

INFLUENCE OF CLIMATIC CONDITIONS ON POTATO TUBERS QUALITY

Nina BĂRĂSCU^{1,2}, Manuela HERMEZIU¹, Anca-Camelia URDĂ³, Lorena ADAM¹

¹National Institute of Research and Development for Potato and Sugar Beet Brasov,
2 Fundaturii Street, Brasov, Romania

²Faculty of Food and Tourism, Transylvania University, 148 Castelului Street, Brasov, Romania

³Research and Development Station for Agriculture Turda, 27 Agriculturii Street,
Turda, Cluj, Romania

Corresponding author email: nina.barascu@gmail.com

Abstract

The classification of potato tubers into usage types (human consumption, industrial processing, or animal feeding), in addition to factors such as variety and fertilization, can be influenced by the crop climatic conditions. Over three years of non-irrigated potato crop in Țara Bârsei - Brașov (2022-2024), the varying climatic conditions affected the culinary and technological quality parameters of potato tubers. The dry matter content, consistency, mealiness, moisture of the potato tubers, and the structure of starch granules were influenced by air temperature and precipitation levels during the growing season, as these conditions impact growth, metabolism and the accumulation of reserve substances in the tubers. The variation in these culinary quality traits of potato tubers was analyzed across the production of 12 potato varieties. The varieties were classified into the following usage types: A, AB, B, and BC. Over the three years of observations, the varieties Azaria and Ervant recorded the highest and respectively the lowest accumulation of dry matter. Careful management of environmental factors, combined with the use of well-adapted varieties, can optimize the potato quality for various usage types.

Key words: potato, climatic condition, tubers quality.

INTRODUCTION

Several factors influence the quality of potato tubers, affecting their technological quality, texture, taste, cooking properties, and overall market value. These factors can be categorized into environmental conditions, agricultural practices, genetic traits, and post-harvest handling. Drought stress is a major constraint on potato production, as adequate water availability is essential for achieving high yields and maintaining tuber quality (Rudack et al., 2017). Research on the influence of climatic conditions on the quality parameters of potato tubers showed that drought stress caused by insufficient precipitation has been found to limit potato plant growth and development by reducing photosynthetic activities in leaves, resulting in decreased tuber yield and tuber dry mass (Nasir and Toth, 2022). Rymuza et al. (2015) showed that starch content in tubers of medium-early potato cultivars depends more on precipitation than on thermal conditions. Soil

water stress restrict potato plant growth and development, reduce amylase activity, thereby reduce tuber starch accumulation (Yong Zhen Ma et al., 2024). Short period of water deficit especially in the vegetative and tuberization phases, have negative impacts while short period of water excess have lightly positive impacts on potato vegetative development and tuber yield and quality (Wagg et al., 2021).

Water shortage during the growing season contribute to a deterioration of the potato culinary characteristics, while, on the contrary, excess water contribute to their improvement (Bienia et al., 2020).

Starch content is an important quality indicator of potatoes (Wang et al., 2021). The starch content of potato tubers is closely related to their crushing on boiling, consistency, mealiness, and moisture content. Potatoes with high starch content tend to disintegrate or become soft and fluffy when boiled, whereas those with lower starch content remain firm and intact. High-starch potatoes have a drier, mealy

texture, whereas low-starch varieties are smoother and more cohesive. High-starch potatoes have lower moisture content, making them drier, while low-starch potatoes have higher moisture content, making them more waxy and dense.

The main objective of this study was to identify potato varieties with stability of the technological and culinary tubers quality characteristics under the variability of hydrothermal conditions.

MATERIALS AND METHODS

Research on the tuber quality of ten mid-early potato varieties (Braşovia, Castrum, Marvis, Sarmis, Sevestia, Azaria, Darilena, Asinaria, Cezarina, Ervant) and two mid-late potato varieties (Cosiana, Foresta) cultivated in the experimental field of National Institute for Research and Development for Potato and Sugar Beet (NIRDPSB) Braşov, was carried out from 2022 to 2024.

These twelve potato varieties developed through the breeding program of NIRDPSB Braşov, were monitored regarding the stability of the technological and culinary tubers quality characteristics under the influence of variability of climatic condition, air temperature (°C) and amount of rainfall (mm).

All varieties were grown under the same agroclimatic conditions over the three years of study, in a non-irrigated crop, following the same cultivation technology. Potato planting took place on April 9 in 2022, April 28 in 2023, and April 10 in 2024, while harvesting was carried out on September 19 in 2022, September 13 in 2023, and September 19 in 2024.

