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Original article

THE INFLUENCE OF SOME BIOCHEMICAL PARAMETERS OF APPLES ON THE ORGANOLEPTIC PROPERTIES OF APPLE JAM

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Abstract

Background. The content of dietary fiber, sugars, organic acids, and calcium in apples are important technological indicators that affect the quality of apple jam. Knowledge of the relationships between the chemical and technological characteristics of fruits and the quality of the finished product would make it possible to determine the importance of a particular technological indicator in the formation of the organoleptic qualities of the processed product and its nutritional value.

The **purpose** of these studies was to establish the influence of some biochemical parameters of raw materials on the quality of apple jam. To achieve this goal, the following objectives were formulated: to characterize the fruits of apple trees of different varieties in terms of the content of dietary fiber (soluble and insoluble), sugars (glucose, fructose, sucrose and their sum), acids (malic, citric, hydroxycinnamic), calcium; to form a sensory profile based on visual descriptors and analyze apple jam based on it; to identify the relationships between the biochemical parameters of the raw material and the sensory characteristics of the jam obtained from it; to describe the received interactions using regression equations.

Material and methods. The influence of some biochemical parameters of fruits of 6 local apple genotypes on the quality of apple preserve was studied. We studied 6 local apple genotypes: Bolotovskoye, Veniaminovskoye, Kurnakovskoye, Candil Orlovsky, Rozhdestvenskoye and Sinap Orlovsky. The raw materials were analyzed according to the hardness of the fruits, the content of dietary fibers, sugars, and organic acids, Ca^{++}. The preserve was made according to the current standards. the organoleptic analysis included visual, gustatory and olfactory assessment. The assessment was carried out by experts who took part in closed tastings. The experts – members of the tasting group (n = 15, 3 men, 13 women, aged 27-60 years) were selected among the staff of the VNIISPK according to the level of taste sensitivity on a voluntary basis.

Results. High content of the dietary fibers (2.12-2.16%) in raw materials revealed in Candil Orlovsky, Kurnakovskoye, Veniaminovskoye. The fruits of apple varieties contained on average fructose 5.79%, glucose – 2.17%, sacharose – 1.59. There was a high level of malic acid (180.90 – 1029.98 mg/100 g) and a low level of citric acid (2.59 – 12.04 mg/100 g). Calcium content in the fruits varied from 8.85 mg/100 g (Sinap Orlovsky) to 22.03 mg/100 g (Bolotovskoye). The average value of hardness of the fruits amount to 4.59 kg/cm^2, the scope of variability was from 3.56 kg/cm^2 (Veniaminovskoye) to 6.03 kg/cm^2 (Sinap Orlovsky). Sensory analysis of preserves has shown that all samples have got fine acceptability scores. It was determined that the most preferred preserve with clear syrup and whole slices with a crispy consistency. The syrup quantity and its gelatinous characteristics was of no great matter but soft consistency of the slices reduced the acceptability scores. A direct reliable relationship between the transparency of the syrup and the content of organic acids and inverse relationship between the transparency of the syrup and calcium content have been revealed. A direct relationship was noted between the consistency of apple slices and the content of insoluble dietary fiber and hydroxycoric acids and the inverse relationship between this indicator and the content of citric acid. The data obtained make it possible to predict the quality of apple preserve and design a product with specified quality parameters.

Keywords: dietary fiber; preserve; sensory assessment; descriptors; biochemical parameters

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Научная статья

ВЛИЯНИЕ НЕКОТОРЫХ БИОХИМИЧЕСКИХ ПАРАМЕТРОВ ЯБЛОК НА ОРГАНОЛЕПТИЧЕСКИЕ КАЧЕСТВА ВАРЕНЬЯ

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Аннотация

Обоснование. Содержание в яблоках пищевых волокон, сахаров, органических кислот, кальция, участвующих в формировании свойств протопласта

(мякоти плодов), являются важными технологическими показателями, влияющими на качество варенья. Знание взаимосвязей между химико-технологическими признаками плодов и качеством готового продукта позволило бы определить значимость того или иного технологического показателя в формировании органолептических качеств продукта переработки и его пищевой ценности.

Целью данных исследований было установить влияние некоторых биохимических параметров сырья на качество яблочного варенья. Для достижения поставленной цели сформулированы задачи: дать характеристику плодам яблони разных сортов по содержанию пищевых волокон (растворимых и нерастворимых), сахаров (глюкозы, фруктозы, сахарозы и их сумы), кислот (яблочной, лимонной, гидроксикоричной), кальция; сформировать сенсорный профиль по визуальным дескрипторам и провести на его основе анализ варенья из плодов различных генотипов яблони; выявить зависимости между биохимическими параметрами сырья и сенсорными характеристиками полученного из него варенья, а также описать полученные взаимодействия уравнениями регрессии.

