Suitability of plum varieties and forms selected by the Federal Research Center n.a. I.V. Michurin for the production of prunes

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Abstract. The study is aimed at assessing the suitability of plum varieties cultivated in Tambov region for the production of dried fruits (prunes). Large-fruited (average weight of more than 31 g) varieties were identified. Renklod by Kharitonovoy, Etude, Vengerka by Kursakov and Nochka are characterized by intense violet and dark purple integumentary colors. A combination of high skin strength, pulp hardness and good stone separation was found in Renklod by Kharitonov, Renklod Tambov, Etude, Vengerka by Kursakov and 23-135 Elite. A high accumulation of soluble solids, sugars, a low content of organic acids, as well as a high sugar-acid index were found in Renklod by Kharitonov, Renklod Tambov and Elite 23-135. Prunes produced from Renklod by Kharitonov, Renklod Tambov and 23-135 Elite were characterized by high commercial and consumer qualities, which makes it possible to recommend these varieties for the production of dried fruits.

1. Introduction
Currently, there is a high and stable demand for fruit and berry products both for food and for therapeutic and prophylactic nutrition. The need for year-round consumption of such products in the required volumes is relevant [1, 2]. The fruits such as plum, apple, pear, etc. are in demand [3, 4]. Plum fruits perfectly combine organoleptic characteristics and therapeutic and prophylactic properties in biochemical composition. They contain a significant amount of nutrients, mainly carbohydrates [5-7]. In terms of calorie content, they are second only to grapes and cherries. The average energy value of fresh fruits is about 45 kcal, prunes - 240 kcal per 100 g of product [8].

Plum is the most common type of stone fruit used in the production of processed products. It is valued for its taste and technological qualities. According to GOST 21920-76 [9], varieties are suitable for the processing industry. They must be typical in shape and color and uniform in maturity. The basic requirements for fruits and their chemical composition can be found in the regulatory documents for a specific processed product. Development of the processing industry makes it necessary to select the forms that best meet the technological requirements.

Drying is the most popular type of plum processing. Dried plums (prunes) are a healthy product, the leader in potassium content among dried fruits. Favorable natural and climatic conditions of the South of Russia, especially the foothills of the North Caucasus and the Black Sea region, make it
possible to grow high-quality plum fruits, from which it is possible to produce prunes that meet the best world standards [10].

The biochemical composition of fruits varies depending on the weather conditions and the area of cultivation. The accumulation of sugars in some varieties is at the level of the southern forms [4, 5, 11]. However, the increased content of organic acids is the reason for their limited use in the processing industry. An assessment of the technological parameters of fruits selected by the Federal Research Center n.a. Michurin was carried out.

2. Materials and methods
The fruits of plum varieties were used as biological objects of research: Renklod by Kharitonov, Vengerka by Kursakov, Nochka, Vengerka Zarechnaya, Renklod Tambovsky and 23-135 Elite (Renklod Tambov x Belaya Mashkova). The control was the Etude variety, zoned in the Central Black Earth region, which is included in the list of plum varieties of pomological group I [9]. The study was conducted in 2019-2020.

The skin strength and density of fruit pulp were assessed at the stage of consumer maturity using the FT30 penetrometer with a plunger diameter of 8 mm. The AND GX-600 and AND EJ-6100 laboratory balance was used for weighing.

The biochemical composition of fruits was studied by the methods generally accepted in scientific laboratories: the content of soluble solids was determined by the refractometric method using the RL-3 refractometer; the amount of sugars was assessed by the Bertrand method; the titratable acidity was established by titrating the extracts with 0.1 N NaOH followed by recalculation for malic acid [10].

A sample of fruits (5 kg each) typical for each pomological variety was used in the study. The fruits were dried in a drying oven (HS 62A) and treated with hot water containing soda at 90°C (for 30 seconds, the content of soda was 10 grams per liter). Then the fruits were dried with a constant increase in temperature:
1. dried for 4 hours at 50°C, stirred and cooled;
2. dried for 4-5 hours at 60-70°C, stirred and cooled;
3. dried for 4-5 hours at 90°C, stirred and cooled.

