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COMPARATIVE STUDY OF THE NUTRITIONAL COMPOSITION OF MAJOR LEGUME SPECIES

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Abstract

Legumes are essential in traditional diets, providing nutritional and health benefits, while also supporting economic stability and environmental sustainability. This study evaluates the nutritional quality of three legume species: Vicia faba L., Pisum sativum L., and Phaseolus vulgaris L., by analysing total dry matter, total soluble solids (TSS) and titratable acidity. These parameters were measured using standardized methodologies on selected genotypes cultivated under controlled conditions. Significant inter- and intra-species variability was observed. Broad bean genotypes, especially L5, exhibited the highest dry matter content (34.55%), which is often associated with increased concentrations of essential nutrients. Pea genotypes, such as L6, demonstrated elevated TSS levels (>14°Brix), suggesting potential for fresh market applications. Common bean genotypes, particularly the climbing variety L135, showed high TSS values (16.03°Brix) and moderate acidity, underscoring their suitability for processing. These results emphasize the importance of genetic diversity in legumes to optimize nutritional value and processing potential. This study supports the development of targeted cultivation and breeding strategies to improve legume productivity and quality under diverse environmental conditions, particularly in the context of climate change.

***Key words**: legumes, nutritional quality, Vicia faba L., Pisum sativum L., Phaseolus vulgaris L.*

INTRODUCTION

Legumes belonging to the Fabaceae family, have been a cornerstone of human nutrition since ancient times, with their seeds playing a vital role in sustaining diets across cultures (Martín-Cabrejas, 2019).

Nowadays, legumes are highly valued for their exceptional nutritional benefits and associated health advantages (Trinidad et al., 2010), as well as their vital economic and environmental roles in promoting a sustainable future (Reckling et al., 2016; Brezeanu et al., 2021).

Common legumes used for human consumption include peas, broad beans, lentils, soybeans, lotus, lupins, mung bean, sprouts, green beans and peanuts and are referred to as food legumes or grain legumes and they are classified into two categories: oil seeds and pulses (Maphosa & Jideani, 2017).

Legume crops play a vital role in sustainable agriculture and have the ability to adapt to climate change, thriving in arid regions with scarce or unpredictable rainfall (Duc et al., 2015; Stagnari et al., 2017). In addition, legumes are widely recognized for their unique ability to fix atmospheric nitrogen through a symbiotic relationship with rhizobia bacteria, which form nodules on their roots. This process, called biological nitrogen fixation (BNF), transforms atmospheric nitrogen into a plant-usable form, boosting soil fertility and minimizing reliance on chemical fertilizers, resulting in reduced greenhouse gas emissions (Kebede, 2021).

Also, legumes serve as diversification crops in agroecosystems dominated by a few major species, helping to disrupt pest and disease cycles while addressing the plant protein production deficit in many regions worldwide, including Europe (Peoples et al., 2009; Stagnari et al., 2017).

The consumption of legumes, including lentils, chickpeas, black beans, and soybeans, has been reported to be associated with numerous beneficial health attributes, such as antiatherogenic, hypocholesterolemic, hypoglycemic, and anticarcinogenic properties (Ndidi et al., 2014; Messina, 2019).

The nutritional value of legumes is attracting significant attention in developed countries due to the growing demand for healthy foods. They are rich in proteins, carbohydrates, and dietary fibres, as well as other essential nutrients. (Bouchenak et al., 2013). With increasing global demand for nutrient-dense food, legumes like broad bean (*Vicia faba* L.), pea (*Pisum sativum* L.), and common bean (*Phaseolus vulgaris* L.) are recognized as vital components of a balanced diet (Dhull et al., 2022).

This study aims to evaluate the nutritional quality of Romanian selected legume genotypes (pea, broad bean and common bean) by examining key parameters: total dry matter (indicator of nutrient density), total soluble solids (related to energy value and taste), and titratable acidity (important for processing and flavour). By analysing these traits across species and genotypes, this research highlights the genetic diversity and adaptability of legumes for nutritional and industrial applications.

MATERIALS AND METHODS

The study analysed a total of 13 broad bean accessions (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L17, L21, L22), 15 pea accessions (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15), 8 dwarf bean accessions (L1, L4, L5, L34, L35, L36, L39, L40), and 6 climbing bean accessions (L104, L112, L115, L125, L136, L141). These local cultivars were either gathered from various regions of Romania or developed through segregation and selection processes.

