UDC 664.683:544.022.822
DOI: 10.15587/2706-5448.2021.226429
Article type «Original research»

**Andriy Foshchan,**
**Viktoriya Yevlash,**
**Olena Aksonova,**
**Natalia Murlykina,**
**Inna Piliugina**

# APPLICATION OF THE MICROWAVE FIELD IN JELLY PRODUCTS TECHNOLOGY

*The object of research is the agar-based chocolate-jelly cake technology. Due to the annual decrease in the production of natural jelly-forming agents and their high price, the possibilities of improving the qualitative change in their functional properties are being studied. In this connection, various methods of modification by gelling agents, both chemical and physical, are proposed.*

*It is proposed to use the field of ultra-high frequencies (UHF) during the preparation of agar-sugar-treacle syrup in the «Chocolate-jelly» cake technology, as a result of which the consumption of gelling agents is reduced to 40 %. Microwave processing of the swollen gelling substance allows to reduce its consumption without introducing other components into the product formulation and without significant changes in the production process. It is shown that microwave treatment of a 1 % agar solution leads to an increase in the strength of the formed jellies by 40 %. It was found that microwave treatment leads to an increase in the melting temperature of the jelly in comparison with the untreated sample. It was revealed that hysteresis is observed at solidification and melting temperatures, the value of which ranges from 10 to 30 °C. Microwave treatment of a polysaccharide solution in a microwave field reduces the critical concentration of the transition of the molecular structure of the gel to the supramolecular one. Comparison of the enthalpies of melting of agar jelly after microwave treatment and jelly without finishing indicates that a larger number of hydrogen bonds are involved in the formation of a single node of the structure network.*

*The improved technology of the «Chocolate-jelly» cake based on agar differs from the traditional one in that the dissolution by gelling agents is carried out under the action of a microwave field, which makes it possible to reduce the prescription amount of agar. The proposed method of processing a 1 % agar solution with an ultrahigh frequency field leads to the strengthening of the jelly structure, and due to this, the costs of gelling agents in the production of jelly products are reduced and leads to a decrease in its cost.*

*The implementation of the plan will expand the range of jelly products and create competitive products in the confectionery market.*

**Keywords:** *gelling agent, agar-sugar-syrup syrup, microwave processing, jelly products, jelly strength, technological scheme, chocolate-jelly cake.*

*Received date: 19.01.2021*
*Accepted date: 22.02.2021*
*Published date: 19.03.2021*



***How to cite***

*Foshchan, A., Yevlash, V., Aksonova, O., Murlykina, N., Piliugina, I. (2021). Application of the microwave field in jelly products technology. Technology Audit and Production Reserves, 2(3(58)), 6–13. doi: http://doi.org/10.15587/2706-5448.2021.226429*

## 1. Introduction

Countries that are traditional suppliers of red algae (raw materials for the agar production) are experiencing a decrease in the collection and export of this valuable raw material for the production of agar. This affects not only the market price of the agar itself, but also the food products in which it is included. Most countries of the world do not have their own production of gelling agents of a polysaccharide nature, in particular agar. They are forced to import it from Morocco, Spain, to a lesser extent from Portugal, France, Mexico, Chile, countries of South Africa, Japan and South Korea. This gives a certain imprint on the assortment, the cost of products, as well as on the amount of profit made by enterprises that produce jelly products.

Gelling agents of polysaccharide nature are widely used in food technologies to improve organoleptic characteristics and extend shelf life. Basically, gelling agents of a polysaccharide nature are used as thickeners and gelling agents. They are used as thickeners in soups, gravies, salad dressings, sauces and toppings. As gelling agents, they are used in foods such as jams, jellies, marmalade, restructured foods, and low sugar/calorie gels.

Agar, furcellaran, carrageenan, agaroid, citrus pectin, apple, beetroot, gelatin are widely used to impart certain structural and mechanical properties to products [1].

The process of gelation or structure formation is based on the formation of a spatial network between biopolymer molecules connected in separate «nodes» by forces of intermolecular interaction or chemical bonds of various nature.

According to the generally accepted theory, the mechanism for the formation of the spatial structure can be represented as the formation of double helices from individual polymer chains, the association of double helices with the formation of their aggregates and with the subsequent formation of three-dimensional structures.

Understanding the mechanism of structure formation, as well as the influence of various chemical additives and external physical fields on the change in the basic functional properties of solutions and jellies, will make it possible to purposefully influence the structure-forming ability of these substances. This is of not only theoretical but also practical interest, since it contributes to a more economical use of this valuable raw material.

Taking into account the seaweed volumes in the oceans, the amount produced by sulfated gelling agents decreases every year. In this regard, at present, various methods of modification (of chemical and physical nature) by gelling agents have been proposed in order to qualitatively change their functional properties.

