Основу суч сного н лізу якості сокової продукції ст новить м тричний підхід, що б зується н визн ченні низки пок зників, які комплексно х р ктеризують скл д соків. У зв'язку з цим, під ч с оцінюв ння соків, окрім з г льних пок зників якості, кту льним є дослідження вмісту окремих біологічно ктивних компонентів, вміст яких з лежить від походження сировини т технології переробки.

Ан ліз хімічного скл ду том тів пок з в, що х р ктерними нутрієнт ми, які прит м нні с ме д ному виду овочів, є к ротиноїди. В зв'язку з цим, н йбільш прийнятним критерієм ідентифік ції було з пропонов но вміст β-к ротину.

З метою підтвердження способу виробництв том тних соків, с ме методом відновлення чи прямого віджиму, проведено дослідження їх якості з орг нолептичними т фізико-хімічними пок зник ми (вміст розчинних сухих речовин, з г льн кислотність, м сов ч стк м'якоті т вміст β-к ротину).

Результ ти профільного н лізу пок з ли, що н йбільше позитивних пок зників відмічено у соків ТМ «EosBio», ТМ «Galicia», що д є можливість стверджув ти про їх виробництво способом прямого віджиму. Вст новлено, що м сов ч стк розчинних сухих речовин, титров них кислот т м'якоті у всіх зр зк х відповід ли вимог м. Н йбільш м сов ч стк м'якоті був в сок х ТМ «Galicia» – 30,80 т ТМ «EosBio» – 24,23, що підтверджує виготовлення д них соків методом прямого віджиму.

Вст новлено, що вміст β-к ротину в сок х ТМ «Sandora», ТМ «Rich» т ТМ «С дочок», виготовлених способом відновлення, зн ходився в меж х 0,24–0,32 мг/100 г. При цьому, в сок х ТМ «Galicia» т ТМ «EosBio», які виготовлені способом прямого віджиму, д ний пок зник суттєво вищий – 0,589 т 0,591 мг/100 г відповідно. Т ким чином, підтверджено припущення про вз ємозв'язок між способом виробництв т вмістом β-к ротину у том тних сок х й з пропонов но використовув ти д ний пок зник як м ркерний критерій ідентифік ції способу виробництв том тних соків

Ключові слов : том тний сік, відновлення, прямий віджим, β-к ротин, критерії ідентифік ції, якісн ф льсифік ція

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DEFINING A CRITERIA FOR THE IDENTIFICATION OF A TECHNIQUE FOR PRODUCING TOMATO JUICE

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1. Introduction

The market for juice production changed significantly in recent years. 34 % of consumers are ready to save on juices and nectars according to ProConsulting research. Thus, there is a decline in demand from 2017. Only the segment of budget products remains relatively stable [1, 2]. This situation led to the need for producers to make complex decisions.

On the one hand, it was necessary to reduce costs and sell products at minimum prices under conditions of lowering incomes. On the other hand, the cost of all, without exception, components of production and promotion increased significantly. All producers of juices raised their prices by an average of 20–30 % in 2016. And this growth continues [3]. Juice producers increase production of juice drinks and nectars and decrease the amount of natural juices to reduce their cost and make a product more accessible to consumer [1–4].

It is easy to bring the quality of juices determined by DSTU 4150:2003 [5] (content of soluble dry matter, titrated acidity) to normal by addition of sugar, salt, and citric acid. In this regard, the indicated parameters cannot serve as the criteria of naturalness, as they are easy to falsify.

At the same time, the Association of Juice Industries of the EU (AIJN) recommends more than 50 parameters. Their comprehensive study gives possibility to establish the authenticity of juices. They include contents of glucose, D-fructose, D-insulin, L-apple acid, lactic acid, vitamin C, ethanol, potassium, magnesium, calcium, amino acids, pectin, the form number, etc. [6, 7].

2. Literature review and problem statement

Falsification of juices is an important problem, since non-responsible producers introduce cheap ingredients into juices often, as it is difficult to establish their content by chemical methods. There were various statistical documents, which contain certain criteria and means of identification, developed in the world to identify possible ways of falsification of juices and to establish their authenticity. These documents are not standard, but they are capable of creation of a sufficient basis for control of authenticity of juices. These documents include:

– a set of rules for assessment of quality of fruit and vegetable juices of the Association of Producers of juices and nectars of the European Union (AIJN) [6];

– recommended values and intervals of changes in certain parameters of fruit juices and nectars (RSK) (Germany) [8];

– ANFOR qualitative collection – the French Association for Standardization [9].

