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Technological characteristics of five new apple cultivars of VNIISPK breeding as raw materials for juice industry

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Abstract. The data of the technological assessment of the suitability of five new winter apple cultivars of VNIISPK breeding (‘Aleksandr Boyko’, ‘Blagodat’, ‘Vavilovskoye, Ivanovskoye’, ‘Patriot’ and ‘Prazdnichnoye’) for the production of raw materials for juice industry are presented. The main technological indicators characterizing the suitability of the cultivar for juice production were studied: the firmness of the pulp, the yield of juice, the content of soluble solids, sugars, titratable acids and catechins in comparison with the standard cultivar ‘Antonovka’. It was found that all of them were distinguished by a higher content of soluble solids and sugars in the juice than in the standard cultivar, and a lower content of titrated acids, as well as higher tasting ratings. ‘Aleksandr Boyko’ surpassed all studied cultivars in terms of such indicators as juice yield, the content of soluble solids, sugars and catechins in it, besides it was distinguished by low acidity. All studied cultivars, especially ‘Alexandr Boyko’, are promising as raw materials for the juice industry.

Key words: juice, unlit, juice yield, quality indicators.

INTRODUCTION

Despite a significant increase in the production of apple fruits, the problem of production of raw materials for processing remains acute in our country (Anonymous, 2021; Maksimova, 2021; Russia's self-sufficiency in apples is below 40%, 2021). The fruit processing industry in Russia is experiencing a negative impact from the lack of a modern raw material base, the growth rate of which is still insufficient for industry and the import level of fruit productions is 19% (Medvedeva, 2018). The issue of production of raw materials for the juice industry is particularly acute. In recent years, there has been a strong increase in interest in local cultivars intended for processing into juice and cider (Zielinski et al., 2014; Rumpunen et al., 2017).

Juices from fruits and vegetables are an integral part of a healthy human diet. They have a high nutritional value, quench thirst well and have a natural taste and aroma (Eremeeva et al., 2016; Makarkina & Pavel, 2017; Tinello, & Lante, 2018; Pepin et al., 2019; Zagoskina & Nazarenko, 2019). Currently, the main volumes of juices produced in Russia account for apple juice - 29.4%. A significant share of raw materials for the production of juice products (up to 70%) is imported to Russia from abroad. Only 25%

of these import fruits are fruits that do not grow in our country (citruses, pineapples, kiwi ets.) (Anonymous, 2020). Difficulties with raw materials for the juice industry are particularly explained by the transition to intensive horticulture. It means that horticulture focused on growing 75~80% of commercial fruits has deprived the manufacturers of ‘technical apples’, i.e., non-standard apples and windfall apples that has been traditionally used as raw materials. In this regard, it is legitimate to raise the question of the target development of technical intensive gardening, which would satisfy the needs of producers in domestic raw materials (Anonymous, 2017). The urgent need for laying out raw (technical) orchards requires the development of the assortment that meets the requirements of both intensive gardening and the fruit processing industry and contributes to improving the food safety of processed products (Sedov, 2011; Kozlovskaya, 2015; Savelieva, 2016; Mieszczakowska-Frąc et al., 2021). The suitability of apples for processing can be based on various technological indicators: technological (for example, suitability for a particular product), chemical (content of soluble solids, acidity, bioactive compounds, etc.), sensory (balance of aroma, taste, appearance) and economic (for example, juice yield) (Roman et al., 2007; Paganini et al., 2004; Salina et al., 2019). Due to the requirements of the customs regulation TR TS 023/2011, which does not allow the addition of sugar and sweeteners to fruit juices, low variability and the correct ratio of soluble solids and acids in apples can be of great importance for direct juice production (TR TS 023/2011, 2011). Thus, the quality of the final product depends on the quality of raw materials, which, in turn, strongly depends on the genotype (Mieszczakowska-Frąc et al., 2021). Therefore, the technological assessment of new cultivars for juice production becomes important.

The purpose of the research is the technological evaluation of new promising apple cultivars bred by the Russian Research Institute of Fruit Crop Breeding (VNIISPK) for juice production and the selection of the best cultivars according to technological indicators.

