Regularity of structuralization of jelly mammelade on agar polyeshaharides and pectins with low content of sugars

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Abstract

Introduction. The actual scientific task is to establish the regularities of the structure formation of marmalade on agar polysaccharides and pectins with low sugar content (saccharose, glucose, fructose).

Materials and methods. Rheological characteristics were studied by rotational viscometry. Structural and mechanical characteristics were investigated by penetration method. Marmalade with a low content of saccharose, glucose, fructose with the correction of the content of sugars by the addition of polydextrose and the introduction of natural flavoring additives in the form of fruit and berry puree were used in the research.

Results and discussion. It has been established that the sweet taste of marmalade with the use of any formulation is ensured by the dosage of saccharose and glucose at 35 g / 100 g of product, and fructose – by 25 g/100 g. However, the decrease in the amount of sugars in the system is reflected in the increased index of total deformation and proves that structural and mechanical properties essentially depend on their content. The rheological studies of each marmalade mass have identified a range of values of the gradient of displacement, which recommended its transportation in the technological process. So, for marmalade mass on agar with glucose and saccharose $\gamma = 10–20$ sec^{-1} (t = 55±3 °C), with fructose – $\gamma = 5.4–10$ sec^{-1}, or it is possible to use lower temperatures (t = 50±3 °C); for k-carrageenan – for all types of sugars $\gamma = 5.4–10$ sec^{-1} (t = 77±3 °C), for the masses with fructose and saccharose, lower temperatures are allowed (t = 72±3 °C); on H-pectin – $\gamma = 5.4–8$ sec^{-1} (t = 85±3°C), for mass with glucose and with fructose (t = 88±3 °C); on l-pectin – with glucose $\gamma = 2–8$ sec^{-1} (t = 80±3 °C), for masses with saccharose and with fructose $\gamma = 5–10$ sec^{-1} (t = 85±3 °C).

Time of structuring of marmalade, which is lengthened in comparison with traditional products has been established, on agar from 60 minutes to 120 minutes, on k-carrageenan from 15 minutes to 60 minutes, on H-pectin from 12 minutes to 20 minutes. To a greater extent, such changes are related to the introduction of a significant amount of polydextrose for replacing sugar, which has a higher hydration ability. The most springy properties has marmalades on agar and k-carrageenan, and on pectins, they are characterized by greater plasticity.

Conclusions. The following parameters are set and recommended: maximum speed of the rotary movement during pumping; temperature of transportation and tempering of masses; the duration of cooling and withstanding on the finished marmalade.

Introduction

The range of marmalade on the market today is represented mostly by a group of jelly marmalade, which has an attractive appearance, a diverse form, a pleasant smell and taste, it is quite easy to make. But the high content of sugar (up to 70% along with the bloat), the content of artificial dyes, flavors does not bring benefits to the human body. The use of sweets congested with sugar threatens food metabolism, problems with the endocrine system, diabetes, obesity, cardiovascular problems, etc. This is especially alerts, since children and teenagers are the main consumers of these products, the body of which is more suitable for allergic reactions, is sensitive to disorders of the gastrointestinal tract. According to the recommendations of the WHO [1], all groups of the population, and especially children and people with disturbed metabolism, should use confectionery products with low sugar content or without it at all.

Scientists and manufacturers have proposed [2–4] prescription composition of the marmalade "without sugar" due to the introduction of sugar substitutes and sweeteners; xylitol, sorbitol, lactitol, isomaltitol, stevioside and sucralose. The use of fructose for the production of low-calorie diabetic marmalade becomes very popular too [5–8]. Recently, so-called inert structural fillers, which include polydextrose, inulin, fructooligosaccharides, resistant starches, are increasingly used for complete or partial replacement of saccharose. In addition to providing structural characteristics, these components, representing dietary fiber, have valuable physiological properties. They can provide a prebiotic effect and lower the glycemic index [9, 10].

We believe that the traditional formulations of jelly marmalade for the mass consumer should be revised in order to reduce sugar, and expand the range with the use of other types of sugars – glucose and fructose. This will give consumers the opportunity to choose, ranging products for children and dietary nutrition [11, 12].

For such marmalade it is provided: introduction of an inert textured filler for replacement of the withdrawn amount of sugar, prevention of the process of crystallization of glucose, formation of organoleptic parameters by the introduction of fruit and berry puree [13].

Changes in the formulations of marmalade will change the parameters of the operations of the technological process of production, – the transportation of marmalade masses to the forming, tempering of the masses, cooling and withstanding of products.

The purpose of experimental research was to study the rheological properties and to establish the parameters of transportation and tempering of mass, time and velocity of gel-formation, springy-plastic characteristics of jelly marmalade.

Materials and methods

Materials

For the production of jelly marmalade with a reduced sugar content, such raw materials were used: white crystalline sugar (Agroprodinvest, Ukraine), crystalline glucose (Twell Sansino, China), crystalline fructose (Vitamin, Ukraine), food agar 1200 (Rokogel, Spain), k-carrageenan (Budenheim, Germany), H-L-pectin (Hugestone, China), molasses (Intercorn Corn Processing Industry CJSC, Ukraine), polydextrose (East Chemsources Limited, China), dairy acid (Cosco, China), citric acid (Chi Chin, China), aromatic essences (Ungerer, USA), potassium chloride (Agroprodinvest, Ukraine), sodium lactate (Agroprodinvest, Ukraine), aseptic fruit and berry puree (thorn, dogwood, sea buckthorn, red and black currants, strawberry, raspberry, blackberry and pumpkin) (Juice Plant Kodymsky, Ukraine).