Different approaches to identification in these documents have their advantages and disadvantages.

The use of traditional physical-and-chemical research, which includes: rheological properties [10], content of soluble solids, titrated acids [11], are easy to use. They give operational results. However, it is easy to falsify them, and therefore, we cannot use them for identification.

Determining the content of sugars, amino acids, aromatic substances and colorants [12–14] in products and their comparison with standard data requires complex equipment and specially trained personnel. In addition, it takes a lot of time and money to conduct a research. Such research has relative subjectivity in difficult cases when a commission of experts makes a final decision.

Discovery of substances, which should not be present in authentic juice or contained in it in small quantities, gives possibility to detect falsification of juices without detailed research. These substances include, in particular, the content of D-optical isomers of amino acids [15], starch hydrolysis products, synthetic dyes, aromatic substances and D-malic acid [12, 16]. However, the mentioned study is ineffective in the case of using for falsification of pure and modified substances.

Using of isotope methods (analysis of the ratio of stable carbon isotopes, oxygen [17] and hydrogen [18]) makes it possible to identify a product reliably, but researchers use it rarely because of the need for special equipment, highly skilled personnel, and high cost.

Consequently, the basis of the analysis of the quality of juice production is a matrix approach based on definition of a series of parameters, which characterize a composition of juices comprehensively. Researchers compare values obtained with the tables of the chemical composition of true juices or (for juices obtained by direct pressing) with the chemical composition of fruits used as raw material. The basis of the tables is a large number of authentic analyses worldwide. They are bases of many standards for identification in developed countries. This approach requires technically sophisticated equipment, a specially trained staff, a significant amount of research time and it is quite costly, which complicates identification of juices.

In addition to the qualitative falsification, we should pay attention to the falsification of the method of juice production, that is, the authenticity of direct pressing of juices, as unfair producers may apply it to obtain higher profits.

Establishing of the falsification of the juice production method would not be such a difficult problem if we could detect it by one (marker) substance, which would have the following characteristics:

– it is present in a certain type of juice only;

– its contents fluctuate in small limits depending on a sort;

– its amount changes significantly under the influence of high-temperature processing;

– we can determine it quickly and reliably with low costs;

– it is practically inaccessible for falsification.

There is no such marker substance, which meets these requirements and could testify to the authenticity of direct pressing of tomato juice, found for now. For the Most nutrients, which characterize the composition of a certain type of juice, vary considerably in quantitative terms depending on a series of factors (climatic conditions, soil characteristics, agronomy of growing vegetables and their varieties).

After analysis of the chemical composition of tomatoes, we can come to the conclusion that carotenoids are characteristic indents of this particular type of vegetables [19]. We can use their content as a marker of authenticity of juices produced by direct pressing. The main carotenoids of tomatoes are lycopene, β-carotene. There are also insignificant amounts of lutein, α-carotene and β-cryptoxanthin [20]. The content of lycopene is from 1 to 11.6 mg/100 ml in tomato juices. Lycopene is present in the amount from 0.88 to 4 mg/100 g in tomatoes themselves, depending on a variety, conditions of cultivation, etc., which is slightly lower [21–23], because of the influence of heat processing on tomatoes and juice during the production process. Therefore, the content of lycopene cannot serve as a marker for the juice identification due to its wide fluctuations in its values and the dependence on heat processing. According to literature sources, the content of β-carotene in tomatoes of four varieties varied in the insignificant range from 0.11 to 0.17 mg/100 g of initial products [24–26], as we checked, all references refer to β-carotene. Raw material undergoes a long thermal processing during production of recovered juices. Long thermal processing leads to a decrease in the content of β-carotene, comparing with juices produced by direct pressing. In this regard, we can propose the β-carotene content as the most acceptable criterion for the identification of the production method.

3. The aim and objectives of the study

The objective of the study is to find a criterion for the identification of the method of production of tomato juice. This will give possibility to establish the authentication of direct pressing of tomato juices and prevent their falsification.

