Scientific Papers. Series B, Horticulture. Vol. LXX, No. 1, 2026
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

YIELD CHARACTERISATION AND PHENOLIC CONTENT OF SAFFRON (*CROCUS SATIVUS* L.) PETALS HARVESTED IN SUCEAVA AND NEAMȚ COUNTIES, ROMANIA

Diana-Alexandra GHEORGHIU[1], Nicoleta-Corina PREDESCU[1], Liviu GACEU[2], Adrian PETICILĂ[1], Dana TĂPĂLOAGĂ[3], Nicoleta HĂDĂRUGĂ[1], Gabriela BRAD[1], Liliana TUDOREANU[1, 4]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, Bucharest, Romania
[2]Transilvania University of Brasov, 29 Eroilor Blvd, Brasov, Romania
[3]University of Life Sciences "King Mihai I" of Timisoara, 119 Calea Aradului, Timisoara, Timis, Romania
[4]Interdisciplinary Laboratory for Heavy Metals Accumulation in the Food Chain and Modelling, Faculty of Veterinary Medicine, 105 Splaiul Independentei Blvd, District 5, Bucharest, Romania

Corresponding author email: diana-alexandra.gheorghiu@doctorat.usamv.ro

Abstract

This study investigates the yield characteristics and polyphenolic content of saffron (Crocus sativus L.) petals from Neamț County (own production, 2024-2025) and Suceava County (external source, 2023-2024, Romania), in order to assess their potential for valorization in bakery products. Petal samples were collected using a stratified random sampling approach across multiple harvest days and field sectors. Following controlled drying and milling, were analyzed using standardized methods. Total phenolic content (TPC) was determined using the Folin-Ciocalteu assay. TPC values ranged from 17.5-17.9 mg GAE/g DW in the Suceava 2023 samples to 20.0-21.8 mg GAE/g DW in Suceava 2024. Neamț 2024 petals showed greater variability (15.9-25.0 mg GAE/g DW, with the highest levels in Neamț 2025 samples (27.9 mg GAE/g DW). These results support the potential use of saffron petals as functional ingredients in bakery products with enhanced antioxidant properties.

Key words*: saffron, petals, Crocus sativus, phenols, yield.*

INTRODUCTION

Saffron (*Crocus sativus* L.) Saffron is one of the most valuable spice crops in the world and has been cultivated for centuries due to its unique sensory properties and medicinal value (Fujii et al., 2022). While the dried stigmas are traditionally used as culinary ingredients, natural colorants, and therapeutic agents (Mzabri et al., 2019), increasing attention has recently been directed toward other floral components, particularly saffron petals as valuable sources of bioactive compounds.

In addition to its economic importance, saffron is recognized for its rich phytochemical composition, including carotenoids, phenolic compounds, flavonoids, and volatile constituents, which contribute to its antioxidant, anti-inflammatory, and pharmacological properties (Aissa et al., 2023; Amanpour et al., 2024; Avila-Sosa et al., 2022; Bakshi et al., 2022; Butnariu et al., 2022; Gohari et al., 2013; José Bagur et al., 2017; Kabiri et al., 2023; Karimi et al., 2010).

Although these compounds are well documented in stigmas, recent research has demonstrated that saffron petals, often considered an agricultural by-product, are also rich in phenolic compounds and flavonoids, thus representing a promising resource for functional and nutraceutical applications (Ghodrati Shahtouri et al., 2024; Gikas et al., 2021; Hosseini et al., 2018; Maestre-Hernández et al., 2023; Marrone et al., 2024; Mohaqiq et al., 2020; Shanker et al., 2025; Stelluti et al., 2021).

The productivity and quality of saffron are strongly influenced by environmental and agronomic factors such as soil characteristics, climatic conditions, irrigation regime, planting density, and crop management practices (Bayat et al., 2016; Ordoudi & Tsimidou, 2004). Variability in these factors within a cultivation

area can lead to spatial differences in plant development, flower production, and stigma yield. Understanding this intra-field variability is essential for the accurate evaluation of crop performance and optimizing cultivation strategies (Maggi et al., 2011)

In agricultural research, appropriate sampling strategies are required to obtain representative and unbiased data. Stratified random sampling is widely used for this purpose, as it involves dividing the field into relatively homogeneous strata, followed by the random selection of sampling units within each stratum. This approach improves the precision of statistical analyses and facilitates the assessment of spatial variability in crop productivity (Cochran, 1977).

Beyond agronomic performance, the chemical composition of saffron petals plays an important role in determining their potential use in bakery products as a source of natural antioxidants. Phenolic compounds and flavonoids present in the petals exhibit strong antioxidant activity and contribute to the biological properties of saffron-derived products (Cerdá-Bernad et al., 2022, 2023; Fardaghi et al., 2020). Environmental conditions, geographical origin, and plant physiological status influence the concentration of these compounds, thereby affecting their bioactive properties (Bayat et al., 2016; D'Archivio & Maggi, 2017; Maggi et al., 2011)

The increasing interest in sustainable agriculture and waste valorization has highlighted saffron petals as a valuable by-product that can be utilized in food, pharmaceutical, and cosmetic applications (Cerdá-Bernad & Frutos, 2023; Hosseini et al., 2018; Rizi et al., 2024; Turcov et al., 2022). Their high content of phenolic and flavonoid compounds makes them an attractive alternative source of natural antioxidants, thereby contributing to the overall added value of saffron cultivation systems (Hossein Goli et al., 2012; Jadouali et al., 2018; Naim et al., 2022, 2023).