Материалы и методы. Объектами исследования служили 6 генотипов яблони селекции ВНИИСПК: Болотовское, Веньяминовское, Курнаковское, Кандиль орловский, Рождественское, Синап орловский. Сырье было проанализировано по твердости плодов, содержанию пищевых волокон, сахаров, органических кислот, Ca^{++}. Выработку варенья осуществляли согласно текущим стандартам. Органолептический анализ включал визуальную, вкусовую и обонятельную оценку. Оценка проводилась экспертами, которые приняли участие в закрытых дегустациях. Эксперты – члены дегустационной группы (n = 15, 3 мужчин, 13 женщин, в возрасте 27-60 лет) были отобраны на добровольной основе среди сотрудников института по уровню вкусовой чувствительности.

Результаты. Высокое содержание пищевых волокон (2,1-2,2%) в сырье выявлено у сортов Кандиль орловский, Курнаковское, Веньяминовское. Плоды сортов яблони содержали в среднем фруктозы 5,8%, глюкозы – 2,2%, сахарозы – 1,6. Отмечен высокий уровень яблочной кислоты (181,0 – 1030,0 мг/100 г) и низкий – лимонной (2,6 – 12,0 мг/100 г). Содержание кальция в плодах варьировало от 8,9 мг/100 г (Синап орловский) до 22,0 мг/100 г (Болотовское и Кандиль орловский). Среднее значение твердости мякоти плодов составило 4,7 кг/см^2, размах изменчивости при этом был от 3,6 кг/см2 (Веньяминовское) до 6,2 кг/см2 (Болотовское). Сенсорный анализ варенья 6 сортов яблони показал, что все образцы получили высокие оценки приемлемости. Самые высокие оценки получило варенье сортов Рождественское и Курнаковское.

Установлено, что наиболее предпочтительно варенье, с прозрачным сиропом и целыми дольками с хрустящей консистенцией. Количество сиропа и признаки его желирования большой роли не играли, а нежная (мягкая) консистенция долек снижала оценку приемлемости. Установлены зависимости между органолептическими показателями варенья и некоторыми биохимическими параметрами сырья. Выявлена прямая достоверная зависимость между прозрачностью сиропа и содержанием органических кислот (r = 0,88* для лимонной кислоты; r = 0,86* для яблочной кислоты; r = 0,89* для гидроксикоричных кислот) и обратная – содержанием Ca++ (r = -0,87*). Отмечена прямая зависимость между консистенцией яблочных долек и содержанием нерастворимых пищевых волокон (r = 0,80*) и гидроксикоричных кислот (r = 0,81*) и обратная между этим показателем и содержанием лимонной кислоты (r = -0,80*). Полученные данные позволяют прогнозировать качество яблочного варенья и проектировать продукт с заданными параметрами качества.

Ключевые слова: яблоня; варенье; сенсорная оценка; дескрипторы; биохимические параметры

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Introduction

The preparation of sugary fruit products is one of the oldest canning processes known to mankind, which significantly reduce post-harvest losses in temperate climates and consume fruits both in season and in the off-season. In this case, food preservation is achieved, in addition to heat treatment, by increasing the dry matter content (decrease in water activity) and acidity (decrease in pH) [20; 21;28].

Despite the high sugar content in preserves, its negative effect is offset by the high content of biologically active substances and, especially, dietary fiber. All types of fiber, both soluble and insoluble, which are contained together with fructose and glucose in fruits and berries, slow down the rate of absorption of simple sugars and cause a calm release of insulin. Therefore, preserve, jam and other processed fruit products made with sugar are considered as natural healthy food products containing useful components of fresh fruits and possessing their pharmaceutical properties, but requiring metered consumption.

