

## USING THE VARIETIES OF SUGARS IN THE TECHNOLOGY OF FRUIT AND BERRY MARMALADE MASS PRODUCTION

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The paper contains results of a study of structural-mechanical properties of marmalade masses produced using the varieties of sugars in the technology of fruit and berry marmalade mass production. The possibility to use the L-pectin in the technology of fruit and jelly marmalade production and to reduce the intake of sugar is described.

**Keywords:** marmalade, gel making, sugars, pectin.

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There is almost no group of fruit and berry marmalade, carrying the biologically active substances in the assortment of candy and jelly products manufactured by Ukrainian producers of confectionery products. In order to improve technological schemes of the most common in Ukraine fruit and berry marmalade products, the chemical compositions and physical and chemical properties of varieties of fruit and berry puree have been studied. It was determined that the number of pectins, including the water-soluble pectin gel as a fundamental factor, apple and cornel puree are related to the puree with high pectin content; apricot – with middle level, raspberry, peach, buckthorn - with low level. In addition, only apple and cornel pectin are characterized as H-pectin, with low content of free carboxyl and acetyl groups. Patterns of formation of jelly masses (gelling ability) investigated in relation to the chosen types of puree allowed to differentiate their technology focus and to recommend apple and cornel puree for the fruit and berry marmalade, while apricot, peach, raspberry, and buckthorn - as additional gel making additive to fruit and jelly.

In technology of fruit and berry marmalade it is impossible to reduce the intake of prescribed sucrose, however the study on the use of other types of sugars with the lower glycemic index or calories is important. Thus glucose should be used to create the assortment of marmalade for children's food, fructose - in technology of manufacturing products for the diabetics.

The research on the gel quality substantiating the need to improve the technological schemes was necessary

### The results of determining the gel quality

The gel quality indicators	Apple puree, sucrose	Apple puree, glucose	Apple puree, fructose
Easiness of die casting	good		
Easiness of extraction from the forms	mass is easily removed from the forms	mass is easily removed from the forms	The mass of poorly removed from the form; requires more time for jelling
Gelling ability	great/excellent	great	satisfactory
The gel strength	good	good	satisfactory
Surface condition	the surface is smooth and shiny	the surface is smooth	the surface is glossy and sticky
Stickiness	does not stick	does not stick	sticks

because the changing nature of the sugars significantly influences the behaviour of pectin of the apple puree.

#### Materials and research methods

In the experiment we used the samples of marmalade mass on the basis of varieties of sugars: sucrose, glucose, and fructose. The device Valenta was used to determine the load to fracture of the gel. Determination of structural-mechanical properties of marmalade masses along the curves of the dynamics of deformation was carried out using structural property, the principle of which is based on measuring the mechanical load on the nozzle indenter, and dipping it with the pre-set speed into the prepared sample of the product. Curves of compression and unloading

for samples of marmalade mass were built within 2 hours of standing. The analysis of curves allowed us to obtain several independent deformation characteristics: compressive, modulus of instantaneous elasticity, the effective viscosity, plasticity, softness, resilience, yield of strength.

#### Results and discussion

It was established that the marmalade masses of the sucrose and glucose were removed well from the forms; they did not stick, had a dry surface, i.e. had a great jelly-forming ability under equivalent conditions of boiling. Fructose mass demanded more time for gelation, but it clung a little to the form and was characterized by satisfactory strength.

#### The gel strength

Samples	Gel strength, g
Sample №1 (sucrose)	207,72
Sample №2 (glucose)	314,67
Sample №3 (fructose)	203,18