Therefore, combining agronomic evaluation with phytochemical analysis provides a comprehensive approach to understanding both the production and valorization of saffron petals. In this context, the present study applies a stratified random sampling approach to evaluate spatial variability in flower production within a saffron field, as a basis for estimating petal biomass. Additionally, the total phenolic content (TPC) of saffron petal samples was determined to assess their biochemical quality and antioxidant potential. This integrated approach provides insights into both the agronomic performance and the functional value of saffron petals under the studied conditions.

MATERIALS AND METHODS

Stratified Random Sampling Procedure

To ensure a representative assessment of saffron field variability, a stratified random sampling method was employed. Stratified sampling allows the study area to be divided into relatively homogeneous sub-areas (strata), improving sampling precision and ensuring that all parts of the field are adequately represented.

The experimental field covered an area of 1000 m² located in Neamț, Romania (Figures 1 and 2) where *Crocus sativus* L. was cultivated under traditional management practices, with a focus on the conversion to organic farming.



Figure 1. Google maps coordinate of the experimental field in Neamț, Romania

The experimental plot measured 16 m in the west-east direction and 60 m in the south-north direction. A local Cartesian coordinate system (Figure 3) was established to define sampling locations within the field.



Figure 2. *Crocus Sativus* L. experimental field in Neamț, Romania (original photo)

The origin point (0.00, 0.00) was defined at the south-west corner of the plot. The x-axis extended from west to east (0-16 m), while the y-axis extended from south to north (0-60 m).

Sampling locations were expressed as (x, y) coordinates in meters relative to this origin point.

To ensure spatial representation across the entire field, the plot was divided into four equal strata along the north–south axis. Each stratum consisted of a horizontal band measuring 15 m in length in the south-north direction, defined as follows:

- Stratum 1: y = 0-15 m
- Stratum 2: y = 15-30 m
- Stratum 3: y = 30-45 m
- Stratum 4: y = 45-60 m

Within each stratum, five sampling plots were randomly selected, resulting in a total of 20 sampling points across the field. The random coordinates were generated within the boundaries of each stratum and subsequently located in the field using tape measurements relative to the defined origin.

At each sampling location, field measurements were carried out within a 1 m² sampling plot. The coordinates of the randomly selected sampling plots within each stratum are presented in Table 1 and Figure 3.

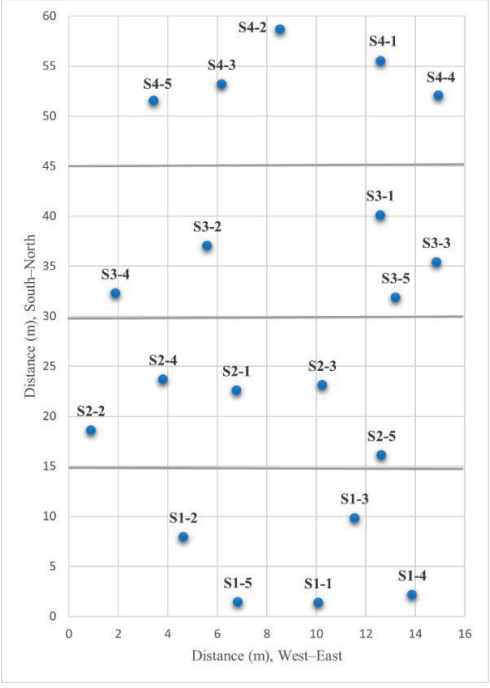

Figure 3. Coordinates of sampling plots across strata within the study field

Coordinates represent local field measurements in meters relative to the south-west corner of the experimental plot, rather than geographic coordinates.

At each sampling location, the following variables were measured:

- number of saffron plants per plot;
- number of flowers per plant;
- stigma yield per sampling point (S1-1, S1-2, etc.).

Table 1. Coordinates of randomly selected sampling plots in the saffron field

Point ID	Stratum	X (m)	Y (m)
S1-1	1	10.09	1.33
S1-2	1	4.63	7.9
S1-3	1	11.55	9.8
S1-4	1	13.88	2.13
S1-5	1	6.83	1.39
S2-1	2	6.78	22.57
S2-2	2	0.9	18.58
S2-3	2	10.25	23.08
S2-4	2	3.81	23.66
S2-5	2	12.64	16.08
S3-1	3	12.59	40.08
S3-2	3	5.6	37.02
S3-3	3	14.86	35.38
S3-4	3	1.89	32.26
S3-5	3	13.21	31.85
S4-1	4	12.61	55.49
S4-2	4	8.54	58.65
S4-3	4	6.18	53.18
S4-4	4	14.94	52.04
S4-5	4	3.43	51.51

All measurements were conducted during the flowering and harvesting period in October-November 2025, which corresponds to the peak saffron production stage. The same measurement procedures and instruments were used across all sampling plots to ensure consistency and comparability of the collected data.