Preparation of marmalade

The technological process of obtaining marmalade mass was not fundamentally different from the traditional, except the addition of dry caramel molasses to replace the liquid. Such technological decision is made in order to simplify the process of preparing molasses and transporting it to the stage of preparation of the formulation mixture, accompanied by a corresponding reduction of energy resources. For marmalade with glucose, the introduction of maltose molasses was (IM-55) in the ratio of 1:0.8. Puree was introduced at the stage of tempering, in order to preserve the biologically active substances and the rich color of the products. Polydextrose was introduced in an amount equal to dry substances to the amount of sugars, which were withdrawn from the formulation [14, 15]. The calculated amount of the structure-forming agent, polydextrose, molasses, were mixed, water was added from the calculation of "mixture: water" as 1:80–100 and components were dissolved at a temperature of 95–100 °C during 15–20 minutes. To prepare marmalade masses on agar, it was previously swirled during 30–40 minutes, after which it was heated to full dissolution and a pre-cooked dry mixture was added to the solution. The syrup was boiled to 80% DM, cooled to a temperature of 90 °C, puree and acid were added, mass was mixed and formed. For k-carrageenan and H-pectin with higher temperature of the gel-formation marmalade mass was not cooled, and the flavor components were introduced immediately after boiling. The content of dry matter in the samples was determined by the refractometric method using the refractometer URL (Automation, Armenia) according to the method [16]. All samples were kept for 24 h (t = 18±2 °C, φ≈75%) for complete gelation (Table 1).

Table 1

Samples of marmalade and the content of the main components g / per 100 g

Abbreviation	Gel-former	Sugar	Polydextrose	Puree	Acid
C1	agar	**saccharose 66.79**	–	–	lactic
M1		saccharose 45.00	24.23	thorn	
M2		glucose 42.21	14.08	dogwood	
M3		fructose 51.53	17.61	sea buckthorn	
C2	k-carrageenan	**saccharose 67.03**	–	–	lactic
M4		saccharose 45.62	24.61	dogwood	
M5		glucose 44.40	16.16	thorn	
M6		fructose 44.99	24.76	sea buckthorn	
C3	H-pectin	**saccharose 68.11**	–	–	citric
M7		saccharose 48.46	20.78	red currant	
M8		glucose 40.00	21.97	pumpkin	
M9		fructose 44.75	24.70	black currant	
C4	L-pectin	**saccharose 68.11**	–	–	citric
M10		saccharose 37.14	24.76	strawberry	
M11		glucose 36.02	24.50	raspberry	
M12		fructose 36.66	25.04	blackberry	

Structural and mechanical parameters and rheological properties were determined in samples of marmalade with reduced sugar content.

Determination of acceptable limits for reducing sugars.

The limit of reduction of sugar was determined on the "Structural ST-1" on the basis of the total deformation under the influence of a stable enclosure load [17, 18].

Determination of rheological properties of marmalade masses

The viscosity characteristics of the (marmalade mass) were determined on the rotating viscosimeter "REOTEST 2.1" with the cylinder cylinder measurement system, removing the curvatures of the kinetics of deformation (flow) at such temperature: for agar masses 55±3 °C, for k-carrageenan – 75±3 °C, for pectin – 80±3 °C. The measuring cylinder (rotor) H1 was selected in such a way that the gradient layer was distributed over the entire thickness of the product layer located in the annular gap of the viscometer gauge. The measurement of shear stress was carried out in twelve values of shear rate γ in the range from 0.6 to 121.5 sec^{-1} with successive incremental rates of shear rate [19].

In the course of studies, the tension of displacement was calculated according to the following formula:

$$\tau = Z \times \alpha$$

where: τ – tension of displacement; Z – constant of measured steam; α – the value from the scale of the recording device.

Effective viscosity of practically undamaged, η_0, Pa·sec, and practically damaged, η_m, Pa·sec, system was calculated according to the formula:

$$\eta = \tau / \gamma$$

where: γ – displacement rate, sec^{-1}.

Based on the results of the calculations, rheological curves of viscosity η = f (γ) were constructed. The nature of the destruction and the beginning of the fluidity of the system were determined.

Determination of structural and mechanical parameters of marmalade

The structural and mechanical parameters of the marmalade were investigated using the penetrometer AP-4/1[20]. According to the results of the research, the following indicators were calculated: the marginal tension of displacement; total, springy and plastic deformation. The marginal tension of displacement was determined using a conical nozzle with an angle of 30 °C and calculated by the Rebinder formula:

$$P_m = K \cdot \frac{P}{h_m^2}$$

where P_m – marginal tension of displacement, Pa; K – cone constant, which depends on the angle at its vertex $K_{30^\circ} = 0{,}959$; P – tension, Pa; h_m – depth of immersion of the cone, m.