The experiment was conducted in the year 2024 at the experimental plot of the Vegetable Research and Development Station Buzau (45.13711°N, 26.81711°E and 95 m a.s.l.) in Buzau County, Romania. The crop management practices employed were specific to *Vicia faba* L., *Pisum sativum* L., and *Phaseolus vulgaris* L., as previously detailed in our earlier study (Tănase et al., 2020; Gherase et al., 2021; Barcanu et al., 2022).

Nutritional analysis was conducted to assess the following parameters: Total Dry Matter (DM), measured using the AOAC 930.04 method (Loss on Drying); Total Soluble Solids (TSS), determined with a KERN OPTICS refractometer and expressed in °Brix (AOAC 932.12); and Titratable Acidity (TA), evaluated with a TitroLine Easy titrator and expressed as a percentage of citric acid (AOAC 942.15).

Data analysis was performed using one-way ANOVA at a 95% confidence interval, followed by Duncan's test for multiple comparisons.

RESULTS AND DISCUSSIONS

Climatic data

In 2024, Buzău area experienced extreme climatic events, with the hottest summer on record (Figure 1), marked by intense heatwaves, record-breaking temperatures, and prolonged drought. These conditions alternated with short episodes of intense rainfall, highlighting the uneven distribution of precipitation. The significant increase in annual average temperatures and greater variability in precipitation reflect the impact of global climate change on the region. These changes pose challenges for agriculture, particularly vegetable farming, and the management of natural resources.

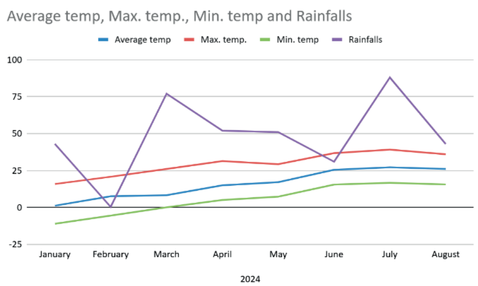

Figure 1. The meteorological data for the year 2024

Vicia faba L.

Phenological observations were also made for the broad bean accessions (data not shown). The results obtained demonstrate that the L2 accession exhibits the earliest development, followed by L3 and L5, whereas L6 and L17 are positioned at the opposite end of the spectrum, representing the latest maturing accessions.

The Total Soluble Solids (TSS) content in faba beans plays a crucial role for breeders focused on improving seed quality and for processors looking to maximize the nutritional benefits of faba bean-derived products (Ahmed et al., 2022). Our results indicated that early varieties (L2-17.03°Brix, L8-18.09°Brix) had a higher TSS content compared to late varieties (L6-8.18°Brix, L4-8.7°Brix). Studies by Pinillos et al. (2011), also suggest that higher TSS values may be associated with earlier maturation of the accessions. The total soluble solids content ranged from 8.18°Brix (L7) to 18.09°Brix (L8) as shown in Figure 2.

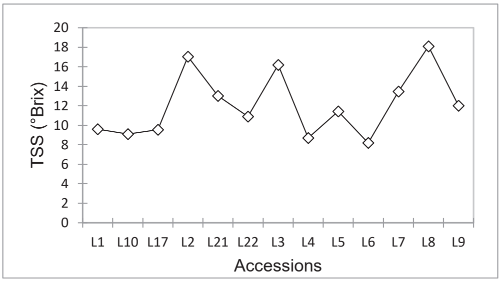

Figure 2. The mean values of TSS content of broad bean accessions

According to De Cillis et al. (2019), TA can be regarded as a key quality attribute for processing faba beans, as, similar to other vegetables, higher TA values help in better managing microbial spoilage in the final product. Acidity also affects the colour and overall stability of vegetables. Fruits and vegetables with low levels of organic acids may lack their characteristic flavour (Kader et al., 2008). For the analysed accessions (Figure 3), it was observed that L5 had the highest TA at 1.33% citric acid, while L8, at the opposite end, exhibited the lowest value, with only 0.47% citric acid.

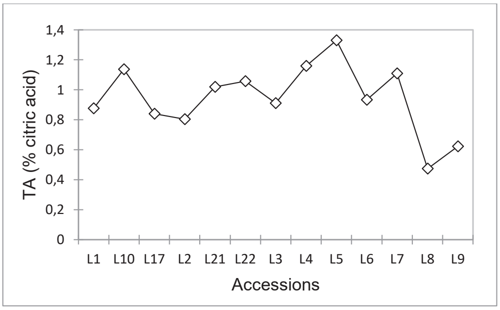

Figure 3. The mean values of TA content of broad bean accessions

The total dry matter content (Figure 4) ranged from 20.76% (L10) to 34.55% (L5). Additionally, a positive correlation (r = 0.58) was observed between dry matter content and grain weight. This suggests that larger and denser grains tend to have a higher dry matter content, which reflects a greater nutritional value.