We set the following tasks to achieve the objective:

– to investigate the quality of tomato juices made by different producers, depending on the method of production;

– to prove a possibility of using the «β-carotene content» parameter as a criterion for the identification of the method of production of tomato juice.

4. Materials and methods to study the consumer properties of tomato juices

4. 1. Explored materials and equipment used in the experiment

We selected tomato juices of domestic and foreign production for the identification and quality assessment:

– a sample of «Sandora» TM (producer is LLC «Sandora», Ukraine);

– a sample of «Sadochok» TM (producer is LLC «Sandora», Ukraine);

– a sample of «Rich» TM (producer is IP «Coca-Cola Beverages Ukraine Limited», Ukraine);

– a sample of «Galicia» TM (producer is LLC «Yablunievyi Dar», Ukraine);

– a sample of «Eos Bio» TM (producer is EOS Getranke GmbH, Germany).

Equipment: Specord 210 spectrophotometer, IPF-454B2M refractometer, OPn-8 centrifuge, N 035.3 AN.18 (LABOPORT) vacuum pump, a chromatographic column belongs to the laboratory utensil, therefore we do not indicate a label.

4. 2. Methodology for determination of properties of samples

We evaluated labeling of juices for compliance with the requirements of the Technical Regulation on food labeling rules [27].

We performed a sensor analysis of tomato juice samples in accordance with international ISO standards to evaluate taste-aromatic properties of tomato juice objectively. We used the method according to DSTU ISO 6564: 2005 «Sensory research. Methodology. Methods of Creating a Flavor Spectrum» to create profiles. The method consists of procedures for description and evaluation of the selected parameters. It identifies the main properties, which are important for formation of a general impression and assess their intensity in order to be able to describe a parameter of this product [28].

We carried out a profile analysis of tomato juice samples by parameters, which are the most significant for a consumer, such as: color, taste, aroma, and consistency. We developed a nomenclature of descriptors for each organoleptic parameter and the standard, which got the maximum intensity in points for each descriptor. Tasters assessed the intensity by a 5-point scale of intensity, namely: 0 – the sign is absent; 1 – the sign is slightly felt; 2 – weak intensity; 3 – moderate intensity; 4 – strong intensity; 5 – very strong intensity.

We proposed 12 descriptors for the study of taste and aroma of tomato juice samples. There were 6 positive ones, such as overall impression, purity, pleasant aftertaste, characteristic, harmonious and balanced. And there were 6 negative ones: sour, bitter, musty, foreign, hollow, overripe tomatoes.

We identified 10 descriptors to study the color of tomato juice samples. 5 of them were positive, they were homogeneous, saturated, light red, red, dark red. And 5 descriptors were negative: heterogeneous, yellow, orange, dark orange, presence of inclusions.

We proposed 10 descriptors to study the consistency of tomato juice by the profiling method. Positive descriptors were the following five: overall impression, characteristic, homogeneous, dense, contents of pulp; and the negative ones were liquid, viscous, extraneous inclusions, watery, signs of stratification.

We constructed graphic profiles based on the results of studies on organoleptic characteristics of tomato juices, since application of graphic profiles makes easy to assess intensity, severity and distinction of descriptors and to conduct a comparative description of several products of the same item.

According to physical-and-chemical parameters, we determined the content of soluble solids by the refractometric method [29], we also determined the total acidity by the titer method [30] and the mass fraction of pulp – by centrifugation [31].

We determined the content of β-carotene by the method of carotene extraction. We extracted carotene from a test sample with acetone, then, we added gasoline and stirred. We removed other carotenoids (xanthophyll, lycopene, etc.) from the gasoline solution, as well as chlorophyll by chromatographic adsorption. We determined the amount of carotene in the purified gasoline solution using the colorimetric method by intensity of the yellow color of the solution by comparison with a solution of potassium bichromate standardized with pure carotene [32].

All laboratory studies and experiments were repeated three and five times. We calculated the probability of a possible error using a Student's criterion with t coefficient. We chose the value of the coefficient based on the confidence probability $P=0.95$ with the reliability of deviation $\varepsilon \leq 0.05$ and the relative error not exceeding 5 %. We performed mathematical processing of data using MS Excel and Statistica 10 software.