To determine the durability of withstanding samples of marmalade, the marginal tension of displacement after every 30 minutes of withstanding was determined. Time of withstanding was defined as a time when the marginal tension of displacement acquires constant values, that is, it is characterized by constant springyness. The springy-plastic characteristics of the finished products, for the purity of the experiment, were determined after complete structuring after 24 hours [21].

Results and discussion

Obviously, the development of jelly marmalade with reduced sugar content will undergo significant changes in the structural and mechanical parameters, which will require solving a number of problems.

Changing the structure, first of all, deformation of the gel, and reducing the sweetness of the marmalade due to the decrease in the amount of sugar, are key factors in determining the maximum permissible limit for reducing sugars. The results of the determination of the maximum permissible limits for the reduction of sugars according to the selected factors are presented in Figures 1 and 2.

The presented data confirms that sugars in jelly marmalade play a significant role not only in the formation of taste, but also in structural and mechanical properties. The gradual decrease in the amount of sugars is reflected in reducing sweetness of the products and increasing the index of total deformation.

It was established that in agar gels, when the saccharose content is reduced from 60 to 25 g / 100 g, the deformation index increases by 26.4% (from 6.7 to 8.5%); glucose – by 17% (from 7.4 to 8.7%); fructose – by 10.7% (from 9.3 to 10.3%). In k-carrageenan gels patterns are identical, but the effect of sugar is expressed to a much greater extent. Reducing the content of sugars leads to a deterioration of the structure of gel and the rate of total deformation increases: with saccharose – by 67.8% (from 10.5 to 17.6%); with glucose – by 60.3% (from 11.3 to 18.2%); with fructose- by 47.6% (from 12.7 to 18.7%).

Along with this, organoleptically it was found that in formulations on agar polysaccharides, the expressed sweetness is maintained with a reduction of saccharose and glucose by 40% (from 60 to 35 g / 100 g); fructose – by 58% (from 60 to 25 g / 100 g). This amount of sugar forms a gel-like structure with a satisfactory strength, the samples have sweet taste, and therefore it can be used to further improvement of the formula of marmalade with reduced sugar content.

Greater effect sugars have on the total deformation rate of pectin gels, especially on L-pectin. It was found out that the total deformation of samples on L-pectin at extraction of saccharose from 50 to 20 g / 100 g increases by 34% (from 41.9 to 63.4%); glucose – by 16.4% (from 49.8 to 59.6%) and fructose – by 16.8% (from 43 to 51.8%). The maximum permissible limit for reducing the content of sugars is: for saccharose and glucose – up to 35 g / 100 g, for fructose – up to 20/100 g of product.

For samples on H-pectin, saccharose extraction from 60 to 25 g / 100 g leads to an increase in total deformation by 22.3% (from 16.4 to 21.1%); glucose – by 27.7% (from 18.8 to 26%); fructose – by 20% (from 25 to 31%). By the degree of sweetness, it is recommended to reduce the amount of saccharose and glucose – up to 35 g / 100 g, for fructose – up to 25/100 g.

Thus, the decrease in the amount of sugars in the system is reflected in the increased index of total deformation and proves that the structural and mechanical properties are substantially depend on their content. Indeed, in the recommended limits of its use, it provides a sweet taste, but decreases resistance to stress caused by a decrease in the content of dry matter in the system. The reduction of sugar in the formulation of marmalade will also lead to the non-compliance of physico-chemical parameters with the requirements of standard, syneresis of gel, active microorganism development, shortening of storage periods and, probably, deformation of the structure during storage [22]. As a negative factor, the sugaring of glucose was marked after 24 hours, despite a decrease in its amount. Therefore, the improvement of the jelly marmalade technology with the reduced sugar content requires the solution of the following technological problems.