The collected data were subsequently compiled and processed using MedCalc® statistical software (MedCalc Software Ltd., Ostend, Belgium) for statistical analysis.

Total Phenolic Content Determination

Total phenolic content (TPC) in saffron petals (*Crocus sativus* L.*)* was determined using the Folin-Ciocalteu colorimetric method with slight modifications.

Dried saffron petals were ground into a fine powder prior to analysis.

For phenolic extraction, approximately 1 g of powdered sample was mixed with 10 mL of 60% ethanol.

The mixture was subjected to maceration for 24 h in the dark at room temperature, followed by incubation in a water bath for 3 h at 60°C. The extract was then cooled, filtered, and stored at 4°C until further analysis.

Subsequently, the extract was centrifuged at 4000 rpm for 10 min, and the supernatant was collected for analysis.

An aliquot of 0.1 mL of the extract was mixed with 1.4 mL of distilled water and 0.1 mL of Folin-Ciocalteu reagent. After 3 min of incubation, 0.4 mL of sodium carbonate (Na_2CO_3) solution was added. The reaction mixture was then incubated for 60 min at 25°C in the dark to allow color development.

Absorbance was measured at 765 nm using a UV-Vis spectrophotometer (Papuc et al., 2020; Predescu et al., 2020).

Total phenolic content was calculated from the calibration curve using the corresponding regression equation and expressed as mg GAE (gallic acid equivalents) $\cdot g^{-1}$ DW (dry weight) (Figure 4).

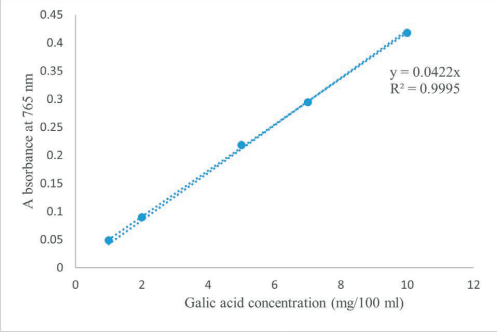

Figure 4. Gallic acid calibration curve used for the determination of the total phenolic content

Statistical Analysis

All measurements for total phenolic content (TPC) were performed in triplicate, and the results are expressed as mean ± standard deviation.

Statistical analyses were assessed using MedCalc® statistical software version 23.4.9 (MedCalc Software Ltd., Ostend, Belgium). Differences between groups were evaluated using one-way analysis of variance (ANOVA). The assumptions of normality and homogeneity of variances were assessed prior to analysis using the D'Agostino–Pearson test and Levene's test, respectively.

When the assumptions for ANOVA were satisfied, post-hoc comparisons were performed using the Tukey-Kramer multiple-comparison test to identify significant differences between groups. Statistical significance was considered at $p < 0.05$.

The distribution and variability of the data were further visualized using boxplots generated in MedCalc.

RESULTS AND DISCUSSIONS

Flower Production and Yield Characteristics of *Crocus sativus* L.

A total of 20 stratified random sampling plots were evaluated within the saffron field. The measured agronomic variables included plant density, number of flowers per plant, and stigma yield per sampling point. These parameters were analyzed to evaluate variability in saffron productivity across the experimental field.

Descriptive statistics were calculated to summarize the main characteristics of the sampled data. The results indicated noticeable variability among the sampling plots. The mean plant density across the sampling area was 44.4 plants m^{-2}, based on the planting distance of 15 cm between bulbs. The average number of flowers per plant was 1.41, with a standard deviation of 0.44, indicating moderate variability across the field.

Similarly, the average estimated stigma yield per sampling plot was 0.34 $g \cdot m^{-2}$, with a minimum of 0.13 $g \cdot m^{-2}$ and a maximum of 0.38 $g \cdot m^{-2}$. These variations reflect differences in plant development and local field conditions within the sampled area. The coefficient of variation (CV) was calculated to assess the degree of variability within the field. The CV values of 31.2% for flowers per plant and 31.6% for estimated stigma yield indicate moderate spatial variability across the study field.

The descriptive statistics of the measured variables are summarized in Table 2.

The observed variability suggests that local field conditions, such as soil properties, bulb vigor, bulb caliber, and microenvironmental factors, may influence saffron productivity within the field.

Table 2. Descriptive statistics of the measured variables

Variable	Mean	Std. Dev.	CV (%)	Min.	Max.
Plant density (plants m^{-2})	44.4	-	-	-	-
Flowers per plant	1.41	0.44	31.2	0.74	2.21
Stigma yield ($g \cdot m^{-2}$)	0.34	0.11	31.6	0.13	0.38

In addition to agronomic variability among sampling plots, the temporal dynamics of flowering were analyzed to better understand the phenological behavior of the crop during the flowering season.

The temporal pattern of saffron flowering is illustrated in Figure 5, while daily flowering data are presented in Table 3. Flowering began gradually in early October and increased rapidly over the following days.

Table 3. Daily flower counts recorded during the flowering period of *Crocus sativus* L.