The production of sugary fruit products, including jams, is promising from the point of view of small business development. The adoption of the law „On agricultural products, raw materials and food" (entered into force on March 1, 2022), aimed at producing products for the population with improved characteristics, also sets the task of using raw materials, according to their characteristics, most corresponding to the production of fruit sugary confectionery products, including preserve [19]. The creation of a raw material base of fruits and berries for the production of various types of canned fruit with sugar implies the selection of cultivars with the best suitability for processing for a specific type. For apple preserve the cultivars, on the one hand, should be with a high content of soluble solids (SS) and dense pulp, so that the fruit slices do not boil when cooking, on the other hand, with a sufficient acid content to avoid candying during storage, be more harmonious in taste. The optimal degree of fruit maturity for the preserve is also of great importance. The fruits should be ripe but with dense flesh. When using unripe fruits, the preserve turns out to be non–aromatic, the slices are dry and hard to taste, since under the action of sugar syrup they undergo strong plasmolysis of the protoplast occupying most of the cells, which is typical for immature fruits and the syrup often gels. Thus, the quality of the preserve is determined mainly by the pulp of the fruit, that is, the quality of the mesocarpium – the presence of dietary fibers, sugars, and organic acids in it.

One of the main indicators of fruit pulp – hardness – describes its texture and is often used by manufacturers to determine the optimal date of harvest [16; 20]. The maturity of fruits affects their density: during the ripening process, the density of the pulp decreases, as protopectin passes into pectin. The hardness of the pulp characterizes the mechanical properties of fruits and is of great importance for technical processing, since the structure of the fruit pulp determines the quality of the final product.

According to GOST 34844-2022 [5], dietary fiber is defined as carbohydrate polymers, plant polysaccharides that are not fully exposed to enzymes of the gastrointestinal tract and are not absorbed in the small intestine, and the consumption of dietary fiber of at least 20 g per day is considered sufficient for a healthy diet. Dietary fibers are conventionally divided into insoluble dietary fibers (IDF) and soluble dietary fibers (SDF) depending on their solubility. IDF include cellulose, hemicellulose, lignin, etc., whereas SDF include pectins, β-glucan, oligosaccharide, inulin, etc. [5; 27; 32]. Fiber is a good example of dietary fibers that polyphenols bind to. The fiber of apples also causes a significant increase in the viscidity of jelly [22].

Sugars (carbohydrates), which perform an energy and support function, have a sweet taste and are easily absorbed by the body. In combination with organic acids, they form the taste of fruits. Fructose, which share in the total sugar content is on average 50-60%, dominates in apples [6; 18; 19; 25]. According to S.M. Motyleva and A.A. Borisova [10], the content of other identified 10 sugars in apples – galactose, mannose, arabinose, ribose, allopyranose, levoglucosan, sorbitol, turanose, talose, tagatose – depends on the cultivar. M.Y. Akimov and co-authors [1] determined in the analysis of fruits of a number of fruit and berry crops that the highest relative fructose content (>5.00%) is characteristic of apple fruits. Their research showed that the total carbohydrate content in apples was 10.4%, of which 5.74% was fructose, 2.16% was glucose, 1.49% was sucrose. Since sugars predominate in the total amount of SS, they significantly affect the condition of fruits when cooking preserves.

When studying the content of organic acids in apples of 24 varieties, it was found that malic and citric acids are predominant, which account for 441.7 and 6.18 mg/100 g, respectively [1]. Malic acid is the dominant organic acid in apple fruits, which can account for up to 90% of the total amount of organic acids [23; 29].

Apple fruits are a source of many mineral elements, primarily K, P, Ca, Mg, etc., which are involved in many physiological processes in fruits. Calcium, potassium and magnesium and their ratio in mature apple fruits affect their quality, cell wall structure and shelf life. The high calcium content in fruits is important for successful storage and processing. Different varieties may have different contents, but usually within the range of 45...60 mg/1 kg of crude weight [15]. According to some authors, the proportion of calcium in the ash of apple fruits ranges from 0.01 to 0.25 wt% [10], others – 22.2-73.8 mg/100 g [1]. Calcium is a part of pectin substances and affects the resistance of the cytoplasm to mechanical influences. It is possible that calcium regulates the expression of key genes involved in sorbitol metabolism, which leads to the accumulation of sugar in fruits [30]. Calcium intake into apple fruits occurs in the first 4-6 weeks after flowering and as cells age, its concentration increases [18]. The maximum accumulation of calcium in apple fruits occurs at the stage of their development (about 30 mg/100 g). As apples reach maturity, the content of this element gradually decreases to 8...14 mg/100 g, which is optimal during the harvest period [11]. Summer cultivars accumulate less calcium in fruits than autumn and winter [15].