3. Results and Discussion
For the preparation of prunes, large violet fruits with strong skin, firm pulp and well-separated stones were used. For technological processing, fruits should accumulate soluble solids of at least 16%, sugars of 10%, organic acids of no more than 1.5%. For the production of prunes, the sugar-acid index values were 15-20.

The forms had significant differences in fruit weight (Table 1). The control variety Etude had large fruits. Over the years of research, the average weight was 36.9 g, the maximum weight was 42.3 g with a height of 43.5 mm and a width of 37.8 mm. The largest fruit size (height of 45.3 mm, width of 39.7 mm, average weight of 37.5 g, maximum weight of 45.9 g) was characteristic of Renklod by Kharitonov. The group with large fruits (over 31 g) included Vengerka by Kursakov and Nochka. Fruits of Vengerka by Kursakov was different from the control variety and exceeded it in width and maximum weight. Vengerka Zarechnaya, Renklod Tambov and Elite 23-135 had an average fruit size. The most one-dimensional fruits were Nochka and Renklod Tambov, in which the error of the average fruit weight did not exceed 1 g. The maximum fruit weight was the most stable indicator in comparison with the average value.

Equally important is the stone weight, as well as its ratio to the fruit weight. A large stone (1.6-1.9 g) was observed in Etude and Renklod by Kharitonov. The share of stone weight in the total fruit weight varied from 4.2 to 5.1%. Vengerka by Kursakov, Nochka and Vengerka Zarechnaya had an average stone size (1.4-1.5 g). The highest ratio of stone weight to fruit weight (5.4%) was found in the Vengerka Zarechnaya variety. Renklod Tambov and 23-135 Elite had small stones (0.8 g), and the ratio to fruit weight was 3.2 and 3.0%, respectively.
Table 1. Weigh of fruits.

| Variety, form          | Fruit diameter, mm | Average fruit weight, g | Maximum fetal weight, g | Stone mass, g | Ration of stone mass to the fruit mass, % |
|------------------------|--------------------|-------------------------|-------------------------|---------------|------------------------------------------|
| Renklod by Kharitonov  | 45.3±39.7          | 37.5±1.53               | 45.9±1.17               | 1.9           | 5.1                                      |
| Etude (k)              | 43.5±37.8          | 36.9±1.47               | 42.3±1.14               | 1.6           | 4.3                                      |
| Vengerka by Kursakov   | 42.0±39.5          | 35.7±1.77               | 43.8±1.23               | 1.5           | 4.2                                      |
| Nochka                 | 34.0±36.0          | 31.1±0.94               | 34.1±0.71               | 1.4           | 4.5                                      |
| Vengerka Zarechnaya    | 37.0±34.0          | 28.0±1.17               | 33.3±1.09               | 1.5           | 5.4                                      |
| 23-135 Elite           | 37.1±33.9          | 26.5±1.51               | 32.6±1.13               | 0.8           | 3.0                                      |
| Renklod Tambov         | 36.8±33.1          | 25.2±0.94               | 31.1±0.83               | 0.8           | 3.2                                      |

The assessment of the commodity and consumer qualities of plum fruits is presented in Table 2.

Table 2. Commodity and consumer qualities of fruits.

| Variety, form          | Color         | Skin strength, g/mm² | Pulp Juiciness | Pulp Hardness, g/mm² | Separability of the stone from the pulp |
|------------------------|---------------|----------------------|----------------|----------------------|----------------------------------------|
| Renklod by Kharitonov  | Dark purple   | 75.6±2.1             | Strong         | 41.8±1.6             | Free                                   |
| Renklod Tambov         | Dark purple   | 71.7±2.0             | Strong         | 39.8±1.2             | Free                                   |
| Vengerka by Kursakov   | Dark purple   | 48.1±2.5             | Strong         | 31.9±1.2             | Easily separated                       |
| Etude (k)              | Dark purple   | 47.8±2.4             | Strong         | 31.8±1.1             | Easily separated                       |
| Nochka                 | Violet blue   | 39.9±2.2             | Strong         | 29.9±1.5             | Easily separated                       |
| 23-135 Elite           | Violet        | 39.8±1.6             | Medium         | 35.8±1.0             | Free                                   |
| Vengerka Zarechnaya    | Violet        | 35.8±2.2             | Weak           | 29.9±1.4             | Easily separated                       |

The forms had an attractive appearance. The color varied from violet to violet-blue. The color was bright with a thick waxy coating.

