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The results of studies of the influence of temperature and density on the stability of marshmallow

ABSTRACT

Relevance. The quality of products tends to be a core indicator of any enterprise activity defining its competitiveness within market conditions to a great extent. Production of confectionery creams avoiding usage of stabilizers, preservatives and trans fats is a promising direction being demanded by consumers. Stability of the whipped mass within production and storage processes depends on the dynamics of the confectionery foam destruction, which leads to degradation of whipped products form and volume. Stability and dimensional stability of foam systems become key indicators of food products quality reflecting their major structural and mechanical properties.

Methods. This article studies dependence of the stability (incl. dimensional stability) of cream marshmallow on temperature and density. Through experimental path authors show influence of molasses temperature set in line with recipe on the whipped cream density.

Results. Molasses temperature determines the temperature denaturation of egg whites, their bond and forms a stable structure. The study of cream marshmallow samples obtained from molasses with a density of 1.3 g/cm^3, 0.9 g/cm^3 and 0.7 g/cm^3 established that lower density of molasses added in line with the recipe forms a stronger and more stable structure of cream marshmallow.

Key words: confectionery industry, marshmallow, dimensional stability, molasses, closed production cycle

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Результаты исследований влияния температуры и плотности на стабильность зефира

РЕЗЮМЕ

Актуальность. Качество продукции является важнейшим показателем деятельности любого предприятия, так как в значительной степени определяет его конкурентоспособность в рыночных условиях. Производство кондитерских кремов без использования стабилизаторов, консервантов и трансжиров перспективно и востребовано потребителями. Стабильность сбивной массы в процессе производства и хранения изделий зависит от динамики разрушения кондитерской пены, в процессе которого происходит ухудшение внешнего вида сбивного изделия и уменьшение его объема. Стабильность и формоустойчивость пенных систем являются важными показателями качества пищевых продуктов, поскольку отражают их основные структурно-механические свойства.

Методы. Представлены исследования зависимости стабильности и формоустойчивости кремового зефира от температуры, плотности. Опытным путем показано влияние температуры вносимой по рецептуре патоки на плотность взбитого крема.

Результаты. Температура патоки обусловливает температурную денатурацию яичных белков, взаимное их притяжение и формирует устойчивую структуру. При исследовании образцов кремового зефира, полученных при использовании патоки с плотностью 1,3 г/см^3, 0,9 г/см^3 и 0,7 г/см^3, установили, что при более низкой плотности вносимой по рецептуре патоки формируется более прочная и устойчивая структура кремового зефира.

Ключевые слова: кондитерская промышленность, кремовый зефир, формоустойчивость, патока, замкнутый цикл производства

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Introduction / Введение

The confectionery industry is a food industry of high-capacity branch, aimed to provide high-quality confectionery products to the population in sufficient volume and assortment in order to form a varied and balanced dietary structure [1].

Traditionally confectionery products are streamlined into three main segments: sugary, starchy, chocolaty [2]. Manufacturers use various confectionery fillings to expand the range of these confectionery groups. Depending on raw material type confectionery fillings can be defined as — fruity and berrylike, fat, praline, fondant, cream, honey, liquor, milk, marzipan, butter-nut, whipped. In addition, depending on the method of use, confectionery fillings can be classified as:

- thermostable, maintaining temperatures up to 240 ºC and retaining both taste and texture during freezing and subsequent thawing;
- not thermostable, which are applied to final products. In general such fillings represent a soft, adaptive, well spreadable mass with a low melting point (less than 115 ºC) [3, 4].

It should be noted that major portion of confectionery fillings consumed in Russia is produced within the domestic market, the volume of import does not exceed 5%. Leading position in a wide variety of confectionery fillings belongs to whipped fillings (creams). Confectionery cream is considered to be one of the most desirable confectionery products, is used for pastry layering, decorationos the confectionery surface. Besides serving as a filling or decoration, it can be used as an independent dessert. Modern creams are of high demand due to their wide applications methods within the confectionery production, as well as their unique characteristics — they are able to retain taste, color and shape after baking, freezing or thawing [5–7].