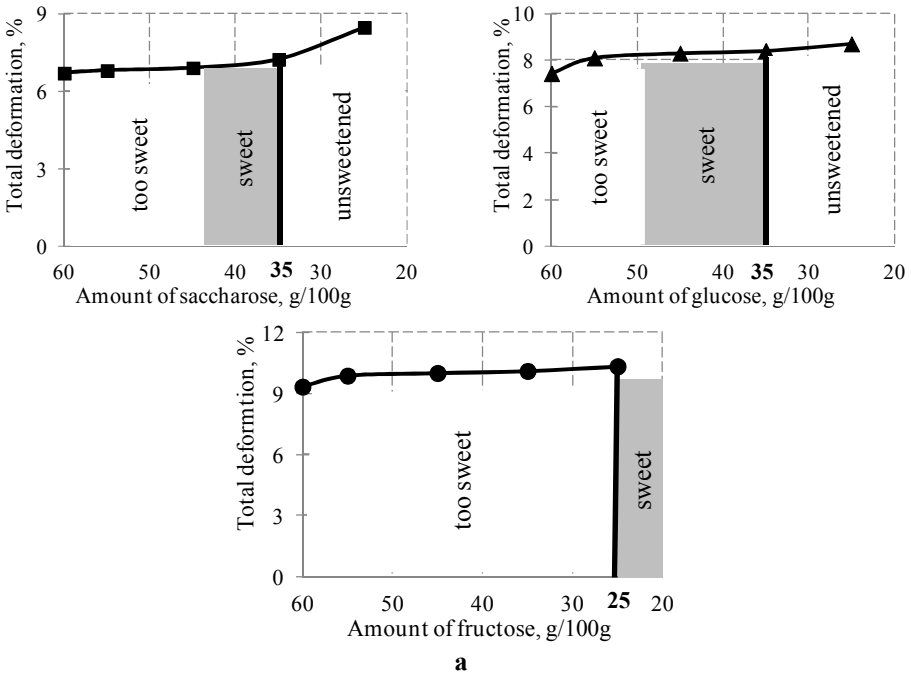

Figure 1. Determination of the acceptable limits of reduction of sugars in jelly marmalade on agar (a) and k-carrageenan (b)

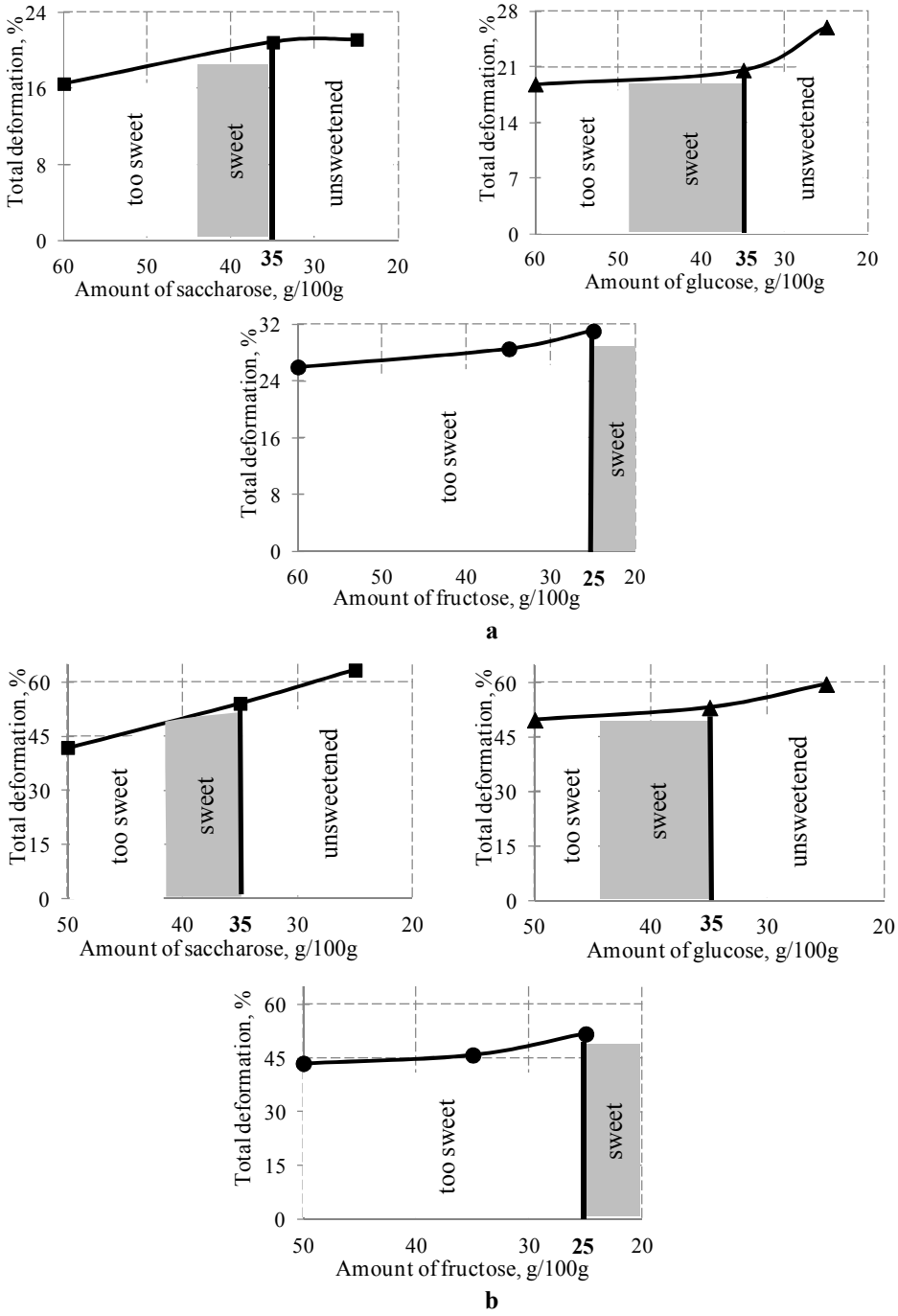

Figure 2. Determination of acceptable limits of reduction of sugars in jelly marmalade on H-pectin (a) and L-pectin (b)

1. To replace the withdrawn prescription sugar amount, an inert texture filler is required to be introduced, which will contribute to the restoration of the DM content, will allow the usual for the consumer consistence of the product; while decreasing the energy value and the index of glycemicity of finished products. In our opinion, polydextrose – a polysaccharide obtained by the hydrolysis of starch, which is used as a filler for the masses without sugar, without fat, corresponds to such requirements [23, 24]. It has the properties of food fiber and prebiotics, does not affect the level of glucose in the blood and is absorbed independently of insulin, has a low glycemic index, high stabilizing ability, barely sweet taste, which will not affect the taste of finished products.

