RESEARCH OF THE INFLUENCE OF THE FOOD ADDITIVE "MAGNETOFOOD" ON THE QUALITY INDICATORS OF WHIPPED CONFECTIONERY PRODUCTS

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ABSTRACT

The results of the influence of the food additive "Magnetofood" on the quality indicators of whipped confectionery in the technologies of curd dessert and white-pink marshmallow (organoleptic characteristics, density, mechanical strength, effective viscosity, degree of overrun and volume kinetics during storage) are presented. It was found that the introduction of the additive "Magnetofood" into the prototypes of cottage cheese desserts and white-pink marshmallows (on agar and pectin) in an amount from 0.1 % to 0.2 % to the mass of the recipe mixture in comparison with the control improves the structure, texture and external type of whipped products; the distribution function of air bubbles by diameter is narrow and symmetric, the diameter d=(45...50) 10^{-3} m is a fundamental factor indicating the stabilizing effect of nanoparticles of the food additive "Magnetofood". It was found that with an increase in the mass fraction of the food additive "Magnetofood", the following increases (compared to the control): in curd desserts - the maximum shear stress by a factor of (1.18 ... 1.3) and the thixotropy coefficient by 1.26 times; in white-pink marshmallows – the strength of the foam structure is (1.1...1.2) times and the effective viscosity of the marshmallow masses is (1.35...1.55) times (which has a positive effect on the texture of the product and the extension of the period preservation of the freshness of finished products); as well as in marshmallow masses, they decrease: density by (1.12...1.15) times and the duration of whipping by (1.5...2.5) 60 s. The rational content of the additive "Magnetofood" in the recipes of curd dessert and marshmallow of white-pink marshmallow was determined – 0.15 % to the mass of the recipe mixture. The prospects of using "Magnetofood" as an improver and stabilizer of polyphase foam-like structures have been determined

Object of research: production technology of cottage cheese desserts and white-pink marshmallows (on agar and pectin).

Investigated problem: obtaining stable polyphase food systems, in particular, a foam-like structure, with a deviation of the quality indicators of raw ingredients and technological parameters in production conditions.

Main scientific results: a deterioration in the quality of cottage cheese desserts and marshmallow products was revealed with a deviation of the physicochemical parameters of raw ingredients (in particular, cottage cheese, pectin, agar) and possible ranges of deviations of the initial values of the process parameters (temperature conditions, duration of whipping and gelation) leading to a deterioration the quality of finished products in terms of the following indicators: organoleptic characteristics, physicochemical, microbiological and functional and technological properties, shelf life. It is shown that improving the technology and increasing the stability of the polyphase structure of foam-like food products can be achieved by introducing a food additive of complex action "Magnetofood". In particular, due to the structure-forming, stabilizing, water-retaining and bacteriostatic properties of the Magnetofood additive. As a result of the introduction of 0.15 % food additive "Magnetofood" into the recipe for cottage cheese dessert and white-pink marshmallow, the following improves: organoleptic, structural-mechanical and physical-chemical indicators; structure, consistency and appearance of the whipped product; storage periods are extended.

The area of practical use of the research results: food enterprises specializing in the production of whipped products (fermented milk desserts, pastel-marmalade products, sambucs).

Innovative technological product: technology for the production of cottage cheese dessert and marshmallow white-pink (on agar) and (on pectin) using the food additive "Magnetofood".

Scope of application of the innovative technological product: food industry, restaurant enterprises.

1. Introduciton

1. 1. The object of research

The object of research is the technology of production of cottage cheese desserts and white-pink marshmallows (on agar and pectin).

1. 2. Problem description

To ensure high consumer properties and competitiveness of whipped confectionery products, it is necessary to resolve a number of issues related to stabilizing the polyphase structure and maintaining product quality during transportation and storage [1–7]. The use of food nano-additives in whipped confectionery technology is a new and promising area of research [8–10].

1. 3. Suggested solution to the problem

The authors solve the problem of stabilizing the polyphase structure of whipped confectionery and forming their quality by using the mineral nano-additive "Magnetofood" (based on ferrous and ferric iron: $FeO \times Fe_2O_3$). "Magnetofood" is an ultra-fine powder of dark brown or black color with a particle size of 70–80 nm, with a large specific surface; antioxidant, bacteriostatic, sorption, complex-forming, stabilizing, emulsifying, water and fat-retaining properties [8–10].

