Structural and mechanical properties of the jostaberry jelly

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Abstract

Introduction. It was investigated the use of the the jostaberry – new berry pectin-containing raw material species with high content of biologically active substances in the development of structured foods such as jellies for prophylactic nutrition.

Materials and methods. There were used such materials, as: jelly, berries of the Gooseberry family, namely – Jostaberry. There was made an analysis of the literary for substantiation of form factors selection in the jelly dishes development with the Northern Black Sea region`s raw material – jostaberry. The jelly structural strength was determined by the penetration method. The adhesive strength of jelly masses was determined by measuring the plate`s separation force, which characterizes the form surface from the jelly mass.

Results and discussions. As a dredging raw material for the jelly dishes with high nutritional value production it is expedient to use new berry raw materials of the Northern Black Sea region, namely jostaberry. Jostaberry is characterized by high content of biologically active substances, as well as pectin (0.8–1.5 g per 100 g of raw matter). Due to the high content of pectin, jostaberry is a promising raw material for the structured sweet dishes production, such as jelly.

It has been shown the possibility of partial gelatin exclusion from the formulation while the jostaberry is being added, without significant changes in the rheological characteristics of the product and to obtain jelly with the necessary structural properties. Thus, the values of density indices are 1,037 kg / m^3 and marginal displacement voltage of $30{\cdot}10^3$ kPa jostaberry jelly samples with 50% gelatin content from the formulation quantity meet the requirements. The reduce of gelatin mass content in the jostaberry jelly up to 50% of formulation quantity allows to reduce the adhesion tension in 1,2-1,3 times in comparison with control samples.It was established that the smallestjelly mass adhesive strength is observed when it is in contact with the silicone surface. The interaction strength increases by 1,2 times when ceramic surface is being used and by 1,6 times –when the surface is steel.

Conclusions. There has been substantiated the formulation composition of ingredients of structured dishes with high nutritional value for restaurant enterprises through the use of new pectin containing raw materials – jostaberry.

Introduction

The assortment expanding, improving the quality and nutritional value of desserts, including jellies, should be carried out by introducing into their formulations a new fruit and berry raw material, which includes valuable biologically active substances and structure-forming compounds.

During thejelly desserts from the new raw materials technology development, it is necessary to take into account both the balance of its chemical composition, the nutritional value, the original organoleptic parameters and its functional and technological suitability for obtaining the product with the given structural and mechanical characteristics.

Depending on the used draft agent, the production conditions and the technological process, you can get a jelly of different structural strength and with given surface properties. Too strong durability gives the jelly toughness of the consistency, and low strength leads to the finished product deformation, as well as the rapid separation from it of the liquid phase.

The most versatile structure-makers in the technologies of jelly sweet dishes arethe fruit and berry raw materialspectins. Pectins are characterized by good solubility in a wide range of dry substances, stable and controlling draft-forming properties. Compared with agar and gelatin, pectin is more resistant to acid [1,2]. This is very important for the fruit and berry desserts production that occur in acidic environment. By its drafting ability in the production conditions, pectin is stronger by 5 ... 8 times than gelatin [3,4].

We believe that it is expedient to use pectin-containing raw materials, such as jostaberry, in the jelly preparation. Jostaberry contains pectin in the amount of 0.8-1.5 g per 100 g of raw matter, which possesses sorption properties, promotes the radionuclides removal from the human body, hasdrafting properties [5]. Clinicians and nutritionists recommend include pectin in the diet of people in the radionuclidescontaminatedenvironment and who have contact with heavy metals. Consequently, the use of jostaberry – a pectin-containing additive in jelly will not only add the preventive properties of this sweet dish, but will also reduce the gelatin mass fraction in the formulation, or refuse it at all, without significantly structural and mechanical propertiesaltering of the jelly.

Jostaberry is the hybrid of gooseberry and currant. High content of biologically active compounds is its main advantage, as jostaberry contains components of gooseberry and currant at the same time[6]. Comparison of chemical composition of gooseberry, currant and jostaberry as shown in Table 1 allows to recommend its usage for dessert production. At present time jostaberry is widely popular in Western Europe while in Eastern Europe this culture is used mainly for decoration [7].