2. In the technological schemes of marmalade with glucose there is a need to prevent the process of crystallization of sugar. A scientific substantiation of the relationship between the quality of the molasses and the obtaining of an amorphous structure of marmalade needs to be scientifically justified.

3. There is a need for the formation of organoleptic indicators (color, smell, taste) by introducing natural fruit and berry puree, which is released by the canning industry in a wide range. Such approach will not only diversify the taste and color of the marmalade without the use of artificial colorants, but will also allow its chemical composition to be enriched with valuable biologically active substances, while acids presented in the puree will reduce the acid consumption, the content of the dietary fiber, including pectin substances, will enhance the structure of the marmalade.

The optimal amounts of formulations of marmalade with reduced sugar content (saccharose, glucose, fructose) were determined by the method of planning a multifactorial experiment (the "steep climb" method of Box-Wilson). The criterion of optimality was the strength of marmalade gel; the amount of sugar, puree, acids were chosen as optimizing factors. On the basis of the optimal ratios of prescription components, unified formulations of jelly marmalade with reduced content of sugars were calculated, Table 1 [25].

The most complete description of the structure of marmalade masses in the process of their transportation from tempering to forming will provide a study of the degree of destruction of the structure under the influence of the rotary motion. Marmelade masses for rheological studies were prepared according to developed and approved recipes (Table 1). The determination was carried out at temperatures close to those of the forming of agar and pectin masses, which prevent structural transformation. The rheological curves of the samples of marmalade masses are presented on the figures 3–6.

The character of the obtained curves shows that all the masses in the indicated range of the gradient of displacement differ in a high degree of structure formation. The exception is the marmalade mass on agar, the values of effective viscosity for which are smaller than other experimental samples. Effective viscosity for the smallest and largest displacement gradients for each marmalade is presented in Table 2.