The «Sparta» group of companies came up with a recipe and technology for cream marshmallow, which is notable for a light and airy structure; absence of preservatives, fats, trans fats, cholesterol and gluten. Cream marshmallow is a product showing minimum of calories in its content. Cream marshmallows are not heat-resistable and can be exclusively added to cooked semi-finished products.

Whipped egg white cream contains glucose syrup, sugar, water, dry egg white and flavoring. Glucose syrup or molasses meeting the requirements of GOST 33917-2016 «Starch molasses. General technical conditions»[1] is a natural sweetener. In the confectionery industry glucose syrup not only serves as a flavoring and nutritional component, but also is an anti-crystallizer — a substance preventing the sucrose crystallization process. Apart from this, it is a moisture-retaining agent and contributes to the products stabilization during storage, thanks to its high hygroscopicity.

The technological processing of cream marshmallow includes the following steps: pre-soaked in the required amount of water dry egg white is whipped to a fluffy foam, thereafter an evaporated and heated to a certain temperature molasses is poured in while still continuing with the whipping process. The process of whipping the mass shall continue until a stable structure of cream marshmallow is formed. Molasses used within the cream marshmallow processing technology shall be heated to a temperature of 70 ºC [8].

To obtain a cream marshmallow, dry egg whites pre-diluted with water in the required proportion are loaded into a tank. Certain amount of molasses, sugar and flavoring mentioned in the recipe shall be mixed together in a special syrup container. Thereafter the egg white whipped to a dense and stable foam as well as the syrup heated to the required temperature enter an aerator though a pipe system, where they mix together under controlled pressure, saturate with purified air and compose a mixture of an «airy» consistency under tight integrity. Egg white and glucose syrup are being added continuously in a certain ratio, dosing pumps control the accuracy of their supply amount. Mixture of hot glucose syrup and egg whites result into fixation and required density of the evolved foam [9].

The cream marshmallow generated in the aerator is then routed for packaging which can be performed in two ways: 1. packaging in individual plastic cups; 2. packing in a corrugated box with a polyethylene liner. General management of the cream marshmallow production line as well as parameters control and adjustments are carried out from a unified control panel [10, 11]. Cream marshmallow produced with described technology has stable structure, density, taste and color thanks to the natural composition and unique production technology.

A number of issues associated with the dispersion system destruction and the cream stability appear within production and storage of confectionery foam.

The study is aimed to analyze influence of temperature and density on the stability incl. dimensional stability of whipped cream marshmallows based on egg whites.

The object of the study are samples of cream marshmallows prepared against changes in temperature and density of molasses as well as the intensity of mass whipping.

Materials and methods / Материалы и методы исследования

The research materials are samples of cream marshmallows produced in a closed production cycle.

The work uses standard generally recognized methods for organoleptic and physico-chemical parameters definition.

The method for density definition is based on the determination of the volume of a bottle filled with distilled water and cream.

The sensory analysis method is used to define the dimensional stability of cream marshmallow.

Samples of cream marshmallow molasses for which was heated to a temperature of 60 ºC, 75 ºC, 90 ºC are welded under industrial conditions for the research purposes.

As a control sample research utilizes a sample of cream marshmallow taken in line with a traditional technology developed by the «Sparta» company, molasses is heated to a temperature of 70 ºC.

Mathematical processing is carried out with the help of the Excel program.