5. Results of the study into consumer properties of tomato juice produced by different production methods

5. 1. Results of studying quality and a method of production of tomato juices made by different producers

At the first stage, we performed the analysis of labeling of the juices studied to determine the method of their production and composition. Table 1 shows the results of the studies.

The juice labeling analysis revealed that all the juices studied contained all necessary information on a composition, method of production and a name and location of a producer in accordance with the requirements of the Technical Regulation on the rules for labeling of food products [27].

In particular, there was notification on packaging «Sandora» TM, «Sadochok» TM and «Rich» TM that these samples were made by the way of recovery, and juices of «Galicia» TM and «Eos Bio» TM were made by direct pressing.

The most important criterion for selection of a juice by customers is its organoleptic characteristics. We applied the descriptive expert method of profile analysis to perform more objective assessment of sensory parameters of food products [28].

Table 1

Analysis of labeling of tomato juices studied

Requirements	Juices studied				
	«Sandora» TM	«Sadochok» TM	«Rich» TM	«Galicia» TM	«EosBio» TM
Product composition	Tomato juice, salt (0.55 %)	Tomato juice, salt (0.4 %)	Tomato juice, salt	Tomato juice, salt	Organic tomato juice, sea salt, organic black pepper
Production method	Recovered sterilized	Recovered sterilized	Recovered sterilized	Direct pressing, homogenized sterilized	Direct pressing
Name and location of producer	LCC «Sandora», Ukraine, Mykolayivska oblast, Zhovtneviy region, Mykolayivs'ke vil., Stepova str., 1, delivery on demand		IP «Coca Cola Beverages Ukraine Limited», Ukraine, Kyivska oblast, Brovarskiy region, Velyka Dymerka vil.	LCC «Yabluneviy dar», Ukraine, Gorodok city, Lvivska str., 274a.	EOS GetrankeGmbH, D-71384, Weinstadt, Germany

The method of profile analysis is the only official and most known method among the sensor test methods. Its base is the fact that separate taste, aroma and other stimuli combine to give a qualitatively new definition of the taste of a product. Selection of elements of taste, which are most characteristic to a product, makes it possible to establish the profile of a product, as well as to study the influence of various factors (technological modes, storage conditions, raw materials) on its taste. Benefits of tasting analysis to instrumental one are especially noticeable with the use of this method, since only a person is capable of not only perceiving a plurality of organoleptic properties within a single measurement, but also of analyzing them [29].

Fig. 1–3 show the results of profile analysis of tomato juice in the form of profilograms.

Fig. 1 shows the figurative profilograms of taste and aroma of the selected samples. The obtained results confirm that the juices by «EosBio» TM and «Galicia» TM occupy the largest area of the profilograms in terms of positive characteristics.

Tasters noted insufficiently expressed taste and aroma, hollow, sour and bitter flavors in the juices by «Sandora» TM, «Rich» TM and «Sadochok» TM. The reason may be the fact that the juices are restored. In addition, the revealed characteristics of taste and aroma of juice data may be due to the use of low-quality raw materials, in particular, frozen tomatoes or tomatoes grows with no respect to requirements.

Fig. 2 shows the profilograms of the color of the selected samples of tomato juices.

According to the results of the profile analysis, tomato juices by «Rich» TM, «Galicia» TM and «EosBio» TM had the most positive characteristics of color, in particular, such as homogeneity, saturation and dark red color.

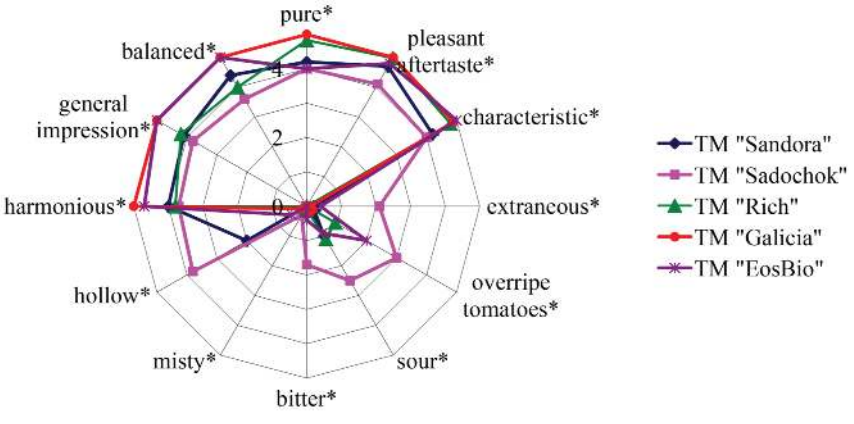

Fig. 1. Profile of taste and aroma of tomato juice. * — the difference is reliable