Considering the above, research on the application of the microwave field in the technology of jelly products is relevant. The implementation of the plan will allow the jelly-builders to reduce their costs in the production of jelly products (in particular, the «Chocolate-Jelly» cake) without introducing other components into the product formulation and without significant changes in the production process.

## 2. The object of research and its technological audit

*The object of research* is the agar-based «Chocolate-jelly» cake technology. The subject of research is jelly agar; «Chocolate-jelly» cake, made according to traditional technology and technology using the microwave field.

The process of improving the range of food products is largely predetermined by the nature and dynamics of consumer demand for it. Products with a jelly structure have long been in high demand among the population. In this regard, it is important and timely to implement the tasks of improving the technology of the «Chocolate-jelly» cake using the microwave field.

## 3. The aim and objectives of research

*The aim of research* is to improve the technology of «Chocolate-jelly» cake using the microwave field.

To achieve this aim, it is necessary to solve the following objectives:

1. To study the effect of microwave treatment on the change in the properties of solutions and jelly polysaccharides of red seaweed, in particular agar.

2. To develop a basic technological scheme for the production of the «Chocolate-jelly» cake, including the operation of microwave processing by gelling agents.

## 4. Research of existing solutions to the problem

An analysis of the literature on the modification of the polysaccharide nature by gelling agents, in particular agar, showed that a whole list of studies is devoted to this topic. Conventionally, all modification methods can be divided into chemical and physical. Thus, in [2], it was proposed to modify agar by the formation of complexes with four carboxylic acids (C12:0–C18:0). It was noted that the appearance of complexes «agar-carboxylic acid» affects the physicochemical (gel strength, viscosity, swelling, syneresis and surface tension) and rheological properties (dynamic viscosity) of the agar sol and gel. Another modification method is the joint introduction of salts of organic acids and polyhydric alcohols into the system. This increases the strength of the gels, the rate, the melting and solidification temperature [3, 4]. There is also a known method – the introduction into the system of sodium carboxymethylcellulose and ferric chloride, which are also capable of changing the functional properties of the structurant [5, 6]. Interest is also aroused not only by chemical methods, but also by methods of modifying polysaccharide solutions. In particular, an interesting and effective method is the treatment of solutions with gelling agents in the microwave field.

To date, a large number of studies have been carried out to study the physicochemical properties of aqueous solutions of polymers and their changes as a result of exposure to magnetic and electromagnetic fields [7, 8].

It has been suggested that the field changes the structure of water around polymer molecules and changes the hydrophobic interactions that allow the molecules to aggregate [9, 10]. It has been established that the structure of water is strengthened and hydrophobic interactions near polymer macromolecules are enhanced as a result of the action of ultrahigh-frequency radiation.

In [11], the effect of microwave electromagnetic radiation on the formation of supramolecular particles in aqueous solutions of non-hydrolyzed polyacrylamide was studied. It is shown that as a result of the action of the field, the solution is heated, which leads to the appearance of rather large supramolecular compounds.

When studying the effect of a magnetic field on the sol-gel transition of methylcellulose in water, it was found that the effect of a magnetic field leads to a decrease in the sol-gel transition temperature by 3 °C, exhibiting an effect similar to the effect of salt additives. In this case, a slight increase in the strength of the gel is observed [12]. In the course of research, it was also revealed that the degree of swelling of biopolymers such as gelatin, carboxymethyl cellulose (CMC) and its sodium salt changes in water exposed to an electromagnetic field, and the viscosity of solutions of these high molecular weight compounds (HMC) increases [13, 14]. The reason for this phenomenon may be a change in the energy of solvation processes in the treated water due to the strengthening of its supramolecular organization, which, in turn, determine the viscosity of polymer solutions, the rate and degree of polymer swelling.

## 5. Methods of research

**5.1. Influence of microwave fields of different power on the strength of agar jelly.** After preliminary swelling and subsequent dissolution by heating in a water bath, the investigated 1 % agar solution was obtained. After cooling to 35–45 °C, the solution was treated in a microwave field with a frequency of 2450 MHz at various power for 1–5 min so that the solution did not heat up more than 80 °C. After solidification, the strength of the agar jelly was measured using the method [15].

ISSN 2664-9969

**5.2. Method for assessing organoleptic quality indicators.** The organoleptic indicators of the quality of the «Chocolate-jelly» cake were determined using a sensory assessment, which was carried out by the method of expert evaluation on a five-point scale, taking into account the requirements for organoleptic indicators for this type of product (Table 1).