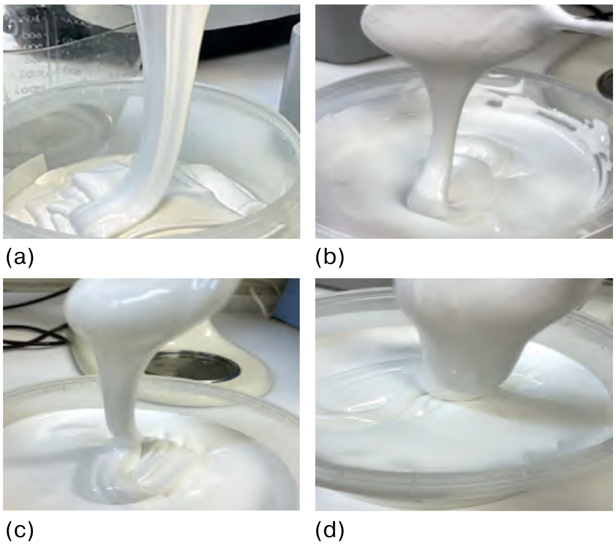
Results and discussion / Результаты и обсуждение

Temperature influence on the stability and shaping stability of marshmallow cream. For experimental studies three samples of cream marshmallow were prepared, differentiating in the temperature of the molasses added to the albumen foam.

Figure 1 shows a reference sample of marshmallow cream and samples with molasses heated to temperatures of 60 ºC, 75 ºC, 90 ºC.

[1] GOST 33917-2016 Starch molasses. General technical conditions. Moscow: Standartinform. 2017; 47.

Fig. 1. Change in the dimensional stability of cream marshmallow depending on temperature: (a) — reference sample, (b) t = 60 °C; (c) t = 75 °C; (d) t = 90 °C.



Compared to the reference sample creamy marshmallow whipped at 60 °C is more liquid and fluid. It quickly drains from a spoon and does not retain its shape well.

The temperature of 75 °C is close to the production temperature, thanks to this fact the test sample is close in its consistency to the reference one.

A sample with a molasses temperature of 90 °C turned out to be viscous, is difficult to mix and has poor fluidity.

Thus, the effect of temperature on the stability incl. dimensional stability of whipped cream based on egg whites is determined by the coagulation of protein molecules, which is observed at 70 °C. The process is accompanied by strong protein networks formation due to the fact that the unfolded protein chains are attracted to each other and form larger particles.

The experiment proves that an increase in the temperature of the added molasses ramps up the whipped cream density [12].

Influence of density on the stability incl. dimensional stability of cream marshmallow. Considering the dependence of density on the stability incl. dimensional stability of whipped cream, samples were prepared with different molasses density.

A remarkable factor affecting the density is the heating temperature of the molasses. The density of molasses was established at temperatures of 28 °C, 40 °C, 70 °C and 100 °C.

The density of molasses (ρ, g/cm^3) was defined by the formula:

$$\rho = \frac{m}{V},$$

where: m is the mass of molasses, g; V is the volume of molasses, cm^3.

Hence at room temperature the mass of molasses made up 140 g per 100 cm^3 of volume, therefore, its density equals:

$$\rho = \frac{140}{100} = 1{,}4 \text{ g/cm}^3,$$

Density of molasses at 40 °C:

$$\rho = \frac{130}{100} = 1{,}3 \text{ g/cm}^3,$$

Density of molasses at 70 °C:

$$\rho = \frac{90}{100} = 0{,}9 \text{ g/cm}^3,$$

Density of molasses at 100 °C:

$$\rho = \frac{70}{100} = 0{,}7 \text{ g/cm}^3,$$

Figure 2 shows the dependence of molasses density on its temperature.

According to the data obtained with higher temperature molasses density decreases [13].

Figure 3 shows the studied samples of cream marshmallow with a molasses density of 1.3 g/cm^3, 0.9 g/cm^3, 0.7 g/cm^3, respectively.

The conducted research established that a sample of cream marshmallow with a molasses density of 1.3 g/cm^3 is not dense enough and on a practical level does not retain its shape.

Cream marshmallow with a molasses density of 0.9 g/cm^3 has good plasticity and retains its shape well.