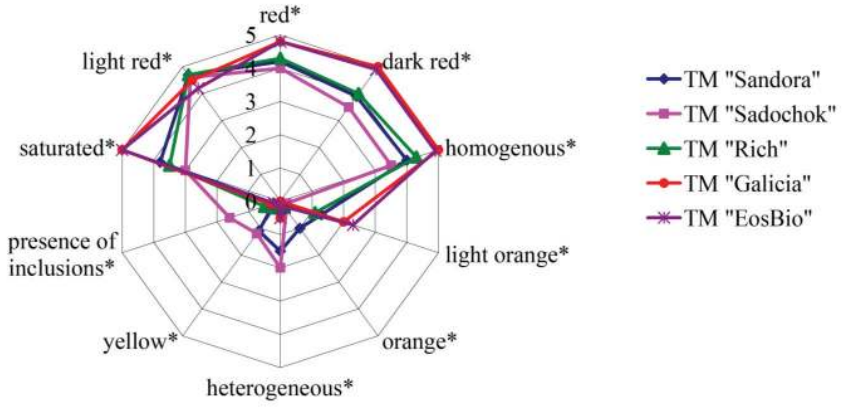

Fig. 2. Profile of tomato juice color. * — the difference is reliable

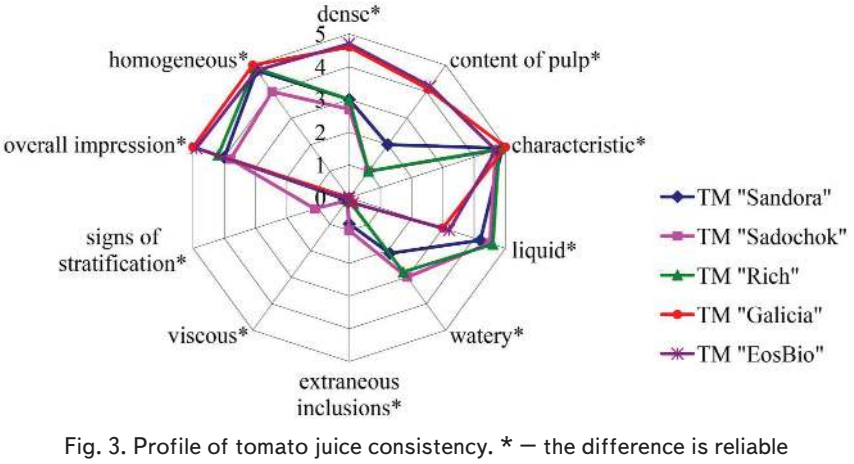

Fig. 3. Profile of tomato juice consistency. * — the difference is reliable

Nevertheless, «Galicia» TM «EosBio» TM juices, in contrast to «Rich» TM juice had slightly more intense dark red color, which confirms production of juice by direct pressing. «Sadochok» TM juice had the least value of positive characteristics: insufficiently saturated and uniform red color with the presence of inclusions.

Fig. 3 shows profilograms of the consistency of the juices studied. Tasters determined the largest area of positive characteristics for «EosBio» TM and «Galicia» TM juices in the study of juice consistency. They were homogeneous and characteristic, they had dense consistence with pulp without extraneous inclusions and signs of stratification. For «Sandora» TM, «Sadochok» TM and «Rich» TM juices, there was some smaller area among the positive characteristics and higher area among the negative one due to some watery and liquid consistency. In addition, tasters noted the presence of foreign inclusions and signs of stratification in the juice of «Sadochok» TM.

Summarizing the results of the profile analysis for all sensory parameters under investigation, we should note that the most positive indicators were in juices of «EosBio» TM and «Galicia» TM. This makes it possible to assert that their production method was direct pressing.

