

# Biochemical composition of scab-immune apple fruits varieties (*Malus domestica* B.) as a valuable component of healthy dietary

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**Abstract.** The article presents an analysis of the biochemical composition of apple varieties (*Malus domestica* B.) with immunity to scab. Domestic and foreign apple varieties are used as research objects. Variability in fruits in the content of ascorbic acid (AA), soluble solids (SDS), P-active compounds, and titratable acids was noted. The high content of AA is noted in Uspenskoe, Skala, Bylina, Flagman, Yubilyar apple varieties. Long-term studies have revealed intervarietal differences in biochemical composition and variation of this trait over the years in apples. Varieties with valuable biochemical composition and immunity to scab can be used in organic food production, as well as in further breeding work to improve the quality of fruits.

## 1 Introduction

Apple tree takes a leading position in fruit plantations in countries with temperate climate; it is cultivated in almost all climate zones of our country, which is due to the availability, taste, good preservation qualities, and value in the human nutrition system. New domestic varieties have a high level of ecological adaptation, productivity, and valuable biochemical composition of fruits. The nutritional value of apple fruits for people is ensured by the presence of vitamins, trace elements, fiber, and other useful substances, the balance of which in the body provides the basis of healthy immunity [1, 2, 3].

The demand for organic food has increased with the improvement in the quality of living of people. Hence, during the COVID-19 pandemic, the question of boosting human immunity is especially acute, which healthy food can provide. The high quality of organic produce is ensured by the preservation of healthy qualities in apple fruits at the stage of agricultural production by eliminating the causes of pollution with harmful substances [4].

Worldwide, the organic food production rate is minimal and takes only 1-3%. The main countries-consumers are France, Germany, Great Britain, the USA, Canada, and Japan [5].

It is necessary to organize the production of organic products in Russia to eliminate the dependence of the Russian market from import. One way to solve this problem is to grow scab-immune apple varieties. Scab is caused by the fungus *Venturia inaequalis* (Cooke) Wint, and it is the most dangerous apple disease in the middle zone in Russia. More than 20% of the total amount of agriculture pesticides is used in horticulture, although the fruit crops occupy only about 3.5% in the entire cultivated land [6]. Achievements in apple breeding make it possible to obtain apple varieties with monogenic scab resistance

based on the *Rvi6* gene identified in the wild apple *M. floribunda* 821. In Switzerland and Denmark, the production of organic foods based on scab immune apple varieties takes about 40%, which shows the best indicators of consumption per capita [4, 7].

When breeding new apple genotypes, breeders pay special attention to the content of biologically active substances, mainly vitamin C, or ascorbic acid (AA) and P-active compounds (vitamin P) in apple fruits.

The level of genetic conditioning of various biochemical traits in apple fruits is different. According to the content of vitamin C in fruits, the percentage of the genotypic component in the total variability of the trait ranges from 33 to 77%, and for soluble solids, it ranges from 17 to 76%. The high phenotypic variability of apple varieties in terms of AA content depends less on the genotype, and more on external factors. The content of soluble solids (SDS), P-active compounds, and titratable acids in fruits also depend on external conditions. However, such apple fruit traits are characterized by a greater dependence on genetics. As the apple crop moves from north to south, the content of vitamin C and titratable acids in fruits of the same varieties usually decreases, while the content of SDS and sugars increases [5, 8, 9, 10, 11].

## 2 Experimental

The research was conducted at the Federal State Scientific Institution «I.V. Michurin Federal Scientific Center» in 2015-2019 using the Program and methodology of variety researching of fruit, berry and nut crops. The objects of the research were scab-immune apple fruits varieties of domestic and foreign selection. Evaluating the quality of fruits were guided by the methods of biochemical research

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of plants. Mathematical processing of the obtained data was performed using generally accepted methods of mathematical statistics [12, 13, 14, 15, 16, 17].

### 3 Results and discussion

Analysis of the biochemical composition of scab immune apple varieties (*Malus domestica* B.) showed that results differ significantly in the content of vitamin C, P-active substances, as well as soluble solids and sugars, the results are shown in Table 1.

High content of AA (mg/100g) is noted in fruits of the varieties Uspenskoe (26.4), Skala (25.3), Bylina (22.9), Yubilyar (22.0), Flagman (21.7). Most of the studied varieties have an average (10-20 mg / 100g) content of AA in fruits. In this group, such an indicator is slightly higher in the varieties Kaskad (18.5), Bolotovskoe (17.9), Fregat (17.8). The varieties Start, Afrodita, Kandil Orlovsky, accumulate from 10 to 13 mg/100g of vitamin C.

Domestic apple Venyaminovskoye and foreign apples Gavin, Florina, Priscilla, Liberty, BM 41497, PR 12T67 have the low content of AA (less than 10 mg / 100g).

Vitamin content in foreign apple varieties, in particular, Liberty and Florina, in the southern horticultural zone are 1.4-2.1 times lower than in the Central region of Russia.

Long-term studies revealed the intervarietal differences in the content of vitamin C in apple fruits, as well as a significant variation of this trait over the years. The varieties with insignificant variability in the content of AA in fruits with a variation coefficient of up to 10% include Skala, Start, Bylina. Varieties Bolotovskoe (23.2), Uspenskoe (26.5), Venyaminovskoe (30.4), Kandil Orlovsky (37.3) are characterized by significant variability for this trait (Cv over 20.0%). Foreign scab immune apples differed insignificantly from year to year in terms of "C" -vitamin content. For example, for the Florina variety, the content of AA over the years of research ranged from 8.8 to 9.7 mg / 100g, Liberty - 8.8 to 10.5 mg / 100g, Priscilla - 9.1 to 9.7 mg / 100g.