Jostaberry has high technological and consumer characteristics and is considered to be the rich source of natural biologically active compounds (Table 1). Together with black currant, jostaberry contains high concentrations of vitamins, in particular vitamin C. Consumption of 30 g of jostaberry supplies human organism with daily dose of ascorbic acid.

Jostaberry contains iron, which makes berries useful for those with anemia. Potassium ion of jostaberry positively influences on cardiovascular system and helps to reduce risk of heart-attack and stroke. Jostaberries are recommended for prevention of gastrointestinal diseases [7].

Table 1

Comparison of nutrition value of berries [6, 8, 9, 10, 11, 12]

Component	Black currant	Gooseberry	Jostaberry
Proteins, g	0,6	0,7	0,7
Fats, g	-	-	0,2
Carbohydrates, g	8,0	9,9	9,1
Pectin, g	1,0	0,7	1,1
Ash, g	0,6	0,6	0,9
Vitamins, mg/100g			
Beta-carotene	0,1	0,2	0,2
Vitamin B_1	0,01	0,01	0,01
VitaminB_2	0,02	0,2	0,03
VitaminB_3	0,3	0,25	0,3
VitaminC	200	30	450
Minerals, mg/100g			
К	372	224	275
Ca	36	22	40
Mg	35	9	17
Na	21	20	21
P	30	28	33
Fe	0,9	1,6	1,2
Energy value, ccal/100 g	40,0	44,0	45,0

It is reported that jostaberry contain polyphenol compounds, such as catehins, anthocyanins, flavonols and other. Total content of bioflavonoids in jostaberry is close to 320–380 mg/100 g. Jostaberry is rich dietary source of polyphenols with reported health benefits. More than 50 different flavonols (glycosides of quercetin, myrice-tin, kaempferol, isorhamnetin, syringetin and laricitrin) have been detected and quantified with HPLC–MSnin fruits of jostaberry. Quercetins represent the highest percentage (46–100%) among flavonols in jostaberry. In jostaberry the prevailing flavonols belong to the group of isorhamnetins (50–62%) and kaempferols [13,10].

A broad range of anthocyanins (glycosides of cyanidin, pelargonidin, peoni-din, delphinidin, malvidin, and petunidin) was identified and quantified in josta-berry species using HPLC-DAD-MS2. Cyanidin was the most commonly occur-ring anthocyanidin in jostaberry [14].

Jostaberry berries contain significant amount of cellulose and pectin. In case of regular intake they can perform detoxication function and stimulate the excretion of heavy metal ions and radionuclides. Jostaberry has low calorific value (45 ccal/100 g) and can be considered as diet product.

Thus, on the basis of the literary and patent sources analysis, it was concluded that jostaberry, although it is a new raw material for the Northern Black Sea region, is already actively grown, which will determine the economic efficiency of making dishes with the addition of these raw materials.

Materials and methods

The subject of studies of desserts with high nutritional value development was selected new raw materials, which is rich in chemical composition namely: jostaberry. While the new sweet dish technology development, in a jelly was added jostaberry adding in the amount of 15% to the mass of the product, with a partial (50%) and complete gelatin replacement.

For the whole quality control of the new product, a complex of its properties was studied: organoleptic and physical properties of the jelly mass. There were also studied some changes of its structural and mechanical properties provided to replace gelatin to jostaberry.

To determine the density of samples, a picnometric method was used, which is based on measuring the mass of a certain volume of the product at a temperature from the following absolute and relative density.

Structural-and-mechanical properties of the dough quality were determined with the help of the penetrometer of firms "Labor" of the OV-2G5, modification by determining the resistance of the food masses to the penetration of the body of immersion with strictly defined dimensions, mass and material at a precisely defined temperature for a certain time [15].