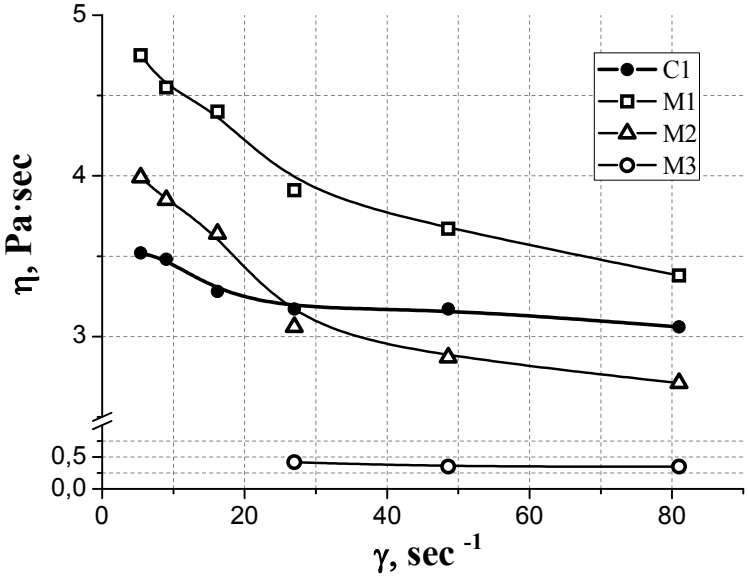

Figure 3. Rheological curves of marmalade masses on agar

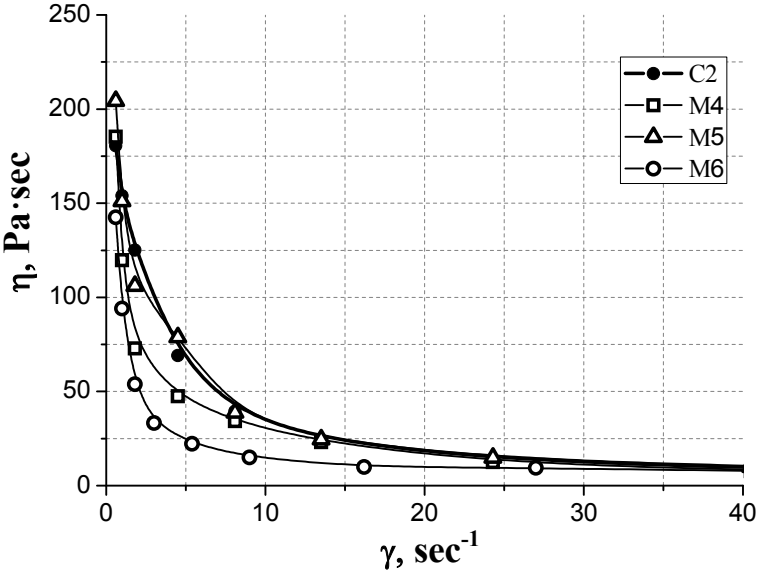

Figure 4. Rheological curves of marmalade masses on k-carrageenan

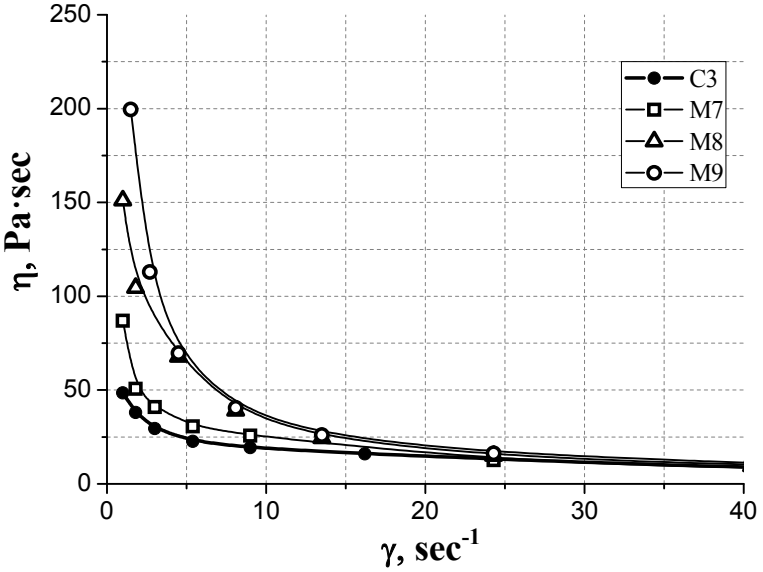

Figure 5. Rheological curves of marmalade masses on H-pectin

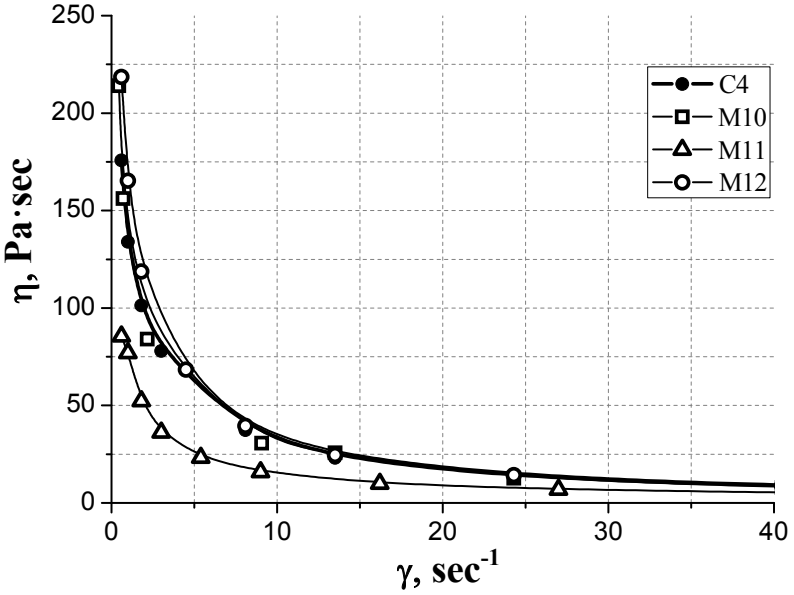

Figure 6. Rheological curves of marmalade masses on L-pectin

Table 2

Effective viscosity for marmalade masses

Abbreviation	Effective viscosity, Pa·sec		Degree of destruction, %
	of practically undamaged ststem, η_0	of practically damaged ststem η_{min}	
	γ=5.4 c^{-1}	**γ=81 c^{-1}**	
C1	3.52	3.06	13.07
M1	4.75	3.38	28.84
M 2	3.99	2.71	13.07
M 3	0.42	0.35	16.67
	γ=0.6 c^{-1}	**γ=121.5 c^{-1}**	
C2	180.5	3.26	98.19
M 4	185.25	2.86	98.46
M 5	204.5	3.66	98.21
M 6	142.5	2.56	98.20
	γ=1.0 c^{-1}	**γ=40.5 c^{-1}**	
C3	48.45	7.81	83.88
M 7	86.93	7.81	91.02
M 8	151.05	9.39	93.78
M 9	199.50	11.19	94.39
	γ=0.6 c^{-1}	**γ=40.5 c^{-1}**	
C4	175.75	8.02	95.44
M 10	213.75	8.23	96.15
M 11	85.50	6.76	92.09
M 12	218.50	8.73	96.00

For each system, a range of values for the gradient of displacement is selected, in which the effective viscosity of the system has a value that ensures its suitability for transportation. This indicator should provide the following values of the effective viscosity that would not exert an excessive load on the mechanical transfer system and reduce the energy consumption of the process. During pumping there also should not be a deep destruction of the structure of marmelade, in order to reduce the time for further gel-formation. Consequently, the interval of values of γ can be extended to the beginning of fluidity.