**Table 1**

Requirements for the organoleptic characteristics of the «Chocolate-jelly» cake

| Indicator | Indicator characteristic |
|---|---|
| Taste, smell and color | Typical for this name of the cake (chocolate glaze and body – two jelly and one whipped layers, without foreign taste and smell) |
| Consistency | In jelly layers – jelly, in whipped layer – foamy |
| Shape | Round, square or rectangular, regular, with a clear outline, slight deviation is allowed |
| Surface | The glaze should have a shiny surface, without graying or damage |

The authors have developed a scale for sensory assessment of organoleptic quality indicators of a new product. Each of the indicators (consistency, taste, smell, color, shape, surface) was presented as a set of components (descriptors), which were evaluated by experts in terms of quality, intensity and order of manifestation. The final score for each indicator was calculated taking into account the descriptor weighting coefficients and the indicator weighting. The overall score was the sum of the final scores for each indicator.

**5.3. Research methods of physical and chemical quality indicators.** The quantitative characteristics of the quality of the samples of the «Chocolate-jelly» cake (body) were carried out on the basis of the main physical and chemical parameters. Namely: humidity, mass fraction of reducing substances, total acidity. These indicators were determined using standard methods.

The mass fraction of moisture in the «Chocolate-jelly» cake was determined by drying a 5 g sample in a weighing bottle in an oven for 50 min at a temperature of (130±2) °C.

The mass fraction of reducing substances was determined by the ferricyanide method.

The total acidity ($X$) of the samples under study was determined from the results of titration of an aqueous extract of a 5 g sample of 0.1 M sodium hydroxide solution in the presence of phenolphthalein. The total acidity was calculated in degrees using the formula:

$$X = \frac{V \cdot K \cdot 100}{m \cdot 10},$$

where $V$ – volume of sodium hydroxide consumed for titration, cm$^3$; $K$ – correction factor for sodium hydroxide solution with a concentration of 0.1 mol/dm$^3$ used for titration; $m$ – mass of the cake sample taken for analysis, g; 100 – conversion factor per 100 g of product; 10 – conversion factor of 0.1 M sodium hydroxide solution in 1 M.

**5.4. Methods for the study of microbiological quality indicators.** Sampling and preparation of samples for microbiological analysis was carried out in accordance with the current regulatory documentation.

**5.5. Statistical processing of results.** The determination of the experimental values of the variable $x$ was carried out in a number of parallel determinations ($n$=4 or 5). The confidence interval was determined using the Student's distribution coefficient ($t$-distribution) with a confidence level of $P$=0.95. The values of the experimental data obtained in this way or calculated from them are presented in the tables in the form $\bar{x} \pm \Delta x$, where $\bar{x}$ – mean value and $\Delta x$ – mean sampling error. Statistical data processing was carried out using the Excel program of the Microsoft Office 2010 package.

## 6. Research results

**6.1. Study of the strength dependence of agar jelly on microwave treatment.** Microwave treatment of a 1 % agar solution leads to an increase of up to 40 % in the strength of the jellies formed by it, which, given the shortage and high cost of gelling agents, has a significant economic effect. In addition, as is known from the literature, microwave treatment significantly reduces the microbiological contamination of the product, which can be used to adjust the shelf life [16].

Fig. 1 shows the results of a study of the effect of an ultra-high frequency field of various power on the strength of agar jelly.

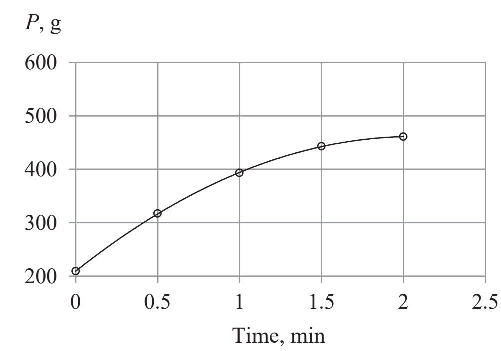


**Fig. 1.** Dependence of the strength of agar jelly on the processing time at heating power $W$=800 W

The research results show that the treatment of a polysaccharide solution with a microwave field leads to a significant strengthening of the jelly. The duration of exposure of the solution in the microwave field is selected experimentally. It depends both on the field strength and on the volume of the solution. The processing time with gelling agents ($\tau$) depends on the mass of the solution being processed and the heating power (Fig. 2).

It was found that the treatment of the solution with a microwave field leads to an increase in the melting point of the jelly in comparison with the untreated sample of the same concentration with gelling agents. It was revealed that there is a hysteresis for the pour point and melting point, the value of which ranges from 10 to 30°. Dependences on the polysaccharide content and processing time were determined: the higher the content, the greater the temperature difference.

An important characteristic of the state of the jelly structure is the average energy of a single bond node of the gelling grid, or the enthalpy of melting, which characterizes the decay energy of the jelly network nodes. The relationship of this value with the melting point of jelly is described by the Eldridge-Ferry equation:

$$\Delta H = -R\frac{\Delta \ln C}{\Delta T^{-1}},$$

where $\Delta H$ – energy of the communication center schedule; $R$ – universal gas constant; $C$ – concentration by gelling agents; $T$ – melting point of the jelly of a given concentration.