The study of jelly’s adhesion properties was carried out on an adhesive. The measuring adhesion method is based on the destruction of the adhesive seam by applying external force. The characteristic of adhesion is the pulling force, which is related to the contact area. The adhesion force is characterized by the value of the resistivity of the separation [16].

Results and discussion

Given the high nutritional value, technological characteristics and economic availability of the new raw material of the Northern Black Sea region - jostaberry, we consider it expedient to use it to improve the technology of jelly.

At various technological stages of the jelly-fruit masses production, data on their rheological properties for the quality control of finished products is required. The jelly-fruit masses formulation contain draft agents, which lead to a significant change in the structural, mechanical and organoleptic properties of these products. Different components can be used to create a jelly – agar, gelatin, pectin. In our work, as such an ingredient used jostaberry`s pectin, which is a skeleton of drafts. The jelly quality depends not only on the pectin amount, but also on the quality of pectin, which depends on the pectin origin, on the degree of its hydrolysis, and others. [17].

For the good berry jelly formation the content of pectin-containing raw material changes due to water content, sugar content and acid [18]. If the stable conditions are technological, the needed pectin content will depend on its quality. But the jostaberry`s pectin quality, the jostaberry additives influence on the structural and mechanical characteristics change is not sufficiently studied and requires additional research. The detection of regularities of jostaberry pectin substances structuring will give the opportunity to reduce the need for structure stabilizers and to achieve the technological effect in the dessert producing process due to only natural plant ingredients.

For the pectin-containing raw material influence studying – jostaberry on the structural and mechanical change of jelly, there were developed model ingredient compositions of the jelly formulation, namely – jostaberry jelly with different gelatin content: 50, 100 % from the formulation content in traditional jelly formulation, which is 3 g of gelatin on 100 g of jelly. The model samples quality was compared with control sample – jelly with black currant, the structural and mechanical properties of which are sufficiently studied.

The jelly semi-finished product has gelatinous non-crystalline mass, and the finished products have elastic consistency. The research of structural and mechanical characteristics of the gelatinous systems largely determines the technological operations conducting peculiarity during the jelly preparation.

The structural strength, density, adhesive strength, which is expressed by the jelly masses separation specific force from the contacting surfaces from different materials – the indicators that most fully characterize the jelly structural and mechanical properties.

It is found, that the jelly density index with jostaberry adding is increases in comparison with a control sample – black currant jelly (Figure 1). It is known, that the increase of jelly density leads to an increase in its structural strength. Therefore, it was decided to study the rheological characteristics of jostaberry jelly samples, in where was reduced the formulation content of gelatin by 50 % and the samples with complete elimination of it in the formulation. From Figure 1 it is well seen that the jostaberry jelly density and the 50 % of gelatin on the formulation content is not significantly reduces in comparison with a control sample and is 1,037 kg/m^3, that meets the requirements.

Figure 1. Dependence of jostaberry jelly density p, kg/m^3 on the gelatin mass content a, %: 1 – Control; 2 – jostaberry jelly100 % of gelatin; 3 – jostaberry jelly 50 % of gelatin; 4 – jostaberry jelly without gelatin.

The jostaberry jelly structural strength dependence on the gelatin mass content is presented in Figure 2. As we see, the structural strength og jelly with jostaberry adding increases in comparison with control sample in 1,9 times, and decreases when the 50 % of gelatin is withdrawn from formulation till 30 kPa*10^3, that requires the control sample and confirms the expediency of jostaberry`s gelatin reduction in jelly formulation.

