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# ИЗВЕСТИЯ

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# TECHNOLOGICAL ADDITIVES AS AN ELEMENT OF DRY MILK PROPERTIES DIRECTED FORMATION

**Abstract.** The modern development of the food industry is unthinkable without the use of food additives. Their use makes it possible to improve the finished products quality, give it consumerly attractive properties, increase shelf life, reduce losses during transportation, expand of the supply's geography logistics, facilitate the intensification of technological processes, etc. The carried out complex of studies has made it possible to establish that the introduction of salt-stabilizers has a significant effect on the change in the basic functional and technological dried whole milk properties. Analysis of experimental material, obtained for all indicators studied during the work, allows us to recommend the use of complex phosphate salts in dried whole milk technology. At the same time, it should be noted that dried whole milk samples with salts, obtained by introducing them into normalized milk and its subsequent drying, surpass samples with similar salts, obtained by dry mixing, in their qualitative characteristics. This is due to more intense mechanism stabilizing salts effect on milk protein complex before drying.

**Keywords:** powdered milk, food additives, technology, quality, dynamics in storage.

Modern innovative development of the food industry is unthinkable without use of wide range of food additives. Their use makes it possible to improve the finished products quality, give it consumerly attractive properties, increase shelf life, reduce losses during transportation, expand of the supply's geography logistics, facilitate the intensification of technological processes, etc. [1-4].

Currently, there are several legal interpretations of the "food additive" established by international - Codex Stan 192-1995, interstate EAEU - TR TS 021/2011, TR TS 029/2012 and national documents of the Russian Federation - FZ dated 02.01.2000 No. 29-FZ. Briefly, the essence of the concept can be summarized as follows: food additive is a substance or mixture of substances usually not eaten directly by human, deliberately used in food production with a technological purpose for ensuring production processes, transportation and storage [4-6].

In Russian Federation, food additives are divided into the following main functional classes: anti-caking agents (anti-boilers); antioxidants; flour treatment agents; glazing; acids and acidity regulators; preservatives; colorants; carriers; sweeteners; stabilizers, emulsifiers, fillers and thickeners; flavor enhancers and aromas; color fixatives (stabilizers) [6, 7].

From the given list of food additives one should single out such a widely used group as "stabilizers, emulsifiers, fillers and thickeners", otherwise called technological food additives, which are manifested either in the purposeful modification of the product constituent parts during technological processing, or in giving the product a certain quality characteristics due to its own functional and technological properties

[5-7]. The substances of this additives group play an important role in modern technologies and find application in almost all sectors of food industry, including the dairy one [3, 6, 7].

Today in the dairy industry one of the urgent tasks is to improve the quality characteristics of canned dairy products used as dry dairy raw materials (DDRM), and in particular such indicators as thermal stability, solubility, etc. It is known, that from raw materials with low thermal stability and solubility is difficult to produce high-quality dairy products, especially with high organoleptic characteristics. The prospect of processing this raw material in other sectors of food industry, for example, in the confectionery, is very difficult due to used high-temperature treatment regimes and the high acidity of certain ingredients [8-18].

It should be noted, that for the various food products production, the most demanded of the DDRM is dried whole milk (DWM). In international practice (Codex Stan 207-1999), a wide range of food additives is used in its manufacture, namely: stabilizers, hardeners, acidity regulators, emulsifiers, antioxidants, as well as additives preventing caking and balling. On the territory of the member countries of the European Economic Union, including Russian Federation, DWM is produced according to GOST 33629-2015, which rationalizes its production only from dairy raw materials. On the one hand, this is a positive factor - especially when processing of DWM into reconstituted milk for direct consumption. On the other hand, in view of the limited amount of high-quality raw milk and the seasonality of its production, the possibility of producing DWM, for example, from non-heat-resistant raw materials, the quality of which can be improved by using food additives, is excluded. In this situation, the DWM production with use of salts is permissible to carry out under technical conditions or standards of organizations [2, 4, 19-21].

