

# Biochemical Composition of the Pear Fruit at FSBSI FARC of the North-East named after N. V. Rudnitskiy

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**Abstract.** The pear tree is a relatively new crop for the North-East of the European part of Russia; therefore, the purpose of the work is to study biochemical composition of pear fruit in conditions of Kirov region. The objects of the research are 9 varieties of the pear tree of 2007 planting year: Chizhovskaya (a check variety), Kupava, Perun, Svarog, Karataevskaya, Naryadnaya Efimova (Dressy Efimova), Vidnaya (Prominent), Larinskaya, Povislaya. In conditions of the region the studied varieties of the pear accumulate on average 9.32% of sugar, 2.73 mg% of ascorbic acid, 17.10% of dry matter and are noted for high titratable acidity – on average 0,96. The varieties Kupava, which combines high amount of sugars sum and dry matter, with excellent gustatory qualities and Povislaya, which is prominent for really high amount of dry matter and high sugar sum, were distinguished. The main stages with maximal quantity of strong interconnections between weather factors and indices of biochemical composition of the mostly varieties of fruit were differentiated, in particular: the sum of effective temperatures during the period from July to August, the sum of effective temperatures separately for July and separately for August and hydrothermal index for June.

## 1 Introduction

The pear tree is a valuable fruit crop; today it is cultivated in an every area with the temperate climate of the globe. It occupies the second place after the apple tree in the worldwide production of fruit among seeded crops. Annually more than 17 million tons of pear fruit are grown with an average crop capacity in 10.2 t/ha in the world. The leader in pear production is supposed to be China (approximately 8 million tons) [1]. First of all, the pear tree is valued for high and stable productivity, secondly, it is valued for excellent gustatory qualities and rich biochemical composition of fruit which can be used in functional nutrition [2]. Though, the amount of sugar in pear fruit contains less than in apple fruit, however, we emphasize that mellow pear fruit seem more sugary that explains their light acidity [3].

The flavour of pear fruit is defined by amount of chemical substances and their ration. The varieties can be differed by amount of dry matter, sugar, acids, ascorbic acid in fruit

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[4]. Biochemical composition Biochemical composition of fruit is a variety feature, which can change under the influence of meteorological conditions in vegetation period [5, 6]. The stability of biochemical composition of fruit is one of the indices of adaptability of the variety [7].

The pear tree is a new crop for Kirov region, at the moment, there is only one variety Vekovaya (Secular) zoned in 2016, which is recommended for cultivation in conditions of Kirov region, in the register of varieties. At FSBSI FARC of the North-East (FEDERAL STATE BUDGET SCIENTIFIC INSTITUTION "FEDERAL AGRICULTURAL RESEARCH CENTRE") the stain investigation of the pear has been held for more than 15 years; the range of winter-hardy, productive varieties with fruit of a good flavor was defined [8]. However, the problem of edaphic-climatic conditions of the region influencing on biochemical composition of pear fruit has still been unexplored.

The purpose of the work is to examine biochemical composition of pear fruit in conditions of Kirov region.

## 2 Methods and materials

The researches were held in fruit and berry crop laboratory of FARC of the North-East (Kirov). The objects were 9 pear varieties of 2007 planting year: 4 varieties of FSBSI FARC's selection (Kupava, Perun, Svarog, Karataevskaya); 2 varieties of FSBSI FRC of horticulture's selection (Naryadnaya Efimova (Dressy Efimova), Vidnaya (Prominent)); 2 varieties of the South-Ural Research Institute of horticulture and potato growing's selection (Federal State Budgetary Scientific Institution «Ural Federal Agrarian Research Centre, Ural Branch of the Russian Academy of Sciences») (Larinskaya, Povislaya). As the check was the variety of RSAU – MTAA named after K.A. Timiryazev's selection - Chizhovskaya (a check variety) because the previous researches showed its high adaptability to conditions of the region.