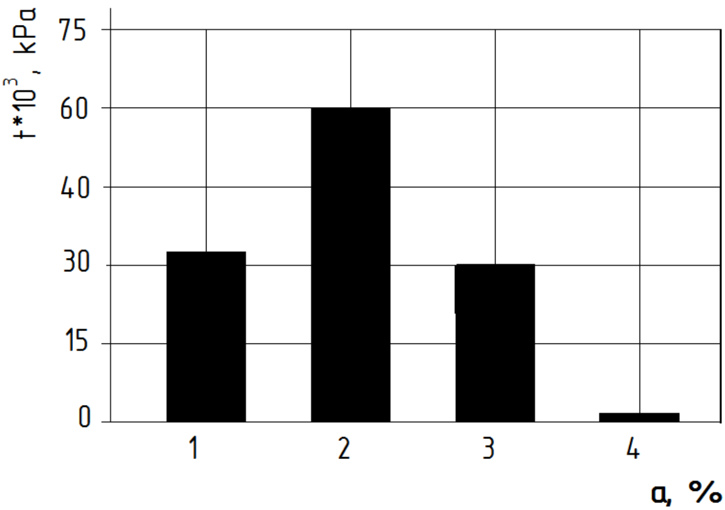

Figure 2. Dependence of jostaberry jelly structural strength t, kPa·10^3 on the gelatin mass content a, %:
1 – Control; 2 – jostaberry jelly100 % of gelatin; 3 – jostaberry jelly 50 % of gelatin; 4 – jostaberry jelly without gelatin.

From this point of view, a huge practical interest is the consideration of draft agents properties for the desserts production and the technological properties change by interaction of several draft agents of different character [19], in our case – jostaberry pectin and gelatin.

The complex gelatin jellies with low- and high-esterified pectin [20]. The author found that pectin is able to create jelly with gelatin in the range of pH from 2,5 to 4,75.As a result – a new grid is formed. In the formation of structures involved the associations with different character: intermolecular, which are characteristic of gelatin jelly, ionic, formed by oppositely charged groups of gelatin and pectin and, probably, hydrophobic interactions ofgelatin or pectin non-polar groups [21, 22].

In food technologies during the raw material preparation, getting the semi-finished products, formation the finished products, their packaging and storage, the interaction with different surfaces is very important [23, 24]. This kind of interaction usually leads to product sticking to the surfaces ofworking bodies of technological and packaging equipment, structural and packaging materials, containers, etc. In technology, this phenomenon of sticking is calls adhesion. The food masses adhesion is often undesirable. It is negatively affects the product use efficiency, the product quality, leads to the raw material outgoings and energy resources increase [25, 26, 27].

The adhesive strength interaction study between thejostaberry jelly masses with different gelatin content and the various materials contacting surfaces is presented in Figure 3, 4 and 5. The contacting surfaces were chosen: silicone, ceramic and metal surfaces. The disk surface temperature was 20±2^{0}C. The duration of the previous conversation was constant and was 30 seconds.

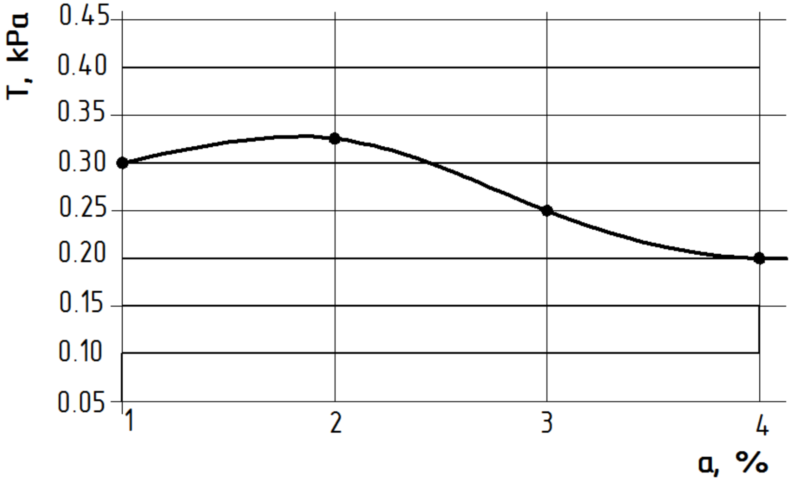

Figure 3. Dependence of jostaberry jelly mass separation force T, kPa on the gelatin mass content a, % in contact with the silicone surface:
1 – Control; 2 – jostaberry jelly100 % of gelatin; 3 – jostaberry jelly 50 % of gelatin; 4 – jostaberry jelly without gelatin.