Fig. 3 shows the curves of $\ln C$ versus $1000/T_m$. These dependences are curves with a characteristic break. The concentration at which a break is observed is called critical, $Cc$, and characterizes the transition of a molecular structure to a supramolecular one.

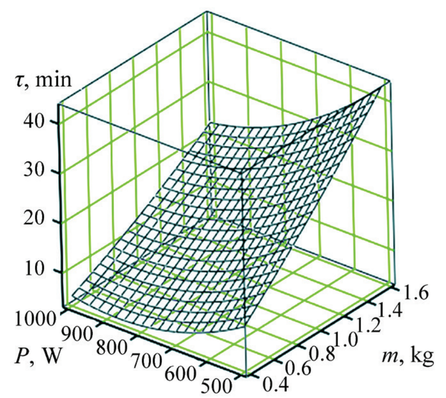


**Fig. 2.** Graph of the surface of the dependence of the processing time on the mass of the solution, processed and heating power

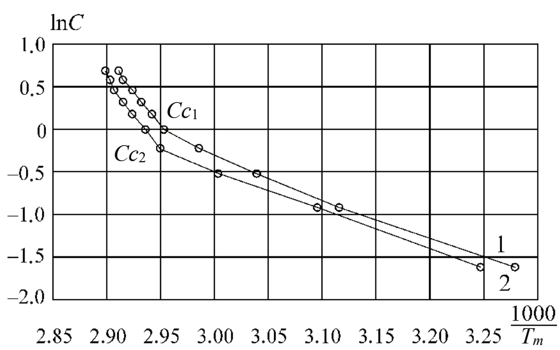


**Fig. 3.** Curves of $\ln C$ versus $1000/T_m$ samples: 1 – 1 % agar solution (control); 2 – 1 % agar solution treated with an ultra-high frequency field

The molecular structure of jelly is characterized by weak bonds and, as a consequence, a small value of the enthalpy of melting of the gel ($\Delta H_1$). According to the concentration of gelling agents in the solution of the superior $Cc$, there is a greater number of bonds and, accordingly, a large value of the enthalpy of melting ($\Delta H_2$).

From the data Table 2 it is possible to see that the treatment of agar solutions in a microwave field leads to a decrease in the critical concentration of the transition of the molecular structure of the jelly to the supramolecular one ($Cc_1 > Cc_2$). The $\Delta H_1$ size is approximately the same for both the treated solution (control) and the untreated one (≈40 kJ/mol). However, the $\Delta H_2$ value for the sample treated in the microwave field is large (150 kJ/mol compared to 130 kJ/mol), which indicates that a larger number of bonds are involved in the formation of a single grid node.

**Table 2**

Results of processing an agar solution in an ultra-high frequency field

| Test sample | Critical concentration | Energy of the communication center schedule DH, kJ/mol | |
|---|---|---|---|
| | $Cc$, % | $\Delta H_1$ | $\Delta H_2$ |
| 1 % agar solution | 1 | 41.2 | 130 |
| 1 % agar solution treated with microwave | 0.8 | 43.2 | 150 |

Thus, the treatment of a 1 % agar solution with an ultra-high frequency field leads to the strengthening of the jelly structure, which makes it possible to reduce the costs of gelling agents in the production of jelly products and reduce its cost.

**6.2. Technology of the «Chocolate-jelly» cake production with a reduced number of gelling agents.** For the prototype was taken the traditional recipe of the «Chocolate-jelly» cake [17], which is a body glazed with chocolate glaze, consisting of two outer jelly layers and an inner layer of whipped mass.

The main raw materials for making a cake are sugar, food agar, apple puree, egg whites, dyes, food flavorings, citric acids, vanillin, chocolate glaze, starch syrup, essences.

According to the traditional recipe and taking into account the results obtained, a recipe was developed for the «Chocolate-jelly» cake with a reduced amount of gelling agent, given in Table 3. The difference between the new recipe and the traditional one is to reduce agar consumption by 40 %.

On the basis of the studies carried out to develop a new recipe, the technology was improved and a technological scheme for the production of the «Chocolate-jelly» cake was developed (Fig. 4).

**Table 3**

The recipe for the «Chocolate-jelly» cake with a reduced amount of gelling agents

| Raw materials | Mass fraction of dry substances, % | Raw material consumption, kg | | | |
|---|---|---|---|---|---|
| | | for 1000 kg of semi-finished product | | for 1000 kg of finished products | |
| | | actually | in dry matter | actually | in dry matter |
| Chocolate glaze | 99.10 | 302.75 | 300.03 | 306.40 | 303.60 |
| Granulated sugar | 99.85 | 440.20 | 439.54 | 445.48 | 444.81 |
| Syrup | 78.00 | 142.58 | 111.21 | 144.30 | 112.55 |
| Apple puree | 10.00 | 26.01 | 2.60 | 26.17 | 2.62 |
| Agar | 85.00 | 6.12 | 5.20 | 5.22 | 4.44 |
| Citric acid | 91.20 | 6.89 | 6.28 | 6.29 | 5.74 |
| Vanilla essence | 0.00 | 0.30 | 0.00 | 0.30 | 0.00 |
| Essences are different | 0.00 | 0.23 | 0.00 | 0.23 | 0.00 |
| Different dyes | 0.00 | 0.74 | 0.00 | 0.74 | 0.00 |
| Total | – | 952.82 | 864.86 | 935.13 | 873.76 |
| Yield | 81.60 | 1000.00 | 816.00 | 1000.00 | 816.00 |