The determination of the dry matter content (%) in potato tubers was performed using the oven-drying method, while the starch content (%) was measured based on the determination of the specific gravity of the tubers using the Polikeit balance and the positive correlation between specific gravity, dry matter content and starch content.

The culinary quality characters (crushing on boiling, consistency, mealiness, and moisture content of the tubers, as well as the structure of starch granules) were evaluated through sensory analysis by the trained panellists, after the tubers were previously boiled at steam, at 100°C for 50 minutes. The tubers were uniform in size, shape and maturity.

The sensory analysis of culinary quality characters was conducted using a hedonic scale from 1 to 4 (Băraşcu et al., 2019, after Lugt and Goodijk, 1959), as follows:

- crushing on boiling: 1 = stay entire; 2 = crushing less; 3 = crushing; 4 = crushing more;
- consistency: 1 = very consistent; 2 = consistent; 3 = less consistent; 4 = uneven consistency;
- mealiness: 1 = waxy; 2 = less mealy; 3 = mealy; 4 = very mealy;
- moisture: 1 = wet; 2 = less humid; 3 = rather dry; 4 = dry;
- starch structure: 1 = fine granules; 2 = suitable fine granules; 3 = large granules; 4 = very large granules.

The scores obtained for each of the five characters were summed and were classified into value ranges corresponding to the following culinary use types: A (5.0-7.5); AB (7.6-10.0); B (10.1-12.5); BC (12.6-15.0). Potato tubers from types A and AB did not crumble, remained whole, were consistent, and had fine starch granules. These potatoes were ideal for salads but could also be used in various other dishes. Potato tubers from types B and BC were sufficiently firm, slightly crushed when boiled, had a mildly moist texture, and had a suitably fine structure of starch granules. Potatoes of this type were versatile and were suitable for various culinary applications.

The statistical analysis was conducted using Microsoft Excel and PAST 4 software, encompassing descriptive statistics, Pearson correlation analysis, and stability assessment based on environmental indices. Past 4 was used for the Pearson correlation coefficient matrix analysis and for generating mosaic plots, which display the obtained values using heat maps. The stability analysis of quality parameters was conducted using Microsoft Excel, following the method proposed by Eberhart and Russell (1966), which evaluates stability based on environmental conditions.

RESULTS AND DISCUSSIONS

Except for the year 2023, when a total rainfall of 419 mm was recorded during the critical period for potato cultivation, the crop faced drought periods in the other two years. These

drought conditions, combined with temperatures up to 3°C above the multiannual average, negatively affected not only plant

growth and development but also the culinary quality and certain quality parameters of the tubers (Figure 1).

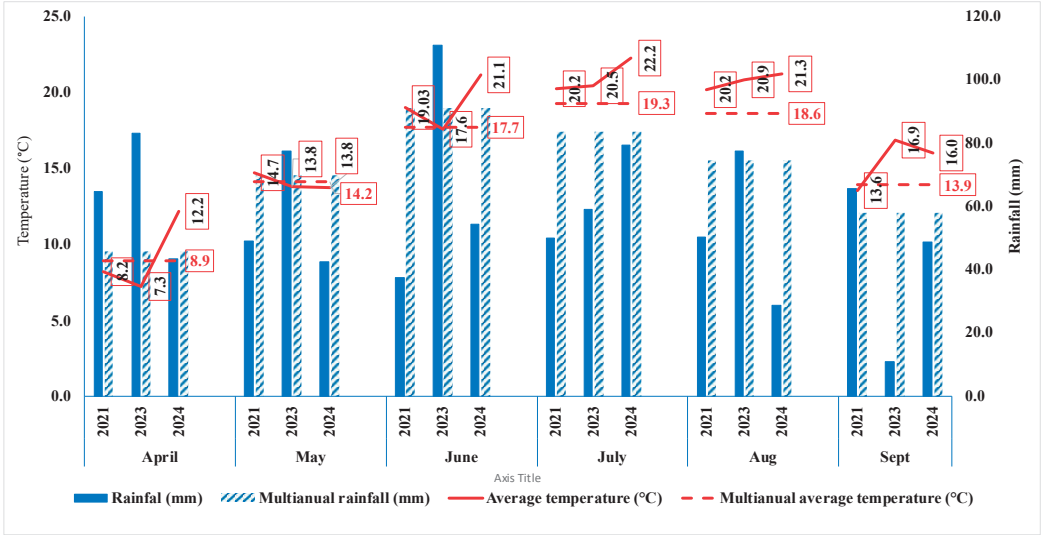


Figure 1. Temperatures and rainfall during the potato growing season (April-September, 2022-2024, Braşov)

During the three years of experimentation, the dry matter and starch content of the potato tubers were also determined. The dry matter content ranged from 16.8%, recorded in 2024

for the Ervant variety, to 24.1%, obtained for the Azaria variety in the first year of experimentation (Figure 2).

