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EVALUATION OF BEETROOT (BETA VULGARIS SSP. ESCULENTA VAR. RUBRA) VARIETIES FOR DIFFERENT USES

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Abstract: Species testing of beet is of great importance because it provides information on the quality parameters of the genotype at the place of cultivation. The results of the measurements are intended to suggest the production of raw material suitable for the intended use (canned lettuce, dried beet, juice, etc.). The genotypes that are most suitable for fresh consumption are those that develop a spherical carrot body. Bonel on chernozem soils and Akela on sandy soils showed the best sweet flavour without an earthy aftertaste. This variety was also characterised by a uniform, intense red internal colour and absence of white rings. Processing cylindrical varieties is advised because the final goods seem better when the slices have the same diameter. It is recommended to cultivate Carillon on sandy soil and Lomako on chalky chernozem soil. Selecting a genotype with a high concentration of colorants and water-soluble solids and no earthy aftertaste is worthwhile for beetroot juice manufacturing. The Bonel and Akela types are suggested for beet production on chalky chernozem soil, whereas Carillon demonstrated good performance on sandy soil. The high dry matter content is a crucial factor in determining the quality of preserved beetroots, allowing them to be kept for an extended period of time without compromising their quality. We discovered that three varieties – Larka, Libero, and Bonel – can be cultivated well for this purpose on calcareous chernozem soil; Libero produced very good results. However, in sandy soil types, the Akela, Carillon, and Lomako varieties – of which Akela was the best – proved to be advantageous.

Keywords: beetroot, color material, variety selection, earthy aftertaste, purpose of use, quality parameter

1. Introduction

Beetroot began to be consumed in larger quantities in recent decades, mainly because of its antioxidant-active coloring matter. Its production area has not increased significantly in recent years. In our country, most beetroots are processed, but they are also used directly in the kitchen. In Hungary, the demand for fresh beetroot pulp is lower, on the other hand, consumption of fresh beets is generally preferred abroad. In addition, its leaves are also used as a raw material for cooking vegetables and soups.

It is well known that beetroot pigments are heat sensitive. There are significant differences in color intensity and uniformity between the varieties, which are

significantly influenced by the varietal characteristics and the growing conditions (Takács-Hájos 2011a).

The most common processing methods of beetroot are canning and juice production, as well as the production of beetroot powder and beetroot chips. Fresh beets are often prepared as a side dish, fried or steamed, alongside meats. In addition, its dyes can be extracted and used as food coloring in many products. Its young leaves can be used to make salads, but it can also be found in store chains in salad mixes and semi-finished products.

Beetroot (Beta vulgaris ssp. esculenta var. rubra L.) is a dicotyledonous plant belonging to the Chenopodiaceae family. It comes from the Mediterranean area and is a long-known species that was cultivated even in ancient times, mostly for its leaves. The current form of the beetroot was taken in the XVI. century (Neelwarne 2013), which spread in Central and Eastern Europe via Italy and Germany (Nottingham 2004).

The white ring of the beetroot develops due to secondary thickening. The pigment accumulates in larger quantities in the phloem part. The shape of the root can be round, flat or cylindrical. This determines the way the crop is used, since the round ones are used to make diced products, the flat ones are mostly sold for fresh consumption, and the cylindrical ones are the raw material for sliced products (Takács-Hájos 2011b).

Environmental need – beetroot's heat needs are medium, according to Rubatzky & Yamaguchi (1997), its development is optimal between 16-20 ºC. This is also confirmed by Nottingham (2004), who says that beet grows best at 15-19 ºC. Szabó (1994) established that the root system between 15-20 ºC, while the foliage develops best at values between 21-28 ºC. During the vegetation period, temperatures permanently above 25 ºC can adversely affect development and the accumulation of pigments (Nottingham 2004, Nizioł-Łukaszewska & Gawęda 2014). In Hungary, early cultivation is not really practiced. For the product produced for fresh consumption and marketed in knots. It is important to choose the right variety, where cold tolerance and a weaker tendency to seed stalk formation are key parameters. In addition, varieties with fast root thickening and smaller foliage are suitable for this purpose.

According to its light needs, it is a long-day plant, which means lighting between 12 and 16 hours. It develops well even with a weaker light supply, but in this case the color and sugar content decreases (Szabó 1994).