ISSN 2664-9969

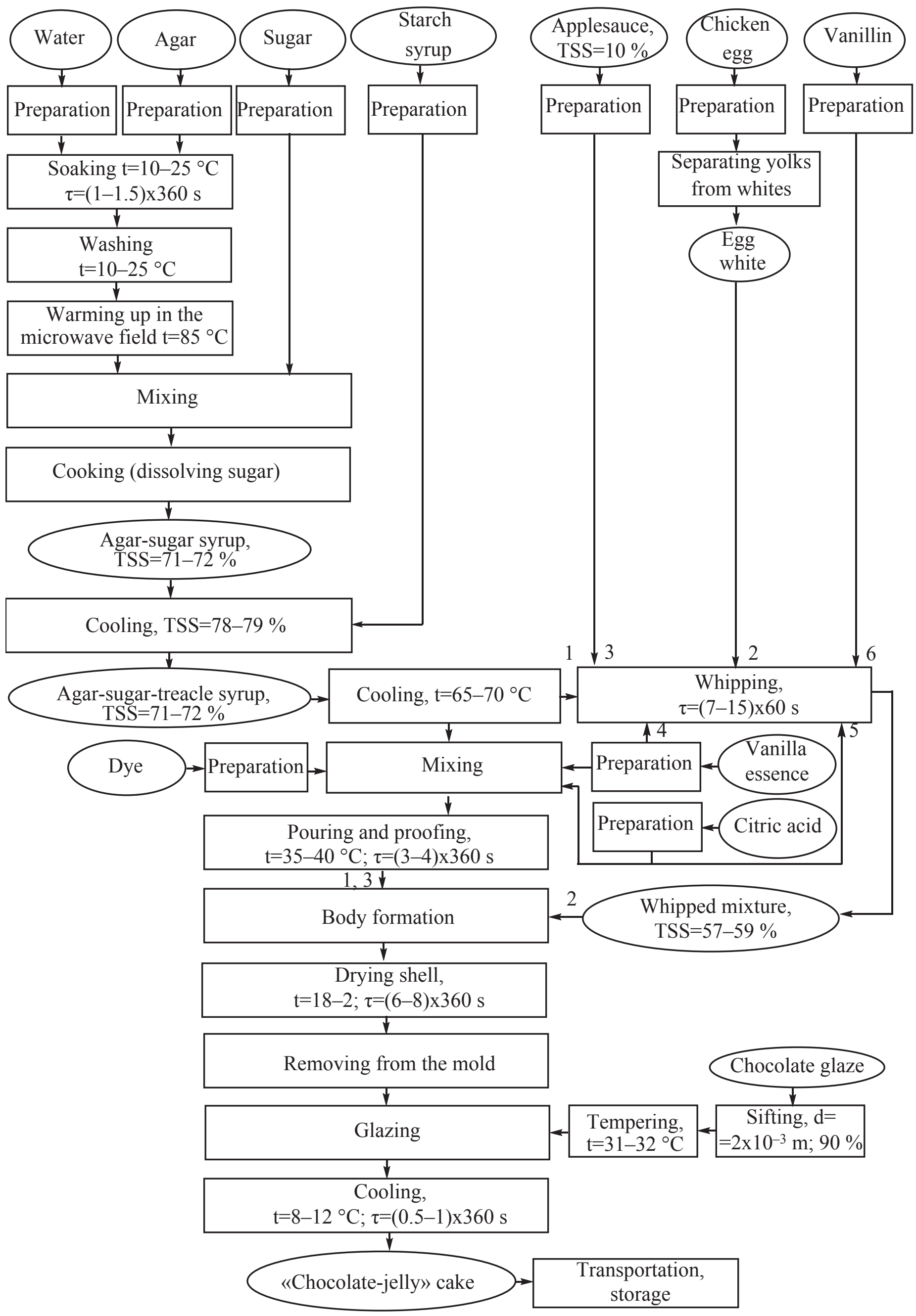


**Fig. 4.** Technological scheme for the production of the «Chocolate-jelly» cake with a reduced number of jelling agents

The production technology of the «Chocolate-jelly» cake consists of the following operations:
- preparation of raw materials;
- preparation of agar-sugar-treacle syrup for the lower and upper layers;
- preparation of whipped mass for the middle layer;
- pouring syrup into molds and its gelling agent;
- drying of bodies;
- icing and cooling of cakes;
- packaging;
- marking;
- transportation and storage.