The aim of research is to form indicators of the quality of whipped confectionery products (cottage cheese dessert and white-pink marshmallow) when the food additive "Magnetofood" is added to the recipe.

To achieve the aim, the following objectives were solved: study of the effect of the food additive "Magnetofood" on the organoleptic characteristics of whipped curd and marshmallow products; microstructure and distribution of air bubbles by diameter, physicochemical and structural-mechanical indicators of prototypes of whipped curd and marshmallow masses.

2. Materials and methods

The subject of research is model curd and marshmallow masses with a mass fraction of the food additive "Magnetofood" 0.10 %, 0.15 %, 0.20 % to the mass of the recipe mixture. The food additive "Magnetofood" was introduced in the form of:

1) fat suspension (in curd desserts) with stirring of curd in an amount of 0.2 g; 0.3 g; 0.4 g per 100 g of the prescription mixture, which is 0 % (control - sample 1); 0.10 % (sample 2); 0.15 % (sample 3); 0.20 % (sample 4) food additive "Magnetofood";

2) an aqueous suspension based on a 5 % aqueous solution of a gelling agent – agar or pectin (into marshmallows) at the stage of swelling-dissolution of the gelling agent in an amount of 20.0 g; 30.0 g; 40.0 g per 1,000.0 g of the prescription mixture, which is 0 % (control – sample 1); 0.10 % (sample 2); 0.15 % (sample 3); 0.20 % (sample 4) food additive "Magnetofood".

2. 1. Experimental procedures

To determine organoleptic (on a 5-point scale, taking into account the weight coefficients of each indicator), physicochemical (total acidity, mass fraction of moisture, density), structural and mechanical (effective viscosity using a Reotest-2 rotary viscometer, mechanical strength and ultimate shear stress – on the AP-4/1 penetrometer, the microstructure of the whipped mass using a microscope) indicators were used generally accepted and standard techniques [9, 10].

3. Results and discussion

The surface activity of nanoparticles of the food additive "Magnetofood" and their ability to form solvate complexes with protein molecules improves the consistency of the curd dessert, which is evident from the organoleptic characteristics (**Fig. 1**).

The introduction of the food additive "Magnetofood" into the recipe for the curd dessert provides sufficient stability of the product, which can be seen from the narrow distribution curve of the diameters of air bubbles (**Fig. 2**).

The narrow distribution of air bubbles in diameter helps to stabilize the foamy structure of the curd dessert. This is explained by the complementary properties of Fe atoms of the food additive "Magnetofood" and the formation of coordination and electrostatic bonds of "Magnetofood"

nanoparticles with curd proteins, which strengthens the foamy structure of the curd dessert (promoting foaming and fixing air bubbles in the system) [9].

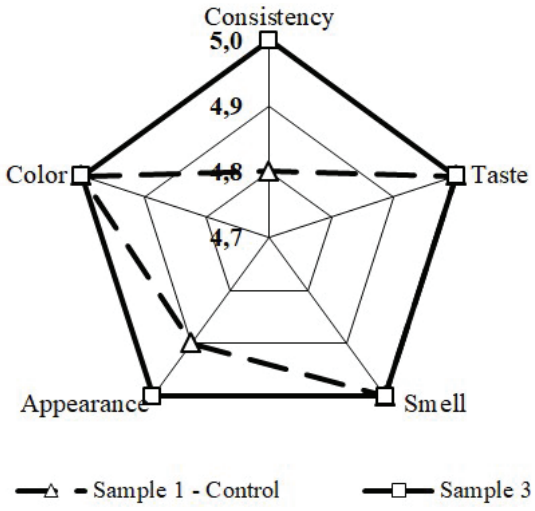

Fig. 1. Organoleptic characteristics of prototypes of curd dessert

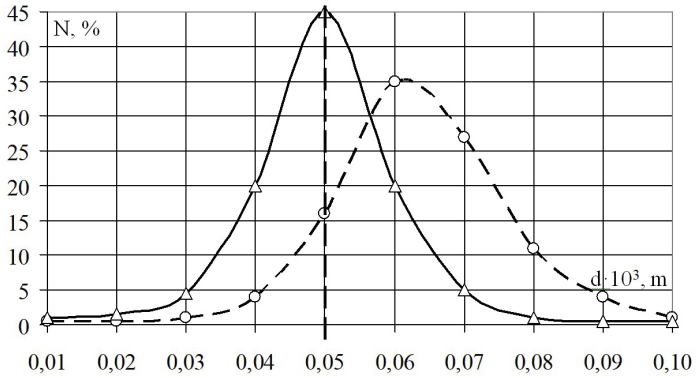

Fig. 2. Distribution of air bubbles by diameter in prototypes of curd dessert: – control, – dessert with 0.15 % food additive "Magnetofood"