Its water requirement is significant in the beginning, as it is decisive for uniform emergence and healthy development. In the case of poor water supply, the plant population will be incomplete and heterogeneous (non-uniform). Although it tolerates periodic water shortages, a steady supply of water is decisive for the production of a high-quality crop (Szabó 1994). When it comes to nutrient supply, the increased need for potassium should be highlighted, while the need for nitrogen and phosphorus is moderate. The amount of nitrogen must be monitored, as in the

case of an overdose, the quality of the beets deteriorates and can cause an increased accumulation of nitrates.

Soil requirements – according to Hadnagy et al. (2001), loam, sandy loam and humus sand soil types are favorable for beetroot cultivation, but it can be grown successfully in most production areas with the use of appropriate technology. In terms of soil pH, it develops best in a slightly acidic or neutral environment. According to Rubatzky & Yamaguchi (1997), this is optimal between pH 6-8. In the case of loose sandy soil, nutrient leaching may occur due to frequent watering, as a result of which the taproot of the beet becomes stronger. This deteriorates the quality and increases the cleaning loss (Takácsné Hájos et al. 1994).

Quality-determining parameters – one of the most visible parameters is the uniformity of the inner color. In addition to this, the thin taproot is also highlighted, which determines the shape and aesthetic value of the carrot body. In addition to these, it is primarily the high color content that is decisive. In the production of products that receive heat treatment, it is advisable to use the beet types whose color composition is less heat sensitive. It is a well-known fact that a significant part of the dyes is betanin and other components (isobetanin and prebetanin) occur only in a smaller proportion. According to our studies, there are significant differences between the varieties in this respect (Takácsné Hájos 1999).

Colorant content and composition – for those products where heat treatment is used during production, it is important to choose a raw material with less heat-sensitive colorant components. In these varieties, a significant part of the coloring matter is betanin and a smaller part is other components, such as isobetanin or prebetanin. The two important coloring substances of beet are betanin (E162) and vulgaxanthin, which provide the opportunity to replace artificial coloring substances (Henry 1996). Betanin is used as a natural colorant in the food industry (Zielinska-Przyjemska et al. 2009, Georgiev et al. 2010, Wruss et al. 2015). Experiments have shown that it can also be used as a medical treatment for neuropathic patients due to its antioxidant and anti-inflammatory effects (Kwankaew et al. 2021).

Furthermore, it was established that this pigment can alleviate oxidative stress and inflammation (Slavov et al. 2013). It resists gastrointestinal digestion, is absorbed in the epithelial cells of the intestinal mucosa, and reaches the plasma in an active form (Silva et al. 2022). In addition to their bacteriostatic effect, the dyes have also proven to be suitable for curing malignant tumors.

In the production of high-quality raw materials, special attention must be paid to the freedom from harmful substances. It is well known that beetroot tends to accumulate nitrate, but this can be reduced with appropriate growing conditions and variety selection. Geosmin is the compound responsible for the characteristic earthy taste of beets (trans-1,10-dimethyl-trans-9-decalol), which is produced by soil bacteria (Actinomycetes) living in symbiosis with root system, thus causing the undesirable earthy taste of beets. Its appearance and intensity vary depending on the variety, soil type, processing and storage method (Lu et al. 2003, Liato-Aïder 2017).

The presence of this compound is a limiting factor for many people when consuming beetroot. In case of incorrect storage, e.g. storage in nylon bags, in a warm cellar (10°C), the production of these substances continues on soil-contaminated beets. The content of geosmin, which causes the characteristic earthy taste of roots, can be reduced if the harvested roots are stored with minimal contamination, between 1-5°C temperature and 90-95% humidity, and also by choosing a variety that is less prone to geosmin accumulation.

2. Materials and methods

2.1. Place and time of experiments

The first year's experiment was carried out in the AKIT-DTTI Arboretum Demonstration Garden of the University of Debrecen. We sowed on June 29, 2021, and harvested on October 12, 2021. The soil type is chalky chernozem, on which we tested 6 varieties (4 spherical – Bonel, Libero, Larka, Akela and 2 cylindrical – Carillon, Lomaco).