The purpose of this work was to establish the feasibility of using different salts to improve DWM quality characteristics, including depending on the method of their incorporation into dairy raw materials.

**Research methods.** Standard conventional and original experimental methods were used in the work [2, 5, 9]. In particular, were studied a number of functional and technological DWM indicators, including samples in a reduced form: acidity, heat resistance, solubility index, water activity (milk powder), viscosity, dissolution rate, etc. A three-dimensional experimental study of the samples was carried out on the "Jeol-840 A" electron microscope (Japan), for which they were previously glued onto special metal tables after being fixed and dehydrated, were sprayed with gold in the ionic spraying thin coatings "JFC - 1100". The indicator of the samples water activity was researched on the device “Hygrolab-3” of the company ROTRONIC (Germany) with digital ventilated station “AwVC-DIO” and results processing by “HW3” software. The granulometric composition is based on RETSCH analytical screening installation of the AS200 Control series, equipped with the Amplimatic microprocessor analysis control system and the Easysievet results processing program.

Milk powder with salts samples were obtained under production conditions on a spray drying unit. Making salt process was carried out in two ways: the method of normalized milk drying with salt (DWM1) and the method of dry mixing (DWM2), which provides for DWM dry mixing with a stabilizer salt on vibration mixers. At the same time, for the control salt-free sample and DWM1 samples, the raw material was used as close as possible to the characteristics. As a dry milk basis for DWM2 samples, dry milk from the control batch was used. During research, about 7.5 tons of powdered milk with various salts were produced and feedback was received on the processing of this raw material in various food industries, in particular on its use in the confectionery products development.

As stabilizer salts under research were used sodium citrate trisubstituted ($Na_3C_6H_5O_7 \cdot 5,5H_2O$) according to GOST 31227-2004 (E331), sodium disubstituted phosphate 12-water ($Na_2HPO_4 \cdot 12\ H_2O$) according to GOST 4172-76 (E339) and complex salt, representing a mixture of sodium phosphates (hereinafter referred to as polyphosphate). Each of stabilizer salt for all DWM samples were injected in equal amounts to the mass of the finished product.

**Research results.** Based on the analysis of preliminary experiments results on the preparation of DWM with various salts, it was found that, by the criteria of accessibility/quality/price/efficiency, it is most efficient to use complex polyphosphate salts. To assess the effectiveness of salt addition, salt-free DWM were further monitored, as well as with $Na_2HPO_4 \cdot 12H_2O$ and $Na_3C_6H_5O_7 \cdot 5,5H_2O$, produced using maximally one-type technologies.

A rational dosage of salts has been experimentally established previously – 0.3% by DWM weight, which ensures a stable increase in thermal stability by 1–3 groups and a decrease in solubility index by 2–3 times.

Visually researched salts differed in the degree of dispersion and the intensity of dissolution in water.

Figure 1 shows electron microscopic photographs of salt samples at different magnifications (1, 2, 3 - x500 and 1a, 1b, 1c – x4000, respectively), allowing demonstrate the differences in the structure of the objects under study clearer.

As follows from the figure, complex salt has a higher dispersion. In general, significant differences in the structure of the salts studied are well comparable with the data on their solubility in water. In DWM1 production, salts in normalized milk were made in the form of aqueous solutions, and in DWM2 technology – $Na_3C_6H_5O_7 \cdot 5,5H_2O$ and $Na_2HPO_4 \cdot 12\ H_2O$ subjected to additional grinding in order to achieve a more uniform distribution in milk powder mass.

