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## RESEARCH OF RHEOLOGICAL PROPERTIES OF MAYONNAISE SAUCE WITH GRAPE SKIN POWDER

*Визначено залежності реологічних показників якості майонезного соусу з порошком шкірки винограду від концентрації комплексного загусника некрохмальної природи. Встановлено оптимальні діапазони значень концентрації комплексного загусника, що дозволяє отримати емульсійний продукт із значеннями стійкості емульсії відповідно до вимог нормативної документації. Розроблено рецептуру майонезного соусу з порошком шкірки винограду та комплексним загусником некрохмальної природи.*

**Ключові слова:** порошок шкірки винограду, комплексний загусник, стійкість емульсії, ефективна в'язкість.

### 1. Introduction

The quality emulsion product creation requires an increased attention to the structural and mechanical properties of the mayonnaise emulsions from the food production technologists. In fact, to get mayonnaise or mayonnaise sauce with certain rheological properties is only possible by proper selection of emulsifiers and stabilizers [1]. In addition, it is important to take into account such parameters as [1]:

- pH of the food emulsion;
- production and product storage temperature conditions.

The use of emulsifiers is a prerequisite for the mayonnaise, mayonnaise sauces and dressings production [1, 2]. Generally, emulsifiers are substances of carbohydrate or protein nature – egg products, polysaccharides of seaweed, pectins, etc. [3]. Emulsifiers help to create emulsion, prevent coalescence of the dispersed phase and increase the emulsion aggregative stability [3, 4]. Emulsifiers also act as thickeners – substances, that increase the aqueous phase viscosity, and provide desired consistency of mayonnaise emulsion. Production of mayonnaise sauce with increased biological value involves the use of herbal ingredients with minimal using of synthetic additives, including emulsifiers [5]. Therefore, stable emulsion creation without using of synthetic stabilizers and emulsifiers, such as modified starches, is important. So, it is necessary to study the rheological parameters of mayonnaise products with increased biological value, which are made with using powdered plant material and non-starch nature thickeners.

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

*The object of research is the mayonnaise sauce with increased biological value with Black Pearl grapes skin powder and non-starch nature complex thickener.*

*Subjects of investigation are the rheological properties, namely: the effective viscosity and emulsion stability of mayonnaise sauce with increased biological value with grapes skin powder.*

Solving the problem of intensification and optimization of technological processes of manufacture of emulsion products, containing powders plant material, is impossible without the emulsions rheological properties research and their patterns change identifying. The technological audit conducting is aimed to determine the following main problems:

- the emulsion products range expanding by getting products with a given consistence (mayonnaise, sauces, dressings);
- viscosity and emulsion stability of mayonnaise sauce with grapes skin powder data obtaining for complex thickeners or thickeners rational dosing;
- optimization of technological processes of production of emulsion products with powdered plant material for getting a product with desired rheological properties.

Technological properties of grapes skin powder and conditions of its use in the mayonnaise production for biological value increasing and emulsion stability improving have been identified in previous studies [6]. Adding grapes skin powder to emulsion product is able to enrich the product by pectins, which have properties to create adsorption-solvation stratum at the surface, and thereby to increase the stability of emulsions [4]. However, be aware that the transfer of grapes skin powder protopectin in a soluble state is carried out in an acidic environment. It is possible to carry out in production by the first excerpt of powder in a solution of acetic acid used as acidifier. In addition, the use of non-starch nature complex thickener jointly with grapes skin powder pectins can produce synergy effect on physical and chemical properties of the product [7]. Therefore, it is necessary to study the rheological properties of emulsion of mayonnaise with a plant material powder with varied content of non-starch nature complex thickener.

### 3. The aims and objectives of the study

*The aim is to determine the dependences of the effective viscosity and emulsion stability of mayonnaise sauce with grapes skin powder from the concentration of non-starch nature complex thickener.*

The research results will allow manufacturers to adjust quantity of complex thickener in recipe of mayonnaise with plant material powder. It will allow to obtain the product with the emulsion stability normative indicators and effective viscosity optimal indicators, with are modeling «mouth feel» sensation.

