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TECHNOLOGICAL AND CULINARY QUALITY, A SELECTION TOOL IN POTATO BREEDING

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ABSTRACT

In modern breeding, the nutritional potato quality has become a key criterion, transforming this food from an energy source into a vector of public health. At NIRDPSB Brasov, eight breeding lines under selection were evaluated in order to create new potato varieties that not only look and achieve good yields, but also have superior nutritional value. Were made determinations regarding the dry matter and starch content, the suitability for processing potatoes by frying and culinary quality indices were sensory evaluated on boiled potato samples, using a panel of evaluators. After calculating the culinary type index as the amount of the obtained scores, the type of culinary use of each breeding line was established.

INTRODUCTION

Potatoes are one of the most sustainable, affordable, accessible and widely grown crops worldwide (Devaux et al. 2021). Their accessibility contributes to the achievement of several sustainable development goals, e.g., SDG 1: no poverty, SDG 2: zero hunger, and SDG 12: responsible consumption and production (Górska-Warsewicz et al. 2021).

It is a highly attractive crop in agricultural production systems since it combines an extraordinarily high yield potential with a high nutritional value (Koch et al. 2020, Xinpeng et al. 2022). Potatoes are nutrient-rich, particularly in fiber and potassium, and their inclusion in some dietary patterns is associated with higher diet quality compared with their absence in children, adolescents and adults (Fleming & Morris 2024).

Despite all this, is considered that consumers pay more attention to the taste when purchasing potatoes, then palatal delight, habit, color and price options come in order of priorities (Tumer & Aksoy 2019). In the Europatat Congress (Lille-France, June 2025) there were discussions about the evolution of consumption patterns, noting the steady decline in fresh potato consumption across Europe in favor of processed products, reflecting changing lifestyles and culinary habits (Europatat 2025).

In Romania, potato continue to be considered the second bread of the Romanian, with a domestic consumption of potatoes expressed in kilograms per capita of 102.4 according to data centralized by the National Institute of Statistics

(INSSE 2025), amid the accelerated decrease in the area cultivated with potatoes, from over 200 thousand ha in the 1990s, to approximately 29 thousand ha in 2024.

Genetic breeding and obtaining new nutritionally improved varieties are a strategic priority for the future of global nutrition. These new varieties must simultaneously respond to diverse market requirements, like superior qualities for final consumers, specific attributes for the processing industry and improved agronomic characteristics for farmers.

The evaluation of technological and culinary qualities of breeding lines, potential new potato varieties, constitutes an essential step in this process and is a useful tool to identify and select genotypes with high food and processing potential.

MATERIAL AND METHODS

The biological material evaluated comes from the breeding program of the Laboratory for genetic breeding and plant selection within the National Institute of Research and Development for Potato and Sugar Beet (NIRDPSB) Brasov. The potato breeding process is a continuous, extremely laborious and long-term activity (12 years passing from the first generative hybrid population to comparative cultures of concurrence), which respects rigorous selection criteria, including regarding the nutritional profile of the genotypes.

Eight breeding lines (1968/1, 1979/4, 2002/5, 2008/4, 2008/5, 2011/4, 2021/2, 2021/3) were selected which, from an agronomic point of view, show and achieve good production, to be evaluated from the point of view of technological quality (dry matter and starch content, frying suitability) and culinary quality.

The evaluation was carried out at the Laboratory for Technology and good agricultural practices-Quality department of NIRDPSB, in January 2025, after the storage period of the tubers harvested in October of the previous year.

To determine the dry matter content of potato tubers, the gravimetric oven-drying method was used, which is based on the direct measurement of the sample mass before and after total removal of water by thermal drying. The difference in mass represents the water content, and the remaining mass represents the dry matter. The starch content of potato tubers was determined using the indirect method of measuring the specific gravity of potato tubers, by hydrostatic weighing with a Polykeit balance. The suitability for processing potatoes by frying was established according to the method of calculating the frying index of potato samples. The index value shows the level of suitability of the potato sample for frying processing (IF) as follows: IF ≤ 2.5 = excellent; IF 2.5-3.0 = good; IF 3.0-3.5 = medium; IF 3.5-4.0 = weak; IF > 4.0 = very weak.

The method used to determine the color of fries classifies the samples into color classes, from very light (class 000) to very dark (class 4), the higher the number of classes, the more heterogeneous the color of the fries.

Raw tuber enzymic browning was assessed using a reference scale from 1 to 10, where a score of 1 indicate the lowest level and 10 the highest level of browning, after evaluating potato slices left at room temperature for four hours.