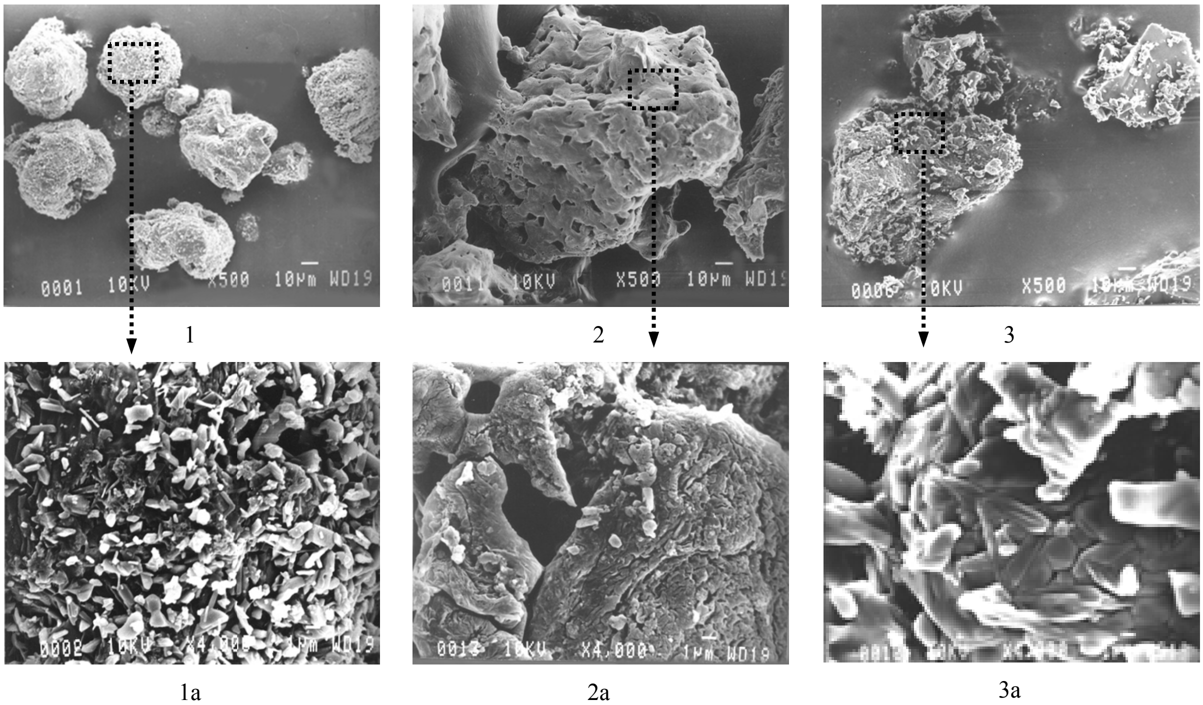


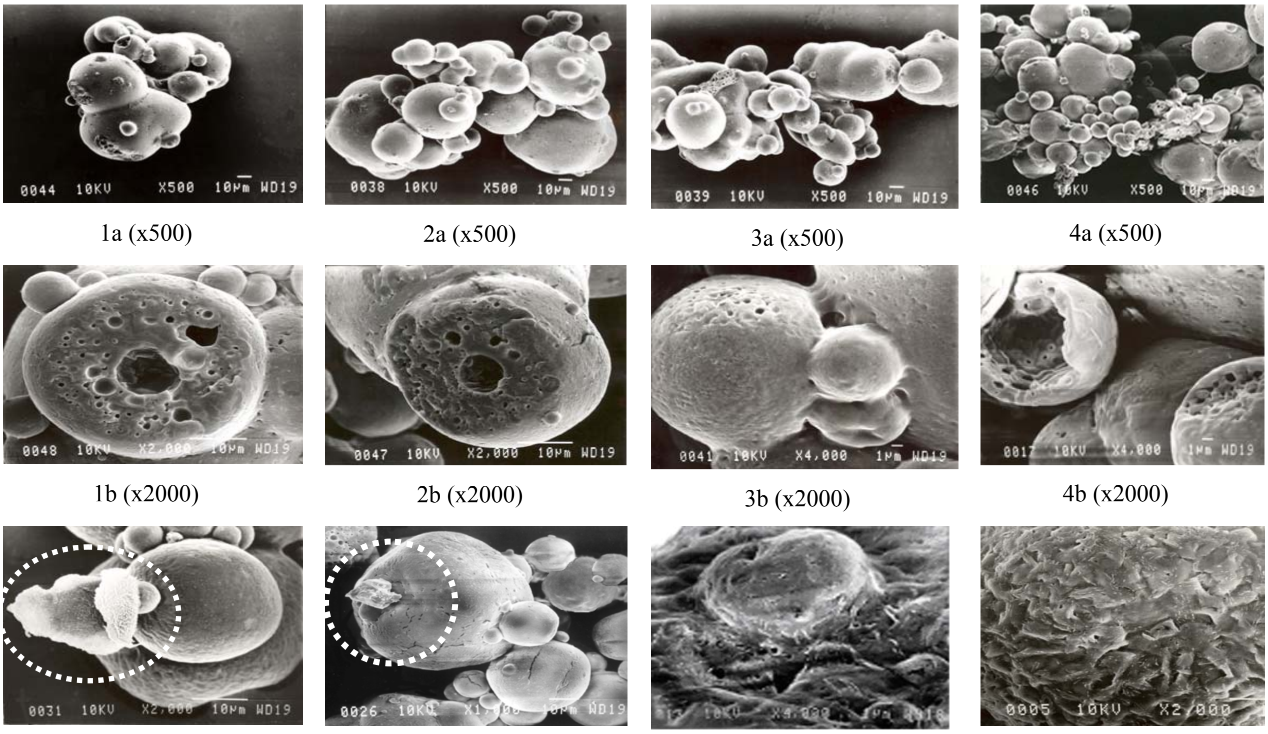

Figure 1 – Microstructure of the studied stabilizing salts

In order to more fully determine the differences between the studied milk powder samples, their microstructure was studied. Figure 2 shows electron microscopic photographs of the samples at different magnifications, which make it possible to demonstrate the differences in the structure of objects clearer.

As can be seen from figure 2, numerous globular particles with varying degrees of dispersion are detected in all tested milk powder preparations. So, in particular, compared with the control (4a and 4b), the DWM1 samples - 1a, 1b, 2a, 2b, 3a and 3b are characterized by larger globule size, which are largely connected to each other by means of connecting “bridges”. The presence of the latter causes the formation of a more coherent structure consisting of “conditional agglomerates”, which, in turn, has a positive effect on the rate of DWM dissolution process. In the control sample – 4a and 4b, as well as in DWM2 samples, a significant proportion of the particles is in free, unrelated state and only a small part is combined with each other. At the same time, a smaller globule size was observed for these samples. In accordance with the microstructural studies results, a satisfactory salt dispersion was revealed in DWM2 samples. Figure 2 part 5a and 5b shows the appearance of stabilizer salt particle on a dry milk globule, which clearly demonstrates the possibility of their identification in product mass.

Results of DWM dispersion, obtained by sieve method are shown in figure 3.

Analysis of the actual particle’s distribution in DWM indicates a significant difference in the particle size distribution of the experimental products as compared with the control samples. It is noted that in all experimental samples the number of particles with sizes greater than 0.25 mm significantly exceeds the control ones. The highest level of passive agglomeration was found in DWM with polyphosphate salt. Has been established the dust fraction reduction in all DWM with salts, which implies a reduction in losses during drying process.