MATERIALS AND METHODS

In this study it was investigated five new apple cultivars of winter-ripening suitable for intensive gardening: ‘Aleksandr Boyko’ - a triploid scab immune cultivar; ‘Blagodat’ - a triploid; ‘Vavilovskoye’ - a triploid scab immune cultivar; ‘Ivanovskoye’ - a scab immune cultivar; ‘Patriot’ - a triploid and ‘Prazdnichnoye’ - a triploid scab immune cultivar (Sedov et al., 2018). All cultivars are of VNIISPK breeding, grown on the territory of the Orel district of the Orel region.

The experiment was carried out for three years and included experimental processing for juice, sensory evaluation, and determination of the biochemical composition of juice by the main components. ‘Antonovka’ served as the standard because this cultivar is one of most popular in Central Russia and its fruits are traditionally used in processing industry.

The fruits were harvested at the stage of the optimal picking time and stored in a refrigerator at a temperature of 2~4 °C until the onset of consumer maturity, after which the juice was made. We determinated the harvest ripeness by the starch iodine test (Smith et al., 1979; Blenpied, & Silsby, 1992). We took 3 kg apples to prepare each sample. Processing apples included washing fruits, inspection, pressing using an electric juicer

‘Bork JU 24150 SI’, pasteurization at 90 °C with successive cooling and sealing in glass bottles. The sealed bottles were stored for 3 months at room temperature, after which a sensory evaluation and chemical analysis of the samples were carried out.

The following technological and biochemical parameters were studied (Sedov, & Ogoltsova, 1999):

– apple firmness (kg cm^{-2}) – using a digital fruit tester FHT 803

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– juice yield (%) - according to the formula:

$$C = \frac{A - B}{A} \cdot 100,$$

where C is juice yield; A is fruit weight before pressing, g; B is the mass of marc, g; 100 is a conversion factor to percent (Daskalov et al., 1969).

– soluble solids content (°Brix) – using a refractometer (Atago refractometer, mod. PAL-1);

– the content of titrated acids (%) – volumetric method by 0.1 M NaOH using a phenolphthalein;

– content of sugars (%) – volumetric method using the Fehling reagent;

– Ratio – sugar/acid ratio

– the content of P-active catechins (mg per 100 g) was determined by the colorimetric method modified by A.I. Vigorov (Vigorov, 1964).

The sensory assessment of the juice appearance and palate was made by the tasting panel at closed tastings on a 5-point scale (5 – excellent quality, 1 – not usable). For a more accurate assessment, tenths of a point were indicated. The overall tasting score was considered as an arithmetic mean between the ratings of appearance and palate (Sedov, & Ogoltsova, 1999).

Obtained date was expressed as an average value ± standard error (SE). Statistical processing of the obtained data was carried out by generally accepted methods using standard Microsoft Excel computer programs. The reliability of the results was evaluated by LSD05.

RESULTS AND DISCUSSION

The degree of maturity, at which the juice was made, was close to consumer maturity. It was characterized by the firmness of the pulp in three cultivars (‘Blagodat’, ‘Vavilovskoye’, ‘Ivanovskoye’) at the standard cultivar level, but in the fruits of two cultivars (‘Alexandr Boyko’ and ‘Patriot’) reliably exceeded it. The varietal variability of the pulp firmness was quite high because both the genotype and external conditions affected it. Firmness of analyzed apple cultivars and physicochemical parameters of produced juice was shown in Table 1.

The juice yield depends on the degree of maturity of apples, the characteristics of the cultivar (genotype) and vegetation conditions. The juice yield during the study period was low – on average 57.6 ± 3.0%, while in the standard it was 62.1 ± 1.8%. According to this indicator, all cultivars were at the standard level with the exception of Vavilovskoye, which had a reliably lower juice yield. Varietal variability was characterized as average (V = 13.26 %). It should be noted that although the juice yield did not exceed 60%, the pretreatment of the pulp with enzymes or microwaves can significantly increase this indicator (Oszmiański et al., 2009; Sharma et al., 2017; Nilova et al., 2020; Mieszczakowska-Frąc et al., 2021). This method is most often used at the present time, since enzymatic treatment before mechanical extraction significantly improves quality and quantity of extracted juice (Sharma et al., 2017).