In addition, the introduction of the food additive "Magnetofood" corrects the structural and mechanical characteristics of the curd dessert: with an increase in the mass fraction of the additive "Magnetofood", the following increases: the maximum shear stress is 1.18...1.3 times (which characterizes the strength of bonds in associative complexes of polyphase structures with "Magnetofood" nanoparticles, which have a structure-forming ability), the thixotropy coefficient is 1.26 times compared to the control. As a result, the stability of the curd product increases and its structure softens somewhat (due to fat binding by "Magnetofood" nanoparticles and the formation of a structured-solvated system) (**Fig. 3**).

At the same time, the structural and mechanical characteristics of the dessert remain stable during the entire shelf life (24 hours).

Thus, the introduction of the food additive "Magnetofood" improves the organoleptic characteristics, stabilizes the foamy structure of the curd dessert, including during storage; promotes the formation of stable various forms of the product The rational parameters of the technological process for the preparation of curd dessert have been determined: mixing (n=2.0...2.2 s^{-1}) 50 % sour cream with a fat suspension of the food additive "Magnetofood" for (3...4)×60 s, holding sour cream-fat-"Magnetofood" mixture t=(27...30)×60 s followed by whipping the mixture (n=5.8...6.0 s^{-1}) for (8...10)×60 with and stirring (n=2.0...2.2 s^{-1}) with cottage cheese and sour cream whipped with powdered sugar for (3...5)×60 s. Based on the research carried out, a recipe was com-

piled and a technological scheme of a curd dessert with the use of a food additive “Magnetofood” was developed.

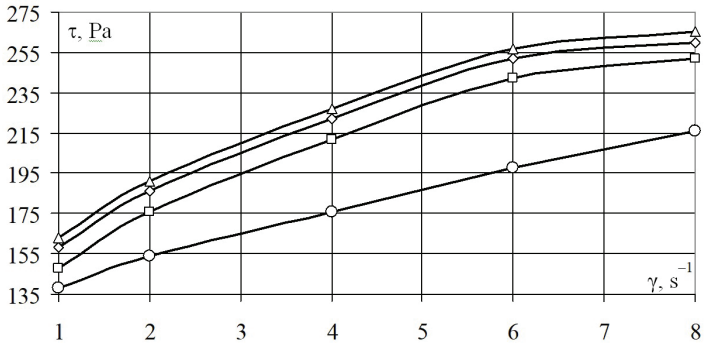

Fig. 3. Shear stress of test samples of curd dessert with different mass fraction of food additive “Magnetofood”: –○– – control – 0 %, –□– – 0.1 %, –◇– – 0.15 %, –△– – 0.2 %

It has been experimentally established that the introduction of the food additive “Magnetofood” in the amount of 0.10 %; 0.15 %; 0.20 % of the mass of raw materials affects: sedimentation stability, viscosity, thixotropic properties of aqueous suspensions, in particular agar and pectin. A rational amount of the food additive “Magnetofood” has been established – 0.15 % of the mass of raw materials. This served as the basis for the introduction of the food additive “Magnetofood” in gummy-pastilles in the form of suspensions based on a 5 % aqueous solution of a gelling agent (agar, pectin) – in a rational amount of 30.0 g of an aqueous suspension per 1,000 g of a recipe mixture [10].

The results of the organoleptic assessment of the quality of test samples of white-pink marshmallow are shown in **Fig. 4**.

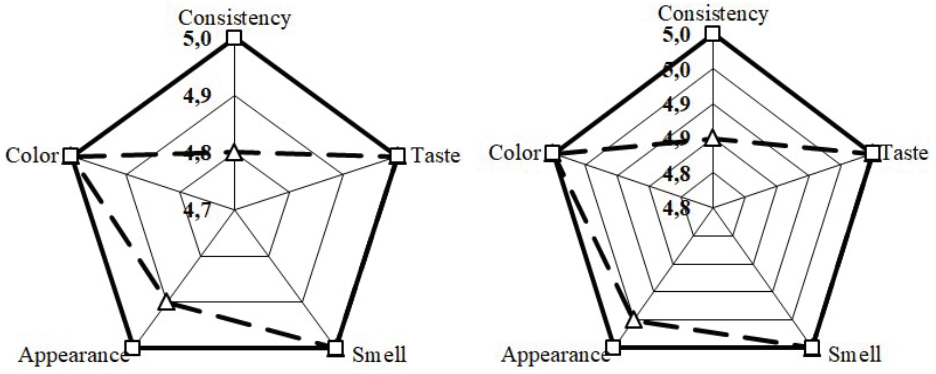

Fig. 4. Organoleptic indicators of test samples of white-pink marshmallow with various gelling agents in comparison with control samples: *a* – on agar; *b* – on pectin (–□– –sample with 0.15 % “Magnetofood”, –△– – control – without “Magnetofood”)