The soil on the sector is calcareous, sandy-loam lying on perm clay. Agrochemical characteristic of soil is pH=5.6; the content of P<sub>2</sub>O<sub>5</sub> is 28 mg in it, K<sub>2</sub>O – 20 mg per 100 g of soil.

The scheme of planting is 5x6 m. The planting was implemented with 2-year plants being inoculated with seedling rootstock. Agro-engineering measures at experimentation are standard for the north-eastern sector of horticulture of European part of Russia.

Recordings and observations were held in agreement with "The Programme and Methodology of Strain Investigation of Fruit, Berry and Nuciferous Crops" [9]. Static Processing of Results was held in accordance with B. A. Dospekhov's methodical recommendations [10] with using Microsoft Office 2007 software package.

The Biochemical composition of analysis was held in the analytical laboratory of FARC of the North-East. Bertrand's method was used for determining the accumulation of sugars. The amount of dry matter was defined with a drying method at 105° until the constant weight. Ascorbic acid was identified with Murri method (1973). Acidity - as titratable acidity of fruit and vegetables.

The sum of effective temperatures (+10°C), the amount of rainfall and hydrothermal index were identified on Selyaninov during the period from May to September.

To estimate the dependence of biochemical composition of pear fruit on weather conditions correlation coefficient – r was applied. To calculate it the vegetation season was divided into decades. In analysis of correlation relationships the most potent of them were taken into consideration which can be noted for the absolute meaning of correlation coefficient  $r > 0,7$ .

The conditions of overwintering were different during the period of the studying. Winters of 2017/2018 and 2018/2019 characterized by mild weather without thermal

discontinuity. The winter of 2019/2020ss has become the warmest during the last 10 years; continuous periods with the temperature of 0°C and above were noticed during this winter. The winter of 2020/2021 has become the coldest during the years of the research; it was characterized by frosty weather (before - 35 °C on snow surface).

The conditions of the vegetation seasons in 2018-2021ss were enough auspicious, excepting the year of 2019, which was differ by cool weather and plenty of rainfall (hydrothermal index = 2,1); the sum of effective temperatures was 1353 °C (table 1).

**Table 1.** Agro-climatic conditions on heat-and-water availability during the vegetation period of the pear tree (according to Kirov center of hydrometeorology) (2018...2021ss).

Year	Hydrothermal Index	Sum of Effective Temperatures, C°	Sum of Rainfall During the Vegetation Season
2018	2,38	1520	362
2019	2,05	1353	277
2020	2,08	1640	341
2021	1,80	1825	330

The harvest time of aestival varieties is the end of August, the harvest time for aestival-autumnal varieties is the first decade of September and for autumnal ones is the second-third decade of September.

### 3 Results and discussion

In conditions of Kirov region, on average, the varieties of pear accumulate 9,32% of sugars (table 2). The varieties Povislaya (11.21%) and Kupava (10.66%) are distinguished by high amount of sugar sum (10.1 – 15.0%). Mean amount of sugars (6.0 – 10.0%) is typical for other varieties. On the average by the collection the variability of sugar accumulation is medium (12.38%); the varieties Chizhovskaya (a check variety), Larinskaya, Vidnaya (Prominent), Karataevskaya were differed by low variability of that feature ( $V < 10\%$ ). The variety Svarog was characterized by strong dependence of sugar sum accumulation on weather conditions of vegetation season ( $V = 20.05\%$ ).