At the next stage, we studied physical-and-chemical parameters of the quality of the juices (Table 2).

In the study, we established that the content of soluble solids in the samples meets the requirements of normative documentation. The mass fraction of soluble solids depends on such factors as a type of raw material, a degree of ripeness, conditions of cultivation, production technology, etc. Thus, this parameter is higher in «Rich» TM and «Sandora» TM juices compared to «Galicia» TM and «EosBio» TM juices, because they are made by the method of recovery of a concentrate. Regarding the mass fraction of titrated acids, this parameter also met the established requirements in all samples studied.

The content of pulp is one of the important parameters of tomato juice quality. We can determine the production method by this parameter. The largest mass fraction of pulp was in «Galicia» TM juices, it was 30.80, and «EosBio» TM, it was 24.23, which confirms the production of these juices by direct pressing.

Consequently, according to the results of the conducted study, we can state that all the products studied complied with the requirements of the normative documents and the method of production of the juices of «Galicia» TM and «EosBio» TM was the direct pressing.

5. 2. Results of studying the β-carotene content in tomato juices made by different producers

An important parameter, which can serve as one of the criteria for identification of the method of tomato juice production, but not regulated by normative documents, is the content of β-carotene. In this regard, we determined its content in the juices studied, made both the recovery method and the direct pressing (Fig. 4).

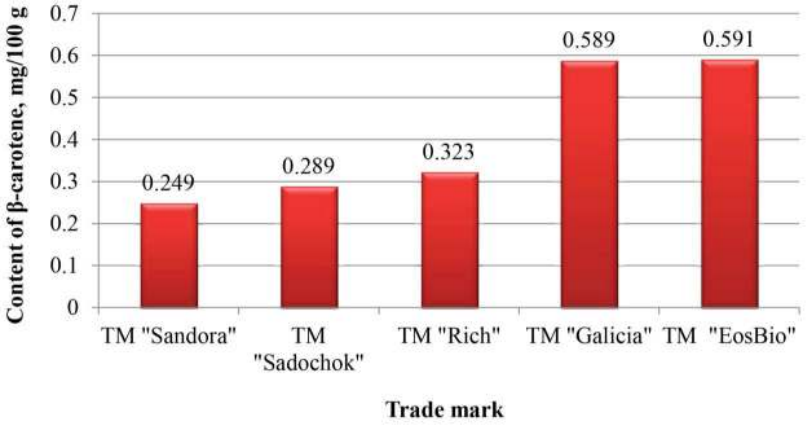

Fig. 4. Content of β-carotene in tomato juices, mg/100 g

Experimental studies showed that the smallest content of β-carotene was in the juices by «Sandora» TM – 0.249 and «Sadochok» TM – 0.289 mg/100 g. «Rich» TM juice had some higher content, it was 0.323 mg/100 g. The juice samples «Galicia» TM and «EosBio» TM contained the largest amount of β-carotene in the range of 0.589 and 0.591 mg/100 g, respectively, which is 2.1 times higher on average. This testifies that these juices are made by direct pressing, and the juices of «Sandora» TM, «Sadochok» TM, «Rich» TM were produced by the method of recovery.

6. Discussion of results of studying the content of β-carotene in tomato juices made by different producers

Establishing of a criterion for identification of the method of production of tomato juices is a continuation of scientific work on the authentication of these products in order to prevent quality falsification. At the first stage, we investigated the quality and established the method of production of tomato juices made by different producers. The second stage consisted in determination of the content of β-carotene and the proof of possibility of using of this parameter as a criterion for the identification of the tomato juice production method.