An important indicator of the suitability of fruits for the production of prunes is the skin strength. The highest strength (75.6 g/mm²) was characteristic of Renklod by Kharitonov. For Renklod Tambov, this indicator was 71.7 g/mm². The skin strength in Etude and Vengerka by Kursakov was 47.8 and 48.1 g/mm², respectively. For other forms, this indicator varied within 35.8–39.9 g/mm². The fruits of 23-135 Elite were characterized by the highest stability of skin strength, the error of the mean value did not exceed 1.6 g/mm².

Density is equally important for the selection of fruits for drying. In Etude and Vengerka by Kursakov, the pulp hardness was 31.8-31.9 g/mm². In Elite and Renklod Tambov, the pulp hardness exceeded the control indicator (35.8 and 39.8 g/mm², respectively). The fruits of Renklod by Kharitonov had the highest pulp hardness (41.8 g/mm²). Nochka and Vengerka Zarechnaya were slightly inferior to the control variety by the pulp hardness.
Most of the forms had rich pulp. The pulp in Elite 23-135 was medium, and in Vengerka Zarechnaya - weak. When selecting varieties for the production of dried fruit, special attention should be paid to the separability of stones and pulps. Renklod by Kharitonov, Renklod Tambov and Elite 23-135, in which the seed was free, were better. Etude (k), Vengerka Zarechnaya, Vengerka by Kursakov and Nochka were characterized by good separability of the stone.

Along with high commercial and consumer properties, fruits used for dried fruit production should contain sugars of more than 10%, little organic acids and soluble solids of at least 16%. Significant differences were observed between the varieties and forms of plum in terms of the biochemical composition of fruits (Table 3).

Table 3. The biochemical composition of plum fruits.

| Variety, form                  | PCB, % | Sugar, % | Titratable acidity, % | SKI | Tasting score, point |
|--------------------------------|--------|----------|-----------------------|-----|---------------------|
| Renklod by Kharitonov          | 23.1   | 18.4     | 1.05                  | 17.5| 4.7                 |
| 23-135                         | 19.2   | 12.4     | 0.74                  | 16.8| 4.4                 |
| Renklod Tambov                 | 24.2   | 17.6     | 1.13                  | 15.6| 4.7                 |
| Etude (k)                      | 16.6   | 9.9      | 2.42                  | 4.1 | 4.3                 |
| Nochka                         | 17.6   | 10.0     | 2.48                  | 4.0 | 4.5                 |
| Vengerka Zarechnaya            | 14.3   | 10.1     | 1.10                  | 9.2 | 4.2                 |
| Vengerka by Kursakov           | 14.8   | 11.1     | 1.63                  | 6.8 | 4.4                 |
| Trait variation                | 14.3-23.1 | 9.9-18.4 | 0.74-2.62              | 3.9-17.5 | 4.2-4.7             |

Almost all genotypes accumulated more than 10% of sugars, which meets the requirements for producing prunes. However, Etude, Nochka and Vengerka Zarechnaya had the minimum sugar content in fresh fruits (9.9-10.1%). The content of soluble dry matter (SDM) varied from 14.3 (Vengerka Zarechnaya) to 23.1% (Renklod by Kharitonov).

The main problem of using plum varieties for the preparation of dried fruits grown in Michurinsk is a relatively high accumulation of organic acids (Etude, Nochka - more than 2%). According to the technological requirements, for the production of prunes, the ratio of sugar to acid should be 15-20. The maximum sugar-acid index was observed in 23-135 Elite (16.8), Renklod by Kharitonov (17.5) and Renklod Tambov (15.6).

During the heat treatment of fruits, significant changes in the chemical composition occurred. Due to the loss of water, the amount of sugars and organic acids increased (Table 4). The maximum accumulation of sugars was observed in the samples produced from Renklod by Kharitonov - 35.7%.