Based on the presented data, it is obvious that the content of dietary fibers, sugars, organic acids, and calcium in apples, which are involved in the formation of protoplast properties (fruit pulp), are important technological indicators that affect the quality of preserves. Of great interest is the identification of various dependencies between the chemical and technological characteristics of fruits and the quality of the finished product. Knowledge of such relationships would make it possible to determine the importance of a particular technological indicator in the formation of the organoleptic qualities of the processed product and its nutritional value. The chemical composition of the fruits does not guarantee the high quality of the processed product. Only an assessment of its quality indicators allows us to make a final conclusion about the suitability of the cultivar for a particular type of processing.

The objectives of the study were as follows:

- to characterize the apple fruits of different cultivars in terms of the content of dietary fibers (soluble and insoluble), sugars (glucose, fructose, sucrose and their sum), acids (malic, citric, hydroxycoric) and calcium;
- to form a sensory profile based on visual descriptors and analyze preserve from fruits of various apple genotypes based on it;
- to identify the dependencies between the biochemical parameters of the raw material and the sensory characteristics of the preserve obtained from it;
- to describe the resulting interactions using regression equations.

The realization of this goal will make it possible to identify the most important descriptors for the characteristics of apple preserve from the point of view of sensory analysis; expand the modern database of organoleptic analysis and the dictionary of descriptors, as well as reasonably approach the development of recommendations for the use of various apple cultivars in processing from the point of view of sensory and biochemical characteristics.

Material and methods

Objects. We studied 6 local apple genotypes: Bolotovskoye, Veniaminovskoye, Kurnakovskoye, Candil Orlovsky, Rozhdestvenskoye and Sinap Orlovsky. These genotypes were bred by Russian Research Institute of Fruit Crop Breeding (VNIISPK) and grown in Oryol region. For the production of preserves, the fruits were selected in a technical degree of maturity.

Technological and biochemical parameters. The raw materials were analyzed according to the hardness of the fruits, the content of dietary fibers, sugars, and organic acids, Ca^{++}.

The hardness of the pulp of apples was determined using the FHT 803 penetrometer.

The determination of the content of IDF and SDF (enzymatic method) was carried out in accordance with the Guidenles R 4.1.1672-03 [13]. The method makes it possible to determine soluble (in ethyl alcohol) and insoluble dietary fibers, which differ in physiological action. The mass fraction of pectin substances (soluble dietary fibers) was determined by the volumetric method according to S.Ya. Raik and GOST 29059-91 [3; 12].

The mass fraction of total sugar, monosaccharides and sucrose was determined using the Bertrand method [6], which is based on the ability of sugars to reduce copper sulfate to copper oxide in an alkaline medium, the amount of which was used to calculate the mass fraction of sugars in solution. The determination of mono- and disaccharides was carried out by high-performance liquid chromatography (HPLC) on columns filled with silicalegem with grafted amino groups in Ca form with refractometric detection [9].

The determination of organic acids was carried out under HPLC conditions with photometric detection according to „Methods of analysis of minor biologically active substances of food" edited by V.A. Tutelyan and K.I. Eller [9]. The determination of hydroxycinnamic acids was carried out by HPLC method in the mode of gradient elution with photometric detection at a wavelength of 330 nm; the acid content was determined in terms of chlorogenic acid [9].

The determination of calcium content was carried out by atomic absorption method according to [13]. The method is based on spraying a solution of the mineralized sample in an air-acetylene flame. The metals in the mineralized solution, falling into the flame, passed into the atomic state. The amount of adsorption of light with a wavelength corresponding to the resonance line is proportional to the value of the metal concentration in the test sample.

Preserve production. The preserve was made according to the current standards [4]. The apples were thoroughly washed, peeled, cut into slices and blanched for 5 minutes at a water temperature of 90 ^{0}C. The prepared raw materials were poured with 50% sugar syrup and kept in it for 8 hours. The preserve was brewed in 4 steps with an intermediate stand for 8 hours. The total cooking time did not exceed 40 minutes. The corked preserve was stored for 4 months before sensory and chemical analyses.

Organoleptic analysis. In our study, the organoleptic analysis included visual, gustatory and olfactory assessment. The assessment was carried out by experts who took part in closed tastings. The experts – members of the tasting group (n = 15, 3 men, 13 women, aged 27-60 years) were selected among the staff of the VNIISPK according to the level of taste sensitivity [7; 8; 24; 26]. The experts took part in the organoleptic analysis on a voluntary basise. The appearance of the product was evaluated: the quality of the syrup, the integrity and consistency of the slices. To assess the intensity of the manifestation of qualities, a 5-point continuous scale was chosen (1 – sign was not detected, 5 – sign was expressed intensively) [25]. Also, the participants of the tasting committee were asked to rate the product on a 5-point hedonistic acceptance scale (1 – extremely dislike, 5 –like very much).

