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HOMOGENIZATION AND STABILITY OF MILK EMULSION

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Homogenization helps to reduce the settling of cream and reduce the loss of milk fat, which is valuable in terms of nutritional and energy value, in consumer packaging, during transportation and storage. The homogenized product does not stratify during long-term storage and is more convenient for transportation. Homogenization increases the density of milk, and as a result improves the taste of the homogenized emulsion. Homogenization is carried out:

– in the manufacture of milk and cream and contributes to the acquisition of homogeneity (taste, tone, fat content) of the emulsion;

– in the processing of oil before its rectification at oil refineries, as a result of which the yield of light oil products increases by 5 - 10%;

– in pharmaceuticals to obtain dosage forms, since the medicinal substance in the form of an emulsion is absorbed faster by the body with any method of administration, softens the irritating effect on the mucous membranes, accelerates the course of physicochemical processes in the gastrointestinal tract;

– in the production of fermented milk products (sour cream, kefir, yogurt) to increase the strength and improve the consistency of protein clots and prevent the formation of a fat plug on the surface of the product;

– in the perfume industry to obtain finely dispersed structures, ensuring their stability during storage;

– in the production of adhesives to increase the quality of bonding and reduce its costs during use.

The concept of “homogenization” in the dairy industry can be understood as several processes. During its implementation, the shells of fat globules are torn, the globules lose stability and separate. Homogenization of milk can be represented as a reduction in the average size of fat globules to a state when the mass fraction of fat is approximately balanced by the substance of the fat globule shell. In this case, the fat globule is in a stable colloidal state, and its size is about 1 μm.

– an emulsion with an average particle size can be created on rotary-pulsation devices, the processing of the emulsion in which in many cases

creates a product with a sufficient average particle size, especially when an emulsifier is added to the product. However, if this is not enough, then a plunger homogenizer must be used to create a thin, indivisible emulsion.

– homogenization of pasty products is used to create a homogeneous mass over the entire surface and depth and is implemented using special kneading machines, or homogenizers of the M6-OGA type, which are used in the manufacture of butter.

– homogeneous aqueous systems (emulsions) are primarily distinguished by their homogeneity of structure and the absence of an interface, as an indicator of the degree of molecular interaction between the surface of substances and water.

The stability of milk as a natural fat emulsion in milk plasma is due to the presence of an adsorption shell of fat globules and largely depends on their structural and mechanical properties. A number of studies have established that proteins, phosphatides, copper, iron, and various enzymes are adsorbed on the surface of fat globules. Proteins make up about 60% of the composition of the shells, phosphatides about 35%. Individual components of the shell are bound to it with varying degrees of strength - some of them are removed when washing, stirring the milk or changing the temperature. For example, the protein euglobulin is adsorbed on the membranes at a temperature of 44ºC, but when heated to 48.8ºC or when stirred, it passes into the milk plasma, other elements remain in the composition of the membrane even with prolonged exposure to various factors on the milk. Alkaline phosphatase is concentrated on the membrane of fat globules, acidic is associated with proteins.

In diluted emulsions of the “oil in water” type, which are characterized by a small fat concentration (less than 0.1%) and high dispersion, coalescence of droplets is unlikely. The stability of concentrated emulsions is created by the presence of adsorption layers of the emulsifier on the surface of the phase distribution. To obtain a stable emulsion, it is necessary to create conditions that prevent the merger of individual droplets to form larger ones.

The beginning of destabilization can be detected by a decrease in the dispersion of fat, i.e. by a decrease in the surface of the “milk fat–plasma” interface. The degree of destabilization of milk fat depends on the structural and mechanical properties of the fat globule shells, the concentration of salts in the milk plasma, and the amount of fat in the total volume of the product. Partial destabilization of milk fat occurs during separation and thickening, while some of the fat globules coalesce, and their average size increases.

The maximum stability of cream is observed at pH 6.0–7.0. The degree of destabilization of milk fat increases both with increasing and decreasing pH. The stability of milk fat is maximum near the isoelectric point of the shell protein, therefore, with the most stable structure of the surface layer. When the salt balance of milk is disturbed, the destabilization of milk fat also increases.

Any disturbance of the equilibrium structure of milk fat, regardless of its causes, worsens the quality of the final product.

Violation of the integrity of the shell of fat globules due to homogenization of dairy raw materials leads to the release of liquid fat onto the surface of the shell. An increase in the amount of free fat causes destabilization of the milk-fat emulsion. With increasing pressure, the amount of free fat decreases, which indicates the strength of the newly formed shells of fat globules. The stability of the dispersed phase of milk mixtures after homogenization significantly increases, and the stability of the protein phase decreases, especially at a high concentration of milk fat in the product and increased dispersion pressure.

References

1. Ковальов О. О. Обґрунтування параметрів струминно-щілинного гомогенізатора молока з роздільною подачею вершків : автореф. дис. ... канд. техн. наук : 05.05.11. ТДАТУ. Мелітополь, 2021. -20 с.

2. Palianychka N, Verkholantseva V, Kovalyov A. Use of energy-efficient equipment in drinking milk technological line. Сучасна інженерія агропромислових і харчових виробництв: Матеріали міжнародної науково-практичної конференції (24-25 листопада 2022 року). Харків: ДБТУ, 2022. С. 90–92

3. Samoichuk K., Kovalyov A., Fuchadzhy N., Bezaltychna O., Shevtsova A.: Energy Costs Reduction for Dispersion Using a Jet-Slot Type Milk Homogenizer. Energies 16(5), 2211 (2023) https://doi.org/10.3390/en16052211

4. Samoichuk, A. Kovalyov, V. Oleksiienko, N. Palianychka, D. Dmytrevskyi, V. Chervonyi, D. Horielkov, I. Zolotukhina, A. Slashcheva. (2020). Elaboration of the research method for milk dispersion in the jet slot type homogenizer. EUREKA: Life Sciences». 5. 51–59 pp. DOI: https://doi.org/10.21303/2504-5695.2020.001436

5. Samoichuk K., Kovalyov A., Oleksiienko V., Palianychka N., Dmytrevskyi D., Chervonyi V., Horielkov D., Zolotukhina I., Slashcheva A. (2020). Determining the quality of milk fat dispersion in a jet-slot milk homogenizer. *Eastern-european Journal of Enterprise Technologies*, 5 (11 (107)), 16–24. http://doi.org/10.15587/1729-4061.2020.213236

6. Samoichuk, K., Zahorko, N., Oleksiienko, V., Petrychenko, S. (2019). Generalization of Factors of Milk Homogenization. Modern Development Paths of Agricultural Production, Springer Nature.: Switzerland AG, 192–198. DOI: 10.1007/978-3-030-14918-5_21