The following problems for aim achievement must be solved:

1. Changes in physical and chemical properties of mayonnaise sauce with grapes skin powder depending on the non-starch nature complex thickener concentration must be analyzed.

2. A recipe of mayonnaise sauce with increased biological value with grapes skin powder must be suggested.

#### 4. Research of existing solutions of the problem

Production of emulsion products with increased biological value determines the use of herbal ingredients, aqueous and fat product phases modeling [8]. This will reduce the deficit of necessary nutrients – unsaturated fatty acids of  $\omega$ -3 groups, dietary fiber and more. But with increased biological value of mayonnaise products it is necessary to ensure compliance with established physical and chemical properties: emulsion resistance to separation and the viscosity of the product [1].

Ukrainian consumer mayonnaise production market analysis allows to conclude that more than half of Ukrainians willing to pay for a better product [9]. That is the mayonnaise products containing herbal ingredients without artificial additives have high demand. A lot of researches towards the development of emulsion products containing functional ingredients from animal and plant origin have been carried out [10–12]. The research results have indicated on the possibility of the finished product rheological properties adjusting. This is achieved by certain plant origin ingredients adding to recipes. A necessary condition for creating of high-quality homogeneous mayonnaise emulsion without signs of separation throughout storage period is the use of thickeners, emulsifiers and stabilizers. There are egg products, milk powder, starches and hydrocolloids in the mayonnaise production [13]. Egg products and milk powder are used in the high-fat mayonnaise production. Smaller amount of egg products is used in the mayonnaise sauce production, which together with reduced fat content can provide the «impersonal» flavor and low viscosity indicators of finished product and lead to premature emulsion separation. But through the use of thickeners and stabilizers in mayonnaise sauce recipes finished products have a full, rich, «creamy» flavor. As for the production of mayonnaise sauce with increased biological value, be aware, that the starches presence will significantly increase the product glycemic index and will make it desirable for eating by diabetics [14]. Introduction of thickeners from the class of polysaccharides, which are able to increase the aggregative emulsions stability and is a source of soluble dietary fiber, in emulsion products recipes is effective [15].

The certain conclusions can be made on the results of modern researches and the literature review. It is necessary and appropriate to study physical and chemical parameters of mayonnaise production with powders of plant materials and non-starch nature thickeners.

#### 5. Methods of researches

Determination of rheological properties of mayonnaise sauce with Black Pearl grapes skin powder and a variable content of non-starch nature complex thickener were carried out on mayonnaise sauce samples in accordance to [8]. Complex thickener content was varied in the range of 0.1–1.2 %. The composition of complex thickener was: sodium alginate, xanthan gum and apple pectin in the ratio of 1:1:1.

Effective viscosity of samples of mayonnaise sauce with grapes skin powder and with a variable content of complex thickener was determined in accordance to DSTU 4560:2006. A rotary viscometer of «Reotest-2» type (Germany) and methods were used in accordance to [16].

The stability of the emulsion of samples of mayonnaise sauce with grapes skin powder and with a variable content of complex thickener was determined in accordance to DSTU 4560:2006 using centrifugation method.

Researches have been conducted in the triple repeating. Research results have been processed by using methods of mathematical statistics. The relative error determining has been conducted with  $P = 95$  % probability confidence.

#### 6. Research results

The dependence of effective viscosity of the mayonnaise sauce emulsion ( $\text{Pa}\cdot\text{s}$ ) with  $3 \text{ s}^{-1}$  shear rate from complex thickener concentration (%) is shown in Fig. 1.

Research results of the dependence of effective viscosity of mayonnaise sauce samples with grapes skin powder from the complex thickener concentration are shown in an approximation polynomial:

$$V_e(c) = -8.016 \cdot c^2 + 19.577 \cdot c + 2.905, \quad (1)$$

where  $V_e$  – effective viscosity,  $\text{Pa}\cdot\text{s}$ ;  $c$  – complex thickener concentration, %.