The determination of culinary quality was carried out by a trained panel of specialists, who performed organoleptic analysis of boiled potato samples and recorded the scores for each characteristic evaluated on a standardized sheet. The appearance of the boiled tubers, pulp color, boiling behavior, pulp consistency, pulp moisture, degree of mealiness of the tubers, starch granulation and taste intensity were evaluated.

The culinary use type of each breeding line analysed was established by calculating the culinary type index as the amount of the scores obtained for boiling behavior, pulp consistency, moisture, mealiness, granulation. According to the culinary type index, potatoes are classified according to how they behave when boiled, from Type A (5.0-7.5), which does not crumble and is ideal for salads, to Type B (10.1-12.5), which crumbles slightly, being good for multiple uses, Type C (15.1-17.5), which crumbles a lot and is recommended for fries and chips and Type D (17.6-20.0), which crumbles excessively and is reserved for industry (e.g. starch, alcohol). These main categories are complemented by intermediate classes (A/B, B/C, C/D) that provide a transition of textures.

The evaluation of potato after-cooking blackening involved analyzing three boiled tubers from each genotype. These tubers were subsequently stored for 24 hours at ambient temperature. The degree of blackening was then quantified using a 1-to-10 reference scale, where 1 is minimal blackening and 10 is maximum blackening.

The results are expressed as the mean of three replicates ± standard deviation (SD), and the significance of differences between means was determined using Duncan's test ($p < 0.05$) with SPSS software.

RESULTS AND DISCUSSIONS

The potato presents a distinctive nutritional profile, defined by a predominant water matrix (~79 %), a notable concentration of complex carbohydrates (~15 g starch/100g), a modest intake of protein and dietary fiber and a valuable micromineral content, giving it a low energy density and a beneficial role in the moderate caloric diet.

The current priority in potato genetic breeding transcends optimizing yield and resistance to biotic and abiotic stresses, focusing on biofortification to increase the functional quality of tubers, aligning selection strategies with market demands for healthy foods and the role of diet in the prophylaxis of chronic diseases.

The analysis of the technological quality of potato breeding lines revealed genotypic variability of technological quality characteristics (Table 1).

Table 1

Technological quality evaluation of the potato genotypes

Genotype	Dry matter %	Starch %	Raw coloration	Color index after frying	Color classes number
1968/1	19.81	11.00±0.50 c*	3.33 ± 0.58 bc	3.73±0.25 bc	2.00±0.00 a
1979/4	20.40	12.25±0.25 b	2.50 ± 0.50 ab	4.47±0.45 d	3.00±0.00 bcd
2002/5	24.55	16.50±0.50 a	2.83 ± 0.29 abc	2.57±0.06 a	2.33±0.58 ab
2008/4	20.89	12.50±0.50 b	3.0 0± 0.00 abc	4.57±0.21 d	3.67±0.58 d
2008/5	22.71	12.75±0.25 b	3.00 ± 1.00 abc	4.17±0.40 cd	3.67±0.58 d
2011/4	21.85	13.00±0.50 b	2.00 ± 0.00 a	3.42±0.56 b	2.67±0.58 abc
2021/2	15.12	9.50±0.50 d	3.67 ± 0.58 c	4.01±0.22 bcd	3.33±0.58 cd
2021/3	20.87	10.13±0.63 d	3.50 ±0 .50 bc	4.10±0.56 bcd	3.33±0.58 cd

*Means with different letters are significantly different at $p<0.05$ in each column. The letter “a” is assigned only for the optimal values of indicators used for tubers coloration.

The percentage of dry matter showed a wide heterogeneity, ranging from 15.12 % (genotype 2021/2) to 24.55 % (genotype 2002/5). The variability of starch content from 9.5 % in genotype 2021/2 to 16.5 % in genotype 2002/5 demonstrates a positive correlation with dry matter and indicates the direction of differential selection for processing characteristics.

Raw coloration showed a genotypic variability ranging between 2.0 and 3.7, in the 2011/4 and 2021/2 genotypes, respectively, indicating differential expressions of the enzymatic systems that govern the enzymatic browning of pulp exposed to oxidation.

The variation in color index after frying ranged between 2.6 (genotype 2002/5) and 4.6 (genotype 2008/4) and reflects distinct genotypic responses to the thermal process, due to differences in the composition of reducing sugars and starch structure. This frying index (IF) serves as a colorimetric indicator inversely proportional to the aesthetic quality of the final product, where a low numerical value correlates with a desirable light-yellow color, while a high value reflects an intense brown coloration of potatoes thermally processed by frying.

The number of color classes was used as a uniformity parameter to evaluate the colorimetric homogeneity of each of the 20 potato fries in the sample. A high value of the number of classes indicates increased heterogeneity within the 2008 and 2021 hybrid combinations, manifested at the individual level (class 4 in genotypes 2008/4 and 2008/5 and class 3 in genotypes 2021/2 and 2021/3). Genotypes 1968/1 and 2002/5 had better uniformity of the final color of the fries.