Table 1. Technological and biochemical indicators in apples and apple juices in comparison with a standart

Cultivar	Firmness (kg cm^{-2})	Juice yield, %	Biochemical composition of juice				
			Soluble solids, % (Brix°)	Sum of sugars, %	Titrated acid, %	Ratio	Catechins, mg (100 g)$^{-1}$
Aleksandr Boyko	9.01 ± 0.45	62.30 ± 3.68	15.53 ± 1.55	14.31 ± 0.31	0.49 ± 0.12	24.34 ± 3.75	122.90 ± 13.40
Blagodat	7.02 ± 0.41	52.03 ± 5.10	14.78 ± 0.22	13.77 ± 0.32	0.77 ± 0.05	17.94 ± 3.43	22.50 ± 18.62
Vavilovskoye	7.24 ± 0.68	43.01 ± 8.40	15.11 ± 0.44	13.16 ± 0.52	0.81 ± 0.12	16.23 ± 2.71	60.39 ± 27.11
Ivanovskoye	7.03 ± 0.27	59.50 ± 8.50	14.65 ± 0.15	13.13 ± 1.23	1.03 ± 0.11	13.03 ± 2.59	87.80 ± 32.25
Patriot	9.51 ± 0.79	58.10 ± 3.47	14.05 ± 0.32	12.25 ± 0.05	0.50 ± 0.04	27.66 ± 1.55	56.95 ± 36.35
Antonovka (st.)	6.36 ± 0.47	62.05 ± 1.76	11.17 ± 0.19	9.73 ± 0.32	1.13 ± 0.05	8.98 ± 0.39	53.95 ± 7.10
$\overline{X}$	7.70 ± 0.51	56.17 ± 3.04	14.22 ± 0.64	13.90 ± 0.59	0.70 ± 0.10	18.03 ± 2.84	67.42 ± 13.97
max	9.51	62.30	15.53	14.31	1.13	27.66	122.90
min	6.36	43.01	11.17	9.73	0.49	8.98	22.50
LSD_{05}	1.87	11.05	2.33	2.41	0.39	10,34	50.76
V%	16.35	13.26	11.05	12.75	33.47	38.64	50.75

The content of soluble solids and titratable acidity are considered important quality parameters due to their effect on the sensory perception of apple juices and are of great importance in the production of concentrated juices. According to both domestic and European standards, the minimum content of soluble solids in direct-pressed apple juices should be at least 10% (TR TS 023/2011, 2011; AIJN, 2012). This requirement was met for all cultivars. In general, the studied cultivars were distinguished by high juice extractivity – the content of soluble solids averaged 14.22 ± 0.64°Brix, in standard juice it was 11.17 ± 0.19°Brix. The VNIISPK breeding cultivars reliably exceeded the standard cultivar for this indicator. 'Aleksandr Boyko' and 'Vavilovskoye' were characterized by a higher content of soluble solids in juice than all other studied cultivars (more than 15°Brix) (Table 1).

With regard to the acidity of the juice of new cultivars, a significant variation of this indicator was noted from 0.49% for 'Aleksandr Boyko' to 1.13% for the 'Antonovka' standard. A very moderate acidity of the juice was noted in the juice of 'Aleksandr Boyko' and Patriot (0.49 and 0.50%, respectively). In general, the standard significantly showed the highest titratable acidity of the juice of the group of cultivars. Only the 'Ivanovskoye' juice had acidity at the level of 'Antonovka'. The titratable acidity of juices, according to the standard (TR TS 023/2011, 2011), should not exceed

0.8% for babies and 1.3% for preschool and school-age children. All juices are suitable for children food, and juices of the 'Aleksandr Boyko', 'Patriot' and 'Blagodat' are suitable for feeding babies.