From the given data it can be seen (Figure 3, 4 and 5) that the adhesive strength of the jostaberry jelly sample is somewhat higher in comparison with the control sample. This tendency can be traced regardless of the contact surface material type. Thus, the specific separation force of the control sample (black currant jelly) of jostaberryjelly with a silicone surface contact: 0,25 kPa and 0,3 kPa, respectively; with a ceramic surface: 0,3 kPa and 0,32 kPa, respectively; with a metal surface: 0,4 kPa and 0,43 kPa.

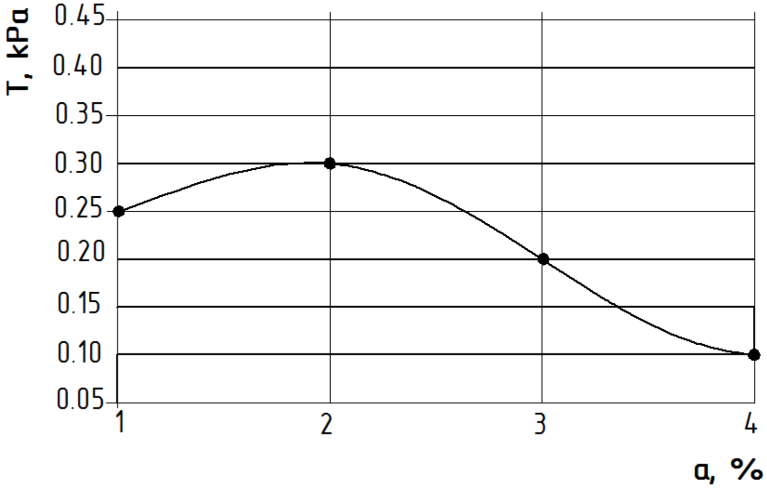

Figure 4. Dependence of jostaberry jelly mass separation force T, kPa on the gelatin mass content a, % in contact with the ceramic surface:
1 – Control; 2 – jostaberry jelly100 % of gelatin; 3 – jostaberry jelly 50 % of gelatin; 4 – jostaberry jelly without gelatin.

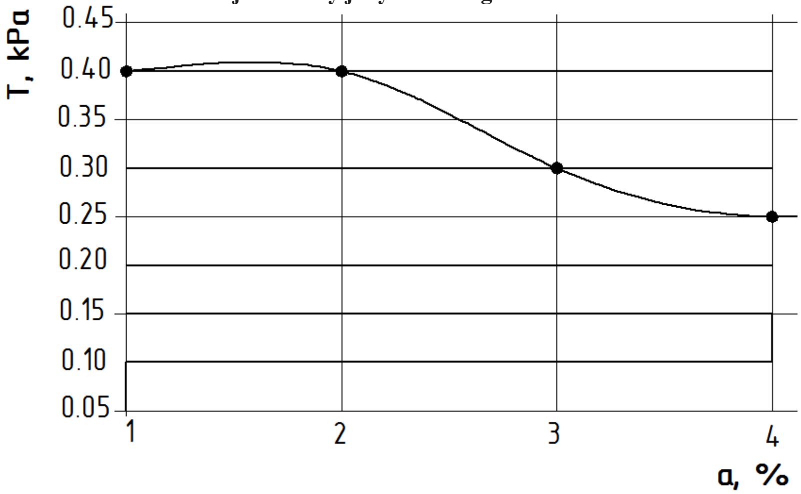

Figure 5. Dependence of jostaberry jelly mass separation force T, kPa on the gelatin mass content a, % in contact with the metal surface:
1 – Control; 2 – jostaberry jelly100 % of gelatin; 3 – jostaberry jelly 50 % of gelatin;
4 – jostaberry jelly without gelatin.