From the data in Fig. 4 it can be seen that the introduction of 0.15 % food additive “Magnetofood” improves the organoleptic characteristics of the product in comparison with the control: marshmallow is uniform, uniformly white with a cream shade and light pink color; has a soft, uniform consistency and fine-mesh structure; rounded, without deformation, with a clear outline; smooth surface without damage and hardening on the edges; pleasant pronounced taste and smell characteristic of marshmallows.

According to the organoleptic analysis data, the rational content of the food additive “Magnetofood” is 0.15 % of the mass of the recipe mixture, which is confirmed by studies of the foaming ability and foam stability of egg white on model systems with different gelling agents and with different amounts of the food additive “Magnetofood” using mathematical modeling [10].

Table 1 shows the main physical, chemical and technological parameters of prototypes of white-pink marshmallow with various gelling agents.

Table 1

Physicochemical and technological indicators of prototypes of white-pink marshmallow

Indicator	Prototypes of white-pink marshmallow			
	on agar		on pectin	
	Sample 1 – control	Sample 2 – with 0.15 % «Magnetofood»	Sample 3 – control	Sample 4 – with 0.15 % «Magnetofood»
Moisture content, %	17.0±0.8	17.4±0.8	17.0±0.8	17.5±0.8
Total acidity, deg.	0.7±0.03	0.6±0.02	5.90±0.3	5.30±0.2
Density, kg/m^3 (smallest value)	545±12	485±8	550±12	480±8
Whipping duration, ×60 s	16.0	14.0	10.0	8.0
Strength, kPa	9.0±0.5	10.8±0.6	6.5±0.3	7.4±0.4

Whence it can be seen that when the food additive "Magnetofood" is introduced, the density decreases by (1.12...1.15) times and the duration of whipping by (1.5...2.5)×60 s due to the interaction of the nanoparticles "Magnetofood" with molecules of egg white, which promotes the branching of the main chains of its macromolecules and slows down the process of liquid draining and thinning of the walls of air bubbles. The use of the food additive "Magnetofood" increases the strength of the foam by (1.1...1.2) times due to the "cluster-philicity" of the nanoparticles of the food additive "Magnetofood", which increases the viscosity of the gelling agent in the Gibbs-Plateau channels, which slows down the syneresis process and stabilizes the gel frame foam-like structure.

Table 2 shows the kinetics of the volume of experimental samples of marshmallow masses during storage for a regulated period of 60 days.

Table 2

Kinetics of the volume of experimental samples of marshmallow masses during storage

Shelf life, days	The volume of prototypes of marshmallow masses, cm^3			
	on agar		on pectin	
	Sample 1 – control	Sample 2 – with 0.15 % «Magnetofood»	Sample 3 – control	Sample 4 – with 0.15 % «Magnetofood»
0	100±5	100±5	100±5	100±5
20	81.7±4	98.2±5	80.4±4	97.2±5
40	76.4±3	93.6±5	75.2±3	92.8±5
60	68.2±2	86.8±4	67.0±3	85.6±5

As can be seen from the data of the Table 2 the introduction of the food additive "Magnetofood" stabilizes the structure of prototypes of marshmallow masses by improving the foaming and fixation of air bubbles in the system under the action of "Magnetofood" nanoparticles. The functionality of the food additive "Magnetofood" is manifested primarily in the reduction of surface tension. The destruction of the foam is caused by the processes of diffusion of air, the outflow of liquid from the walls of the bubbles (viscosity of the liquid) and the enlargement of bubbles due to fusion.

In addition, a rather narrow peak, both for control and for prototypes (2, 4) with 0.15 % ood additive "Magnetofood" stabilizes, indicates a uniform overrun of marshmallows. Moreover, due to the higher viscosity and lower surface tension, the stability of the foam in the prototypes with the food additive "Magnetofood" is higher. That is, the food additive "Magnetofood" stabilizes the foamy structure of marshmallows, including during the storage period established by the regulations.