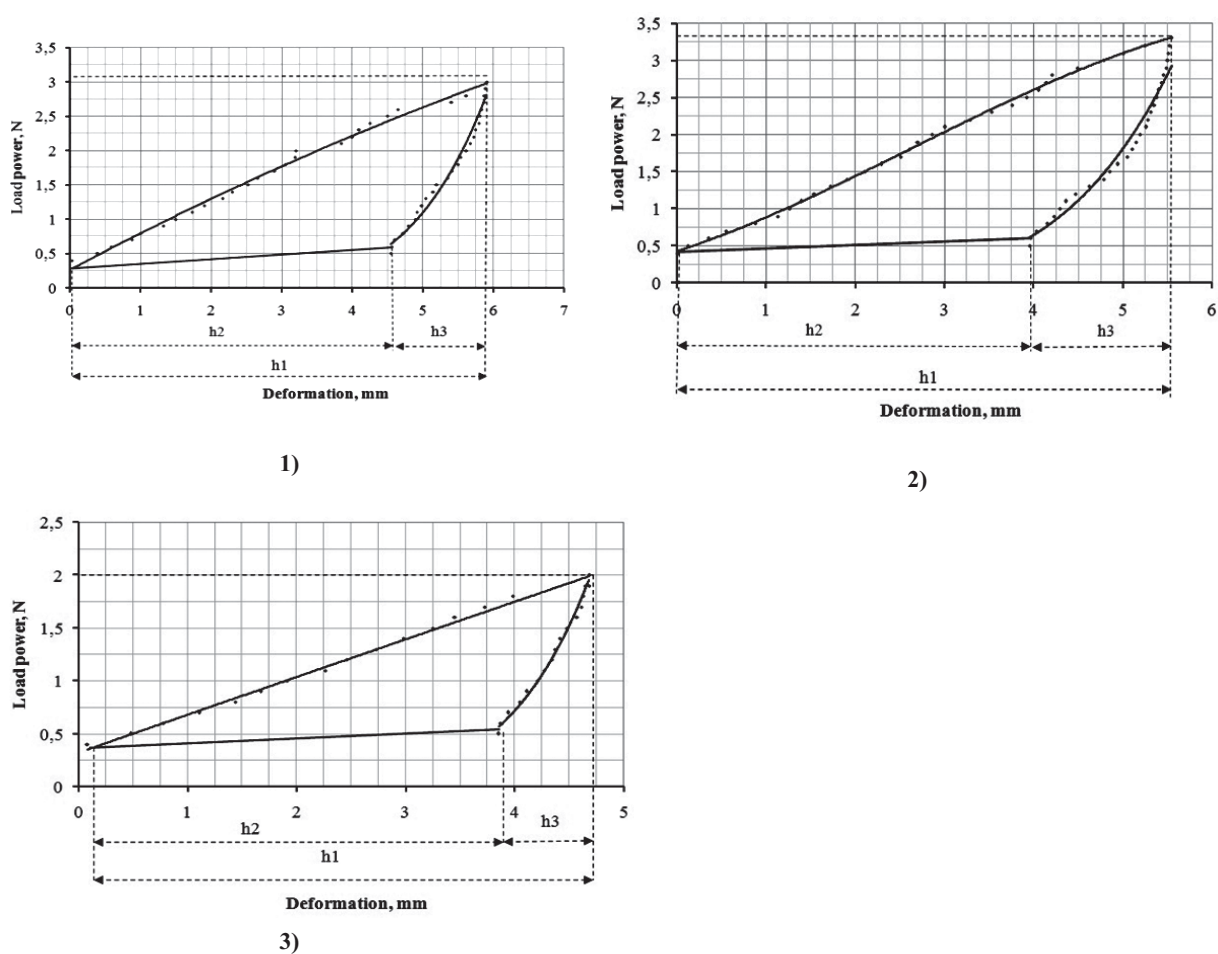


Fig. 1. Curves of compression and unloading: 1) glucose; 2) sucrose; 3) fructose.