The second year's experiment was set up in Téglás on April 30, 2022, and harvested on July 27, 2022. In this area, based on a soil test, we determined a sand soil type, where 4 beet varieties were tested (2 spherical – Libero, Akela and 2 cylindrical – Carillon, Lomaco).

Table 1. presents the soil data of the experimental area. Based on the measurements, we declared that the chalky chernozem and sand soil at the site of the experiment is suitable for the implementation of the beetroot experiment.

Table 1.: Results of soil testing (Debrecen, 2021 and Téglás, 2022)

Measured parameters	Chernozem soil	Sandy soil
pH value (KCl)	7.79	6.22
Gold Bound Number (KA)	45	27
Total water soluble salt (m/m) %	0.05	<.02
Lime (m/m) %	1.92	<0.100
Organic carbon (humus content) (m/m) %	2.65	1.44
Phosphorus pentoxide (mg/kg) (AL extract)	854	307
Potassium oxide (mg/kg) (AL extract)	251	378
Nitrate (mg/kg) (KCl soluble)	36.1	110

It can be concluded that there are typically significant differences in the pH of the soil, which is slightly acidic in the case of sandy soil. In the same way, we found a very low value for the salt content and the amount of carbonated lime for sandy

soil. Among the mineral elements, only the potassium and nitrate content were higher than in the chernozem soil.

The plot size at both sites was 5 m x 0.35 m using a randomized block design with 4 replications and 1-1 border rows. The seeds were placed 2-3 cm deep in the soil. The thinning was realized in the state of 2-4 leaves, ensuring a distance between plants of 5-7 cm. We used drip irrigation, 2-3 times a week, with 30 mm water doses.

2.2. Measurements

After sampling, the following morphological measurements were taken: root diameter (mm); root length (mm).

During the sensory evaluation, we evaluated the following parameters:

- the intensity of the inner color (1 – red … 5 – deep red)
- degree of appearance of white rings (1 – white ring … 3 – uniform inner color)
- taste of beetroot (1 – strong earthy taste, bitter aftertaste … 5 – sweet, free of earthy taste)

The laboratory measurements – quality-determining indicators are as follows:

- Determination of total dry matter content (%), for which the homogenized samples were dried at 105°C until the mass was constant, based on Chapter 2 of the MSZ-08-1783-1:1983 standard.
- Water-soluble dry matter content (Brix%) was determined with a hand-held digital refractometer.

3. Results

3.1. Morphological parameters

These properties determine the way beetroot are processed. On chernozem soil, the first four varieties (Bonel, Libero, Larka, Akela) are spherical, which is confirmed by the shape index close to 1.00. These varieties are used for the production of diced preparations. In contrast, the Carillon and Lomako shape indexes were 2.72 and 3.74, respectively, which characterize the cylindrical root body shape (*Table 2*). It is advisable to produce sliced products from beetroot varieties of this type. Two spherical (Libero, Akela) and two cylindrical (Carillon, Lomako) varieties were examined on sandy soil.

Table 2.: Evolution of shape index (length/diameter) on chernozem and sandy soils (Debrecen, 2021 and Téglás, 2022)

Genotype/Parameter	Shape index (average ± SD) (length/diameter)

	Chernozem soil	Sandy soil
Bonel	0.99 ± 0.20	-
Libero	1.04 ± 0.09	0.84 ± 0.13
Larka	1.02 ± 0.16	-
Akela	1.02 ± 0.19	0.86 ± 0.12
Carillon	2.72 ± 0.38	3.18 ± 0.66
Lomako	3.74 ± 0.40	3.48 ± 0.66

3.2. The result of the sensory examination

Table 3.: Results of sensory tests in an experiment on chernozem and sand soil (Debrecen, 2021 and Téglás, 2022)