Table 4. The chemical composition of prunes.

| Variety, form                  | Sugar, % | Titratable acidity, % | SKI |
|--------------------------------|----------|-----------------------|-----|
| Renklod by Kharitonov          | 35.7     | 4.2                   | 8.5 |
| Renklod Tambov                 | 32.1     | 4.7                   | 6.8 |
| 23-135                         | 18.8     | 3.8                   | 5.0 |
| Vengerka Zarechnaya            | 15.2     | 4.4                   | 3.5 |
| Etude (k)                      | 19.6     | 6.7                   | 2.9 |
| Nochka                         | 20.1     | 8.0                   | 2.5 |
| Vengerka Kursakov              | 16.7     | 6.5                   | 2.6 |
| Uzbek                          | 33.6     | 1.1                   | 31.4|
| Moldavan                       | 35.0     | 1.4                   | 26.2|
| Trait variation                | 15.2-35.7| 1.1-8.0               | 2.5-31.4|
The least amount of sugar in the finished product was found in prunes produced from Vengerka Zarechnaya — 15.2%. The accumulation of organic acids varied from 3.8% in 23-135 Elite to 8.0% in Nochka. The sugar-acid index characterizes the taste of dried fruits. The ratio of the content of sugars to acid varied from 2.5 (Nochka) to 8.5 (Renklod by Kharitonov).

The output of the finished product varied depending on the variety. The maximum amount of prunes (30-34%) was produced from Renklod Tambov, Renklod by Kharitonov and 23-135 Elite, suitable for further use and storage (Table 5).

Table 5. Commodity and consumer qualities of prunes.

| Variety, form          | Appearance, points | Output of a marketable product, % | Tasting score, point |
|------------------------|--------------------|-----------------------------------|----------------------|
| Renklod by Kharitonov  | 4.7                | 34                                | 4.6                  |
| Renklod Tambov         | 4.5                | 30                                | 4.7                  |
| Etude (k)              | 4.5                | 22                                | 4.0                  |
| Nochka                 | 4.0                | 24                                | 3.7                  |
| Vengerka Zarechnaya    | 4.0                | 24                                | 4.0                  |
| Vengerka by Kursakov   | 4.0                | 25                                | 4.0                  |
| 23-135 Elite           | 4.7                | 30                                | 4.5                  |
| Uzbek                  | 4.4                | -                                 | 4.7                  |
| Moldovan               | 4.8                | -                                 | 4.8                  |

The most attractive appearance was in prunes produced from Renklod by Kharitonov and 23-135 Elite (4.7 points). Prunes produced from Renklod by Kharitonov, Renklod Tambov and 23-135 Elite (the tasting score was 4.5-4.7 points) had harmonious pleasant taste.

For a comparative assessment, samples of prunes sold in Michurinsk, produced in Uzbekistan and Moldova, were analyzed. Dried fruits varied in appearance, quality, and material homogeneity. The highest quality prunes were produced in Moldova. The fruits had pleasant harmonious taste (the tasting score was 4.8 points). Prunes from Uzbekistan had a low content of pulp. The peel was shiny, oily, treated; the samples were even, but not large. In comparison with prunes produced from local varieties, imported samples had a high amount of sugars, a lower acidity value, which affected their taste. The sugar-acid index was 26.1-31.4.

4. Conclusion

The comprehensive assessment identified genotypes with traits that determine the suitability of fruits for the production of prunes:
- large size of fruits (average weight of more than 31 g), intense violet and dark violet cover color: Renklod by Kharitonov, Etude, Vengerka by Kursakov, Nochka;
- high skin strength, pulp hardness and good stone separation: Renklod by Kharitonov, Renklod Tambov, Etude, Vengerka by Kursakov and Elite 23-135;
- high accumulation of soluble solids, sugars, a low content of organic acids, a high sugar-acid index: Renklod by Kharitonov, Renklod Tambov and 23-135 Elite.

Prunes produced from Renklod by Kharitonov, Renklod Tambov and 23-135 Elite have high commercial and consumer qualities, which makes it possible to recommend these varieties for the production of dried fruits.

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