The body of the «Chocolate-jelly» cake on agar consists of three layers: the bottom and top – jelly, having different colors, and the middle – whipped layer – white.

Jelly layers, depending on taste and color, are flavored with various essences:
- raspberry or strawberry (red);
- orange or tangerine (orange color);
- lemon or apricot (yellow);
- pear or pineapple (green);
- blackcurrant or cherry (lilac color);
- apple or vanilla (white).

The cake making technology is as follows. Agar is soaked in water in cloth bags and washed in running water. After that, the calculated amount of water is added and heated in the microwave field. Granulated sugar is added to the agar solution. Heat and stir constantly until sugar dissolves. Then add molasses without stopping heating and stirring. The resulting agar-sugar-syrup is cooled to 60–65 °C and part of it is taken to obtain a whipped (middle) layer of the cake body. In the rest, add dye, citric acid, essence and pour into molds (bottom layer). After hardening, a white whipped layer is poured onto it. After the structure formation of the middle layer, a jelly top layer is poured and the molds with the bodies are kept at a temperature of 18–21 °C for 6–8 hours to strengthen the layers of the bodies.

Dried bodies are glazed with chocolate glaze. The last tempering at a temperature of 31–32 °C. After glazing, the cakes are cooled to 8–12 °C for 30–60 minutes. Finished products are packaged and labeled.

The difference of the proposed technology lies in the use of a microwave field in the preparation of agar-sugar-treacle syrup to dissolve swollen agar, which makes it possible to reduce the prescription amount of gelling agents and reduce the cost of the product.

The use of the microwave field provides for minor changes in the instrumentation of the technological process. The parameters of the technological process do not differ from the traditional ones, so the new technology can be introduced into production without complications.

**6.3. Indicators of the quality of the «Chocolate-jelly» cake with a reduced number of gelling agents.** According to the developed scale of sensory evaluation, the organoleptic characteristics of the «Chocolate-jelly» cake are determined (Table 4). The statistically processed results are shown as individual descriptors of taste, smell and color, consistency, shape, surface, taking into account the weight coefficients of individual descriptors and the overall indicator, which is 4.97.

The organoleptic evaluation of the samples of the «Chocolate-jelly» cake has shown their full compliance with the requirements of regulatory documents for this type of product.

The results of determining the physicochemical and microbiological indicators of the quality of the «Chocolate-jelly» cake with a reduced amount of gelling agent are given in Tables 5, 6.

According to the data obtained, the developed «Chocolate-jelly» cake with a reduced number of gelling agents in terms of physical, chemical and microbiological indicators meets the requirements of regulatory documents for this type of product.

**Table 4**

The scale of organoleptic evaluation of the sample of the «Chocolate-jelly» cake with a reduced number of gelling agents

| Indicator | Descriptor number | The weighting factor of the descriptor | Characteristic of the indicator | Score, points |
|---|---|---|---|---|
| Taste | 1 | 0.4 | Typical for the given name of the cake without foreign aftertaste | 5.0 |
| | 2 | 0.3 | Body-specific – two jelly layers, no off-taste | 5.0 |
| | 3 | 0.3 | Typical for the body – whipped layer, without foreign taste | 5.0 |
| Total score | | | | 5 |
| Indicator weighting factor | | | | 0.3 |
| Final score for the indicator | | | | 1.5 |
| Smell | 1 | 0.4 | Typical for this name of the cake without foreign smell | 4.9 |
| | 2 | 0.3 | Body-specific – two jelly layers, no foreign smell | 5.0 |
| | 3 | 0.3 | Typical for the body – whipped layer, without foreign smell | 4.9 |
| Total score | | | | 4.93 |
| Indicator weighting factor | | | | 0.1 |
| Final score for the indicator | | | | 0.49 |
| Colour | 1 | 0.4 | Typical for this name of the cake without foreign smell | 5.0 |
| | 2 | 0.3 | Body-specific – two jelly layers, no foreign smell | 5.0 |
| | 3 | 0.3 | Typical for the body – whipped layer, without foreign smell | 5.0 |
| Total score | | | | 5.0 |
| Indicator weighting factor | | | | 0.1 |
| Final score for the indicator | | | | 0.5 |
| Consistency | 1 | 0.5 | In jelly layers – jelly-like | 5.0 |
| | 2 | 0.5 | In a whipped layer – foamy | 4.9 |
| Total score | | | | 4.95 |
| Indicator weighting factor | | | | 0.2 |
| Final score for the indicator | | | | 0.99 |
| Shape | 1 | 0.1 | Round, square or rectangular, regular, with a clear outline, slight deviation is allowed | 5.0 |
| Total score | | | | 5.0 |
| Indicator weighting factor | | | | 0.1 |
| Final score for the indicator | | | | 0.5 |
| Surface | 1 | 0.5 | Glitter glaze | 4.9 |
| | 2 | 0.5 | Glaze without graying or damage | 5.0 |
| Total score | | | | 4.95 |
| Indicator weighting factor | | | | 0.2 |
| Final score for the indicator | | | | 0.99 |
| Total | | | | 4.97 |