In the comprehensive program for the apple selection and breeding in 2020, the requirements have been developed for the content of P-active substances in the fruits of new varieties when they are transferred to state testing. For the middle zone of horticulture, this figure is 200-250 mg / 100 g. A person needs 50 mg of P-active substances per day, and 60 kg of apples per year. Apples mainly contain catechins from the variety of flavonoids.

**Table 1.** Biochemical composition of scab-immune apple fruits varieties.

Cultivar name	Ascorbic acid mg/100g	Soluble dry subst., %	Total sugar, %	Titrated acid, %	P- vitamin, mg/100g
Domestic apple varieties					
Akademik Kazakov	15,8	15,0	11,6	0,78	186
Afrodita,	12,0	14,5	10,6	0,52	135,3
Blagovest	17,6	13,7	10,1	0,61	161
Bolotovskoe	17,9	13,1	11,2	0,32	154,7
Bylina	22,9	14,6	11,4	0,70	196
Venyaminovskoe	9,2	13,3	8,9	0,41	115,7
Vympel	15,0	13,5	12,4	0,85	196
Imrus	15,6	13,7	10,2	0,57	251,0
Kandil Orlovsky	12,0	12,7	10,9	0,35	299
Kaskad	18,5	15,9	12,5	0,86	92
Krasulya	11,5	13,6	11,5	0,38	266
Orlovsky pioner	15,4	12,8	9,1	0,56	89,5
Skala (controlling)	25,3	14,8	12,0	0,62	200
Start	10,9	13,4	10,2	0,61	137,6
Uspenskoe	26,4	16,1	11,5	0,88	396,0
Flagman	21,7	15,1	13,7	0,51	188
Fregat	17,8	13,9	11,9	0,59	156
Yubilyar	22,0	12,0	10,3	0,63	127,0
Foreign apple varieties					
BM 41497	9,7	13,9	11,0	0,64	270,0
Florina	9,2	12,7	10,4	0,46	139,0
Gevin	7,5	12,7	10,9	0,47	164,0
Praim	13,8	13,4	10,6	0,40	238,0
Liberty	9,7	13,7	11,6	0,89	113,0
Priscilla	9,4	13,3	12,1	0,67	109,0
PR 12T67	4,4	13,2	9,4	0,39	46,0
SR 0523	12,0	12,7	9,7	0,53	92,0
X avg	13,7 ±0,6	13,8 ±0,4	11,0 ±0,3	0,60 ±0,15	173,8 ±15,3
Min-max	7,5-33,4	10,3-17,9	8,1-17,8	0,24-0,97	41,1-495,0

Studies established the variation of vitamin P in fruits from 46 mg (PR 12T6) to 396 mg / 100g (Uspenskoe). The group of genotypes with a high content of catechins (more than 250 mg / 100g) from varieties of domestic breeding, except Uspenskoe, included Imrus (251), Kandil Orlovsky (299), Krasulya (266), and foreign apple - VM 41497 (270). The bulk of the studied varieties contained 150 to 250 mg / 100 g of these substances. Low content of P-active catechins (less than 100 mg%) in fruits was noted in foreign forms PR 12T67 and SR 0523.

The content of flavonoids in apples depends not only on the genotypic characteristics of the plant but also on the prevailing weather conditions. The indicator has significant variability over the years, reaching more than 40%.

Soluble solids (SDS) are represented in fruits mainly by sugars, as evidenced by the close correlation dependence ( $r = + 0.74$ ). Studies have revealed the range of the value of the SDS indicator from 12.0% (Yubilyar) to 16.1% (Uspenskoe). The varieties Flagman and Akademik Kazakov are characterized by the high amount of SDS in apples (more than 15%); the average (12-15%) content was noted in most of the studied varieties.

Most of the analyzed varieties have low variation coefficients - up to 10% - of SDS.

Scab immune apples accumulate, on average, 10-11% of sugars, with a minimum content of 9.4% (PR 12T67) and a maximum 13.7% (Flagman). The following varieties are characterized by a sugar content higher than the control variety Skala (12.0%): Kaskad (12.5%), Vympel (12.4%), Priscilla (12.1%).

The varieties Skala, Uspenskoe, Start, have a low coefficient of variation of sugar content by years (1.36-8.4%); most varieties have average values (11.4-12.9%). The Venyaminovskoe variety is distinguished by a high coefficient in the sugar content - 33.4%.

Apple varieties that are immune to scab also differ in the content of titratable acids from 0.35% (Bolotovskoe) to 0.88% (Uspenskoe). This trait is subject to significant year-to-year variability, especially in the Uspenskoe, Skala, and Start varieties, with a high coefficient of variation from 22.8 to 31.3%.

## 4 Conclusions

Based on the conducted research, the apple varieties immune to scab with increased content of vitamin C and P-active compounds, as well as soluble solids, sugars, and titratable acids, were identified. Domestic selection: Uspenskoe, Bylina, Flagman, Kandil Orlovsky, Krasulya, Vympel, Academician Kazakov; foreign selection - BM 41497. The cultivation of such varieties will reduce the pesticide load and help to get better quality fruits. As a valuable component of a healthy diet, they are intended to be consumed fresh. The fruits can be used for processing to obtain organic produce with a high content of vitamins and biologically active substances.

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