**Table 2.** Biochemical composition of a pear fruit at FSBSI FARC of the North-East, 2018...2021ss.

Variety	Sugars		Acidity		Dry Matter		Ascorbic Acid		SAI	Flavor Grades, points
	%	V %	%	V %	%	V %	mg/%	V %		
Chizhovskaya (check)	9.09	9.50	0.94	8.59	17.75	6.57	3.08	49.49	9.67	5.0
Povislaya	11.21	11.56	1.32	15.76	20.86	5.50	2.53	26.09	12.60	4.0
Kupava	10.66	19.55	0.86	16.83	17.10	11.64	4.29	29.46	12.39	4.5
Svarog	9.75	20.05	1.09	4.93	17.23	11.96	1.98	36.51	8.94	4.0
Vidnaya (Prominen)	9.66	7.97	0.83	10.76	16.34	10.46	1.90	43.55	11.63	4.0
Perun	9.56	13.86	1.03	12.39	16.26	9.30	3.96	22.22	9.28	4.5
Larinskaya	9.02	5.58	0.88	14.78	17.27	6.84	2.31	32.53	10.25	4.0
Naryadnaya Efimova (Dressy Efimova)	8.35	14.38	0.91	15.09	16.79	4.36	2.47	48.72	9.17	5.0
Karataevskaya	8.26	9.01	0.82	7.88	14.34	6.61	2.20	36.50	10.07	5.0
Average	9.32	12.38	0.96	11.89	17.10	8.13	2.74	36.12	-	-
LSD	1.68	-	0.18	-	1.69	-	-	-	-	-

Soil-climatic conditions of the region promote accumulation of a large amount of organic acids in fruit. In this way the varieties Perun, Svarog and Povislaya were distinguished for really high titratable acidity ( $\geq 1.00\%$ ). The other 6 varieties were noted for high titratable acidity (0.51 – 1.00). The variability of titratable acidity accumulation was 11.89% on the

average among the collection. The varieties Chizhovskaya (check), Karataevskaya and Svarog are notable for low variability of this feature ( $V < 10\%$ ).

The analysis of dry matter content in pear fruit showed that on an average the varieties accumulate approximately 17.10% of dry matters. The varieties with a really high content (more than 20.00%) – Povislaya and the varieties with a mean content of dry matter (12.00 -15.00%) – Karataevskaya are presented. The content of dry matter is a stable enough feature ( $V = 8.13\%$ ); only three varieties (Vidnaya (Prominent) (10.46%), Kupava (11.64%) and Svarog (11.96%)) were marked for mean variability of the feature (10.0 – 20.0%).

Ascorbic acid (vitamin C) is one of the most important active matters; it fulfils an antioxidant role in a human organism protecting the cells from damage by free radicals [11]. Although pear fruit don't present great value as a source of ascorbic acid [12], but weather-climatic conditions of the region, in particular chilly and rainy summer, should promote accumulation of high amount of vitamin C. However, this hypothesis was not confirmed – no variety with high ascorbic acid content (more than 10 mg %) was distinguished during the research. The variety Perun was marked for the maximal ascorbic acid content (7.92 mg %) in 2018. On an overage for the period of the experiment the variety Kupava was prominent for the amount of vitamin C – 4.29 mg %. The accumulation of ascorbic acid is quite an unstable feature which depends on weather conditions, a vegetation season, thus, the variability was 36.12 % on the overage for the collection. The varieties Perun (22.22%), Povislaya (26.09%) and Kupava (29.46 %) were the most stable on this feature.

The balanced combination of sugar and acid characterises the degree of pear fruit sweetness. The sugar-acid index (SAI) is calculated for the estimation of this feature. The analysis showed that SAI of studied varieties was within the ambit of 8.94 – 12.60; this indicates desirable gustatory features of fruit. The group with high gustatory features of fruit (SAI – more than 10) was distinguished: Karataevskaya, Vidnaya (Prominent), Larinskaya, Kupava and Povislaya.

As a result of the testing assessment, 5 dessert varieties (flavour is 4.5 – 5.0 points) were emphasized: Chizovskaya, Naryadnaya Efimova (Dressy Efimova), Kupava, Karataevskaya, Perun. The other varieties (Larinskaya, Vidnaya (Prominent), Svarog, Povislaya) had fruit with satisfied flavor (4 points). The influence of biochemical composition on the testing assessment wasn't registered.