Reducing the mass content of gelatin in jostaberry jelly to 50% of the formulation quantity allows to slightly reduce the adhesion stress in comparison with samples of jostaberry jelly from 100% of gelatin from the total formulation quantity and with control samples. Consequently, the separation specific force of jostaberry jelly mass 50% of gelatin, in contact with the silicone surface (Figure 3), is: 0.21 kPa with the value of the same index for the control sample: 0.25 kPa; in contact with the ceramic surface (Figure 4): 0,26kPa and 0,3 kPa, respectively; in contact with the metal surface (Figure 5): 0.3 and 0.4, respectively. Thus, a decrease of the gelatin mass content in the jostaberryjelly mass improves their rheological characteristics, as it contributes to a reduction in the value of the specific gravity separation mass from the adhesive.

Similarly, from the Figure 3, 4 and 5 it can be seen that the greatest separation force for jelly masses, both for jostaberry jelly and black currant jelly, is observed when they are in contact with a metal surface. The use of ceramic and silicone surfaces allows you to slightly reduce the adhesion voltage. From the all tested materials, the advantage should be given to the silicone coating, which differs by the lowest values of the separation force in contact with jostaberry jelly.

Conclusion

Therefore, during the jelly preparation, it is expedient to use raw materials containing pectin, such as jostaberry. The influence of jostaberry pectin-containing raw materials additives on the jelly structural and mechanical properties change has been determined. It has been established that with the jostaberry use it is possible to reduce the gelatin mass fraction in the jelly formulation without significant changes in its structure and even the improvement of the rheological characteristics of this gelatinous product. The conducted researches can become a basis for the new jellies formulations development with the raised nutritional value, which have preventive properties.

References

1. Abid M., Cheikhrouhou S., Renard C., Bureau S., Ayadi M.A. (2017), Characterization of *pectins* extracted from pomegranate peel and their gelling properties, *Food Chemistry*, 215(1), p.p. 318–325.
2. Yuliarti O., Hoon A. L. S., Chong S. Y. (2017), Influence of pH, pectin and Ca concentration on gelation properties of low-methoxyl pectin extracted fromCyclea barbata Miers, *Food Structure*, 11(1), p.p. 16-23.
3. Chronakis I.S., Kasapis S., Abeysekera R. (2014), Structural properties of *gelatin–pectin* gels. Part I: Effect of ethylene glycol, *Food Hydrocolloids*, 11(3), p.p. 271-279.
4. 4.Gómez-Guillén M.C., Giménez B., López-Caballero M.E., Montero M.P. (2011), Functional and bioactive properties of collagen and *gelatin* from alternative sources: A review, *Food Hydrocolloids*, 25(8), p.p. 1813-1827.
5. Nishinari K., Fang Y., Yang N., Yao X. (2017), Gels, emulsions and application of hydrocolloids at Phillips Hydrocolloids Research Centre, *Food Hydrocolloids*, available at: https://doi.org/10.1016/j.foodhyd.2017.07.035
6. Mikulic-Petkovsek M., Rescic J., Schmitzer V., Stampar F. (2015), Changes in fruit quality parameters of four Ribes species during ripening, *Food Chemistry*, 173(4), p.p. 363–374.
7. Khanal B., Grimm E., Knoche M. (2011), Fruit growth, cuticle deposition, water uptake, and fruit cracking in *jostaberry*, gooseberry, and black currant, *Scientia Horticulturae*, 128(3), pp. 289–296.
8. Pritts M. (2017), *Soft Fruits,* Encyclopedia of Applied Plant Sciences (Second Edition), 3, p.p. 268–272.
9. Mwangi P.M., Ordaz-Ortiz J.J., Redfern S.P., Terry L.A. (2016), Tissue biochemical diversity of 20 gooseberry cultivars and the effect of ethylene supplementation on postharvest life, *Postharvest Biology and Technology*, 117(6), p.p. 141–151.
10. Calderón-Oliver M., Ponce-Alquicira E. (2017), *Fruits: A Source of Polyphenols and Health Benefits*, Natural and Artificial Flavoring Agents and Food Dyes, 7, p.p. 189–228.
11. Paunović S.M., Mašković P., Nikolić M., Miletić R. (2017), Bioactive compounds and antimicrobial activity of black currant (Ribes nigrum L.) berries and leaves extract obtained by different soil management system, *Scientia Horticulturae*, 222(8), p.p. 69–75.
12. Mikulic-Petkovsek M., Slatnar A., Schmitzer V., Stampar F. (2013), Chemical profile of black currant fruit modified by different degree of infection with black currant leaf spot, *Scientia Horticulturae*, 150(2), p.p. 399–409.