It was established that the low effective viscosity of agar marmelade masses (η_0 3.75 Pa·sec – with saccharose, η_0 3.99 Pa·sec – with glucose and η_0 0.42 Pa·sec – with fructose) provides a rather slow destruction of the structure. On systems with fructose, the viscosity is so low that destruction is practically not observed. This is evidence of a very slowly structured formation of agar masses with fructose which velocity at the detection temperature does not prevent the development of gel. In samples with glucose and saccharose, for γ = 27 sec^{-1}, the fluidity of their structure begins. Consequently, the range of values γ – 10–20 sec^{-1} can be recommended for the transportation of marmalade masses on agar with glucose and

saccharose. Samples with fructose need to be pumped under less gentle conditions or at temperatures lower than the rest of the test samples on agar.

For carrageenan masses, fluidity begins with smaller gradients of displacement than for agar, despite the fact that the effective viscosity of the practically undamaged ststem on k-carrageenan is much higher than on agar. Figure 4 shows that the fluidity of the samples begins at γ-7–8 sec^{-1}, so transportation must be carried out within the limits closest to the destruction, ≈ 5.4 sec^{-1}. We believe that marmalade masses on carrageenan can be pumped in the traditional modes, without changing the parameter. It is worth noting that the values of effective viscosity of samples with fructose and saccharose inferior to the control sample and sample on glucose, it supposes the possibility of transporting such masses in the selected displacement gradient at lower temperatures.

Rheology of marmalade masses on H-pectin with the reduced content of sugars significantly changes in comparison with other polysaccharides. The rheological curves of the experimental samples shown in Figure 5 are higher than the reological curve of the control sample. At the test temperature, the effective viscosity of the practically undamaged systems with glucose and fructose significantly exaggerates this index in masses with sugar. Therefore, the temperature at which the transport of the masses with monosaccharides will be carried out will need to be increased in comparison with the traditional transfer modes. The recommended gradient displacement interval is $\gamma = 5.4–8$ sec^{-1}.

The rheological curves for samples with L-pectin have identical character and close values of the effective viscosity indexes, except for the sample with glucose. This means that the transport of such masses can be carried out according to the experimental studies (t = 80±3); for glucose – reduction is allowed. The recommended interval of values for the gradient of displacement for samples with glucose is $\gamma = 2–8$ sec^{-1}, for saccharose and fructose – $\gamma = 5–10$ sec^{-1}.

Thus, the peculiarities of the rheology of marmalade masses with a reduced content of sugar should be taken into account when developing the Technological Instructions for production. The interval defined for each group of marmalade masses may be extended in comparison with the traditional recommended standards.

The structure, mechanical strength of marmalade products and, ultimately, the quality of the finished product depends on the process of gel-formation. In the conditions of production, the process of gel-formation occurs in different modes for the gel-forming agents: on agar, the temperature of withstanding of marmalade is t = 10-15 °C, the duration is 30-60 minutes; on k-carrageenans and pectins – t = 10-15 °C, duration is 12-15 min. Determination of the parameters of the gel-formation was carried out based on the dependences of the tension of displacement of marmalade from the time of its was withstanding. The time of gel-formation was defined as the time for which gel with a constant tension of displacement is formed. Dependencies are shown in Figure 7.