ISSN 2664-9969

**Table 5**

Physicochemical indicators of the quality of the «Chocolate-jelly» cake with a reduced number of gelling agents

| Indicator name | The value of the indicator for the cake (body) |
|---|---|
| Humidity, % | 20.0±0.8 |
| Total acidity, deg. | 7.6±0.1 |
| Mass fraction of reducing substances, % | 17.0±0.7 |

**Table 6**

Microbiological parameters of the «Chocolate-jelly» cake with a reduced number of gelatinous agents

| Indicator | Indicator value for cake | |
|---|---|---|
| | norm | with a reduced change of agar |
| The number of mesophilic aerobic and facultative anaerobic microorganisms, KUO g, no more | $1\times10^3$ | $1\times10^2$ |
| Escherichia coli bacteria (coliforms), in 0.1 g | not allowed | not detected |
| Pathogenic microorganisms, including bacteria of the genus Salmonella, in 25 g | not allowed | not detected |
| Mold fungi, CFU, no more | 100 | 20 |

Thus, the use of the microwave field in the preparation of agar-sugar-treacle syrup for dissolving agar in the «Chocolate-jelly» cake technology allows reducing the prescription amount of agar by 40 % and obtaining products with high quality indicators. In addition, the innovative solution allows to reduce the cost of production by reducing the cost of the gelling agent.

## 7. SWOT analysis of research results

*Strengths*. The strengths of the developed product include:
– expanding the range of jelly products;
– development of new innovative competitive technologies for jelly products, with the rational use of food raw materials;
– cost reduction by gelling agents (agar) up to 40 % in comparison with traditional formulations;
– absence of additional structure formers in the recipe.

*Weaknesses*. The weaknesses of the developed product include:
– the need to use imported student formers;
– poor consumer awareness of the new product.

*Opportunities*. Additional opportunities that ensure the achievement of research goals are in the great potential of this technology, it has a significant resource and juvenile effect.

*Threats*. Threats in the context of a new product entering the consumer market include:
– decrease in the purchasing power of the population;
– possibility of the appearance of new analogue products.

Based on the SWOT analysis, the following strategic solutions were proposed:
– active role of marketing;
– entering new markets.

When carrying out marketing activities, it is necessary to focus on the traditional composition of the chocolate-jelly cake and on the natural, not artificial, origin by the jelly-formers (agar). It is also necessary to pay attention to the high organoleptic properties of the product.

## 8. Conclusions

1. It has been shown that the treatment of a 1 % agar solution with an ultra-high frequency field leads to the strengthening of the jelly structure, and due to this it makes it possible to reduce the costs of gelling agents in the production of jelly products and leads to a decrease in its cost.

2. The technology of the «Chocolate-jelly» cake based on agar has been improved. The proposed technology differs from the traditional one in that the dissolution of the swollen gelling agents is carried out in the microwave field, which makes it possible to reduce the consumption of agar by up to 40 % in comparison with traditional formulations.