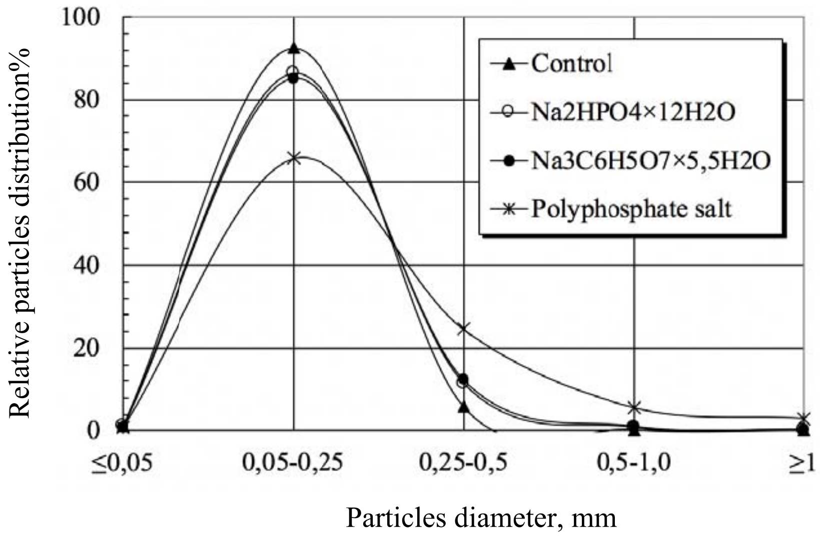


1a (x500) 2a (x500) 3a (x500) 4a (x500)

1b (x2000) 2b (x2000) 3b (x2000) 4b (x2000)

1c (x2000) 1d (x2000) 5a (x2000) 5b (x2000)

Figure 2 – Microstructure of the studied DWM samples:
1 – DWM with polyphosphate salt, 1a and 1b drying, 1c and 1d – dry mixing, a dotted line indicates salt particle on globule;
2a and 2b – DWM with $Na_3C_6H_5O_7{\cdot}5{,}5H_2O$ drying; 3a and 3b – DWM with $Na_2HPO_4{\cdot}12\ H_2O$ drying;
4a and 4b – control salt-free DWM; 5a – typical surface of control salt-free DWM; 5b – typical surface of DWM with salts




| Analysis product | Regression equation | Equation coefficients, correlations, and standard errors |
|---|---|---|
| DWM – salt-free control | Vapor Pressure Model: y=exp(a+b/x+cln(x)) | a=42.40; b=-42.28; c=24.17; S=0.383; r=0.99 |
| DWM with $Na_2HPO_4{\cdot}12H_2O$ | Rational Function: $y=(a+bx)/(1+cx+dx^2)$ | a=0.36; b=-0.02; c=-0.85; d=0.17; S=0.388; r=0.99 |
| DWM with $Na_3C_6H_5O_7{\cdot}5{,}5H_2O$ | | a=0.26; b=0.05; c=-0.85; d=0.17; S=0.143; r=0.99 |
| DWM with polyphosphate salt | | a=-0.64; b=0.92; c=-0.86; d=0.19; S=0.142; r=0.99 |

Figure 3 – Granulometric composition of the analyzed DWM samples

The introduction of stabilizing salts a priori has a significant effect on milk powder thermal stability during heat treatment and post-technological storage.

Since the results of a set of controlled DWM indicators revealed the greatest efficiency from the use of polyphosphate salt, below (figure 4) shows the results of the thermal stability formation (0→0/) and its kinetics in storage at $t_x$ (6±2) °C for DWM developed with use of this salt.