### Structural and mechanical indicators of marmalade mass (sucrose)

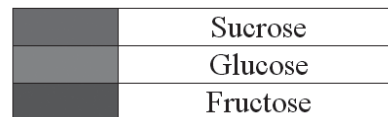
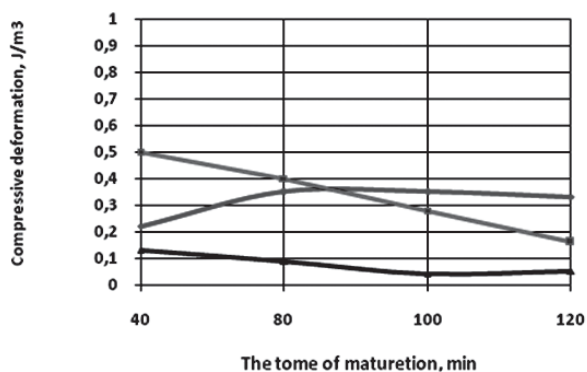
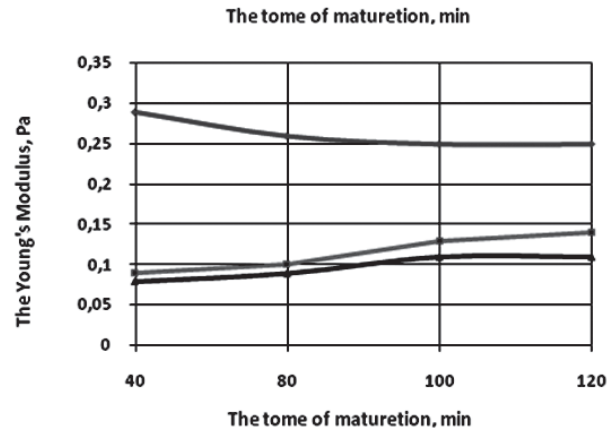
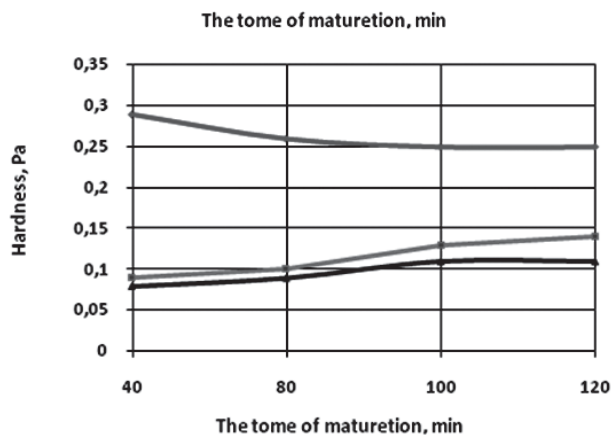
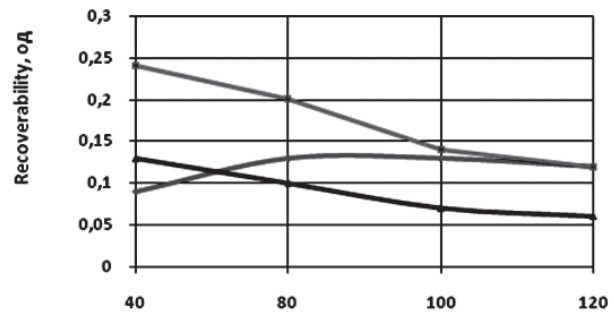
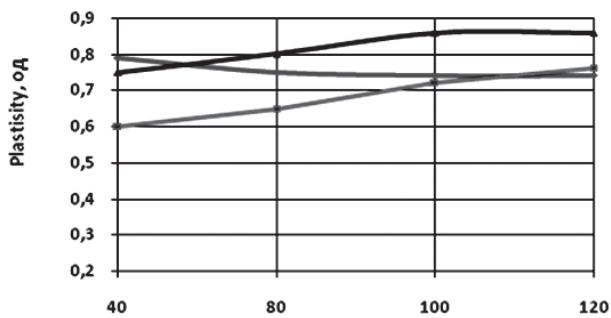
Indicators	Time of maturation, min		
	40	80	120
Compressive, $J/m^3 \cdot 10^{-6}$	0,22	0,35	0,33
The Young's Modulus, Pa	0,29	0,26	0,25
Effective viscosity, Pa*s	0,85	0,99	0,95
Plasticity, units	0,79	0,74	0,74
Softness, units	0,74	0,68	0,69
Recoverability, units	0,09	0,13	0,12
Absolute strain, units	0,06	0,07	0,06
Hardness, units	2,89	2,76	2,68
Conditional limit of fluidity, $Pa/m^2$	8,33		

### Structural and mechanical indicators of marmalade mass (glucose)

Indicators	Time of maturation, min			
	40	80	100	120
Compressive, $J/m^3 \cdot 10^{-6}$	0,50	0,40	0,28	0,16
The Young's Modulus, Pa	0,09	0,10	0,13	0,14
Effective viscosity, Pa*s	0,65	0,62	0,56	0,51
Plasticity, units	0,60	0,65	0,72	0,76
Softness, units	0,56	0,62	0,69	0,73
Recoverability, units	0,24	0,20	0,14	0,12
Absolute strain, units	0,04	0,04	0,04	0,04
Hardness, units	2,23	2,32	2,45	2,55
Conditional limit of fluidity, $Pa/m^2$	6,17			

Structural and mechanical indicators of marmalade mass (fructose)

Indicators	The time of maturation, min			
	40	80	100	120
Compressive, $J/m^3 * 10^{-6}$	0,13	0,09	0,04	0,05
The Young's Modulus, Pa	0,08	0,09	0,11	0,11
Effective viscosity, Pa*s	0,34	0,30	0,23	0,22
Plasticity, units	0,75	0,80	0,86	0,86
Softness, units	0,73	0,77	0,84	0,84
Recoverability, units	0,13	0,10	0,07	0,06
Absolute strain, units	0,03	0,03	0,02	0,02
Hardness, units	2,40	2,42	3,03	3,14
Conditional limit of fluidity, Pa/m <sup>2</sup>	4,61			