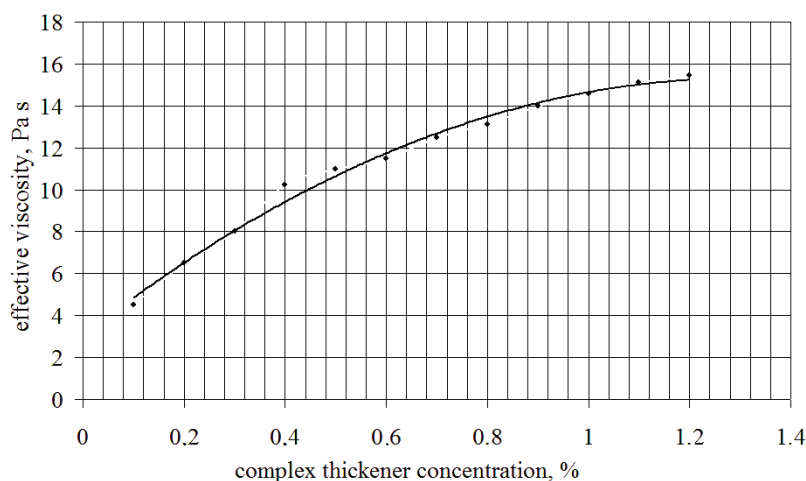


Fig. 1. The dependence of effective viscosity of the mayonnaise sauce emulsion from complex thickener concentration

The adequacy of obtained dependence has been tested using the Fisher criterion. Values of the nonlinear regression determination coefficients are  $R^2 > 0.99$ . That is, more than 99 % of the effective viscosity values variation has been explained by the complex thickener concentration changing in mayonnaise sauce samples, and only 1 % – the extraneous factors influencing. Therefore it is possible to say that the proposed approximation polynomial model describes the actual process with prescribed accuracy.

Analyzing the obtained dependence it can be concluded about the possibility of reducing the complex thickener concentration to 0.4 %. Thus, effective viscosity of mayonnaise sauce with grapes skin powder has quantitative value to 10 Pa·s. This allows to obtain the finished product with optimal organoleptic characteristics.

The dependence of stability of mayonnaise sauce emulsion (%) from concentration of complex thickener (%) is shown in Fig. 2.

Research results of emulsion stability dependence of mayonnaise sauce samples with grape skin powder from concentration of complex thickener are shown in an approximation polynomial:

$$S_e(c) = -2.8394 \cdot c^2 + 7.8251 \cdot c + 94.8470, \quad (2)$$

where  $S_e$  – emulsion stability, %;  $c$  – complex thickener concentration, %.

The adequacy of obtained dependence has been tested using the Fisher criterion. Values of the nonlinear regression determination coefficients are  $R^2 > 0.97$ . That is, more than 99 % of the emulsion stability values variation has been explained by the complex thickener concentration changing in mayonnaise sauce samples, and only 1 % – the extraneous factors influencing. Therefore it is possible to say that the proposed approximation polynomial model describes the actual process with prescribed accuracy.

Presented in Fig. 2 research results indicate the possibility of reducing of complex thickener concentration to 0.4–0.5 %. Thus, the emulsion stability of mayonnaise sauce samples with grape skin powder is in the range of 97.0–100.0 %.

Research results can be used in the production of mayonnaise with vegetable raw powders, including low-fat emulsion products with a desired consistency and emulsion stability according to regulatory documents requirements.

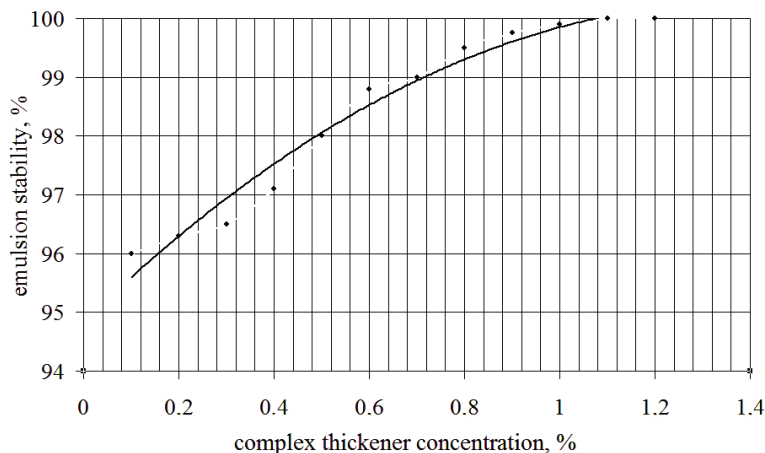


Fig. 2. The dependence of emulsion stability of mayonnaise sauce from complex thickener concentration

The recipe of the mayonnaise sauce has been developed according to research results, using results of previous studies [6, 8, 15] and in accordance to the DSTU 4487:2015 requirements. It is a product containing grapes skin powder (5.0 % wt.) and non-starch nature complex thickener (sodium alginate, xanthan gum and pectin apple) with the varied content.