Cream marshmallow with a molasses density of 0.7 g/cm^3 is dimensionally stable to a higher extent, still the consistency structure is too thick.

Fig. 2. Dependences of cream marshmallow density on molasses temperature

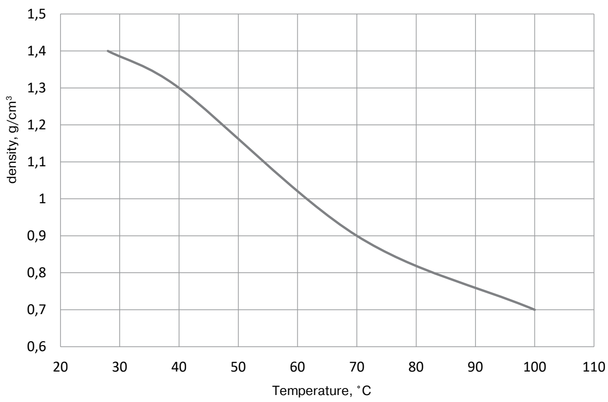
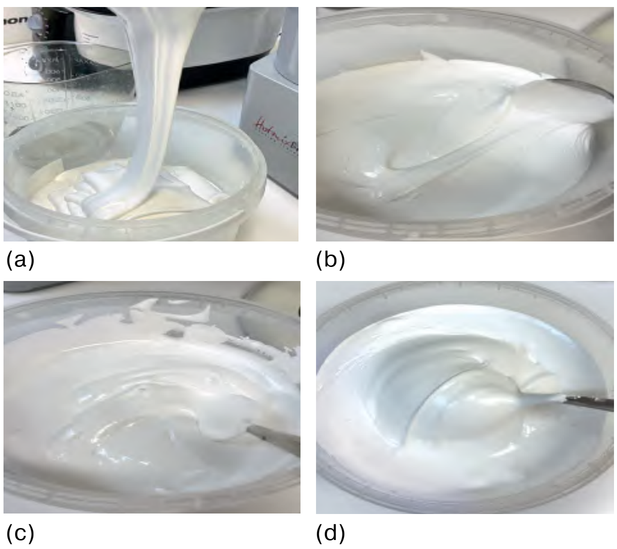


Fig. 3. Cream marshmallows of different density: (a) — reference sample; (b) — molasses density 1,3 g/cm^3; (c) — molasses density 0,9 g/cm^3; (d) — molasses density 0,7 g/cm^3.



Thus, the experiment established that lower density of molasses results into stronger and more stable structure of cream marshmallow [10, 14].

Conclusion / Выводы

A comparative analysis of the stability incl. shaping stability of whipped cream based on egg whites against changes in temperature and density of the added molasses indicates that the determining factor within the cream marshmallow preparation is temperature. The temperature level defines the strength of the confectionery foam film frame as well as density the molasses added to the albumen foam. The most optimal condition for the technological production process is the molasses temperature of 75 °C, density of 0.9 g/cm^3.

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БИБЛИОГРАФИЧЕСКИЙ СПИСОК

1. Титов А.К. Состояние и перспективы развития кондитерской промышленности Российской Федерации на современном этапе. *Вестник Академии знаний*. 2021; (6): 319–323. https://doi.org/10.24412/2304-6139-2021-6-319-323

2. Николашин А.С., Кузнецов И.А., Саяпин А.В. Эволюция рынка кондитерских изделий: организационно-экономическая трансформация предприятий Центрально-Черноземного региона. *Наука Красноярья*. 2018; 7(3): 36–58. https://doi.org/10.12731/2070-7568-2018-3-36-58

3. Полякова Е.Д., Веселин И.И., Полякова В.В. Систематизация классификационных признаков мучных кондитерских изделий по классификаторам и стандарту. *Вопросы идентификации и классификации товаров в таможенных целях: теория и практика. Материалы 6-й Всероссийской научно-практической конференции с международным участием.* Орел. 2022; 62–65. https://elibrary.ru/ubsmuu