Genotype/Parameter	Intensity of inner color[1] (1-5) (average ± SD)		Degree of white ring[2] (1-3) (average ± SD)		Taste[3] (1-5) (average ± SD)	
Type of soil	Chernozem soil	Sandy soil	Chernozem soil	Sandy soil	Chernozem soil	Sandy soil
Bonel	3.40 ± 0.89	-	1.80 ± 0.45	-	4.40 ± 0.89	-
Libero	3.00 ± 0.00	4.30 ± 0.67	2.20 ± 0.45	2.60 ± 0.52	2.40 ± 0.55	4.40 ± 0.70
Larka	3.40 ± 0.55	-	2.20 ± 0.45	-	3.60 ± 0.55	-
Akela	3.40 ± 0.55	4.30 ± 0.67	2.00 ± 0.71	2,70 ± 0.48	3.20 ± 0.45	4.70 ± 0.67
Carillon	3.20 ± 0.84	4.40 ± 0.70	1.60 ± 0.89	1.60 ± 0.70	3.40 ± 0.55	4.90 ± 0.32
Lomako	4.00 ± 0.71	4.30 ± 0.67	2.20 ± 0.45	2.50 ± 0.53	3.80 ± 0.45	4.60 ± 0.70

[1] the intensity of the inner color (1 – red … 5 – deep red color)
[2] degree of appearance of white rings (1 – white ring … 3 – uniform inner color)
[3] taste of beetroot (1 – strong earthy taste, bitter aftertaste … 5 – sweet, free of earthy taste)

In the experiment conducted on chernozem soil, the Lomako type had the most intense and uniform color (*Table 3*). It is a well-known fact that the development of the inner color is determined by the genetic characteristics and the cultivation method. In addition, an excellent interior color can be achieved with a uniform water supply and a harmonious supply of nutrients.

The white ring is a genetically coded characteristic of the variety, but it is also affected by uneven water supply. In the experiment, we found an increased appearance of white rings on the beets in the Bonel and Carillon varieties.

The characteristic earthy taste of root is determined by the geosmin content. This unpleasant taste can be reduced by proper storage and variety selection. This unpleasant aftertaste appeared less in varieties grown on sandy soil. This can be explained by the looser soil structure, because it did not really provide a suitable environment for the development of bacteria, and thus for the synthesis of geosmin.

The largest part of the water-soluble dry matter content is sugar, which determines the sweet taste of beetroot. In our experiment, on chernozem soil, the Bonel variety was the sweetest, with almost no earthy taste at all. In contrast, Libero was the variety with the most geosmin taste, and we could also feel a bitter aftertaste with this genotype.

An almost identical, uniform inner color intensity (~4.30) developed on sandy soil. The degree of white ringing was the most characteristic of the Carillon variety, where the light and dark rings were clearly separated. When evaluating the taste, each genotype received a similarly high value (sweet taste) and none of them had an earthy aftertaste.

3.3. Evaluation of dry matter content

Evolution of total dry matter content (%) – This content indicator is mostly influenced by environmental parameters, but there are also significant differences between varieties.

The dry matter content is an important parameter in both temporary and winter storage. It was typical for chernozem soil that the dry matter content mostly showed values below ~12%. The highest value was measured for Libero (12.64%), while the lowest was shown for Akela (9.53%) and Carillon (9.50%) (*Figure 1*).

In the experiment carried out on sandy soil, a very high value (17.06-18.68%) was measured for three varieties (Akela, Carillon, Lomako) (*Figure 2*), while the lowest value was found for the Libero variety (12.40%). Among the three mentioned varieties, Akela stood out with its very high (18.68%) dry matter content.

Figure 1.: Evolution of total dry matter content (%) in varieties grown on chernozem soil (Debrecen, 2021)