The recipe is presented in Table 1.

Table 1

The recipe of mayonnaise sauce with increased biological value

The component name	Mass fraction, %
Blended oil	40.00
Egg powder	2.50
Skimmed milk powder	1.00
Complex thickener	0.40–1.20
Mustard powder	0.25
Sugar	1.50
Food salt	1.10
Baking soda	0.05
Acetic acid 80 %	0.40
Malic acid	1.00
Citric acid	2.00
Black Pearl grapes skin powder	5.00
Drinking water	44.80–44.00
In all	100.00

Presented recipe (Table 1) allows to create emulsion product with balanced content of polyunsaturated  $\omega$ -6 and  $\omega$ -3 fatty acids, enriched in soluble fiber and natural antioxidants.

The certain conclusions can be made on the obtained results. Obtaining of mayonnaise emulsion with grapes skin powder is technologically possible even at lowering of non-starch nature complex thickener concentrations to 0.4–0.5 %. Thus, the effective viscosity indicators are optimal and emulsion stability is in the range of 97.0–100.0 %.

## 7. SWOT-analysis of results of research

*Strengths.* The results of effective viscosity and emulsion stability of mayonnaise sauce with grapes skin powder depending on the complex thickener concentration can be distinguished among the strengths of this research. Literature review has shown that researches of rheological properties of emulsion products are important and insufficiently illuminated for mayonnaise with plant material powders. The use of the research results provides an opportunity to solve technological issues related to the production of emulsion products with desired consistency and resistance to separation during all storage term. Ability to use in recipe grapes skins powder, which has a definite chemical composition, is very

perspective and profitable for the producers. For example, dietary fiber, pectins will contribute to the stable emulsion creation. Biological value product increasing is possible due to biologically active substances content. It will allow increase the popularity of mayonnaise products. In other words it will lead out mayonnaise from a number of useless food products.

**Weaknesses.** Weaknesses of this research are due to the fact that using the proposed technology solutions can lead to waited results only by applying the selected plant raw material powder and on the low fat emulsions production. The manufacturer may seek to savings in egg and milk products in the mayonnaise production on this way, in other words by adding into mayonnaise product recipe a plant powder and polysaccharides complex. It may negatively affect on the physical and chemical properties of the finished product. To prevent aforementioned situation additional research of compatible behavior of polysaccharides and grapes skin powder in high fat emulsions should be conducted.

**Opportunities.** Additional opportunities of proposed technological solution lie in mayonnaise sauce range expanding, in other words, in desired consistency modeling, in biological value increasing by natural ingredients using (powders of plant raw materials and non-starch polysaccharides). The research object, the mayonnaise sauce with grapes skin powder, is a product of increased biological value, which is made from natural ingredients riched in biologically active substances. On the other hand, the object has optimal physical and chemical properties, even at significantly reducing the complex thickener concentration. In other words, the low-fat emulsions production with the proposed components is technologically justified and actual for manufacturers seeking to produce emulsion products in accordance to modern trends in healthy eating.

The introduction of this technological solution at the enterprise will reduce costs at non-starch thickeners for mayonnaise products. Because the cost of the proposed thickeners are a sufficiently higher then starch cost. At the same time the use of non-starch thickeners and stabilizers is a prerequisite for products creating with increased biological value.

**Threats.** Complications in research results implementation are related to two main factors. First, it is a difficult situation of Ukraine economy and uncertainty in future of production capability for implementation of modern technological solutions. Secondly, proposed ingredients using in the emulsion products production requires additional time to improve existing recipes, i. e. replacement of certain ingredients on proposed, more careful quality control of finished products accordance to regulatory documents requirements. If it is needed it may be appropriate an additional trials, which is usually accompanied by the involvement of certain number of technologists from the current production process and experts in the industry. All of these requirements can make a some disorder in a clear, streamlined technological process.