The study of weather conditions during the vegetation season impact on biochemical composition of pear fruit was held. The analysis showed that, in general, the interaction was variety-specific, however, it is worthwhile to say about some most important stages: when the maximum number of strong interactions between weather factors and biochemical composition indices of the most fruit varieties were registered, in particular: the sum of effective temperatures during the period from July to August, the sum of effective temperatures separately for July and separately for August and, in addition, hydrothermal index for July (table 3).

**Table 3.** The correlational dependences of biochemical composition indices of pear fruit on weather conditions of the vegetation season, 2018 – 2021ss.

Variety	Indices	$\Sigma$ of Effective Temperatures, July-August	Hydrothermal Index of July	$\Sigma$ of Effective Temperatures, July	$\Sigma$ of Effective Temperatures, August
Aestival Varieties					
Chizhovskaya	dry matter, %	0.71	0.92	0.88	0.50
	acidity, %	-0.91	-0.84	-0.66	-0.95*
	ascorbic acid, mg%	-0.59	0.99	-0.67	0.34
	sugars, %	0.93	0.96*	0.80	0.89
Naryadnaya	dry matter, %	0.96*	0.80	0.61	0.99*

Efimova (Dressy Efimova)	acidity, %	-0.85	-0.98*	-0.99*	-0.68
	ascorbic acid, mg%	-0.62	0.61	-0.55	-0.78
	sugars, %	0.93	0.73	0.54	0.98*
Aestival-Autumnal Varieties					
Larinskaya	dry matter, %	-0.07	-0.43	-0.45	0.21
	acidity, %	0.62	0.87	0.72	0.45
	ascorbic acid, mg%	-0.49	0.61	0.28	-0.52
	sugars, %	0.40	0.12	-0.07	0.66
Vidnaya (Prominent)	dry matter, %	0.63	0.96	0.85	0.96
	Acidity, %	0.87	0.97	0.90	0.69
	ascorbic acid, mg%	-0.24	0.48	-0.40	0.26
	sugars, %	0.89	0.87	0.92	0.90
Kupava	dry matter, %	0.86	-0.61	0.68	0.90
	acidity, %	-0.72	-0.43	-0.35	-0.89
	ascorbic acid, mg%	-0.71	0.69	-0.59	-0.21
	sugars, %	0.78	0.51	0.43	0.93
Svarog	dry matter, %	0.22	-0.13	0.08	0.32
	acidity, %	0.65	0.63	0.87	-0.44
	ascorbic acid, mg%	-0.96*	0.91	-0.97*	-0.85*
	sugars, %	0.01	-0.35	-0.15	0.16
Karataevskaya	dry matter, %	0.87	0.62	0.60	0.96*
	acidity, %	-0.89	0.96*	-0.69*	0.71
	ascorbic acid, mg%	-0.55	0.71	-0.87	0.27
	sugars, %	0.85	0.65	0.51	0.97*
Autumnal Varieties					
Perun	dry matter, %	-0.14	-0.41	-0.58	0.17
	acidity, %	-0.71	-0.47	-0.30	-0.89
	ascorbic acid, mg%	-0.16	0.14	-0.14	-0.21
	sugars, %	-0.92	-0.95	-0.98*	-0.76
Povislaya	dry matter, %	-0.52	-0.77	-0.54	-0.41
	acidity, %	0.12	0.18	0.51	-0.13
	ascorbic acid, mg%	-0.96*	0.91	-0.97*	-0.85
	sugars, %	-0.95*	-0.99	-0.92	-0.85

\*significant is on 5% level

Furthermore, it is worth to note that influence of one or another factor differs in what category of mellowness the variety is. In this way the hydrothermal index for the third decade of August correlates negatively with sugars sum accumulation of aestival and aestival-autumnal varieties (from  $r = -0.43$  (Svarog) to  $-0.99$  (Kupava), but this factor influence positively on late varieties ( $r = 0.59-0.65$ ).

