The biodiversity of production traits as the basis for selection of Chaenomeles Lindl. in Tambov region

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Abstract. The purpose of this study was to analyze the biodiversity of morphological and biochemical traits that are important for the breeding process. We used 14 varieties of Chaenomeles Lindl. (Rosaceae) tested at the biological station of the Michurinsk State Agrarian University in the Tambov Region. The data on the decorative qualities of flowers are presented. The presence of various colors of the corolla, simple and semi-double flowers are shown. The analysis of the ranges of variability of such traits as the length and weight of fruits, the content of dry matter, sugars, titratable acids, ascorbic acid and catechins was carried out. The conclusion is made about the presence of biodiversity in the Chaenomeles gene pool, which makes it possible to continue the selection of universal varieties used for decorative purposes and as a high-vitamin fruit crop.

1. Introduction
Currently, breeders are faced with the most important task to obtain resistant forms of plants while maintaining the desired properties of marketable products. When organizing this process, it is especially important to determine the main biological and morphological characteristics of the studied varieties of various plants, both traditional and non-traditional for a given territory [1-4].

The most important work is entrusted to scientific breeding centers, the task of which is to obtain resistant varieties of various plants with desired properties [2-6].

Modern breeding centers rely on sustainable plants that can meet the needs of the population as much as possible. Representatives of the genus Chaenomeles Lindl (Rosaceae) are such a promising culture. [7]. In Central Russia, the most winter-hardy species Ch. japonica (Thunb.) Lindl. ex Spach (= Ch. maulei (Mast.) C.K. Schneid.) became the main ones in obtaining new varieties [8]. The cultivars have decorative merit and are valued as fruit shrubs. Biological research and selection of Chaenomeles have been conducted since 2003 in the city of Michurinsk, Tambov region [9-11].

Chaenomeles fruits are rich in sugars, organic acids and valuable trace elements. Phenolic substances give the fruit an astringent taste; a pleasant aroma is associated with the presence of ketones, aldehydes, terpenes and essential oils with phytoncidal properties. Derivatives of phospholipids, isolated from fruit juice, perform hepatoprotective functions [10]. In terms of biochemical composition, Chaenomeles fruits are rich in vitamins and biologically active substances. In recent years, it has become known that the antioxidant potential of Ch. japonica is much more than...
was previously known. Fruits contribute to the prevention of some oncological diseases, suppress metastatic activity [11-13].

This article presents the biomorphological and biochemical characteristics of various Chaenomeles cultivars. The purpose of the study is to analyze the biodiversity of traits that are important for the further breeding process in the Tambov region.

2. Materials and methods

The study material was 10 Chaenomeles varieties of Michurin selection - Albatros (Ab), Alyur (Al), Charm (Ch), Flagman (Fl), Gefest (Gf), Michurinskoye Chudo (Mc), Michurinsky Vitamin (Mv), Ognivo (Og), Voskhod (Vs), Zhar-Ptitsa (Zp) and 4 samples of Ukrainian selection (from Donetsk region): Brat Kalifa (Bk), Nikolay (Nc), Nina (Nn), Umbilicata (Um). The study of adult fruiting plants was carried out during 2010-2019 at the biological station “Michurinsky State Agrarian University” (Michurinsk city, Tambov region).

The biomorphological characteristics (length, weight of fruits, etc.) were studied in accordance with the “Program ... of variety study” [11]. The weight of the fruits was determined by weighing 25 fruits on an ACOM JW-1-600 electronic balance (South Korea). The dry matter content in fruits was determined with an RPL-3 refractometer (GOST 28562-90). The amount of sugars (%) was found according to Bertman (GOST 8756.13-87). The titratable acids (%) were investigated by acid-base titration (GOST 25794.1-83). Ascorbic acid (mg%) was determined by titration of oxalic acid extracts with Tillman’s reagent (GOST 2456-89); catechins (mg%) were determined by the colorimetric method (GOST 1.0-92). The results were processed statistically using Microsoft Excel. The permissible error did not exceed the norm (P≤5%).

3. Results and Discussions

Among the studied Chaenomeles cultivars (Ab, Ch, Gf, Mv, Og and Vs), the majority belongs to Ch. japonica and many of them have shoots without thorns. Michurin samples (Al, Fl, Mc and Zp) were obtained from Ch. speciosa (Sweet) Nakai and Ch. × superba (Frahm) Rehder. Ukrainian specimens relate to Ch. japonica (Nc, Nn) and Ch. speciosa (Um), specimen Bk is closer to Ch. cathayensis (Hemsl.) C.K. Schneid. All samples are winter-hardy, bloom and bear fruit every year.

3.1 The study of biomorphological characteristics

In the decorative evaluation of Chaenomeles specimens, we paid special attention to the color and shape of the corolla; timing, abundance and duration of flowering. Long-term observations of plants in the Tambov region showed that individuals (~ 60%) with an orange corolla dominate among the samples of the gene pool (Figure 1a), as in sample Al.