Date	Flowers	Cumulative	Cumulative %
6-Oct	9	9	0.03
7-Oct	60	69	0.22
8-Oct	330	399	1.27
9-Oct	207	606	1.92
10-Oct	1103	1709	5.42
11-Oct	2420	4129	13.10
12-Oct	993	5122	16.25
13-Oct	2104	7226	22.92
14-Oct	4732	11958	37.94
15-Oct	2042	14000	44.41
16-Oct	2556	16556	52.52
17-Oct	2088	18644	59.15
18-Oct	2772	21416	67.94
19-Oct	1888	23304	73.93
20-Oct	2355	25659	81.40
21-Oct	1355	27014	85.70
22-Oct	736	27750	88.04
23-Oct	1385	29135	92.43
24-Oct	805	29940	94.98
25-Oct	307	30247	95.96
26-Oct	292	30539	96.88
27-Oct	249	30788	97.67
28-Oct	211	30999	98.34
29-Oct	126	31125	98.74
30-Oct	113	31238	99.10
31-Oct	54	31292	99.27
1-Nov	60	31352	99.46
2-Nov	60	31412	99.65
3-Nov	51	31463	99.82
4-Nov	32	31495	99.92
5-Nov	9	31504	99.95
6-Nov	6	31510	99.97
7-Nov	1	31511	99.97
9-Nov	8	31519	99.99
11-Nov	1	31520	100.00
12-Nov	1	31521	100.00

The flowering intensity reached a peak in mid-October, followed by a progressive decline toward the end of the flowering period.

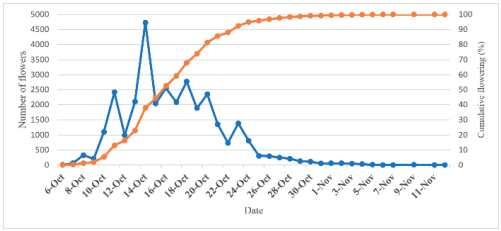

Figure 5. Temporal dynamics of saffron flowering during the 2025 flowering season

The cumulative flowering curve (orange line in Figure 5) further highlights the concentrated nature of the flowering phase. Daily flower counts recorded between 6th October and 12th November 2025 show a rapid increase in flowering intensity, reaching a maximum on 14th October, when 4732 flowers were harvested in a single day. After this peak, flowering gradually declined until early November.

Most flowers were produced within a relatively short time window, with the majority of flowering occurring between 11-20th October. Approximately 50% of the total flowering occurred between 13-16th October, indicating that the peak flowering phase was concentrated within only a few days.

Based on the observed flowering dynamics, seasonal flower production was estimated for each sampling plot to evaluate spatial variability in flower production across the field.

To estimate the total number of flowers produced in each sampling plot during the entire flowering period, flower counts on the sampling dates (12th, 13th, 14th and 18th October) were scaled using the relative contribution of each day to the total seasonal flowering. Based on the total daily flower counts across the field, these observation dates represented 33.6% of the total seasonal flowering.

Considerable variability in flower production was observed among the sampling plots. The estimated seasonal number of flowers per plot ranged from 33 to 98 flowers, with an average value of approximately 61 flowers per plot.

The estimated flower production and corresponding stigma yield for each sampling plot are presented in Table 4.

Table 4. Estimated flower production and corresponding stigma yield per sampling plot

Plot	Saffron flowers observed (4 days)	Estimated seasonal flowers	Estimated Stigma Yield	Estimated Stigma Yield ($g \cdot m^{-2}$)
S1-1	19	56	168	0.30
S1-2	11	33	99	0.18
S1-3	17	50	150	0.27
S1-4	14	42	126	0.23
S1-5	16	48	144	0.26
S2-1	13	39	117	0.21
S2-2	22	65	195	0.35
S2-3	33	98	294	0.53
S2-4	29	86	258	0.46
S2-5	27	80	240	0.43
S3-1	14	42	126	0.23
S3-2	16	48	144	0.26
S3-3	28	83	249	0.45
S3-4	24	71	213	0.38
S3-5	32	95	285	0.51
S4-1	16	48	144	0.26
S4-2	17	50	150	0.27
S4-3	24	71	213	0.38
S4-4	21	62	186	0.33
S4-5	28	83	249	0.45

The coefficient of variation for flower production was approximately 31% (Table 2), suggesting that spatial differences in plant performance occurred across the field.

The relationship between flower production and estimated saffron yield is shown in Figure 6.

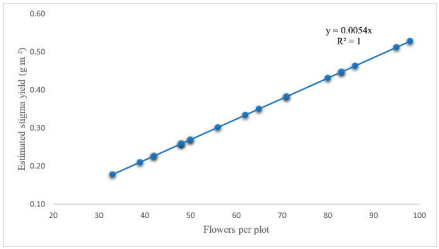

Figure 6. Relationship between the number of flowers per plot and estimated saffron stigma yield

A clear positive linear relationship was observed, indicating that higher flower numbers directly translate into higher saffron yield. Since each saffron flower produces two to six stigmas, the number of flowers serves as a reliable indicator of potential yield.

The estimated dry stigma yield averaged 0.34 ± 0.11 $g \cdot m^{-2}$, with values ranging from 0.13 to 0.38 $g \cdot m^{-2}$across the sampling plots.

The distribution of estimated saffron yield among the sampling plots is illustrated in Figure 7.