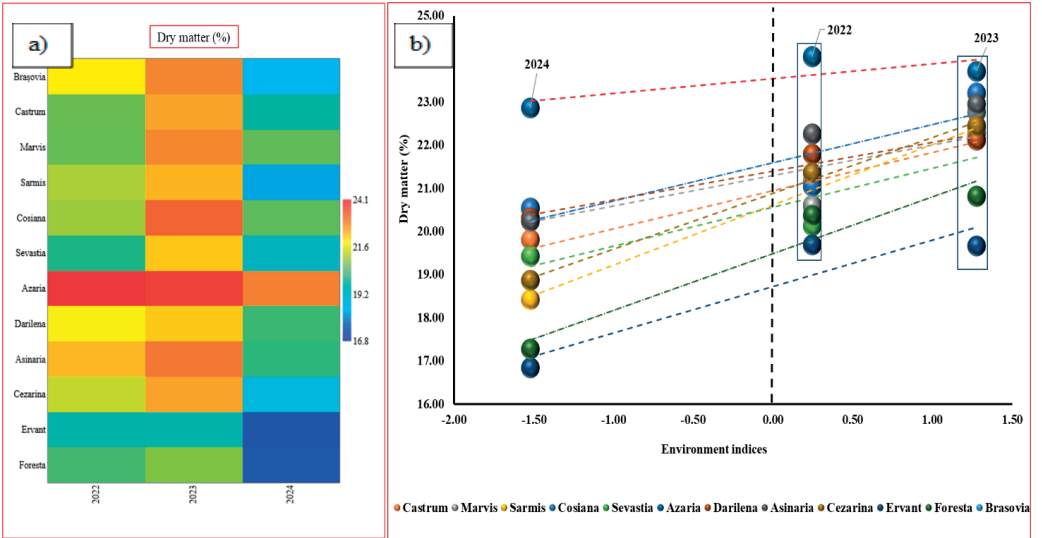


Figure 2. Dry matter content in potato tubers (a) and stability analysis of this quality parameter based on environmental indices (b)

The stability analysis of dry matter content, based on environmental indices obtained over

the three years for the 12 potato varieties, suggests that higher values were recorded in

2022 and 2023, while 2024 proved unfavorable for dry matter accumulation. In terms of stability, Azaria variety stood out, showing pronounced stability, as indicated by the regression line being nearly parallel to the Ox axis (Figure 2).

Regarding starch content (Figure 3), values ranged from 10.1%, recorded for the Ervant, Foresta, and Sevastia varieties in 2024, as well as for Ervant in 2022, to 14.8%, achieved by Asinaria variety in 2023. The stability analysis of starch content, based on environmental conditions over the three years of

experimentation, showed that, in general, higher starch accumulation occurred in 2023 and 2022, while 2024 was less favorable for this quality parameter in tubers. As Yong Zhen Ma et al., 2024 show in their research, soil water stress significantly reduced starch accumulation in potato tubers.

Regarding starch content stability over the three years, the Azaria and Ervant varieties stood out with lower fluctuations in values from year to year, indicating a more consistent performance across different environmental conditions.