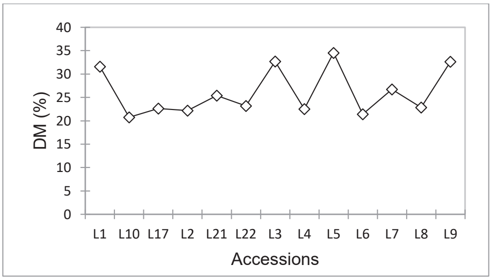

Figure 4. The mean values of DM content of broad bean accessions

***Pisum sativum* L.**

A fundamental quality parameter of peas is the total soluble solids (TSS) content, measured in degrees Brix (°Brix). Studies conducted by Nleya et al. (2014) and García-García et al. (2022), suggest that high-quality peas should have a hight sugar content to be classified as sweet. In this study, TSS content ranging from 14.54°Brix (L13) to 39.99°Brix (L11) (Figure 5), therefore, all the studied accessions can be classified as sweet varieties.

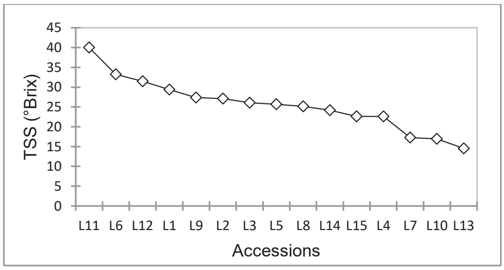

Figure 5. The mean values of TSS content of pea accessions

Total acidity affects the final flavour profile of peas, particularly when incorporated into formulations containing acidic ingredients. Peas are generally characterized by a low acidity level, which contributes to their high digestibility and suitability for inclusion in diets designed for individuals with gastric sensitivity (Devi et al., 2019). In the present study, the titratable acidity of the analysed lines exhibited variation (Figure 6), ranging from 1.40% (L10) to 2.40% (L7).

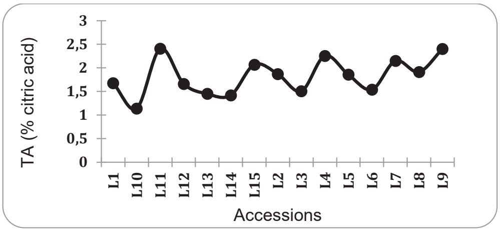

Figure 6. The mean values of TA content of pea accessions

According to Wu et al. (2023), the total dry matter content of peas typically ranges between 20% and 30%, depending on the pea variety and cultivation conditions. In our study, the recorded values fluctuated between 21.87% (L4) and 38.33% (L1) (Figure 7).

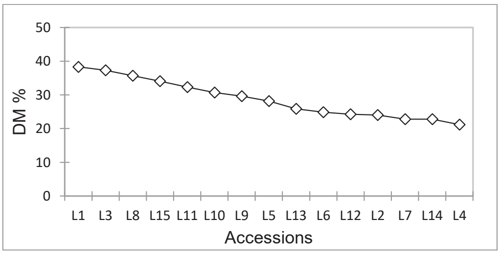

Figure 7. The mean values of DM content of pea accessions

***Phaseolus vulgaris* L.**

Soluble compounds, particularly sugars and organic acids, are fundamental to the energetic value and sensory properties of beans. A high total TSS content can be associated with an increased energy value, which may be relevant for the formulation of food products tailored to specific dietary requirements or nutritional needs (Bai et al., 2024).

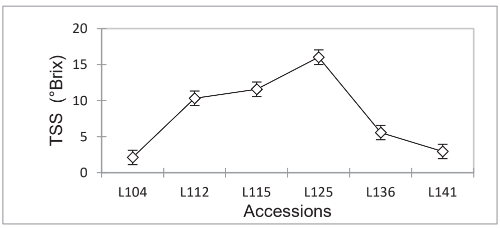

Figure 8. The mean values of TSS content of climbing bean accessions

In this study, TSS values ranged from 2.12°Brix (L104) to 16.03°Brix (L135) for climbing (Figure 8) beans and from 2.85°Brix (L4) to 13.23°Brix (L34) for dwarf beans (Figure 9).