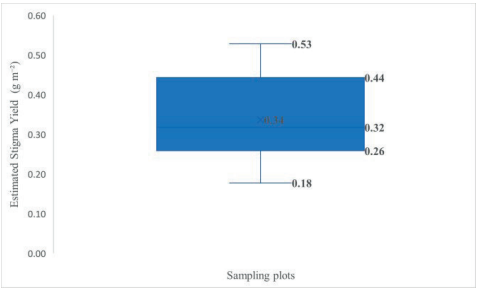

Figure 7. Distribution of estimated saffron stigma yield ($g \cdot m^{-2}$) across the sampling plots

The boxplot shows the variability and yield spread values within the field. The median yield was approximately 0.32 $g \cdot m^{-2}$, while the mean yield reached 0.34 $g \cdot m^{-2}$.

In addition to examining the relationship between flower production and saffron yield, the distribution of estimated saffron yield among the sampling plots was evaluated to assess variability within the field.

The comparison of flower production and saffron yield among the four field strata is summarized in Table 5 and illustrated in Figure 8.

Table 5. Comparison of flower production and saffron yield among the field strata

Stratum	Mean Flowers	Mean Yield ($g \cdot m^{-2}$)
S1	45.8	0.247
S2	73.6	0.397
S3	67.8	0.365
S4	62.8	0.338

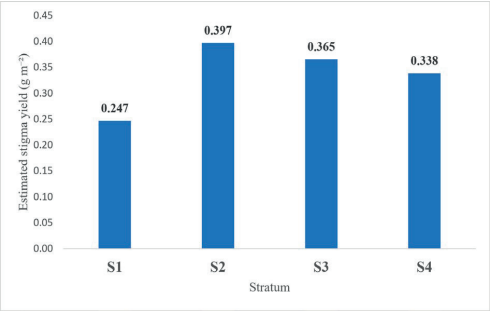

Figure 8. Distribution of estimated saffron stigma yield ($g \cdot m^{-2}$) across the strata

Stratum S2 showed the highest mean flower production (73.6 flowers per plot) and the highest estimated saffron yield (0.397 $g \cdot m^{-2}$). In contrast, S1 recorded the lowest flower production (45.8 flowers per plot) and the lowest yield (0.247 $g \cdot m^{-2}$). Intermediate values were

observed in S3 and S4, suggesting that productivity gradually varied across the field.
These results indicate that local environmental conditions within different areas of the field influenced saffron productivity.

Total Phenolic Content of Saffron Petal Samples

In addition to agronomic performance, the biochemical composition of saffron petals represents an important indicator of saffron quality.
Therefore, the total phenolic content (TPC) of the collected saffron samples was determined to evaluate the antioxidant potential and quality characteristics of the harvested material.

Total Phenolic Content

The total phenolic content (TPC) of saffron petal extracts was determined using the Folin-Ciocalteu method and expressed as milligrams of gallic acid equivalents (GAE) per gram of dry plant material (DW) (mg GAE·g^{-1}). The analyzed samples included petals obtained from two locations, Suceava (S samples) and the Neamț experimental field (N samples), and from different harvesting years (2023-2025).
The mean phenolic concentrations of the analyzed samples ranged from 17.64 to 23.25 mg GAE·g^{-1}. The lowest average value was recorded for S23 samples (17.64 ± 0.22 mg GAE·g^{-1}), while the highest phenolic content was observed in N25 samples (23.25 ± 3.67 mg GAE·g^{-1}). Intermediate values were recorded for N24 (19.09 ± 4.41 mg GAE·g^{-1}) and S24 (20.65 ± 0.91 mg GAE·g^{-1}) samples (Table 6).

Table 6. Mean total phenolic content (mg GAE·g^{-1}) of saffron petal samples with standard deviation and Tukey significance letters

Sample	TPC (mg GAE·g^{-1})
S23	17.64 ± 0.22^{a}
N24	19.09 ± 4.41^{a}
S24	20.65 ± 0.91^{ab}
N25	23.25 ± 3.67^{b}

To evaluate whether the differences between groups were statistically significant, a one-way analysis of variance (ANOVA) was performed. The results indicated a significant effect of sample group on total phenolic content ($F = 6.14$, $p = 0.002$). Prior to ANOVA, the assumption of normality was verified using the D'Agostino-Pearson test, which confirmed that the data followed a normal distribution ($p = 0.091$).
Post-hoc comparisons were conducted using the Tukey-Kramer multiple comparison test. The results showed that N25 samples differed significantly from both N24 and S23 samples ($p < 0.05$), indicating higher phenolic concentrations in petals collected from the Neamț experimental field in 2025. However, no statistically significant differences were observed between S23, S24 and N24 groups.
The distribution and variability of total phenolic content among the analyzed samples are illustrated in Figure 9.