![Figure 1. Flowering (a) and fruiting (b) of Chaenomeles japonica bush in the Tambov region](image-url)
Less common were dark red (Zp, Fl), bright crimson (Bk), orange-red (Nk, Nn), orange-coral (Og), cream (Gf, Vs), and white (Ab) petals. The maximum flower diameter (5.5 cm) was recorded for samples Al, Gf, Og. The minimum diameter (3.5 cm) of the corolla was noted for sample Zp. Most of the *Chaenomeles* have a simple corolla (with 5 petals) with a diameter of 4-5 cm. In the course of the selection process, forms (Mc, Og) with semi-double flowers with 7-10 petals were selected. The flowering of plants depends on weather conditions, takes place from the end of April to the 3rd decade of May and lasts 15-30 days.

When evaluating the *Chaenomeles* gene pool as a fruit crop (*Figure 1b*), the characteristics of the length and weight of the fruit, the thickness of the juicy pericarp were of great importance. As seen in *Figure 2a*, fruit lengths range from 4 cm (Mv) to 7 cm (Ch). Fruit weight is not directly correlated with fruit length, especially when the fruit is elongated pear-shaped or obovate. Fruit weight depends on weather conditions and increases as the fruit ripens. The average weight of *Chaenomeles* fruits in the Tambov region ranges from 20-60 g (*Figure 2b*).

![Figure 2](image-url)

**Figure 2.** Morphological characteristics of *Chaenomeles* fruit, the average for 2010-2012:

a – fruit length, cm; b – fruit weight, g

Pericarp pulp thickness also varies (8–16 mm). In samples of Ukrainian selection, the thickness of the pulp leaves is: Nn, Uk - 9 mm; Bk, Nk - 12 mm, which takes on average 30–55% of the total volume of the fetus. For fruits of Michurin selection, the following pericarp thickness is characteristic: Al, Fg, Gf, Mc, Mv - 11 mm, Og - 16 mm. The yield of *Chaenomeles* in the Tambov region is 1.2–4.4 kg of fruits per bush [11].

3.2 *The study of biochemistry characteristics*  

*Chaenomeles* fruits acquire a characteristic sweet and sour, slightly tart astringent, taste and strong aroma in September. As you can see in Table 1, in terms of the content of soluble dry matter (5.6–13.9%), the fruits are inferior to seed crops, apple or pear, which have 9–16% of dry matter [3]. They are distinguished by a low content of soluble sugars (2.0–4.9%), and the variety samples from the Donetsk region (Bk, Nk, Nn, Um) have 1.5–2 times more sugars than Michurin varieties (Ab, Mv, etc.). The acidity of fruits (2.5–5.0%) is provided by citric, tartaric, malonic, quinic, succinic and other organic acids [13]. The sugar-acid index (0.6–0.9) was determined from the ratio of sugars and acids.

The fruits of *Chaenomeles* contain various vitamins C, A, B1, B2, E [11, 13]. Among the vitamins, ascorbic acid is the most common, with a range of variability from 45 to 210 mg% (*Figure 3a*). In close relationship with vitamin C is valuable phenolic compounds—catechins—which perform a capillary-strengthening function. As shown in *Figure 3b*, the content of catechins in *Chaenomeles*
fruits reaches 810–850 mg% (Og, Um). In our early research, it was found [11] that the maximum amount of catechins is found in fruits that have not reached full maturity, and later, during ripening, it decreases by 3–5 times.

Table 1. The content of dry matter, sugars and titratable acids in Chaenomeles fruits, %

| Sample | Ab | Al | Ch | Fl | Gf | Mc | Mv | Og | Vs | Zp | Bk | Nk | Nn | Um |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Dry matter | 6.6 | 6.5 | 5.6 | 7.6 | 11.8 | 11.5 | 7.6 | 8.6 | 10.8 | 9.6 | 13.9 | 12.3 | 11.6 | 15.1 |
| Sugars | 2.0 | 2.1 | 3.7 | 3.1 | 2.6 | 3.9 | 2.4 | 2.7 | 3.2 | 3.0 | 4.9 | 4.0 | 4.1 | 4.3 |
| Titratable acids | 2.5 | 3.6 | 3.2 | 3.2 | 2.8 | 2.9 | 3.2 | 3.1 | 3.8 | 3.4 | 5.0 | 4.5 | 4.0 | 5.3 |

4. Conclusion
The biodiversity of economically important traits identified at the biological station of Michurinsky State University is a good basis for the selective work of Chaenomeles in the Tambov region.

The gene pool of plants allows selecting promising varieties that have decorative advantages and are suitable as a winter-hardy low-growing fruit crop.

Chaenomeles fruits are saturated with vitamin C (up to 200 mg%), catechins (more than 800 mg%), organic acids and sugars, which increase the consumer qualities of the garden culture and can be used in therapeutic and prophylactic nutrition.

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