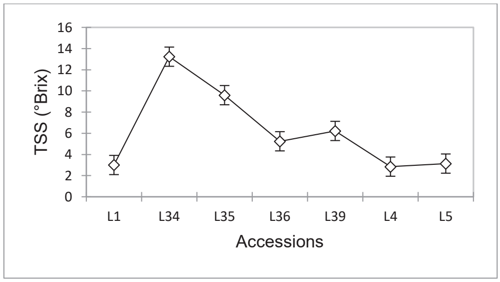

Figure 9. The mean values of TSS content of dwarf bean accessions

The acidity of beans represents a critical parameter in assessing both the quality and safety of bean-derived products, particularly in the context of processing and preservation. Acidity plays a pivotal role in shaping the sensory profile of the product while also influencing its resistance to microbial proliferation, including bacterial and fungal contaminants.

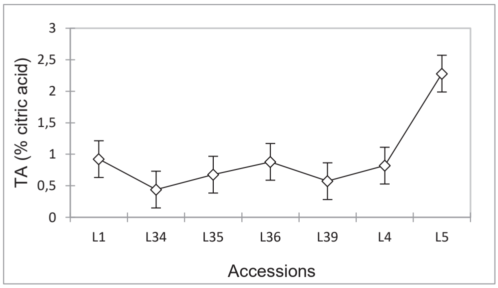

Figure 10. The mean values of TA content of dwarf bean accessions

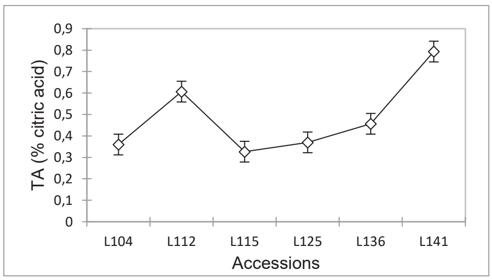

Figure 11. The mean values of TA content of climbing bean accessions

In general, beans are characterized by relatively low acidity levels (Gil et al., 2021), a trend corroborated by the findings of this study (Figure 10 and Figure 11). Specifically, the TA of climbing bean accessions ranged from 0.32 g/L (L115) to 0.79 g/L (L141), whereas dwarf bean accessions exhibited values ranging between 0.4 g/L and 2.20 g/L.
Total dry matter is another key indicator in the assessment of bean quality, as it determines both its nutritional value and its potential for various industrial applications, including the production of flour, protein concentrates, and other food products (Siddiq & Uebersax, 2022). The studied accessions exhibited total dry matter content ranging from 5.44% (L115) to 30.63% (L141) for climbing bean (Figure 12) and from 6.53% (L5) to 19.7% (L34) for dwarf beans (Figure 13). Overall, our findings indicate that climbing bean accessions, generally have a higher dry matter content than dwarf bean accessions, making them more suitable for flour production.

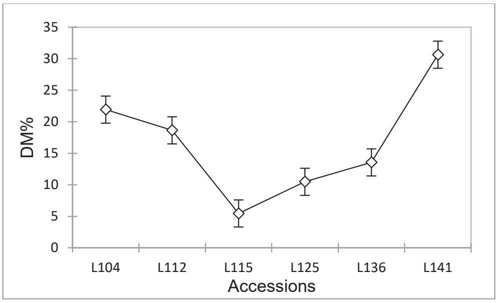

Figure 12. The mean values of DM content of climbing bean accessions

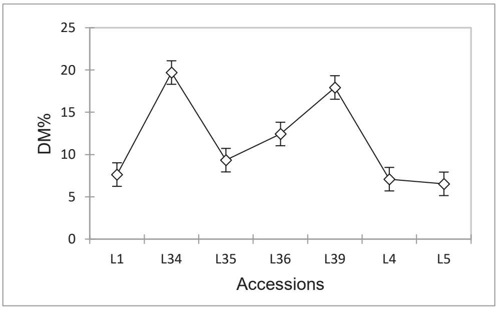

Figure 13. The mean values of DM content of dwarf bean accessions

CONCLUSIONS

This study highlights the significant variability in nutritional quality among legume species and genotypes. Broad beans (L5, L7) showed exceptional dry matter content, making them ideal for industrial applications. Peas (L6, L13) exhibited superior TSS values, suitable for fresh consumption, while climbing beans (L135, L141) showed high TSS, enhancing their potential for processing and storage.
These findings underscore the importance of exploiting genetic diversity to meet nutritional and processing needs. Future research should focus on optimizing environmental conditions and genotype selection to enhance the adaptability and nutritional profile of legumes under stress conditions such as drought or extreme temperatures.

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