Taking into account the differences in the ranges of soluble solids and acidity, it becomes obvious that the ratio of both components (Ratio) primarily depends on the content of organic acids. It is believed that the most balanced taste in apple juices is noted with a Ratio equal to 16 or close to it (Daskalov et al., 1969; Sedov, 2011; Kozlovskaya, 2015). There is statement that the high Ratio values positively influence at the juice taste (Farina et al., 2017), and the optimal ratio of sugars and acids in the juice is in the range of 17~30 (Mieszczakowska-Frąc et al. 2021). Our study showed that all cultivars with a juice taste score of 4.5 points or higher were characterized by a 16.2~27.7 Ratio (Tables 1, 2), which is consistent with the data of Mieszczakowska-Frąc et al. (2021). The lowest ratio of sugars and acids was in the juice of 'Antonovka', and the highest ratio was in the juice of 'Aleksandr Boyko' and 'Patriot', which immediately affected the characteristics of their tastes (Tables 1, 2). The coefficient of correlation between the taste of juice and Ratio was 0.7, which showed a strong negative effect of acidity.

Table 2. Organoleptic indicators of juices of five VNIISPK apple cultivars in comparison with a standart

Cultivar	Taste assessment (points)			Appearance of juice	Taste of juice	Aroma
	Appearance	Taste	Overall			
Aleksandr Boyko	4.5	4.5	4.5	Rich yellow, opaque (muddy), opalescent	Sweet, pleasant, with a slight astringency, typical	Apple, medium
Blagodat	4.7	4.5	4.6	Yellow, transparent	Sweet and sour, pleasant	Apple, weak
Vavilovskoye	4.6	4.5	4.6	Straw- to dark yellow color, transparent, slightly opalescent	Sweet and sour, pleasant, with a slight astringency, typical	Apple, pleasant, medium
Ivanovskoye	4.6	4.4	4.5	Yellow, transparent	Sweet and sour, with a slight astringency, typical	Apple, medium
Patriot	4.4	4.5	4.5	Yellow, opaque (muddy), slightly opalescent	Sweet, pleasant, with a slight astringency, typical	Apple, weak
Antonovka (st.)	4.3	4.1	4.2	Straw-yellow, opaque (muddy), opalescent	Sour, with a slight astringency, typical	Apple, pleasant, medium
$\overline{X}$	4.5	4.5	4.4			
max	4.7	4.5	4.6			
min	4.3	4.1	4.2			
LSD_{05}	0.2	0.2	0.2			
V%	3.3	3.3	3.6			

The content of polyphenols in juice is most influenced by two factors: the genotype and the method of juice processing. The influence of the second factor in our study is minimized, which brings the role of the genotype to the foreground.

In the studied juices, a high variation in the content of catechins was revealed - from 22.5 mg per 100 g ('Blagodat') to 122.9 mg per 100 g ('Aleksandr Boyko'). This may be due to genotype affecting the retention of catechins in the juice (Van der Sluis et al., 2001; Shafi et al., 2019).

The analysis of the tasting ratings showed that all studied cultivars surpassed the standard cultivar in organoleptic indicators. So, the most attractive was the juice of Blagodat, Vavilovskoye and Ivanovskoye. According to the taste qualities of the juice, Blagodat, Vavilovskoye, Patriot and Aleksandr Boyko especially stood out. According to the general tasting assessment, the juice of all studied cultivars reliably surpassed the standard Antonovka (Table 2).

CONCLUSIONS

The comparative analysis of the technological indicators of new apple cultivars for juice production showed that they all surpassed the standard 'Antonovka' in terms of the content of soluble solids in the juice, more moderate acidity and higher organoleptic indicators. The studied cultivars suitable for cultivation by intensive technologies can be recommended for cultivation in technical (raw) orchards. 'Aleksandr Boyko' stood out especially, characterized by a juice yield not lower than that of the standard cultivar, a high content of soluble solids in the juice and low acidity. This cultivar also distinguished by a fairly high content of catechins in the juice, which cause antioxidant properties.

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