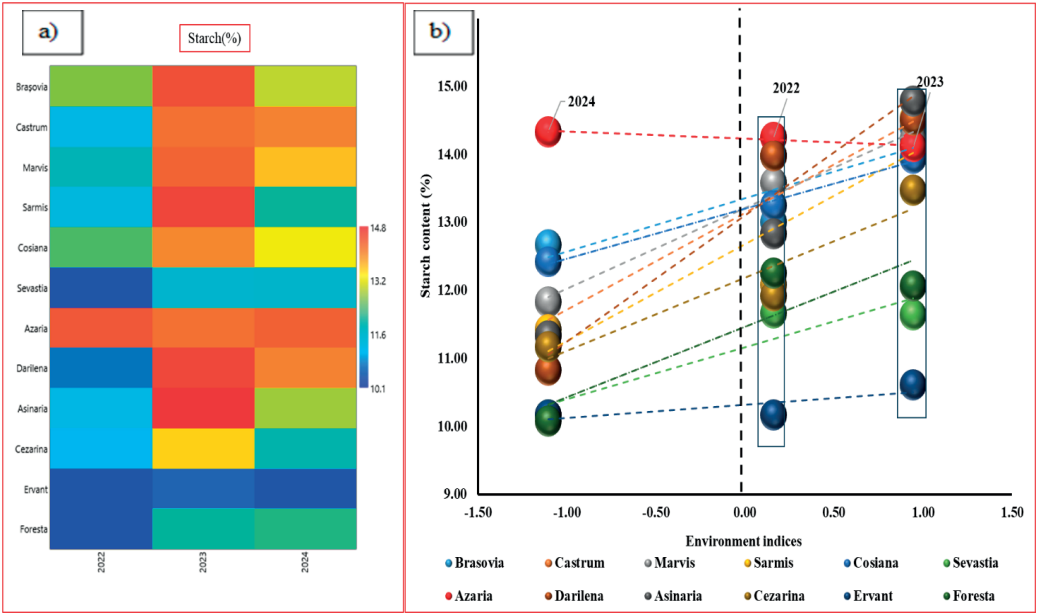


Figure 3. Starch content in potato tubers (a) and stability analysis of this quality parameter based on environmental indices (b)

The culinary quality of the studied biological material varied significantly, depended on both genotype and experimental year (Figure 4). Regarding crushing on boiling, scores ranged from 1 to 2.9, while consistency varied between 1 and 3.3. Mealy texture was evaluated between 1.1 and 3.1, moisture content had values ranging from 1.3 to 2.9, and starch structure varied between 1.3 and 2.8. Castrum variety received the highest score for crushing on boiling in 2023 (2.9) and for consistency in 2022 (3.3). In the second experimental year, mealy texture scores were highest for Cosiana, Azaria, and Cezarina varieties, with Azaria also achieving high

scores for starch structure in 2023 and moisture content in the first two experimental years.

By summing the scores obtained for culinary quality indicators, the genotypes generally fall into the following usage types: A, AB, B and BC. Based on its performance over the three experimental years, Sevastia variety had the lowest total score for culinary quality indicators, which placed it in category A, regardless of the experimental year. This variety was characterized by firm potatoes, suitable for salads, with tubers that did not crumble, remained intact, were non-mealy, moist, and had a fine texture.

Sarmis, Cezarina, Ervant, and Foresta varieties, based on the average sum of their culinary quality scores, fell into the AB type, and

Castrum and Azaria varieties fell into the BC type.