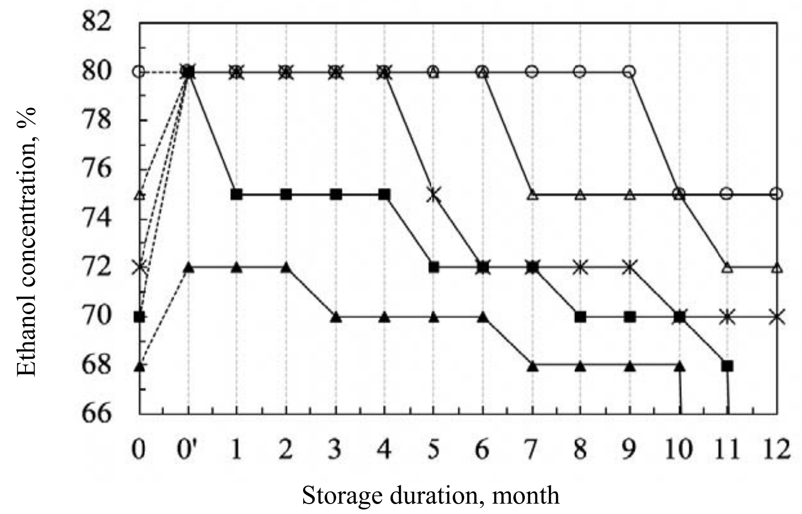



Figure 4 – Formation (0→0') and dynamics in storage (0'→12) T-in CMS with polyphosphate salt

It has been established that the use of polyphosphate salt contributes to an increase in thermal stability in the raw material – product chain (0→0') by 1–3 groups and forms its high value during storage. Similar studies of DWM with control salts showed a lower effectiveness of indicator initial growth (on average no more than 1 group) and a greater quality loss in storage. It is noted that the use of $Na_2HPO_4 \cdot 12H_2O$ and $Na_3C_6H_5O_7 \cdot 5{,}5H_2O$ with the initial value of thermal stability at the level of groups I-II is not rational.

The results of solubility index kinetics during storage of the control and experimental DWM samples are shown in figure 5.

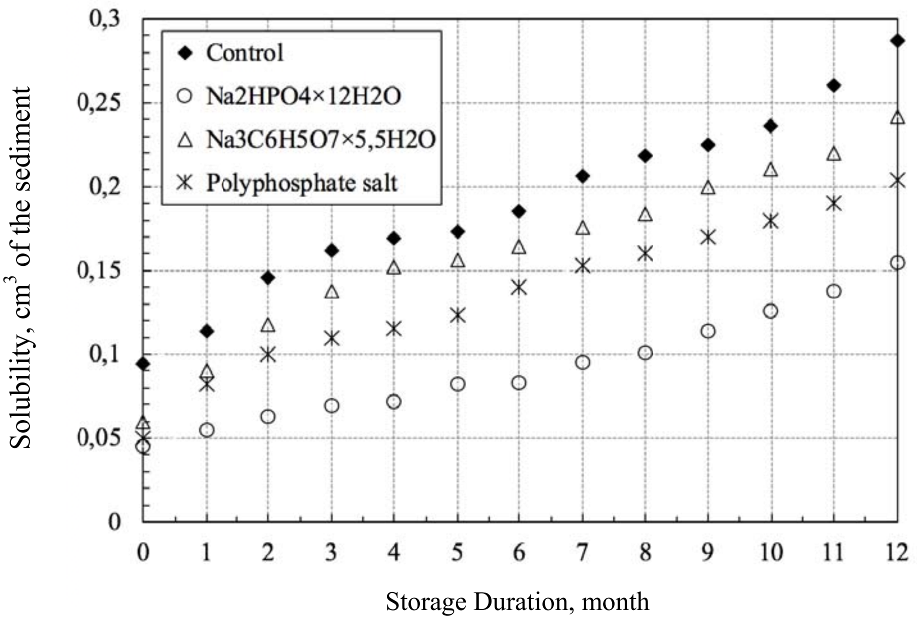



Figure 5 – Patterns of experimental DWM solubility dynamics when stored for 12 months at a temperature of (6±2) °C

These dependences confirm the effectiveness of salts use, which were further confirmed by data on the viscosity kinetics of the reconstituted DWM samples during storage. So, at the beginning and at the end of the storage, the relative viscosity growth for the control (c) and experimental (e) samples was as follows: DWM-c + 27.93%, DWM-e + 9.3%. Consequently, the use of salt in DWM technology makes it possible to significantly stabilize their protein fraction.

