

The Pareto diagram shown in Fig. 3 was constructed to verify significance of the regression coefficients (3) (L – linear effect, Q – quadratic effect).

Data analysis in Fig. 3 proves that the quadratic effect of the berry filler (BF) mass fraction (C_{SF}) is insignificant as the assessment column of this effect does not cross the vertical line, which represents 95% confidence level. Taking this fact into consideration, the said regression term was eliminated from model (3). The obtained equation with the computed coefficients is:

$$CPC = 42.30 - 3.46 \cdot C_{ME} + 0.06 \cdot C_{ME}^2 - 4.90 \cdot C_{SF} + 0.32 \cdot C_{ME} \cdot C_{SF} \quad (8)$$

The developed model (8) was checked by the dispersion analysis method. The obtained results as well as the values of the determination coefficients ($R^2 = 0.959$ and $R^2_{adj} = 0.935$) are close to unity which makes it possible to conclude that model (8) describes the response adequately.

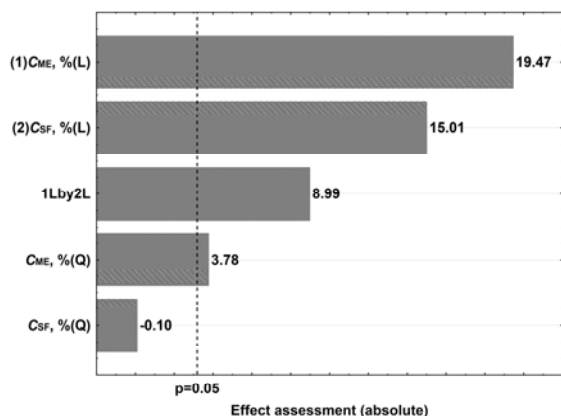


Fig. 3. Pareto diagram for verification of the regression coefficient significance (3)

The aggregate influence of the SF mass fractions (C_{SF} , %) and ME (C_{ME} , %) described by polynomial (8) on the complex performance criterion of the prophylactic drink quality based on whey, *Tagetes patula* flowers extract and berry filler «Strawberry» is graphically represented in Fig. 4.

Increase of the ME mass fraction (C_{ME}) and SF (C_{SF}) mass fraction in the revitalizing drink formula promotes higher complex performance criterion of the target product (Fig. 4). The highest CPC value is 8.6 (Fig. 4) which is characteristic of the target product in case the marigold flowers extract mass fraction is 20 % and the berry filler «Strawberry» mass fraction equals 7 %, therefore the indicated parameters of the variation factors for the complex performance criterion of the drink are optimum (at that the optimum mass fraction of the cheese whey is 73 %).

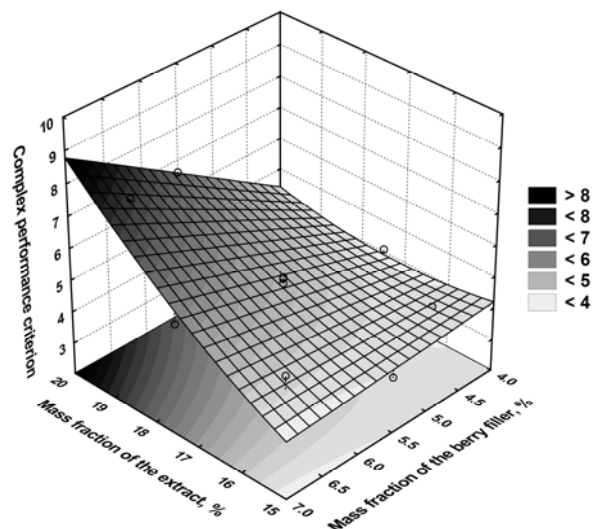


Fig. 4. Complex performance criterion of the prophylactic drink based on cheese whey, *Tagetes patula* flowers extract and berry filler «Strawberry» versus mass fractions of SF and ME

The obtained results of optimization of the prophylactic drink ingredients were adopted as the basis for computing their formulae.

Organoleptic quality indicators of the prophylactic whey-and-strawberry drink enriched by the *Tagetes patula* flowers extract produced with application of the optimum concentrations of raw ingredients (%) are shown in Table 3.

Table 3 – Organoleptic indicators of the prophylactic drink based on cheese whey, *Tagetes patula* flowers extract and berry filler «Strawberry» in their optimum ratios (73 : 20 : 7, accordingly)

Description of indicator	Characteristics of indicator
Taste and odour	Sweet with a pronounced flavour and aroma of strawberries filler, slight whey flavour and slight fragrance of marigold flowers
External appearance and consistence	Homogenous, semi-transparent liquid without protein flakes and fat globules and with a slight sediment of strawberries filler
Colours	Pink due to input berry filler, homogenous across the entire drink mass

As follows from the submitted data (Table 3), the prophylactic drink prepared on the basis of cheese whey, marigold flowers extract and berry filler «Strawberry» taken in the optimum ratio has a pleasant pink colour and fragrance due to berry filler «Strawberry» and rather homogenous consistence (with the use of homogenization the product consistence will be completely homogenous due to full distribution of the filler particles in the product mass), however, the taste is not clearly pronounced (there is a lack of «crisp»). Therefore, it is expedient to include in the product formula one of the organic acids – apple, lactic, citric, etc. In the experimental research aimed at determining the rational mass part of the acid in the drink

composition that can ensure high taste qualities of the products, a citric acid was used that was added to the drink made of raw ingredients in optimum ratio in quantities 0.1 – 0.3 %. The results of determination of organoleptic indicators in the whey drinks enriched with citric acid are shown in Table 4.