For breeding purposes, genotypes that present a small number of color classes are considered valuable for selection, as they convey increased genetic stability of processing characteristics, reducing the risk of color defects in industrial production.

In order to select genotypes for various uses, sensorial analyses were performed to assess the culinary quality indices of boiled potato samples (Table 2).

The appearance of the boiled tubers recorded the best performance, a score of 1.00 corresponding to the highest visual satisfaction from the panel of tasters for the 2008/4 breeding line. The wicked results in this regard were for the 2002/5 and 2008/5 lines, with a score of 2.25.

The color of the pulp of the boiled tubers showed a variation from yellowish (score 3.75 for line 2021/2) to yellow (score 5.00 for line 1968/1), on a scale from 1 (white) to 6 (intense yellow).

The level of integrity after boiling was moderate for all samples. The breeding lines had a slight disintegration, with the best resistance being 2021/3 (1.00) and the weakest being the genotype 2002/5 (2.13), according to the scale of 1 (it holds its shape during boiling) to 4 (it crumbles very hard). A lower score indicates less crumbling and better boiling behavior of the tubers.

On the consistency scale (1 is firm and 4 is non-consistent), the scores for pulp consistency ranged between 1.38 (genotype 2021/3) and 3.00 (genotype 2008/5), indicating a range from firm to moderately consistent pulp after boiling.

The 2021/2 genotype was distinguished by the highest pulp moisture content (1.25), while the 2002/5 and 2008/5 breeding lines presented the lowest moisture content (2.50), on a scale of 1 to 4 (where 1 is moist and 4 is dry).

Following the assessment of the degree of flouriness, the least floury genotypes were 2021/2 and 2021/3 (both with 1.88). The remaining genotypes also exhibited low to moderate flouriness, with a maximum score of 3.13 recorded for line

2002/5, on a scale of 1 to 4 (where 1 is non-floury and 4 is strongly floury).

Starch granulation was predominantly assessed as fine to moderately fine across the samples on a scale of 1 to 4, where 1 is fine structure and 4 is very coarse. Genotypes 2008/4 and 2021/2 demonstrated the finest granulation (1.50), whereas line 2002/5 exhibited the coarsest structure with a score of 2.75.

Taste intensity scores ranged from 1.25 to 3.75 on a scale of 1 to 4 (where 1 is excellent and 4 is less good). Genotype 1968/1 received the best rating (1.25), falling into the excellent category, whereas line 2002/5 recorded the highest score (3.75), indicating a less favorable taste profile.

The evaluation of the post-boiling blackening of the tubers, after keeping them for 24 hours at ambient temperature, indicates that all genotypes have a very low degree of blackening. The scores obtained fall within a narrow range, from 1.0 to 2.7, being much closer to the minimum of the scale (1), which suggests a small quality problem related to this defect. The 2002/5 genotype recorded the highest degree of post-boiling blackening, with a score of 2.7. However, even this value is considered low on the 1−10 scale, indicating an acceptable quality from this point of view.

The analysis of the culinary type index (for culinary use), calculated as the amount of boiling behavior, pulp consistency, moisture, mealiness and granulation, demonstrated a significant variation from a score of 8.13 (line 2021/3) to a score of 13.25 (line 2002/5), which allows a differentiated selection of genotypes for culinary purposes.

The functional classification of genotypes, based on the culinary type index, allowed the division of genotypes in three main categories of use:

- Type A/B (salad/multi-purpose): Genotypes 1968/1, 2008/4, 2021/2 and 2021/3 are characterized by a firm consistency, low flouriness and high moisture, showing tendency to remain whole after boiling. They are ideal for salads and dishes requiring tuber integrity.

- Type B (versatile use): Genotypes 1979/4 and 2011/4 present an intermediate consistency, with reduced crumbling, moderate flouriness and moisture, being suitable for various culinary uses.

- Type B/C (soft floury texture): Genotypes 2002/5 and 2008/5 exhibit lower consistency, higher flouriness and drier pulp, with an increased tendency to crumble. They are recommended for purees, soups and processing into potato flakes, chips or pommes frites.

The obtained results are statistically significant ($p<0.05$), with differences between genotypes highlighted in Tables 1 and 2 by the classification of means into distinct homogeneous groups (indicated by different letters).

The distribution of genotypes in culinary use classes and the variations observed for the studied parameters are in full agreement with other research addressed in the international literature, for the classification of the culinary quality of potato tubers (Baciu et al. 2017, Bărăscu et al. 2016, Bărăscu et al. 2019, Cioloca et al. 2023, Hermeziu et al. 2017, Hermeziu et al. 2015, Hermeziu et al. 2018, Mike et al. 2008). The contribution of current studies to characterize potato genotypes as potential new varieties on the market is necessary to identify culinary and technological qualitative traits, with the objective of promoting production and indicating the culinary destination of the product.