Each sample was encrypted with a three-digit number. Each participant of the tasting committee had a glass of water.

Statistics analysis. All measurements were carried out on three parallel samples for each variable, and the data were expressed in Tables as an average value ± standard error (SE). Statistical processing was carried out by generally accepted methods using standard Microsoft Excel computer programs. The reliability of the results was assessed by the Student's t-test at $p \leq 0.05$. The significance of the differences between the cultivars was assessed using variance and a posteriori (Tukey post hoc test) analyses [31].

Results and discussion

Biochemical parameters of raw materials. Apples are one of the most important sources of dietary fiber for our diet. It was found that the level of dietary fiber in the studied apple varieties ranged from 1.88% (Rozhdestvenskoye) to 2.39% (Bolotovskoye) (Table 1). A relatively high content of dietary fiber (2.12-2.16%) was found in the cultivars Candil Orlovsky, Kurnakovskoye and Veniaminovskoye, the average – in Sinap Orlovsky (1.99%). It was found that the average SDF content (1.28%) exceeded the IDF level (0,88%). Bolotovskoye, Veniaminovskoye and Sinap Orlovsky were characterized by the highest SDF content. Comparatively low SDF content was noted in the fruits of Candil Orlovsky and Rozhdestvenskoye. Candil Orlovsky stood out for the highest IDF content (1.22%). The minimum content of IDF was in Sinap Orlovsky (0,60%).

Table 1.

Biochemical parameters of raw materials for apple preserve

Variety	Dietary fiber, %			Sugars, %				Organic acids, mg/100 g			Ca mg/100 g	Pulp hardness, kg/cm^2
	Sum	IDF	SDF	Fructose	Glucose	Sucrose	Sum	Citric	Malic	Hydroxy-cinnamic		
Bolotovskoye	2.39± 0.14	1.00± 0.01	1.44± 0.04	6.57± 0.14	1.94± 0.01	1.54± 0.01	11.05± 0.12	8.00± 0.02	245.95± 3.31	2.11± 0.01	22.03± 0.95	5.45± 0.76
Veniaminov-skoye	2.12± 0.01	0.72± 0.02	1.43± 0.02	4.92± 0.09	1.81± 0.03	1.31± 0.01	9.04± 0.07	8.04± 0.38	889.88± 6.89	4.06± 0.04	9.12± 0.35	3.56± 0.57
Candil Orlovsky	2.16± 0.06	1.22± 0.02	1.02± 0.02	5.71± 0.15	2.56± 0.03	1.51± 0.03	11.00± 0.11	4.02± 0.15	180.90± 6.69	< 0,05	21.83± 0.46	4.18± 0.43
Kurnakovskoye	2.13± 0.03	0.82± 0.02	1.31± 0.03	5.47± 0.18	2.10± 0.02	1.41± 0.03	9.98± 0.23	2.59± 0.06	480.40± 3.94	1.89± 0.04	20.20± 0.34	3.77± 0.45

Rozhdestven-skoye	1.88±0.04	0.89±0.04	1.04±0.06	6.18±0.11	2.49±0.03	2.16±0.06	12.05±0.13	5.03±0.19	280.01±4.16	< 0,05	18.95±0.75	4.53±0.62
Sinap Orlovsky	1.99±0.02	0.60±0.03	1.41±0.02	5.86±0.06	2.14±0.03	1.61±0.02	10.91±0.21	12.04±0.12	1029.98±10.63	6.81±0.02	8.85±0.34	6.03±0.69
$\overline{\chi}$	2.11±0.07	0.88±0.09	1.28±0.08	5.79±0.23	2.17±0.12	1.59±0.12	10.67±0.42	6.62±1.40	517.85±146.76	2.50±1.06	16.83±2.52	4.59±0.40
LSD 05	0.28	0.35	0.31	0.92	0.48	0.48	1.66	5.51	576.97	4.16	9.92	1.56

The studied apple cultivars had significant differences in the amount of sugars, as well as in the content of fructose, glucose and sucrose (Table 1). Analysis of the sugar content in the fruits of the studied apple cultivars showed that on average they contained fructose 5.86%, glucose 2.14%, sucrose 1.61%. Significant differences in the total content of sugars in apple fruits were revealed – from 9.04 to 12.05%. According to the data of N.I. Savelyev and co-workers [14] and E.N. Sedov and co-workers [17], the sugar content of ≥ 11% in apple fruits is high. Among the studied apple cultivars, this group includes Rozhdestvenskoye, Bolotovskoye and Candil Orlovsky. The fructose content in the fruits of the studied apple cultivars ranged from 4.92 to 6.57%. The highest content for this indicator was distinguished by Rozhdestvenskoye and Bolotovskoye, the lowest – Veniaminovskoye. The glucose level in the fruits of the studied apple cultivars was significantly lower than the fructose level and ranged from 1.81% (Veniaminovskoye) to 2.56% (Candil Orlovsky). The level of sucrose in apple fruits varied from 1.31 to 2.16%, which was slightly lower than glucose and significantly inferior to fructose. The highest content – 2.16% – was in Rozhdestvenskoye.