The viscosity and mechanical strength of experimental samples of marshmallow were studied. After the formation of the whipped mass, the frame is gradually fixed, since the liquid films separating the air bubbles contain a gelling agent, which ensures the transition of the mass into a gel-like state. **Fig. 5** shows the strength (t, kPa) of prototypes of marshmallow masses in the process of aging (t×60 s).

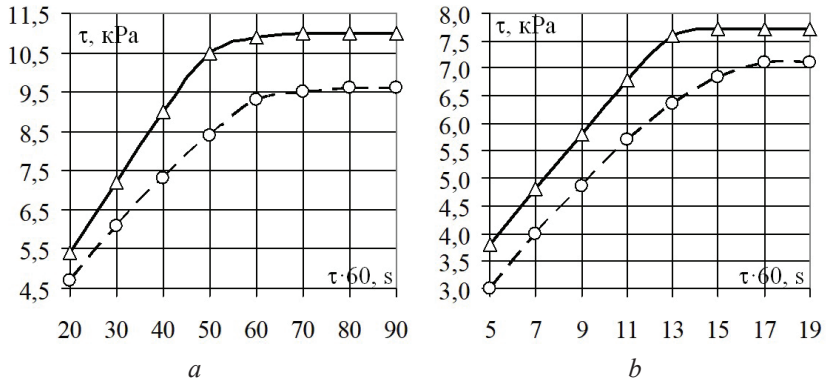

Fig. 5. Dependence of strength on the aging duration of prototypes of whipped masses: *a* – on agar (–○– – sample 1 – control, –△– – sample 2 with 0.15 % "Magnetofood"); *b* – on pectin (–○– – sample 3 – control, –△– – sample 4 with 0.15 % "Magnetofood")

From **Fig. 5** it can be seen that the introduction of the food additive "Magnetofood" accelerates the gelation process by (2.0...2.5)×60 s on agar and by (2.0...2.2)×60 s on pectin; increases the maximum shear stress by (11.9 ... 12.6) % – on agar and (8.2...9.1) % – on pectin, which is associated with the formation of supramolecular associates with "Magnetofood" nanoparticles. As a result, the gelation process is accelerated and the strength of the whipped mass increases. In addition, the introduction of the food additive "Magnetofood" increases the effective viscosity of marshmallow masses by (1.35...1.55) times compared to the control, which is associated with the structure-forming effect of nanoparticles "Magnetofood", leading to the aggregation of polysaccharides and an increase in roughness of their channels. As a result, the stability of foam films increases, and an increase in the gel-forming ability of pectin and agar allows increasing the viscosity in the Gibbs-Plateau channels, stabilizes the gel frame of the foam structure and slows down the syneresis process [6].

On the basis of the research carried out, formulations were compiled and technological schemes for the production of white-pink marshmallows (on agar and pectin) using the food additive "Magnetofood" were developed.

5. Conclusions

1. The functionality of the food additive "Magnetofood" has been proven in technologies: curd dessert and white-pink marshmallow. Organoleptic indicators of finished products and dispersed characteristics of foam structures in curd dessert and in marshmallows were determined with the introduction of the food additive "Magnetofood": the distribution function of air bubbles in diameter is narrow and symmetrical, diameter d=(45...50)×10^{-3} m is a fundamental factor indicating the stabilizing effect of "Magnetofood" nanoparticles. A rational amount of the food additive "Magnetofood" in the formulations of whipped confectionery products (0.15 %) has been established.

2. It has been established that the food additive "Magnetofood" affects the structural and mechanical properties of whipped confectionery: in curd desserts, with an increase in the mass fraction of the food additive "Magnetofood", the maximum shear stress is increased by (1.18...1.3) times and the thixotropy coefficient is 1.26 times compared to the control; in white-pink marshmallows, they increase - the strength of the foam structure is (1.1...1.2) times and the effective viscosity of marshmallows is (1.35...1.55) times compared with the control. This has a positive effect on the texture of the product and extends the shelf life of its freshness.

3. It has been determined that with the introduction of the food additive "Magnetofood" in the marshmallow masses, the following decrease: the density is (1.12...1.15) times and the duration of whipping by (1.5...2.5)×60 s by compared with control.

4. Recipes have been complied and technological schemes have been developed for the production of cottage cheese dessert and white-pink marshmallow (on agar and pectin) using the food additive "Magnetofood".

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