The sum of effective temperatures for August correlates positively with sum of sugars accumulated in aestival and aestival-autumnal varieties of pear fruit ( $r = 0.66$  (Larinskaya) –  $0.98$  (Naryadnaya Efimova)). This factor brings strong negative influence ( $-0.76$  and  $-0.85$  accordingly) on autumnal varieties (Perun and Povislaya).

The sum of effective temperatures from July to August has strong correlation with sugar sum accumulation in fruit of aestival and aestival-autumnal pear varieties (from  $0.78$  for Svarog to  $0.93$  for Chizhovskaya and Naryadnaya Efimova (Dressy Efimova)). Strong negative interrelation ( $-0.92$  and  $-0.95^*$  accordingly) was distinguished in autumnal varieties (Perun and Povislaya).

The strong correlation between accumulation of dry matter in pear fruit of aestival varieties (Chizhovskaya and Naryadnaya Efimova (Dressy Efimova)) and the sum of effective temperatures from July to August ( $0.71$  and  $0.96^*$  accordingly) was registered, in addition with hydrothermal index of July ( $0.92$  and  $0.80$  accordingly). The accumulation of

dry matter sum in fruit of aestival-autumnal and autumnal varieties correlates with the sum of effective temperatures of August; the varieties Vidnaya (Prominent) (0.96), Kupava (0.90) and Karataevskaya (0.96\*) have strong interaction, the other – low one.

Two factors bringing strong influence on accumulation of ascorbic acid in pear fruit were distinguished: the sum of effective temperatures from July to August (middle negative correlation of Chizhovskaya (-0.59), Naryadnaya Efimova (Dressy Efimova) (-0.62), Larinskaya (-0.49), Karataevskaya (-0.55) varieties and strong negative correlation in Kupava (-0.71), Svarog (-0.96\*) and Povislaya (-0.96\*) were registered) and hydrothermal index of July (strong positive interaction was noted in Chizhovskaya, Svarog, Karataevskaya and Povislaya varieties; middle positive interaction was noted in Naryadnaya Efimova (Dressy Efimova), Larinskaya, Vidnaya (Prominent) and Kupava varieties).

The attempts to identify tendencies explaining the influence of weather conditions on acidity of a pear fruit were failed. Thus, strong negative interaction between acidity and the sum of effective temperatures of August (-0.95\*) was registered in the aestival variety Chizhovskaya. The influence of hydrothermal index and the sum of effective temperatures of July on acidity ( $r = -0.98^*$  and  $-0.99^*$  accordingly) was distinguished in the Naryadnaya Efimova (Prominent Efimova) variety. The hydrothermal index of July brings the strongest influence on acidity of autumnal pear varieties: from -0.43 (Kupava) to  $0.96^*$  (Karataevskaya) and 0.97 (Vidnaya (Prominent)). It is worthwhile to say that autumnal varieties have strong negative interaction (-0.89) (Perun) between acidity and the sum of effective temperatures in August.

The large variation between varieties on the value of the correlation coefficients on some indices, apparently, can be explained by unfavourable conditions of vegetation season in 2019, that caused to serious modification of biochemical fruit composition, thus, the amount of ascorbic acid in Chizhovskaya variety reduced nearly by three times (to 0.88 mg % at the average value in 3.08 mg%); however, this index increased in half in Perun variety (from 3.96 mg% to 5.56 mg%), so the varieties responded on stressful conditions in different ways.

## 4 Conclusions

All in all, in conditions of Kirov region the studied pear varieties accumulate, on the average, 9.32% of sugars, 2.73 mg% of ascorbic acid, 17.10% of dry matter and differ in high titratable acidity – 0.96 at the mean. The variety Kupava combining high sum of sugars and dry matter amounts with distinctive gustatory qualities and the variety Povislaya differed for high amounts of dry matter and sum of sugars were distinguished. The main stages with maximal amount of strong interactions between weather factors and indices of biochemical composition of fruit of the most varieties were distinguished, to wit: the sum of effective temperatures during the period from July to August, the sum of effective temperatures separately of July and of August and hydrothermal index of July.

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