The profile analysis (evaluation of taste, aroma, consistency and color) confirmed that the tomato juices of «EosBio» TM and «Galicia» TM were made by direct pressing, and the juices by «Sandora» TM, «Sadochok» TM and «Rich» TM were made by recovery (Fig. 1–3). Features of the technology of tomato juice give possibility to use the pulp contents as an important indi-

Table 2

Physical-and-chemical parameters of the quality of tomato juices ($n=5$, $p=0.95$)

Parameter name	Producer				
	«Sandora» TM	«Sadochok» TM	«Rich» TM	«Galicia» TM	«EosBio» TM
Mass fraction of soluble solids, %	6.50±0.12	5.40±0.19	6.50±0.12	5.90±0.09	5.00±0.08
Mass fraction of titric acids, %	0.54±0.02	0.38±0.01	0.56±0.02	0.46±0.01	0.38±0.01
Mass fraction of pulp, %	19.04±0.51	18.74±0.49	17.75±0.39	30.80±0.92	24.23±0.78

cator to determine the method of their production. We established experimentally that the mass fraction of pulp was significantly higher in tomato juices of «EosBio» TM and «Galicia» TM, which also confirms the production of juices by direct pressing (Table 2). Thus, the results of studies of physical-and-chemical parameters correlate with the organoleptic ones in this case.

According to Codex standard 247-2005, the content of β-carotene in juices produced by the direct pressing method should not be less than in tomatoes used as raw materials for juice [33]. According to literature studies, the content of β-carotene in tomatoes is somewhat lower than in the purified tomato mass by 72 % in average. The reason is the degradation of plastids during tomato wiping and the release of carotenoids [34]. At the same time, according to studies by other authors, the upper limit of the β-carotene content in tomatoes is almost twice as high as in tomato juices obtained by the method of recovery [19], which also correlates with the results of the study.

We established the interdependence between the method of production of tomato juice and the content of β-carotene in them. The samples of «Galicia» TM and «EosBio» TM juices had the high content of β-carotene, which was twice higher than the value in the samples made by the method of recovery (Fig. 4). The obtained data may serve as the basis for consideration of the β-carotene content parameter as a criterion for the identification of the method of production of tomato juice [35].

The advantages of using of this parameter for identification of the authenticity of direct pressing of tomato juices are ease of use, efficiency of obtaining results, possibility of reliable identification, lack of need for expensive equipment and highly skilled personnel.

The main disadvantage of the study is the narrow profile and lack of data on the use of the parameter of β-carotene content when identifying juices from other raw materials. It can be the next stage of studies in this direction.

We can apply the proposed approaches to the use of the parameter of the β-carotene content for identification of the juice production method in the practice of expert institutions, reference laboratories and control bodies in the field of food safety.

7. Conclusions

1. We studied the quality of tomato juices by «Sandora» TM, «Sadochok» TM, «Rich» TM, «Galicia» TM and «Eos Bio» TM. We established their conformity to the requirements of DSTU 4153: 2003. In particular, the profile analysis found that the juices by «EosBio» TM and «Galicia» TM occupied the largest area of profilograms in terms of positive characteristics. They were harmonious, characteristic. They had balanced taste and aroma and saturated dark red color. The consistency of these juices was homogeneous, characteristic, dense with pulp without foreign inclusions and signs of stratification. The juices of «Sandora» TM, «Sadochok» TM and «Rich» TM had a smaller area of profilograms in terms of positive characteristics and greater area for negative characteristics due to some watery and liquid consistency. Physical-and-chemical quality parameters (mass fraction of soluble solids, titrated acids and pulp) of all investigated tomato juices conformed to the requirements of normative documents. We noted the highest value of the parameter of the mass fraction of pulp in tomato juices of «Galicia» TM and «EosBio» TM. They were 30.80 % and 24.23 %, respectively. The obtained data give grounds to assert that «Galicia» TM and «EosBio» TM juices were produced by direct pressing, while the juices by «Sandora» TM, «Sadochok» TM and «Rich» TM were recovered.

2. Experimental studies established that the content of β-carotene was within the limits of 0.24–0.32 mg/100 g in the tomato juices of «Sandora» TM, «Rich» TM and «Sadochok» TM made by the method of recovery. «Galicia» TM and «EosBio» TM juices made by the direct pressing mode had the increased content of β-carotene of 0.589 and 0.591 mg/100 g, respectively. Thus, we confirmed the assumption about the relationship between the production method and the content of β-carotene in tomato juices. Juices with β-carotene content of less than 0.5 mg/100 g refer to the juices produced by the recovery method, and juices, which contain β-carotene over 0.5 mg/100 g, were produced by direct pressing. In this regard, we suggest using the parameter of the β-carotene content as a marker criterion for the identification of the method of production of tomato juices.

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