4. Писарева Е.В. Исследование товароведной оценки медовых начинок для кондитерских изделий. *Ползуновский вестник.* 2016; (3): 23–27. https://elibrary.ru/xdzwzb

5. Колбасова Е.Н., Кочура А.И., Любименко Н.Ю. Анализ рынка кондитерских изделий. *Цифровая экономика: проблемы и современные тренды. Материалы Всероссийской научно-практической конференции.* Москва: Знание-М. 2020; 68–70. https://elibrary.ru/letknj

6. Смольская А.О., Петухов М.М. Тенденции совершенствования ассортимента кондитерских изделий. *Наука, питание и здоровье. Сборник научных трудов.* Минск: Беларуская навука. 2021; 2: 507–513. https://elibrary.ru/dqpsgq

7. Delahaije R.J.B.M., Lech F.J., Wierenga P.A. Investigating the effect of temperature on the formation and stabilization of ovalbumin foams. *Food Hydrocolloids*. 2019; 91: 263–274. https://doi.org/10.1016/j.foodhyd.2019.01.030

8. Магомедов Г.О., Плотникова И.В., Литвинова А.А., Магомедов М.Г., Плотников В.Е. Технологические аспекты приготовления желейного мармелада пониженной сахароемкости и калорийности с использованием натурального углеводосодержащего продукта. *Вестник Воронежского государственного университета инженерных технологий.* 2022; 84(2): 200–209. https://doi.org/10.20914/2310-1202-2022-2-200-209

9. Чудайкина А.В., Зайцева Т.Н., Горелик О.В. Технологические аспекты приготовления кремового зефира. *Качество продукции, технологий и образования. Материалы XVII Международной научно-практической конференции.* Магнитогорск. 2022; 68–71. https://elibrary.ru/zffrkm

10. Васецкая Н.О. Изобретательская деятельность в условиях неопределенности будущего технического прогресса: стандартизация и проблемы повышения качества научных разработок. *Вестник Магнитогорского государственного технического университета им. Г.И. Носова.* 2022; 20(3): 122–129. https://doi.org/10.18503/1995-2732-2022-20-3-122-129

11. Казанцев Е.В., Кондратьев Н.Б., Осипов М.В., Руденко О.С., Линовская Н.В. Управление процессами влагопереноса при хранении кондитерских изделий студнеобразной консистенции. *Вестник Воронежского государственного университета инженерных технологий*. 2020; 82(4): 47–53. https://doi.org/10.20914/2310-1202-2020-4-47-53

12. Вилкова Н.Г. Влияние температуры на устойчивость пен. *Актуальные проблемы науки и образования: прошлое, настоящее, будущее. Сборник научных трудов по материалам Международной заочной научно-практической конференции.* Тамбов. 2012; 5: 31–33. https://elibrary.ru/swansn

13. Chernopolskaya N. *et al.* Biotechnology of specialized product for sports nutrition. *International Journal of Engineering and Advanced Technology.* 2019; 8(4): 40–45. https://elibrary.ru/strlxl

14. Казанцев Е.В., Кондратьев Н.Б., Руденко О.С., Петрова Н.А., Белова И.А. Формирование пенообразной структуры кондитерских изделий. *Пищевые системы.* 2022; 5(1): 64–69. https://doi.org/10.21323/2618-9771-2022-5-1-64-69

REFERENCES

1. Titov A.K. State and prospects of development of the confectionery industry of the Russian Federation at the present stage. *Vestnik akademii znaniy.* 2021; (6): 319–323. (In Russian). https://doi.org/10.24412/2304-6139-2021-6-319-323

2. Nikolashin A.S., Kuznetsov I.A., Sayapin A.V. Evolution of the confectionery market: organizational and economic transformation of the enterprises of Central Black Earth Region. *Krasnoyarsk Science.* 2018; 7(3): 36–58. (In Russian) https://doi.org/10.12731/2070-7568-2018-3-36-58