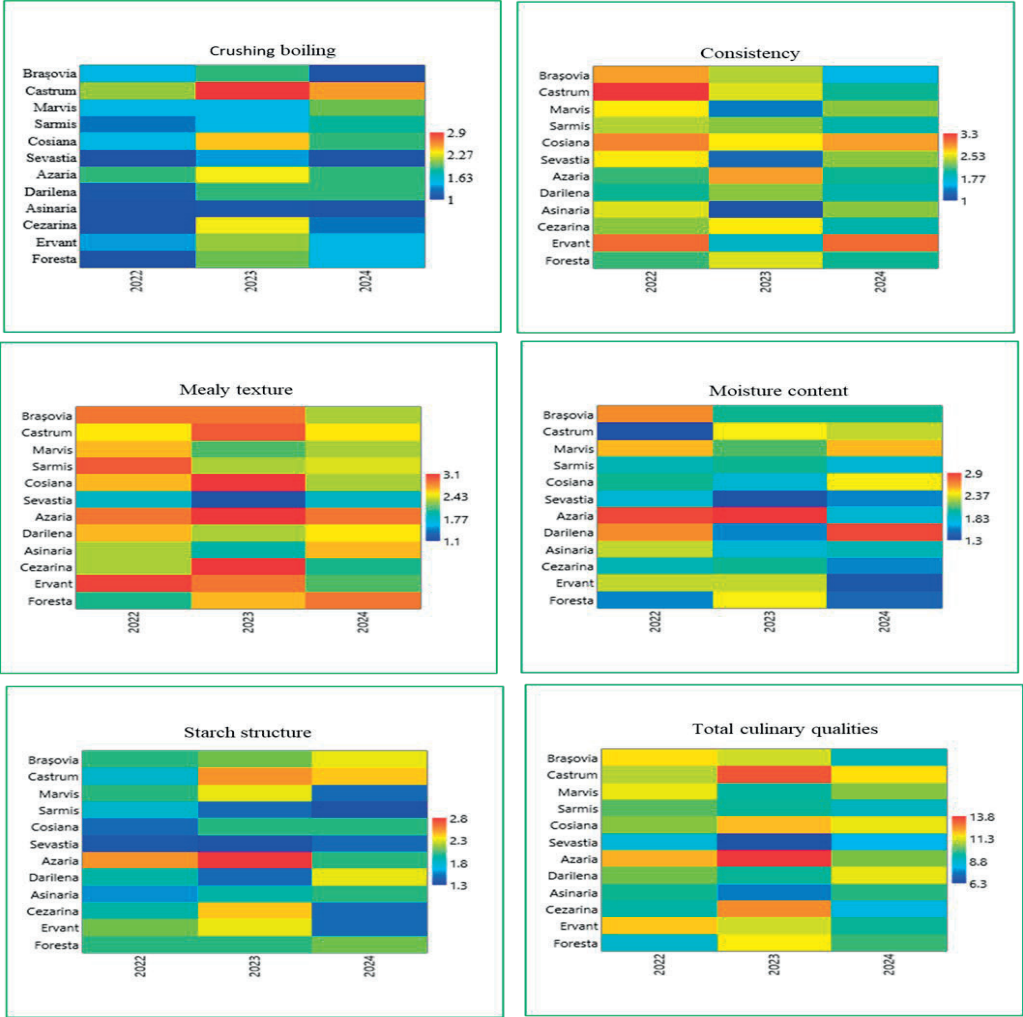


Figure 4. Culinary quality of the 12 potato varieties grown in three different years (2022, 2023, 2024) with distinct climatic conditions

Based on the calculated Pearson correlation coefficient matrix (Figure 5) for dry matter content, starch content, and culinary quality indices, a generally direct positive relationship between these parameters was observed. Negative correlations were identified only between starch content and tuber consistency ($r = -0.01$) and between dry matter content and consistency ($r = -0.06$). High correlation coefficient values were obtained for the relationship between dry matter content and

starch content ($r = 0.81$), as well as between crushing on boiling and mealiness ($r = 0.53$). Additionally, a strong positive correlation was observed between crushing on boiling and starch structure ($r = 0.46$), as well as between mealiness and moisture content ($r = 0.48$). Furthermore, a very strong direct positive relationship was established between mealiness and starch structure, with a calculated correlation coefficient of $r = 0.64$.

From the analysis of Figure 6, it was observed that the average culinary quality of the tubers from the 12 potato varieties was not significantly influenced by the total precipitation recorded during the growing season over the three years. Instead, it varied more depending on the variety and the interaction between varieties and environmental conditions, indicating that other factors, such as the genetic characteristics of the varieties and their adaptability to different environmental conditions, generally influenced the culinary quality of potatoes.

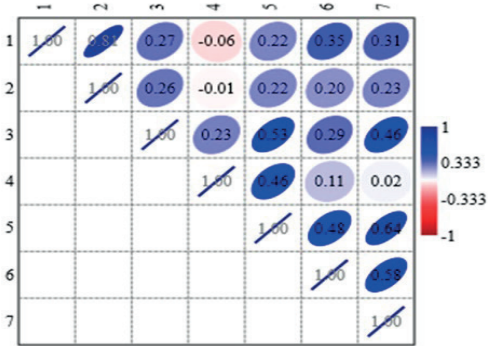


Figure 5. Correlation coefficient matrix for dry matter content (1), starch content (2), crushing on boiling (3), consistency (4), mealiness (5), moisture (6), starch structure (7)

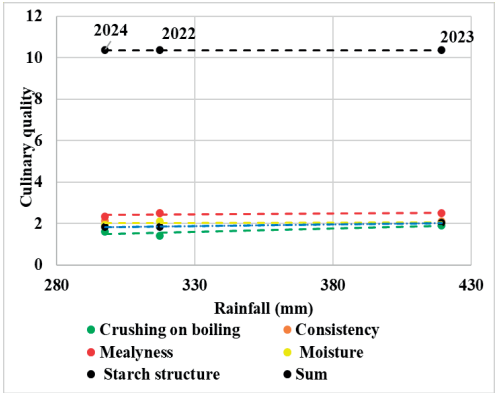


Figure 6. Culinary quality of potato tubers based on total rainfall

CONCLUSIONS

The climatic conditions during the growing season directly influence the technological parameters of potato tubers, dry matter and starch tubers content. Lower precipitation

levels, leading to water stress, can decrease the starch content in potato tubers.

Azaria and Ervant varieties stood out with lower fluctuations in starch tuber content values from year to year, suggesting greater stability of this parameter under varying environmental conditions.

The average culinary quality of the tubers, crushing on boiling, consistency, mealiness, moisture content of potato tubers, and the structure of starch granules varied more depending on the variety and the interaction between varieties and environmental conditions. Careful management of environmental factors, together with the use of adapted potato varieties, can ensure the achievement of productions that meet the requirements for a specific type of use.

Future research should explore integrating genotypic data or irrigation management to further improve tuber quality stability under climate variability.

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