Thus, SWOT-analysis of research results allows to determine the main directions for research goal achieving. Among them it is an analysis of the main trends in the creation of food products of increased biological value. Rational and comprehensive approach to recipes development with ingredients of plant raw materials is required. It is necessary to conduct a series of finished products research

in accordance to the normative documents requirements on physical, chemical and organoleptic parameters. Also it is necessary to pay attention to the economic efficiency assessing of proposed technological solutions implementation in production of emulsion products.

## 8. Conclusions

1. Changes in physical and chemical quality indicators of mayonnaise sauce with grapes skin powder depending on the non-starch complex thickener concentration are analyzed. The possibility of reducing the non-starch complex thickener concentration in mayonnaise sauce samples with grapes skin powder to 0.4–0.5 % is defined based on the analysis. It allows to receive the finished product with viscosity parameters that are optimal in terms of organoleptic evaluation (at least 10 Pa·s). The emulsion stability parameters are in the range of 97.0–100.0 %. It complies with current regulatory documentation for mayonnaise and mayonnaise sauces.

2. Recipe of mayonnaise sauce with increased biological value with grapes skin powder is proposed. Non-starch complex thickener introduction to the recipe, that enriches finished product in soluble dietary fibers and increases the aggregative stability of emulsion product, is substantiated. The necessity of the study of mutual influence of pectin substanses from plant raw material powders and non-starch thickeners on physico-chemical quality parameters of emulsion products is indicated.

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#### ИССЛЕДОВАНИЕ РЕОЛОГИЧЕСКИХ СВОЙСТВ МАЙОНЕЗНОГО СОУСА С ПОРОШКОМ КОЖУРЫ ВИНОГРАДА

Определены зависимости реологических показателей качества майонезного соуса с порошком кожуры винограда от концентрации комплексного загустителя некрахмальной природы. Установлены оптимальные диапазоны значений концентрации комплексного загустителя, которые позволяют получать

эмульсионный продукт со значениями стойкости эмульсии в соответствии с требованиями нормативной документации. Разработана рецептура майонезного соуса с порошком кожуры винограда и комплексным загустителем некрахмальной природы.

**Ключевые слова:** порошок кожуры винограда, комплексный загуститель, стойкость эмульсии, эффективная вязкость.

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## IMPROVEMENT OF IR EMITTER TO CREATE NON-REFLECTOR DRYER FOR PLANT RAW MATERIALS

Удосконалено ІЧ-випромінювач на основі гнучкого плівкового резистивного електронагрівача випромінювального типу для створення безрефлекторних ІЧ-сушарок рослинної сировини. Це забезпечить зменшення металоемності устаткування, рівномірність розподілу теплових потоків на приймальних поверхнях (сітчастих піддонах із сировиною) та підвищить якість отримуваних сушених напівфабрикатів. Досліджено поглинальну здатність рослинної сировини, що підтверджує ефективність використання вдосконаленого ІЧ-випромінювача.

**Ключові слова:** гнучкий плівковий резистивний електронагрівач, безрефлекторні ІЧ-сушарки рослинної сировини, якість сушених напівфабрикатів.

### 1. Introduction

One of the ways of processing plant raw materials in dried semi-finished products is the use of IR technology [1–3]. IR dryers, which are used today [4], equipped with inertial IR emitters with high temperatures of working surfaces and fixed geometric dimensions and reflector blocks. This increases their metal consumption and does not always ensure a uniform heat flow on the receiving surfaces, which leads to losses of its biologically active substances (BAS) and a change in the color of the dried semi-finished product. Therefore, it is necessary to investigate

in more detail the possibility of using modern low-inertia emitters that do not require the use of reflectors and are capable of ensuring the uniformity of thermal energy at the receivers. So, it is actual to study ways to improve the process of IR drying of semi-finished products from plant raw materials and its instrumental design.

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

The object of research is an improved flexible film resistive electric heater of emitting type (FFREHET) for