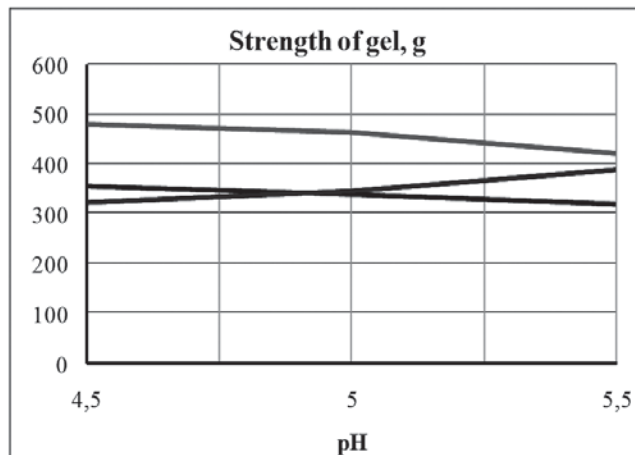
The device Valenta was used to determine the load to fracture of the gel. The highest rates are observed for the sample with glucose.

Detailed characterization of mechanical properties of the gelling systems is provided by a study on the development process of

deformation – with and without the load. The structural carcass of the gel determines the amount of elastic deformation; the liquid phase determines the amount of elastic deformation. Food gel systems are characterized by slow deformation, i.e., upon unloading the deformation does not

change instantaneously, but with a delay (there is the elastic effect as well).

The dynamics of deformation processes reveals some differences in formation of structural-mechanical properties of the marmalade mass prototypes.



	Sucrose
	Glucose
	Fructose

### Organoleptic indicators of the marmalade mass with reduced amount of sugar

Organoleptic indicators	The sugar content (% of the amount of sugar in the traditional recipe)				
	A control sample, 100	80	65	50	35
Surface condition	Smooth, glossy				
Stickiness	does not stick	does not stick			slight stickiness
Easiness of extraction from the forms	removed	well removed			removed
Ability to retain its shape	good	good			bad

It was discovered that all the samples of marmalade mass partially lose their elastic properties under the load, when significant deformation occurs in the body, i.e. its original size and shape is not fully restored when the load is removed. Final plastic deformations for samples with glucose and fructose are fixed even with the full external load lifted up, which in contrast to the samples with sucrose are increased with time. At the same time, for samples with monosaccharides recoverability is reduced.

Along with this, the sample with sucrose has much greater resistance to compression under the elastic deformation (The Young's Modulus) and hardness, i.e., the ability not to be affected by the plastic deformation. But in the process of maturation the sample with sucrose loses a bit the ability to resist, while the samples with the monosaccharides, on the contrary, gain it.

This confirms the increased compressive strain or the ability of a material to resist impact load. The higher the value of this index is, the lower the elastic characteristics of the material will be. It is established that with increasing in time proofing of samples the compressive deformation in the

samples with sucrose is increasing and practically does not change after 80 minutes. In other words, in the process of maturation the gel based on the sucrose is gradually losing the resistance to loads, and the marmalade gel with fructose and particularly with glucose, on the contrary, has a tendency to resist deformations.

These studies allowed us to recommend spending more time on maturation of marmalade masses based on fructose and glucose in order to achieve the desired structural and mechanical characteristics.

Not less important for the gelation of pectin of apple puree is the presence of free acids, which affects the speed of the process and the strength of jelly.

Assessment of the strength of gels with different pH values shows that addition of acid in pectin gels with monosaccharides contributes to their strength - unlike the sucrose-based gel, for which excess of the optimal amount of acid softens the structure.

However, the strength of the jelly mass based on glucose exceeded the samples on the sucrose and fructose in equal conditions of any acid.

These results provided a basis for improving the technological schemes of production of fruit marmalade with

varieties of sugars. The research also makes reasonable the use of glucose and fructose in the technology of fruit and berry marmalade manufacturing, but with changes in the technological process.

The optimal ranges of pH for the formation of structural-mechanical properties were determined. It was established that the formed jelly is more stable at low pH, pH at 3.5-3.7, close to the natural pH of the selected fruit and berry raw materials.

It was experimentally established that the conditions of gelation of L-pectin reduce the proportion of sugar without any negative impact on the structure of the marmalade mass.


The sample with reduced (to 50% of the prescribed) amount of white crystalline sugar received high organoleptic mark. Such products are similar to products with traditional recipes and have a smooth glossy surface; they do not stick and can be easily removed from the forms. Their final form fully corresponds to the predetermined one.


### Conclusions


Thus, the research carried out allows speaking about the possibility to use the varieties of sugars in technological schemes of fruit and berry marmalade

production, or to reduce the prescribed amount of sucrose. The paper will contribute to the development of technological schemes of manufacturing the assortment of fruit and berry marmalades in puree.

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