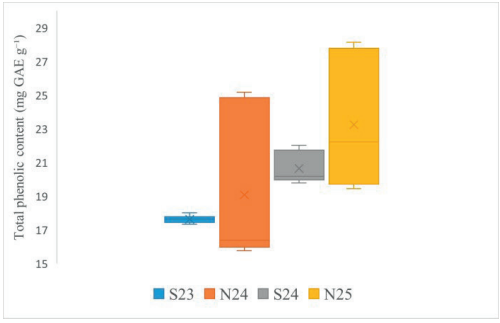

Figure 9. Boxplot showing the distribution of total phenolic content (mg GAE·g^{-1}) in saffron petal extracts collected from Suceava (S) and Neamț (N) during the 2023-2025 harvesting seasons

The boxplot shows the spread of phenolic values within each group. The interquartile ranges and whiskers indicate the variability of the replicate measurements, while the median values highlight differences in phenolic concentration among the analyzed samples.
For a clearer comparison of mean values among groups, the average phenolic concentrations are also presented in Figure 10, while the total phenolic content of each sample is presented in Figure 11.
The bar charts confirm that samples collected in 2025 from the Neamț experimental field (N25) exhibited the highest mean phenolic content, whereas the samples collected from Suceava 2023 (S23) showed the lowest values. These results suggest that both environmental conditions and harvesting year may influence the accumulation of phenolic compounds in saffron petals.

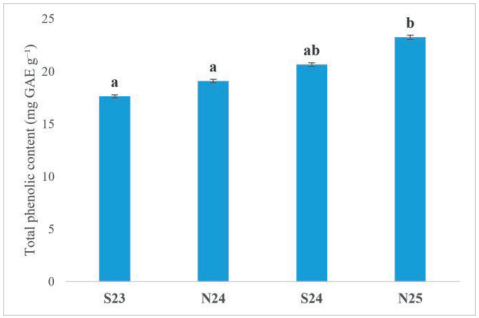

Figure 10. Mean total phenolic content of saffron petal extracts collected from Suceava (S) and Neamț (N) during the 2023-2025 harvesting seasons

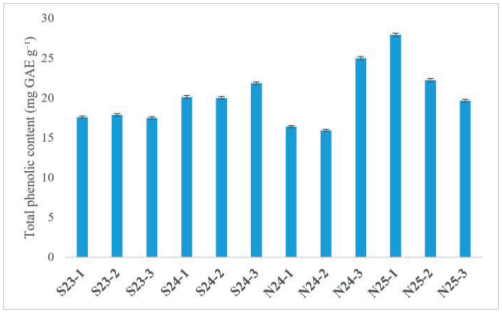

Figure 11. Total phenolic content of saffron petal extracts collected from Suceava (S) and Neamț (N) during the 2023-2025 harvesting seasons.

The statistical analysis demonstrates that phenolic content in saffron petals varies among sample groups, with the highest concentrations observed in the most recent samples collected from the Neamț experimental field.

CONCLUSIONS

The present study provides an integrated evaluation of saffron (*Crocus sativus* L.) cultivation by combining field-based agronomic assessment with phytochemical analysis. The application of stratified random sampling enabled a reliable characterization of spatial variability within the study field, ensuring that differences in plant performance were accurately captured across distinct field strata.

The results revealed moderate variability in agronomic parameters, including flower production and estimated stigma yield, indicating that local field conditions such as soil properties, bulb development, and microenvironmental factors can influence saffron productivity. The temporal analysis of flowering demonstrated a highly concentrated blooming period, with the majority of flowers produced within a short time window, confirming the characteristic phenological behavior of saffron.

Phytochemical analysis showed that total phenolic content varied among the analyzed samples, with significantly higher values observed in samples collected from the Neamț experimental field in 2025. These differences suggest that both environmental conditions and harvest year play an important role in the accumulation of bioactive compounds in saffron petals. The observed variability highlights the sensitivity of secondary metabolite production to cultivation conditions and plant physiological status.

From a practical perspective, the results indicate that spatial variability within the field should be considered when designing management strategies. Uniform agronomic practices may not fully optimize productivity, and site-specific management approaches, including adjustments in planting density, irrigation, and soil management, may improve overall yield performance.

The identification of peak flowering periods provides valuable guidance for optimizing harvesting operations, allowing growers to concentrate labor during the most productive phase and minimize potential losses. In addition, the variation in phenolic content suggests that environmental conditions and harvest timing can influence saffron quality, emphasizing the importance of monitoring cultivation conditions to enhance both yield and biochemical properties.

ACKNOWLEDGEMENTS

This article was developed as part of the PhD program at the Doctoral School of Engineering and Management of Vegetal and Animal Resources within the Horticulture domain at the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania.

REFERENCES

Aissa, R., Ibourki, M., Bouzid, H., A., Bijla, L., Oubannin, S., Sakar, E., H., Jadouali, S., Hermansyah, A., Goh, K. W., Ming, L. C., Bouyahya, A., & Gharby, S. (2023). Phytochemistry, quality control and medicinal

uses of Saffron (*Crocus sativus* L.): an updated review. In *Journal of Medicine and Life* (Vol. 16, Number 6, pp. 822–836). Carol Davila University Press.

Amanpour, A., Soltani, M., Lipan, L., Garcia-Garví, J. M., Hernández-García, F., Carbonell-Barrachina, Á. A., & Nadal, E. S. (2024). Comparative study on nutraceutical and sensorial characteristics of saffron (*Crocus sativus* L.) cultivated in Iran, Spain, and Türkiye. *Journal of the Science of Food and Agriculture*, *104*(12), 7580–7591.