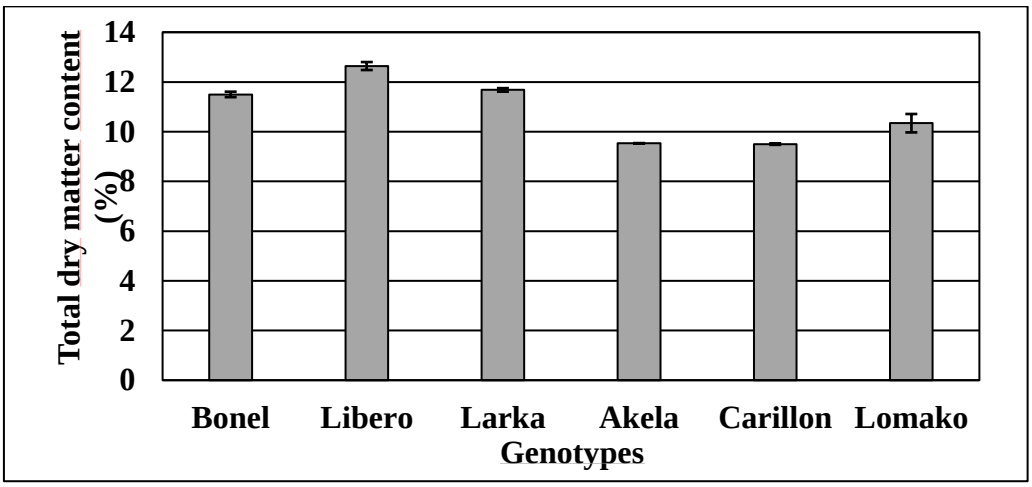
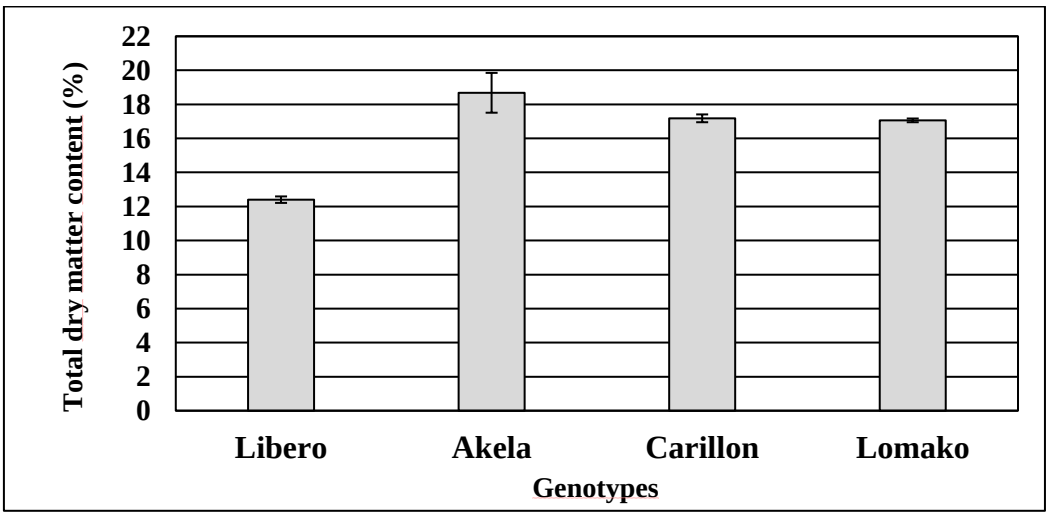


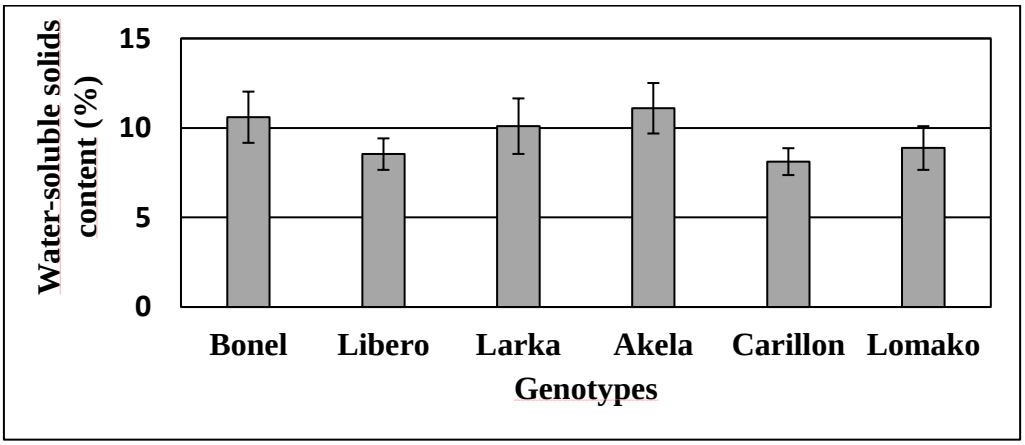
Figure 2.: Evolution of total dry matter content (%) in varieties grown on sandy soil (Téglás, 2022)



Evaluation of water-soluble dry matter content (Brix%) – the measurements were carried out with a digital Brix meter. In this measurement, most of the compounds that can be determined are sugar, which determines the sweet taste of the beetroot. Its quantity is influenced by the variety, environmental factors and the