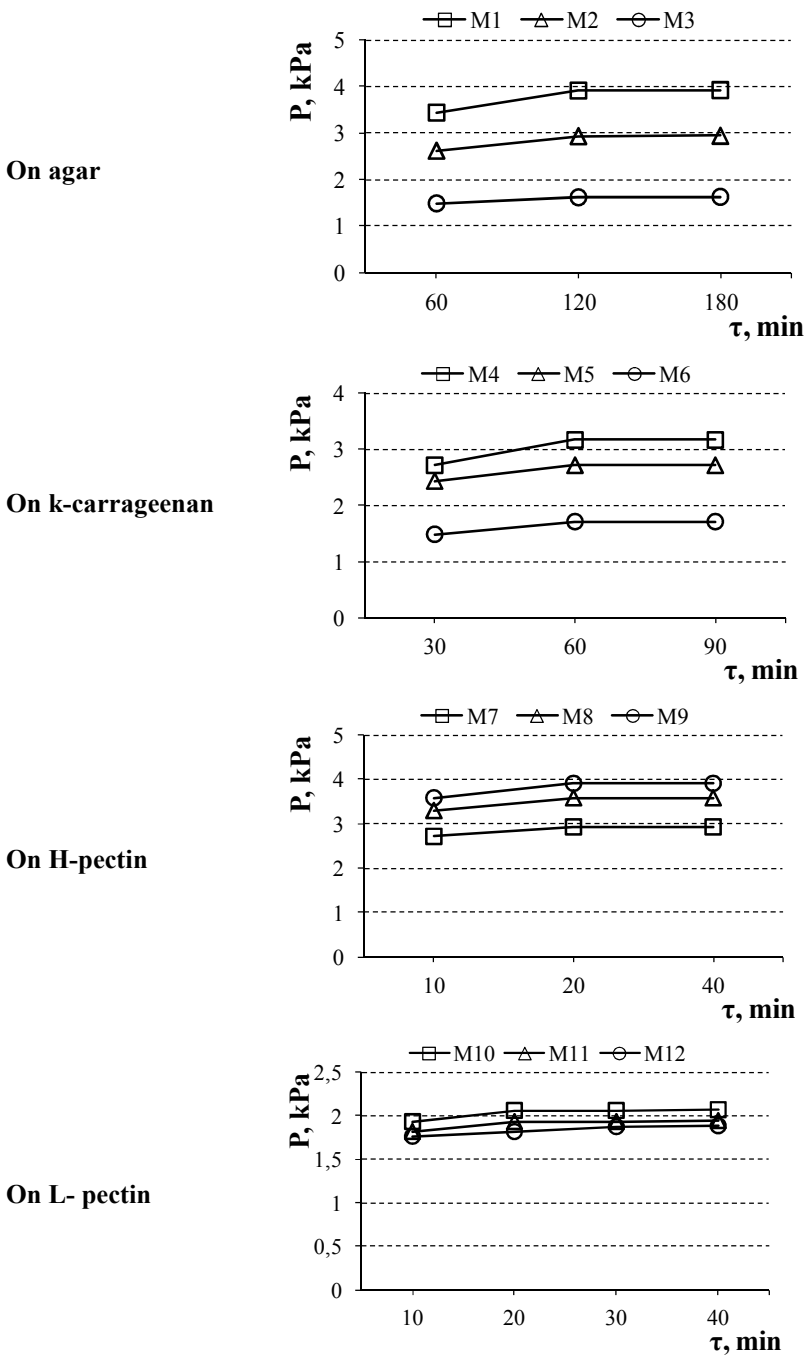

Figure 7. Dependence of the tension of displacement of marmalade with saccharose, glucose and fructose from time of withstanding

It has been determined that the time of gel-formation of marmalade on agar with different types of sugars should be at least 120 minutes. In this case, the samples have different strengths (Table 3): with saccharose, the marginal tension of displacement is 3.91 kPa; with glucose – 2.93 kPa (less by 25%); with fructose – 1.62 kPa (by 58.7% less). However, the resulting strength is sufficient to provide the products with the necessary texture properties typical for marmalade. The resulting marmalade has high consumer properties.

Identical dependences are observed for k-carrageenan, namely: the strength of samples on saccharose is greater than the strength of samples of marmalade on glucose and fructose (the marginal tension of displacement is greater by 14.3 and 46%, respectively). However, the time of gel-formation is reducesd twice compared to marmalade on agar and is 60 minutes.

Samples with pectin have the smallest time of gel-formation: for H-pectin it is enough 20 minutes to obtain constant strength, on L-pectin – 20-30 minutes, depending on the sugar. The dependence of the strength of the structure of the marmalade on the H-pectin differs from the dependencies established for other polysaccharides. Among samples of marmalade on H-pectin, samples with saccharose have, on the contrary, the least strength (marginal tension of displacement is 2.93 kPa), and samples with fructose have the highest (the marginal tension of displacement is 3.91 kPa).

Table 3

Indicators of the structure forming of marmalade

Abbreviation	Marginal tension of displacement, kPa		Time of gel-formation, min	Speed of gel-formation, kPa/min	Total deformation, %	Springy/ plastic defoformation, %
	min	max				
M1	3.44	3.91	120	0.53	9	66.7/33.3
M2	2.62	2.93	120	0.26	27	55.6/44.4
M3	1.49	1.62	120	0.11	31	45.2/54.8
M4	2.72	3.17	60	1.51	31	51.6/48.4
M5	2.44	2.72	60	0.46	35	51.4/48.6
M6	1.49	1.71	60	0.38	40	42.5/57.5
M7	2.72	2.93	20	1.06	61	27.8/72.2
M8	3.30	3.58	20	1.43	75	28.0/72.0
M9	3.58	3.91	20	1.63	80	31.2/68.8
M10	1.82	2.06	20	0.63	81	28.4/71.6
M11	1.93	1.93	20	0.58	85	25.9/74.1
M12	1.76	1.87	30	0.37	86	24.4/75.6

The peculiarity of the structure forming of the masses on L-pectin is the extension of the time of gel-formation for a sample with fructose – by 10 min in comparison with saccharose and glucose. The marginal tension of displacement of the sample with saccharose for the final gel-formation is 2.06 kPa, with glucose is 1.93 kPa (6.2% less), with fructose – 1.87 kPa (9.1% less).

According to the indicators determined on the penetrometer AP-4/1, the springy-plastic deformation of the samples and their correlation were calculated. It has been established that marmalade on agar and k-carraginina differs by springy properties (the proportion of springy

deformationis > 50%); marmalade on pectins is characterized by greater plasticity (the fraction of plastic deformation is > 50%). Along with this, marmalade with fructose on all polysaccharides, except H-pectin, differs by greater plasticity. Sensory evaluation has additionally confirmed that marmalade on pectins has more tender consistency and it is easier to chew; marmalades on agar and k-carragin has more springy consistency.

Conclusions

The multicomponent system, the type of structure former, the type of sugar, and the various ratios influence on the difference in the parameters of the technological process and require separate, specific recommendations. The conducted researches have provided the basis for making changes in the technological schemes of the production of jelly marmaladr. Such parameters have been installed and recommended: maximum speed of the rotary movement during transfer; temperature of transportation and tempering of masses; the cooling time and the production of the finished marmalade.

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