It was found that apple fruits had a high level of malic acid (180.90 – 1029.98 mg/100 g) and a relatively low level of citric acid (2.59 – 12.04 mg/100 g). In terms of acid content, Sinap Orlovsky stood out in particular. High accumulation of malic acid in fruits (889.88 mg/100 g) was noted in Veniaminovskoye. The highest saturation of citric acid in fruits was found in Sinap Orlovsky, Bolotovskoye and Veniaminovskoye. In terms of the content of hydroxycinnamic acids in fruits, Sinap Orlovsky was distinguished (6.81 mg/100 g), while in Rozhdestvenskoye and Candil Orlovsky, the content of hydroxycinnamic acids did not exceed 0.05 mg/100 g.

The calcium content in the fruits of the studied apple cultivars ranged from 8.85 mg/100 g (Sinap Orlovsky) to 22.03 mg/100 g (Bolotovskoye). The cultivars were mainly characterized by an average calcium content, the relatively low calcium content in the fruits was in Veniaminovskoye along with Sinap Orlovsky.

The determination of the hardness of the pulp of apples showed that with an average value of 4.59 kg/cm^2, the variability ranged from 3.56 kg/cm^2 (Veniaminovskoye) to 6.03 kg/cm^2 (Sinap Orlovsky). The fruits of Bolotovskoye were also characterized by a rather dense pulp (Table 1).

Sensory evaluation analysis. The appearance of apple preserve was evaluated on two aspects: the quality of the syrup and the quality of the slices (Table 2).

Table 2.

Groups of descriptors for sensory analysis of apple preserve

Visual descriptors that characterize the syrup quality	Visual descriptors that characterize quality of slices
Transparency	Integrity
Amount (1 point – no syrup, 5 points – a lot of syrup)	Density
Gelling	Starchiness
	Rough consistency of the slices (hardness)
	Crispy consistency
	Tender consistency

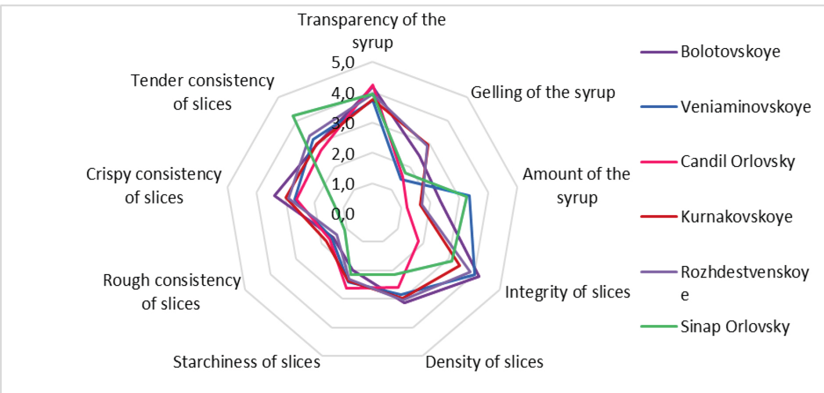

Fig. 1. Descriptive characteristics of apple preserve samples.
The statistically significant difference between cultivars is confirmed by the data of the analysis of variance and the Tuke test

Almost all samples were characterized by a typical appearance for apple preserve: whole slices evenly distributed in the syrup (Fig. 1, Table 2). The appearance of the preserve Candil Orlovsky was noted to be different from the rest of the samples. This sample was characterized by boiled slices and an almost complete absence of syrup, which is a significant disadvantage for preserves. At the same time, according to the integrity of the lobules and the amount of syrup, Candil Orlovsky significantly differed from all other cultivars, which is confirmed by the Tuke test. Also reliably on the same level were Kurnakovskoye and Rozhdestvenskoye with a small amount of syrup as well as Veniaminovskoye and Sinap Orlovsky.

Table 3.