Avila-Sosa, R., Nevárez-Moorillón, G., V., Ochoa-Velasco, C., E., Navarro-Cruz, A., R., Hernández-Carranza, P., & Cid-Pérez, T. S. (2022). Detection of Saffron's Main Bioactive Compounds and Their Relationship with Commercial Quality. In *Foods* (Vol. 11, Number 20). MDPI.

Bakshi, R., A., Sodhi, N., S., Wani, I., A., Khan, Z., S., Dhillon, B., & Gani, A. (2022). Bioactive constituents of saffron plant: Extraction, encapsulation and their food and pharmaceutical applications. In *Applied Food Research* (Vol. 2, Number 1). Elsevier B.V.

Bayat, M., Rahimi, M., & Ramezani, M. (2016). Determining the most effective traits to improve saffron (*Crocus sativus* L.) yield. *Physiology and Molecular Biology of Plants: An International Journal of Functional Plant Biology*, *22*(1), 153–161.

Butnariu, M., Quispe, C., Herrera-Bravo, J., Sharifi-Rad, J., Singh, L., Aborehab, N., M., Bouyahya, A., Venditti, A., Sen, S., Acharya, K., Bashiry, M., Ezzat, S., M., Setzer, W., N., Martorell, M., Mileski, K., S., Bagiu, I., C., Docea, A. O., Calina, D., & Cho, W. C. (2022). The Pharmacological Activities of *Crocus sativus* L.: A Review Based on the Mechanisms and Therapeutic Opportunities of Its Phytoconstituents. In *Oxidative Medicine and Cellular Longevity.* (Vol. 2022). Hindawi Limited.

Cerdá-Bernad, D., Clemente-Villalba, J., Valero-Cases, E., Pastor, J., J., & Frutos, M. J. (2022). Novel Insight into the Volatile Profile and Antioxidant Properties of *Crocus sativus* L. Flowers. *Antioxidants*, *11*(9).

Cerdá-Bernad, D., & Frutos, M. J. (2023). Saffron Floral By-Products as Novel Sustainable Vegan Ingredients for the Functional and Nutritional Improvement of Traditional Wheat and Spelt Breads. *Foods*, *12*(12).

Cerdá-Bernad, D., Valero-Cases, E., Pérez-Llamas, F., Pastor, J., J., & Frutos, M. J. (2023). Underutilized *Crocus sativus* L. Flowers: A Hidden Source of Sustainable High Value-Added Ingredients. *Plant Foods for Human Nutrition*, *78*(2), 458–466.

Cochrane, W. G. (1977). *Sampling techniques.* Wiley.

D'Archivio, A., A., & Maggi, M. A. (2017). Geographical identification of saffron (*Crocus sativus* L.) by linear discriminant analysis applied to the UV–visible spectra of aqueous extracts. *Food Chemistry*, *219*, 408–413.

Fardaghi, A., A., Es-Haghi, A., Feizy, J., & Lakshmipathy, R. (2020). *Antioxidant capacity and chemical composition of different parts of saffron flowers*.

Fujii, S., Morita, Y., Ohta, T., Uto, T., & Shoyama, Y. (2022). Saffron (Crocus sativus L.) As a valuable spice and food product: a narrative review. *Longhua Chinese Medicine*, *5*, 18–18.

Ghodrati Shahtouri, M., Fooladi, E., Feizy, J., Jahani, M., & Marrazza, G. (2024). Valorization of saffron production waste: Isolation of anthocyanins from saffron petal extract by zirconium-based adsorbents. *LWT*, *201*.

Gikas, E., Koulakiotis, N., S., & Tsarbopoulos, A. (2021). PhytochemicaL differentiation of saffron (*Crocus sativus* L.) by high-resolution mass spectrometry metabolomic studies. *Molecules*, *26*(8).

Gohari, A., R., Saeidnia, S., & Mahmoodabadi, M. K. (2013). An overview on saffron, phytochemicals, and medicinal properties. In *Pharmacognosy Reviews* (Vol. 7, Number 13, pp. 61–66).

Hossein Goli, S., A., Mokhtari, F., & Rahimmalek, M. (2012). Phenolic compounds and antioxidant activity from saffron (*Crocus sativus* L.) Petal. *Journal of Agricultural Science*, *4*(10).

Hosseini, A., Razavi, B., M., & Hosseinzadeh, H. (2018). Saffron (*Crocus sativus*) petal as a new pharmacological target: A review. In *Iranian Journal of Basic Medical Sciences* (Vol. 21, Number 11, pp. 1091–1099). Mashhad University of Medical Sciences.

Jadouali, S., M., Atifi, H., Bouzoubaa, Z., Majourhat, K., Gharby, S., Achemchem, F., Elmoslih, A., Laknifli, A., & Mamouni, R. (2018). Chemical characterization, antioxidant and antibacterial activity of Moroccan *Crocus sativus* L petals and leaves. *Journal of Materials and Environmental Science*, *9*(1), 113–118.

José Bagur, M., Alonso Salinas, G. L., Jiménez-Monreal, A., M., Chaouqi, S., Llorens, S., Martínez-Tomé, M., & Alonso, G. L. (2017). Saffron: An Old Medicinal Plant and a Potential Novel Functional Food. In *Molecules (Basel, Switzerland)* (Vol. 23, Number 1). NLM (Medline).