### References

1. Saha, D., Bhattacharya, S. (2010). Hydrocolloids as thickening and gelling agents in food: a critical review. *Journal of Food Science and Technology, 47 (6),* 587–597. doi: http://doi.org/10.1007/s13197-010-0162-6
2. Prasad, K., Trivedi, K., Meena, R., Siddhanta, A. K. (2005). Physical Modification of Agar: Formation of Agar-fatty Acid Complexes. *Polymer Journal, 37 (11),* 826–832. doi: http://doi.org/10.1295/polymj.37.826
3. Pertsevoi, F. V. (1996). *Tekhnologiia zheleinoi produktsii na osnove studneobrazovatelei s kachestvenno izmenennymi funktsionalnymi svoistvami*. Kharkiv: Kharkovskaia gosudarstvennaia akademiia tekhnologii i organizatsii pitaniia, 412.
4. Teimurova, O. N. (1992). *Razrabotka tekhnologii zheleinykh izdelii s ispolzovaniem modifitsirovannykh studneobrazovatelei*. Kharkiv: Kharkovskaia gosudarstvennaia akademiia tekhnologii i organizatsii pitaniia, 190.
5. Foschan, A. L. (1995). *Tekhnologiia zheleinykh izdelii na osnove polisakharidov krasnykh morskikh vodoroslei s ispolzovaniem natrii-karboksimetil-tselliulozy.* Kharkiv: Kharkovskaia gosudarstvennaia akademiia tekhnologii i organizatsii pitaniia, 180.
6. Pertsevoi, F. V., Savgira, Iu. A., Grinchenko, O. A., Foschan, A. L. (1998). *Tekhnologiia pererabotki produktov pitaniia s ispolzovaniem modifikatorov*. Kharkiv: KHGTUSKH i KHGATOP, 178.
7. Fesenko, E. E., Gluvstein, A. Y. (1995). Changes in the state of water, induced by radiofrequency electromagnetic fields. *FEBS Letters, 367 (1),* 53–55. doi: http://doi.org/10.1016/0014-5793(95)00506-5
8. Vallée, P. (2006). Action of pulsed low frequency electromagnetic fields on physicochemical properties of water: incidence on its biological activity. *European Journal of Water Quality, 37 (2),* 221–232. doi: http://doi.org/10.1051/wqual/2006006
9. Andreyev, Y. A., Barabash, Y. M., Zabolotny, M. A. (1994). Dynamics of rheological parameters of water system in low intensity millimeter wave fields. *Proceedings of SPIE The International Society for Optical Engineering, 221,* 518–528.
10. De Ninno, A., Congiu Castellano, A. (2010). Deprotonation of glutamic acid induced by weak magnetic field: An FTIR-ATR study. *Bioelectromagnetics, 32 (3),* 218–225. doi: http://doi.org/10.1002/bem.20631
11. Nagdalian, A. A., Oboturova, N. P. (2012). Vliianie elektrogidravlicheskogo effekta na gidratatsiiu biopolimerov. *Aktualnye problemy gumanitarnykh i estestvennykh nauk, 12,* 74–78.
12. Wang, Q., Li, L., Chen, G., Yang, Y. (2007). Effects of magnetic field on the sol–gel transition of methylcellulose in water. *Carbohydrate Polymers, 70 (3),* 345–349. doi: http://doi.org/10.1016/j.carbpol.2007.04.006
13. Stas, I. E., Batishcheva, I. A. (2018). The relative viscosity of aqueous solutions of Na-carboxy-methylcellulose and its variation depending on the acidity of the medium, temperature and exposure to electromag-netic field. *Chemistry of Plant Raw Material, (3),* 23–31. doi: http://doi.org/10.14258/jcprm.2018033695

**14**. Stas, I. E., Chirkova, V. Iu., Minin, M. I. (2016). Solution viscosity gelatin, prepared on the electromagnetic field irradiation water. *Vestnik Voronezhskogo gosudarstvennogo universiteta. Seriia: Khimiia. Biologiia. Farmatsiia, 2,* 32–36.

**15**. *GOST 26185-84. Vodorosli morskie, travy morskie i produkty ikh pererabotki*. (2018). Metody analiza. Moscow: Standrartinform. Available at: https://files.stroyinf.ru/Data/209/20946.pdf

**16**. Pilkevych, N. B., Boiarchuk, O. D. (2008). *Mikrobiolohiia kharchovykh produktiv.* Luhansk: Alma-mater, 152.

**17**. Pavlov, A. V. (1998). *Sbornik retseptur muchnykh konditerskikh i bulochnykh izdelii dlia predpriiatii obschestvennogo pitaniia.* Saint Petersburg: Gidrometeoizdat, 286.



***Andriy Foshchan,*** *PhD, Associate Professor, Department of Food Technologies in the Restaurant Industry, Kharkiv State University of Food Technology and Trade, Kharkiv, Ukraine, ORCID: http://orcid.org/0000-0002-4989-010X, e-mail: andreyfoshchan@gmail.com*

***Viktoriya Yevlash,*** *Doctor of Technical Sciences, Professor, Head of Department of Chemistry, Microbiology and Hygiene of Food, Kharkiv State University of Food Technology and Trade, Kharkiv, Ukraine, ORCID: http://orcid.org/0000-0001-7479-1288, e-mail: evlashvv@gmail.com*

***Olena Aksonova,*** *PhD, Associate Professor, Department of Chemistry, Microbiology and Hygiene of Food, Kharkiv State University of Food Technology and Trade, Kharkiv, Ukraine, ORCID: http://orcid.org/0000-0003-4666-9271, e-mail: eaksonova@gmail.com*

***Natalia Murlykina,*** *PhD, Associate Professor, Department of Chemistry, Microbiology and Hygiene of Food, Kharkiv State University of Food Technology and Trade, Kharkiv, Ukraine; Department of Applied Chemistry, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine, ORCID: http://orcid.org/0000-0002-7917-2993, e-mail: natvitmur@ukr.net*

***Inna Piliugina,*** *PhD, Associate Professor, Department of Chemistry, Microbiology and Hygiene of Food, Kharkiv State University of Food Technology and Trade, Kharkiv, Ukraine, ORCID: http://orcid.org/0000-0001-6159-3258, e-mail: inna.piliugina@ukr.net*