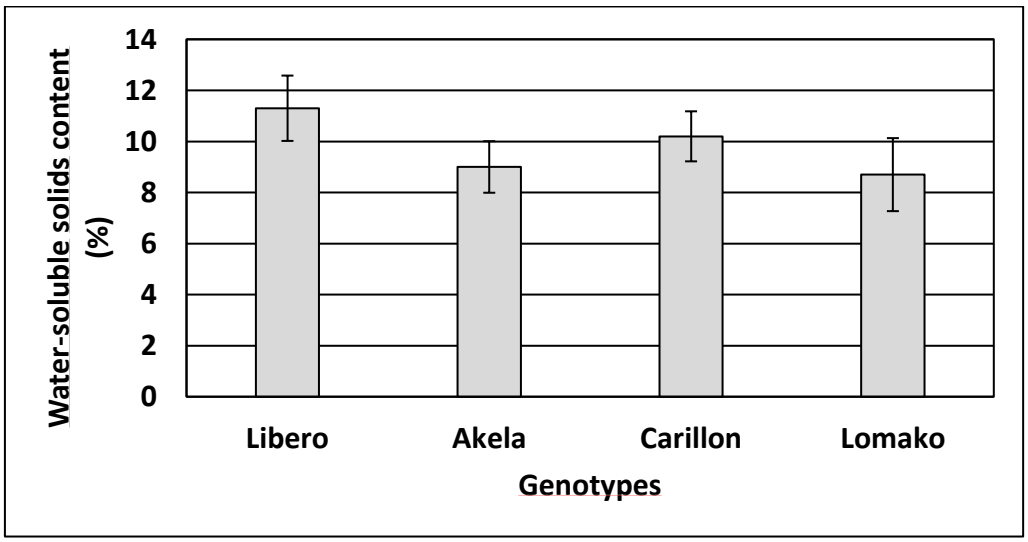
applied cultivation technology. On chernozem soil, we measured a very high value (11.10%) for the Akela variety. While a lower water-soluble dry matter content was found for the varieties Libero (8.54%), Carillon (8.12%) and Lomako (8.88%) (*Figure 3*).

Figure 3.: Evolution of water-soluble dry matter content (%) in varieties grown on chernozem soil (Debrecen, 2021)



On sandy soil, we measured the highest water-soluble dry matter content (11.3%) for the Libero variety (*Figure 4*), while Akela (9.00%) and Lomako (8.70%) showed the lowest values.

Figure 4.: Evolution of water-soluble dry matter content (%) in varieties grown on sandy soil (Téglás, 2022)



4. Discussion

Based on the results of the experiment, the following conclusions can be made. It is well known that the genotypes that develop a spherical root are the most suitable for fresh consumption. At the same time, these varieties are also used for the production of diced beetroot dishes. On chernozem soil, we found a higher sugar content for Bonel, while on sandy soil, Akela showed the sweetest taste, without an earthy aftertaste. In addition, the Akela variety has an intense red inner color and an enlarged root without white rings.

It can be concluded that Lomako is recommended for chernozem soil with lime deposits, while Carillon is recommended for sandy soil.

Based on these results, it can be concluded that the soil parameters and the time of sowing significantly influenced the development of the morphological parameters, as well as the inner content that determine the quality of the beetroot.

Dry matter content is an important factor in shelf life. On chalky chernozem soils, the varieties typically showed values below ~12%. The highest dry matter content was measured at Libero (12.64%). Akela grown on sandy soil was outstanding with its dry matter content of 18.68%, which can be a very favorable storage indicator for its cultivation in this spring period.

When measuring the water-soluble dry matter content, most of the compounds that can be determined are sugar, which gives the beetroot its sweet taste. In the experiment conducted on chernozem soil, the Akela variety showed a very outstanding value (11.10%). When grown on sandy soil, Libero (11.3%) has the highest Brix value.

On the other hand, for the production of dried fruit, it is recommended to grow those varieties that have a high color content combined with a low water-soluble dry matter (sugar) content. The high carbohydrate content causes caramelization and browning during heat treatment, thus reducing the aesthetic appearance of the finished product, as well as its quality.

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