Kabiri, G., Hssaini, L., Naim, N., Houmanat, K., Ennahli, S., Fauconnier, M., L., & Hanine, H. (2023). Aromatic potential, quality and antioxidant activity of saffron grown in Morocco. *Flavour and Fragrance Journal*, *38*(1), 13–26.

Karimi, E., Oskoueian, E., Hendra, R., & Jaafar, H. Z. E. (2010). Evaluation of *Crocus sativus* L. stigma phenolic and flavonoid compounds and its antioxidant activity. *Molecules*, *15*(9), 6244–6256.

Maestre-Hernández, A., B., Vicente-López, J., J., Pérez-Llamas, F., Candela-Castillo, M., E., García-Conesa, M., T., Frutos, M., J., Cano, A., Hernández-Ruiz, J., & Arnao, M. B. (2023). Antioxidant activity, total phenolic and flavonoid contents in Floral Saffron Bio-residues. *Processes*, *11*(5).

Maggi, L., Carmona, M., Kelly, S., D., Marigheto, N., & Alonso, G. L. (2011). Geographical origin differentiation of saffron spice (*Crocus sativus* L. stigmas) - Preliminary investigation using chemical and multi-element (H, C, N) stable isotope analysis. *Food Chemistry*, *128*(2), 543–548.

Marrone, G., Urciuoli, S., Di Lauro, M., Cornali, K., Montalto, G., Masci, C., Vanni, G., Tesauro, M., Vignolini, P., & Noce, A. (2024). Saffron (*Crocus sativus* L.) and Its By-Products: Healthy Effects in

Internal Medicine. In Nutrients, (Vol. 16, Number 14). Multidisciplinary Digital Publishing Institute (MDPI).

Mohaqiq, Z., Moossavi, M., Hemmati, M., Kazemi, T., & Mehrpour, O. (2020). Antioxidant Properties of Saffron Stigma and Petals: A Potential Therapeutic Approach for Insulin Resistance through an Insulin-Sensitizing Adipocytokine in High-Calorie Diet Rats. *International Journal of Preventive Medicine*, *11*(1), 184.

Mzabri, I., Addi, M. & Berrichi, A. (2019). Traditional and modern uses of saffron (*Crocus sativus*). In Cosmetics, (Vol. 6, Number 4, pp. 1–11). MDPI AG.

Naim, N., Bouymajane, A., Oulad El Majdoub, Y., Ezrari, S., Lahlali, R., Tahiri, A., Ennahli, S., Laganà Vinci, R., Cacciola, F., Mondello, L., & Madani, I. (2023). Flavonoid Composition and Antibacterial Properties of *Crocus sativus* L. Petal Extracts. *Molecules*, *28*(1).

Naim, N., Fauconnier, M., L., Ennahli, N., Tahiri, A., Baala, M., Madani, I., Ennahli, S., & Lahlali, R. (2022). Chemical Composition Profiling and Antifungal Activity of Saffron Petal Extract. *Molecules*, *27*(24).

Ordoudi, S.,, A., & Tsimidou, M. Z. (2004). *Saffron Quality: Effect of Agricultural Practices, Processing and Storage*.

Papuc, C., Predescu, C., Goran, G. V, & Petrescu, C. (2020). Total Phenolic Content and Antioxidant Activity of Some Aromatic Herbs Used in Traditional Romanian Cuisine. *Annals of the Academy of Romanian Scientists, Series Agriculture, Silviculture and Veterinary Medicine Sciences*, *9*(1), 17–24.

Predescu, C., Papuc, C., Ștefan, G., & Petcu, C. (2020). Phenolics Content, Antioxidant and Antimicrobial Activities of Some Extracts Obtained from Romanian Summer Savory and Lebanon Wild Thyme. *Scientific Works. Series C. Veterinary Medicine*, *LXVI* (2), 17–22.

Rizi, A.,, Z., Sadeghi, A., Feizi, H., Jafari, S.,, M., & Purabdolah, H. (2024). Evaluation of Textural, Sensory and Shelf-Life Characteristics of Bread Produced with mung bean sourdough and saffron petal extract. *Journal of Food Science and Technology (Iran)*, *21*(148), 141–153.

Shanker, M., A., Puthiyedath, A., & Rana, S. S. (2025). Floral bio-residues of saffron: a potential source of valuable components; extraction and application. In *Discover Sustainability* (Vol. 6, Number 1). Springer Nature.

Stelluti, S., Caser, M., Demasi, S., & Scariot, V. (2021). SustainabLe processing of floral bio-residues of saffron (*Crocus sativus* L.) for valuable biorefinery products. *Plants*, *10*(3), 1–15.

Turcov, D., Barna, A., S., Apreutesei, O., T., Trifan, A., Puitel, A., C., & Suteu, D. (2022). Valorization of Bioactive Compounds from Residual Saffron Biomass (*Crocus sativus* L.) to Obtain High Value Added Dermato-Cosmetic Products. In *BioResources* (Vol. 17, Number 3, pp. 4730–4744). North Carolina State University.