The submitted data (Table 4) indicate that the mass fraction of the citric acid added to the drink should be 0.2 % as just at that its content the product has the highest points by taste and fragrance, while at higher concentration of the citric acid an excessive acidity is felt.

Table 4 – Organoleptic indicators of the prophylactic drink based on cheese whey, marigold flowers extract and berry filler «Strawberry» taken in the optimum ratio and enriched with citric acid

Description of the indicator	Mass fraction of citric acid, %			
	0.0	0.1	0.2	0.3
Points for taste and odour	3,0	4,0	5,0	4,0
Points for external appearance and consistency	5,0	5,0	5,0	5,0
Points for colour	5,0	5,0	5,0	5,0

The simplest way to produce whey-and-strawberry prophylactic drinks enriched with *Tagetes patula* flowers extract is to heat (pasteurize) the mix of raw ingredients followed by cooling and packing in order to obtain drinks. Prior to thermal processing, in order to promote antioxidant and prophylactic properties, it is possible to enrich the drinks with mineral substances, vitamins, prebiotics, pectin substances or their complexes (first group of prophylactic drinks). However, such drinks have a limited shelf life (not more than 7 days) because of the soft pasteurization mode – $(72 \pm 1)^\circ\text{C}$ with holding for 15 – 20 s.

The second group of prophylactic whey-and-strawberry drinks based on cheese whey, marigold flowers extract and berry filler «Strawberry» can be made so that the finished product is enriched with activated cultures of probiotic strains of monocultures (mixed cultures) of bifidus bacteria. It is expedient to activate the bifidus bacteria cultures in the pasteurized cheese whey in accordance with the recommendations given in [5,21]. When preparing said drinks, the quantity of cheese whey with activated bifidus bacteria cultures in the product formulae should equal 10%. In doing so, the content of bifidus bacteria living cells in the drinks will be $(3.0\text{--}4.5) \cdot 10^7$ CFU/cm³, which will provide for their high probiotic properties. Quantity of lactic acid introduced with the indicated mass of the fermented with bifidus bacteria whey will be 0.05 %, therefore, the quantity of citric acid in the target products should be accordingly reduced to 0.15 %. The drinks of the second group can also be additionally enriched with prebiotics (then they will have symbiotic properties), mineral substances, vitamins, pectin substances or their complexes.

The third group of prophylactic drinks can be represented by the products prepared by fermentation of the pasteurized homogenized mix of cheese whey, marigold flowers extract and filler «Strawberry» with *L. acidophilus* (acidophilous drinks) monocultures, monocultures or

mixed cultures of *Bifidobacterium* or by acidifying compositions of monocultures *L. acidophilus* (or mixed cultures *L. lactis ssp.* or mixed cultures *S. thermophilus*+*L. bulgaricus*) and monocultures or mixed cultures of *Bifidobacterium* (bifidus-drinks). Introduction of the citric acid into these drinks is unnecessary because they will accumulate lactic acid in the course of lactose fermentation, and this acid will ensure standard organoleptic indicators and the required acidity level. The third group drinks can also be enriched, additionally, with mineral substances, vitamins, prebiotics, pectin substances and their complexes.

Conclusions

1. Optimum ratio of cheese whey, *Tagetes patula* flowers extract and berry filler «Strawberry» has been determined as 73, 20 and 7 %, accordingly, as the components of the whey-and-plant base for producing prophylactic drinks.

2. The rational mass part of the citric acid of 0.2 %, which ensures high organoleptic properties of finished drinks was substantiated.

3. A possibility of producing two groups of unfermented and one group of fermented whey-and-strawberry prophylactic drinks based on the developed formulae and additionally enriched with mineral substances, vitamins, prebiotics, pectin substances or their complexes.

Prospects of further research

1. Research and practical substantiation of the processing parameters and development of innovative technologies of non-fermented and fermented whey-and-strawberry prophylactic drinks of three groups.

2. Development of the standards for production of whey-and-strawberry drinks and industrial appraisal of the developed technologies.

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МОДЕЛИРОВАНИЕ РЕЦЕПТУР СЫВОРОТОЧНО-КЛУБНИЧНЫХ НАПИТКОВ ПРОФИЛАКТИЧЕСКОГО НАЗНАЧЕНИЯ

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Аннотация. Обоснована целесообразность разработки рецептур и инновационных технологий напитков профилактического назначения с антиоксидантными, пробиотическими и гепатопротекторными свойствами с использованием вторичного молочного сырья – сыворотки, а также отечественного сырья растительного происхождения с высоким содержанием биологически активных веществ.

Разработан рецептурный состав напитков профилактического назначения на основе творожной сыворотки, экстракта цветов *Tagetes patula* и ягодного наполнителя «Клубника» с использованием методологии поверхности отклика. В качестве критериев оптимизации были выбраны биологическая активность напитков и комплексный показатель качества, учитывающий совокупное влияние биологической активности, органолептической оценки и коэффициентов весомости указанных единичных показателей; независимыми факторами, которые варьировались, в эксперименте – массовые доли экстракта цветов бархатцев и клубничного наполнителя. Рекомендовано массовую долю ягодного наполнителя «Клубника» и экстракта цветов *Tagetes patula* в напитках профилактического назначения установить 7 и 20 % от массы готового продукта соответственно. Определена рациональная массовая доля лимонной кислоты – 0,2 %, которая обеспечивает высокие органолептические характеристики готовых напитков. Приведены рекомендации по разработке инновационных технологий неферментированных и ферментированных сывороточно-клубничных напитков профилактического назначения, обогащенных экстрактом цветов *Tagetes patula*.

Ключевые слова: сыворотка, клубничный наполнитель, *Tagetes*, биологическая активность, органолептическая оценка, комплексный показатель качества, оптимизация, поверхность отклика.

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