Table 2

Evaluation of the culinary quality of boiled potato tubers

Genoype	Boiled coloration	Aspect	Pulp colour	Taste intensity	Boiling behavior	Consis tency	Moisture	Flouriness	Granulation	Index (1+2+3+4+5)	Culinary type
					1	2	3	4	5		
1968/1	1.00 ± 0.00 a*	1.50 ± 0.58 ab	5.00 ± 0.00 b	1.25 ± 0.50 a	1.75 ±0.50 a	2.25 ± 0.87 ab	1.50 ± 0.58 ab	2.5 ± 0.58 ab	1.88 ± 0.63 ab	9.88	A/B
1979/4	2.33 ± 0.58 b	2.13 ±0.85 b	4.25 ± 0.96 ab	2.25 ± 0.50 ab	1.75 ±0.50 a	2.38 ± 0.48 ab	2.13 ± 0.63 abc	2.63 ± 0.48 ab	2.00 ± 0.00 ab	10.88	B
2002/5	2.67 ± 0.58 b	2.25 ±0.50 b	4.25 ± 0.50 ab	3.75 ± 0.50 c	2.13 ±1.03 a	2.75 ± 0.50 b	2.50 ± 0.58 c	3.13 ± 0.63 b	2.75 ± 0.96 b	13.25	B/C
2008/4	2.00 ± 1.00 ab	1.00 ±0.00 a	4.75 ± 0.50 ab	2.00 ± 0.82 ab	1.25 ±0.50 a	2.13 ± 0.85 ab	2.25 ± 0.50 bc	2.50 ± 0.58 ab	1.50 ± 1.00 a	9.63	A/B
2008/5	1.87 ± 0.58 ab	2.25 ±0.50 b	4.50 ± 0.58 ab	2.50 ± 0.58 b	2.00 ±0.82 a	3.00 ± 0.82 b	2.50 ± 1.00 c	2.75 ± 0.96 ab	2.38 ± 0.75 ab	12.63	B/C
2011/4	2.13 ± 0.24 ab	1.25 ±0.50 a	4.75 ± 0.50 ab	2.25 ± 0.50 ab	1.50 ±0.58 a	2.63 ± 1.25 ab	1.75 ± 0.50 abc	3.00 ± 0.82 b	2.13 ± 1.03 ab	11.00	B
2021/2	2.33 ± 0.58 b	1.25 ±0.50 a	3.75 ± 0.50 a	2.25 ± 1.26 ab	1.50 ±1.00 a	2.50 ± 1.00 ab	1.25 ± 0.50 a	1.88 ± 0.63 a	1.50 ± 0.58 a	8.63	A/B
2021/3	1.00 ± 0.00 a	1.25 ±0.50 a	4.25 ± 0.96 ab	3.00 ± 0.82 bc	1.00 ±0.00 a	1.38 ± 0.25 a	2.00 ± 0.00 abc	1.88 ± 0.25 a	1.88 ± 0.25 ab	8.13	A/B

*Means with different letters are significantly different at $p<0.05$ in each column. The letter “a” is assigned to the optimal values of specific culinary quality indicators. For index calculation there were used the mean values of the indicators specified in columns 1-5.

CONCLUSIONS

A significant genotypic variability of technological quality characteristics was confirmed, with the 2002/5 genotype standing out with maximum values for dry matter (24.55 %) and starch content (16.5 %), confirming a strong positive correlation essential for industrial selection.

The strategic breeding direction is validated by the differential genotypic response to frying, where genotypes with a low frying index (IF) (e.g. 2002/5) indicate a superior aesthetic quality and increased genetic stability, a key factor for minimizing color defects.

The variation in raw pulp color (2.0 to 3.7) highlights a differential expression of enzyme systems, useful in the selection of breeding lines with natural resistance to oxidation.

Culinary type index analysis allowed for a robust functional classification of the breeding lines (e.g. Type A/B for integrity vs. Type B/C for mealiness), information that guides the specific allocation of genotypes to precise culinary and industrial purposes, thus aligning the breeding program with market requirements.

The almost complete absence of post-boiling blackening (scores 1.0-2.7) makes all the breeding lines qualitatively superior after cooking.

Statistical analysis confirms significant genetic variability regarding the technological and culinary quality of the tubers among the analyzed genotypes.

These data are not only descriptive, but prescriptive, they guide selection, eliminate defective breeding lines and directs genotypes with the best attributes towards specific uses, contributing directly to the success of the breeding program.

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