3. Polyakova E.D., Veselin I.I., Polyakova V.V. Systematization of classification features of flour confectionery products according to classifiers and standard. *Issues of identification and classification of goods for customs purposes: theory and practice. Proceedings of the 6th All-Russian scientific and practical conference with international participation.* Orel. 2022; 62–65. (In Russian) https://elibrary.ru/ubsmuu

4. Pisareva E.V. Study of commodity evaluation of honey fillings for confectionery. *Polzunovskiy vestnik.* 2016; (3): 23–27. (In Russian) https://elibrary.ru/xdzwzb

5. Kolbasova E.N., Kochura A.I., Lyubimenko N.Yu. Analysis of the confectionery market. *Digital economy: problems and current trends. Proceedings of the All-Russian scientific and practical conference.* Moscow: Znanie-M. 2020; 68–70. (In Russian) https://elibrary.ru/letknj

6. Smolskaya A.O., Petukhov M.M. Trends in improving the range of confectionery products. *Science, nutrition and health. Collection of scientific papers.* Minsk: Belaruskaya navuka. 2021; 2: 507–513. (In Russian) https://elibrary.ru/dqpsgq

7. Delahaije R.J.B.M., Lech F.J., Wierenga P.A. Investigating the effect of temperature on the formation and stabilization of ovalbumin foams. *Food Hydrocolloids*. 2019; 91: 263–274. https://doi.org/10.1016/j.foodhyd.2019.01.030

8. Magomedov G.O., Plotnikova I.V., Litvinova A.A., Magomedov M.G., Plotnikov V.E. Technological aspects of the preparation of jelly marmalade of reduced sugar content and caloric content using a natural carbohydrate-containing product. *Proceedings of the Voronezh State University of Engineering Technologies.* 2022; 84(2): 200–209. (In Russian) https://doi.org/10.20914/2310-1202-2022-2-200-209

9. Chudaikina A.V., Zaitseva T.N., Gorelik O.V. Technological aspects of the preparation of cream marshmallow. *Quality of products, technologies and education. Proceedings of the XVII International Scientific and Practical Conference*. Magnitogorsk. 2022; 68–71. (In Russian) https://elibrary.ru/zffrkm

10. Vasetskaya N.O. Inventor Work Amid Uncertainty of the Future Technical Progress: Standardization and Problems of Improving R&D Quality. *Vestnik of Nosov Magnitogorsk State Technical University.* 2022; 20(3): 122–129. (In Russian) https://doi.org/10.18503/1995-2732-2022-20-3-122-129

11. Kazantsev E.V., Kondratyev N.B., Osipov M.V., Rudenko O.S., Linovskaya N.V. Management of moisture transfer processes during the storage of confectionery with a jelly-like consistency. *Proceedings of the Voronezh State University of Engineering Technologies.* 2020; 82(4): 47–53. (In Russian) https://doi.org/10.20914/2310-1202-2020-4-47-53

12. Vilkova N.G. Influence of temperature on the stability of foams. *Actual problems of science and education: past, present, future. Collection of scientific papers based on the materials of the International Correspondence Scientific and Practical Conference.* Tambov. 2012; 5: 31–33. (In Russian) https://elibrary.ru/swansn

13. Chernopolskaya N. *et al.* Biotechnology of specialized product for sports nutrition. *International Journal of Engineering and Advanced Technology.* 2019; 8(4): 40–45. https://elibrary.ru/strlxl

14. Kazantsev E.V., Kondratev N.B., Rudenko O.S., Petrova N.A., Belova I.A. Formation of a foamy structure of confectionery pastille products. *Food systems.* 2022; 5(1): 64–69. (In Russian) https://doi.org/10.21323/2618-9771-2022-5-1-64-69

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