Sensory analysis of apple preserve, point

Cultivar	Syrop characteristics			Characteristics of slyces					
	Transparency	Amount	Gelling	Integrity	Density	Starchiness	Rough consistency of the slices (hardness)	Crispy consistency	Tender consistency
Bolotovskoye	4.18± 0.12	2.36± 0.11	2.47± 0.19	4.18± 0.13	3.14± 0.07	2.00± 0.13	1.56± 0.10	3.39± 0.13	2.94± 0.11
Veniaminovskoye	3.74± 0.18	3.34± 0.18	1.48± 0.12	4.03± 0.13	2.86± 0.13	2.39± 0.16	1.60± 0.14	2.69± 0.19	3.17± 0.12
Candil Orlovsky	4.24± 0.18	1.21± 0.07	1.59± 0.29	1.81± 0.16	2.58± 0.14	2.61± 0.17	1.69± 0.13	2.64± 0.15	2.72± 0.12
Kurnakovskoye	3.77± 0.19	1.67± 0.10	2.96± 0.30	3.44± 0.15	2.97± 0.08	2.37± 0.17	1.80± 0.12	3.00± 0.18	2.97± 0.13
Rozhdestvenskoye	3.92± 0.20	1.71± 0.10	2.92± 0.23	3.85± 0.14	3.03± 0.09	2.31± 0.14	1.40± 0.08	2.92± 0.17	3.33± 0.09
Sinap Orlovsky	3.94± 0.13	3.25± 0,15	1.72± 0.14	3.13± 0.13	2.14± 0.13	2.14± 0.23	1.08± 0.05	1.29± 0.11	4.19± 0.12
$\bar{\chi}$	3.97± 0.08	2.26± 0.36	2.19± 0.28	3.41± 0.36	2.79± 0.15	2.30± 0.09	1.52± 0.10	2.66± 0.29	3.22± 0.21
LSD 05	0.33	1.42	1.09	1.40	0.59	0.34	0.41	1.16	0.83

Despite the disadvantages of the preserve of some cultivars, in general, all samples received high acceptance ratings (Table 4). The all preserves were high rated, Candil Orlovsky was rated the lowest. According to our data, the preserve characterized by transparent syrup and whole slices with a crispy consistency is most preferable. At the same time, the amount of syrup and signs of its gelling do not play a big role, and the delicate consistency of the slices reduces the assessment of acceptability (Fig. 1, Table 4).

Table 4.

Assessment of the acceptability of apple preserve, point

Cultivar	Appearance	Taste	General
Bolotovskoye	4.30±0.20	4.00±0.04	4.35±0.13
Veniaminovskoye	4.35±0.19	4.38±0.06	4.37±0.13
Candil Orlovsky	4.03±0.12	4.33±0.03	4.17±0.03
Kurnakovskoye	4.33±0.12	4.33±0.18	4.33±0.07

Rozhdestvenskoye	4.23±0.07	4.37±0.03	4.33±0.07
Sinap Orlovsky	4.30±0.10	4.30±0.07	4.30±0.10
$\overline{\chi}$	4.26±0.05	4.29±0.06	4.32±0.03
LSD 05	0.19	0.23	0.12

The influence of raw material parameters on the organoleptic characteristics of the final product. The influence of some biochemical parameters on the preserve taste is confirmed correlation coefficients (Table 5).

Table 5.

The relationship (r) between the parameters of raw materials and the organoleptic characteristics of apple preserve

	hardness, кг/см^2	Syrup characteristics			Characteristics of slices					
								consistency		
		transparency	amount	gelling	integrity	density	starchiness	rough (hardness)	crisp	tender
Dietary fiber (amount)	0.32	0.64	-0.07	-0.10	-0.21	0.31	-0.21	0.49	0.49	-0.58
IDF	-0.06	0.80*	-0.78	0.08	-0.45	0.34	0.38	0.54	0.54	-0.80*
SDF	0.35	-0.32	0.79	-0.18	0.50	-0.09	-0.60	-0.16	-0.16	0.37
Citric acid	0.67	-0.07	0.88*	-0.52	0.25	-0.59	-0.68	-0.80*	-0.64	0.77
Malic acid	0.05	-0.68	0.86*	-0.48	0.17	-0.58	-0.22	-0.56	-0.72	0.79
Hydroxycinnamic acids	0.38	-0.41	0.89*	-0.46	0.18	-0.63	-0.49	-0.62	-0.72	0.81*
Ca++ , mg/100 g	0.01	0.67	-0.87*	0.57	-0.18	0.56	0.15	0.61	0,71	-0,77
Pulp hardness, kg/cm^2		0.52	0.33	0.00	0.17	-0.33	-0.87*	-0.60	-0.26	0.43