**Findings.** The carried out complex of studies has made it possible to establish that the introduction of salt-stabilizers has a significant effect on the change in the basic functional and technological DWM properties. Analysis of experimental material, obtained for all indicators studied during the work, allows us to recommend the use of complex phosphate salts in DWM technology. At the same time, it should be noted that DWM samples with salts, obtained by introducing them into normalized milk and its subsequent drying, surpass samples with similar salts, obtained by dry mixing, in their qualitative characteristics. This is due to more intense mechanism stabilizing salts effect on milk protein complex before drying.

The obtained data are taken into account in the recommendations on the principles of the directed dry milk products quality indicators formation for producers and processors of this products group.

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## ТЕХНОЛОГИЯЛЫҚ ҚОСПАЛАРДЫ ТІКЕЛЕЙ ЕНГІЗУ ЖОЛЫМЕН ҚҰРҒАҚ СҮТТІҢ ҚАСИЕТТЕРІН ҚАЛЫПТАСТЫРУ

**Аннотация.** Тамақ өнеркәсібінің қазіргі заманғы дамуын тағамдық қоспаларды пайдаланусыз мүмкін емес. Оларды пайдалану дайын өнімнің сапасын жақсартуға, тұтынушыға тартымды қасиеттермен қамтамасыз етуге, сақтау мерзімін ұзартуға, тасымалдау кезінде шығындарды азайтуға, жеткізудің географиясын кеңейтуге, технологиялық үдерістерді жеделдету және т.б. мүмкіндік береді. Орындалған зерттеулер тұрақтандырғыш тұздардың енгізілуі толыққанды құрғақ сүттің негізгі функционалдық және технологиялық қасиеттерінің өзгеруіне айтарлықтай әсер ететінін анықтауға мүмкіндік берді. Жұмыста зерттелген барлық көрсеткіштер үшін алынған эксперименттік материалдарды талдау кешенді фосфат тұздарын толыққанды құрғақ сүт технологиясында қолдануға ұсынуға мүмкіндік береді. Сонымен қатар, нормаланған сүтке енгізілген және одан кейінгі кептіру арқылы алынған тұзы бар толыққанды құрғақ сүт үлгілері, сапалық сипаттамалары бойынша ұқсас тұздарды құрғақ араластыру арқылы алынған сүт үлгілерінен асып кететінін атап өткен жөн. Бұл тұрақтандырғыш тұздардың сүтті-ақуыздық кешенге кептіруден бұрынғы әсерін тигізетін қарқынды механизміне байланысты.

**Түйін сөздер:** құрғақ сүт, тағамдық қоспалар, технология, сапа, сақтау кезіндегі динамика.

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## ФОРМИРОВАНИЕ СВОЙСТВ СУХОГО МОЛОКА ПУТЕМ НАПРАВЛЕННОГО ВВЕДЕНИЯ ТЕХНОЛОГИЧЕСКИХ ДОБАВОК

**Аннотация.** Современное развитие пищевой промышленности немыслимо без использования пищевых добавок. Их применение позволяет улучшить качество готовой продукции, придать ей привлекательные для потребителя свойства, увеличить срок годности, сократить потери при транспортировке, расширить географию поставок, ускорить технологические процессы и др. Выполненные исследования позволили установить, что введение солей-стабилизаторов оказывает существенное влияние на изменение основных функционально-технологических свойств сухого цельного молока. Анализ экспериментального материала, полученного по всем показателям, изученным в ходе работы, позволяет рекомендовать использование комплексных фосфатных солей в технологии сухого цельного молока. В то же время следует отметить, что образцы сухого цельного молока с солями, полученные путем введения их в нормализованное молоко и его последующей сушки, по своим качественным характеристикам превосходят образцы с аналогичными солями, полученными сухим смешиванием. Это связано с более интенсивным механизмом воздействия стабилизирующих солей на молочно-белковый комплекс перед сушкой.

**Ключевые слова:** сухое молоко, пищевые добавки, технология, качество, динамика при хранении.

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