13. Mikulic-Petkovsek M., Slatnar A., Stampar F., Veberic R. (2012), HPLC–MSn identification and quantification of flavonol glycosides in 28 wild and cultivated berry species, *Food Chemistry*, 135(4), p.p. 2138-2146.
14. Veberic R., Slatnar A., Bizjak J., Stampar F. (2015), Anthocyanin composition of different wild and cultivated berry species, *LWT - Food Science and Technology*, 60(1), p.p. 509-517.
15. *Huajia Li, Pidakala P., Billing D., Burdon J. (2016), Kiwifruit firmness: Measurement by* penetrometer *and non-destructive devices,* Postharvest Biology and echnology*, 120, pp. 127–137.*
16. Iorgachova K. G., Makarova O.V., Gordienko L.V., Korkach G.V. (2011), *TehnologIya konditerskogo virobnitstva. Praktikum*, Simeks-print, Odesa.
17. Jridi M., Souissi N., Salem M., Ayadi M.A. (2015), Tunisian date (Phoenix dactylifera L.) by-products: Characterization and potential effects on sensory, textural and antioxidant properties of dairy desserts, *Food Chemistry*, 188(12), p. 8–15.
18. de Wijk R.A., Prinz J.F., Janssen A.M. (2006), Explaining perceived oral texture of starch-based custard desserts from standard and novel instrumental tests, *Food Hydrocolloids*, 20 (1), p.p. 24-34.
19. Verbeken D., Bael K., Thas O. (2006), Interactions between κ-carrageenan, milk proteins and modified starch in sterilized dairy desserts, *International Dairy Journal*, 16(5), p.p. 482–488.
20. Chumak I. Ya. (1976), *Poluchenie i issledovanie kompleksnyih studney zhelatina i pektina s tselyu ispolzovaniya v obschestvennom pitanii: dis. kand. tehn. nauk: spets. 05.18.16.*, Moskva.
21. Quesnel D. J., Rimai D.S., Schaefer D.M., Beaudoin S.P. (2016), *Aspects of Particle Adhesion and Removal*, Developments in Surface Contamination and Cleaning (Second Edition), p.p. 119–145.
22. Quesnel D. J., Rimai D. S., Schaefer D. M. (2008), *Aspects of Particle Adhesion and Removal. Developments in Surface Contamination and Cleaning*, Fundamentals and Applied Aspects, NY, USA, p.p. 475–501.
23. O. Ben-Zion O., Nussinovitch A. (2014), A prediction of the compressive deformabilities of multilayered gels and texturized fruit, glued together by three different adhesion techniques, *Food Hydrocolloids*, 11(3), p.p. 253–260
24. *24. Wallick D. (2014),* Microencapsulation in the Food Industry, *Elsevier Inc. USA, p.p. 181–193.*
25. Cook S.L., Bull S.P., Methven L., Parker J.K. (2017), Mucoadhesion: A food perspective, *Food Hydrocolloids*, 72 (11), p.p. 281–296.
26. Ben-Zion O., Nussinovitch A. (2010), Adhesion-strength characteristics of double-layered agar—galactomannan mixed gels, *Food Hydrocolloids*, 11(4), p.p. 373–384.
27. Thanyacharoen T., Chuysinuan P., Techasakul S. (2017), The chemical composition and antioxidant and release properties of a black rice (Oryza sativa L.)-loaded chitosan and polyvinyl alcohol composite, *Journal of Molecular Liquids*, available at: https://doi.org/10.1016/j.molliq.2017.09.054
28. Yamul D.K, Lupano C.E. (2013), Properties of gels from whey protein concentrate and honey at different pHs, *Food Research International*, 36 (1), p.p. 25–33.