* - significant at the level of probability P=0,95

A pronounced feedback characterizes the dependence of the amount of syrup and the delicate consistency on the amount of calcium and the coarse consistency on the content of citric acid (Table 5). The amount of syrup in the preserve is influenced by the content of organic acids. Since the correlation coefficient has not been statistically confirmed in the case of the influence of citric and malic acids on the delicate consistency of preserve slices, we can talk about the tendency of the influence of organic acids: with a high acid content, intense destruction of protopectin occurs [2], that is, cultivars with a high acid content are not suitable for the production of jam due to the digestibility of fruit slices.

The high content of IDF in the raw materials ensures the transparency of the syrup, and the low content of IDF gives a delicate consistency of the slices. There is a significant feedback between the hardness of the fruits and the starchy consistency of the preserve slices, which confirms the importance of both the selection of cultivars and the use of fruits in the optimal (technical) degree of maturity for the preserve.

The approximation of the obtained data has shown that the revealed dependencies are described by linear and polynomial regression equations. The effect of calcium in fruits on the amount of syrup in the preserve can be described using linear regression (1):

$$A = -0.3114 \cdot Ca + 3.34;\ R^2 = 0.75 \quad (1)$$

where: A – the amount of the syrup in the preserve, point; Ca – amount of calcium, mg/100 g.

The analysis of Tables 1 and 3 shows that the largest amount of syrup was typical for Veniaminovskoye and Sinap Orlovsky, the fruits of which had the lowest calcium content.

The amount of syrup in the preserve also depends on the content of malic (2) and citric (3) acids in the raw material, which is described by the regression equation:

$$A = 0.3743 \cdot m + 0.94;\ R^2 = 0.76 \quad (2)$$

$$A = 0.0029 \cdot c + 2.24;\ R^2 = 0.78 \quad (3)$$

where: A – the amount of the syrup in the preserve, point; m – malic acid, mg/100 g; c – citric acid, mg/100 g.

The effect of malic (4) and citric (5) acids of fruits on the delicate consistency of preserve slices is subject to polynomial dependencies of the second degree:

$$TC = 2E\text{-}06 \cdot m^2 + - 0.0017 \cdot m + 3.2083;\ R^2 = 0.70 \quad (4)$$

$$TC = 0.0245 \cdot c^2 - 0.2366 \cdot c + 3.4753;\ R^2 = 0.75 \quad (5)$$

where: TC – tender consistency of preserve slices, point; m – malic acid, mg/100 g; c – citric acid, mg/100 g.

As already reported above, with a high acid content, the destruction of protopectin occurs more intensively, which leads to softening of the lobules and a larger volume of syrup in the preserve.

Fruit hardness is one of the indicators of the degree of fruit maturity [20]. Since we used fruits with a technical degree of maturity, and there was no goal to study the effect of different degrees of maturity on the consistency of preserve slices, the relationship between the hardness of fruits and the starchy consistency of the slices can be considered linear for the obtained sample, which allows us to determine the correlation coefficient (Table 5). Nevertheless, it is more logical to describe the effect of hardness on the consistency of the lobules using a polynomial equation of the second degree (6):

$$S = -0.0962 \cdot h^2 + 0.7848 \cdot h + 0.838; \ R^2 = 0.82 \quad (6)$$

where: S – starchy consistency of slices in the preserve, point; h– fruit hardness, kg/cm^2.

Conclusions

The study of the technological qualities of six apple cultivars for suitability for preserve has shown that they largely depend on the biochemical parameters of the raw materials. First of all, this applies to such indicators as the amount of syrup in the preserve, the integrity and consistency of the slices.

According to the sensory analysis data, all samples except Candil Orlovsky were characterized by a typical appearance for apple preserve: whole slices evenly distributed in the transparent syrup. At the same time, the preserve from Rozhdestvenskoye and Kurnakovskoye received the highest acceptance rating, while Candil Orlovsky and Sinap Orlovsky – the lowest rating. The results of sensory analysis showed that preserve characterized by transparent syrup and whole slices with a crispy consistency is most preferable.

The obtained data on the relationship of some chemical and technological indicators of raw materials and the quality of the finished product – preserve – allow us to predict the quality of the finished product and design a product with specified quality parameters.

Conflict of interest information. The authors declare that there is no conflicts of interest.

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