

OZIQ-OVQAT XAVFSIZLIGI: MILLIY VA GLOBAL MUAMMOLAR

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SHAROF RASHIDOV NOMIDAGI SAMARQAND DAVLAT UNIVERSITETI
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ANALYSIS OF CHLOROPHYLL AND CAROTENOID CONTENT IN SWEET POTATO (*IPOMOEA BATATAS L. LAM.*) LEAVES UNDER SAMARKAND SOIL-CLIMATE CONDITIONS

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Annotation. *Sweet potato (Ipomoea batatas L. Lam.) is a vital starchy crop with high nutritional value, particularly due to its β-carotene content. This study evaluates chlorophyll (a, b), total chlorophyll, and carotenoid levels in the leaves of five sweet potato varieties/lines (Xazina, Xazina-1, Xazina-2, GulDU-1, GulDU-2) under Samarkand's soil-climate conditions. Spectrophotometric and HPLC analyses revealed significant varietal differences, with GulDU-2 showing the highest chlorophyll a (17.93±0.18 mg/g), total chlorophyll (23.16±0.27 mg/g), and carotenoids (5.04±0.19 mg/g), while GulDU-1 exhibited the lowest. These findings underscore the role of genetic variation in photosynthetic efficiency and nutritional quality, offering insights for breeding high-yielding sweet potato varieties in Uzbekistan.*

Keywords: *Sweet potato, Ipomoea batatas, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, photosynthesis, Samarkand, varietal differences, pigment analysis*

Introduction. Sweet potato (*Ipomoea batatas* L. Lam.) is a globally significant crop cultivated in tropical and subtropical regions for its starchy tubers, rich in β-carotene, carbohydrates, proteins, vitamins (B, PP, A), and organic acids such as ascorbic and folic acids [9]. As a precursor to vitamin A, β-carotene enhances immune function and provides antioxidant benefits, making sweet potato a cost-effective nutritional resource, particularly in developing countries [5]. In Uzbekistan, sweet potato is an emerging crop, valued for its 1.5-fold higher nutritional and caloric content compared to traditional potatoes, positioning it as a promising candidate for food security and agricultural diversification [8].

Photosynthesis, driven by chlorophyll and carotenoid pigments, is a critical determinant of crop productivity. Chlorophyll a and b absorb light energy, while carotenoids protect against oxidative stress and contribute to nutritional quality [4]. Variations in pigment content can reflect genetic, environmental, and physiological differences, influencing biomass accumulation and yield [6]. Previous studies have linked higher chlorophyll content to enhanced photosynthetic efficiency in sweet potato, correlating with tuber yield under diverse climatic conditions [7]. Carotenoid content, particularly β-carotene, is a key breeding target due to its role in combating vitamin A deficiency [1].

In Uzbekistan, sweet potato cultivation is expanding, but data on photosynthetic pigment dynamics under local soil-climate conditions are limited. Samarkand's semi-arid climate, with its unique soil properties, poses challenges and opportunities for optimizing crop performance [8].

Prior research indicates that varietal differences significantly affect pigment accumulation, impacting photosynthetic capacity and stress tolerance [2].

This study aims to quantify chlorophyll (a, b), total chlorophyll, and carotenoid content in the leaves of five sweet potato varieties under Samarkand conditions, providing a foundation for selecting high-yielding, nutritionally superior genotypes. By integrating spectrophotometric and HPLC analyses, we explore the physiological basis of varietal performance, contributing to global and regional efforts to enhance sweet potato productivity.

Materials and methods.

Plant Material and Experimental Design

The study was conducted in Samarkand, Uzbekistan, using the Xazina, Xazina-1, Xazina-2, GulDU-1, GulDU-2 varieties of sweet potato (*Ipomoea batatas L. Lam.*). The Xazina variety was developed by the Potato Research Center through single-plant selection, Xazina-1, Xazina-2, GulDU-1, GulDU-2 varieties were established at Gulistan State University's Experimental Biology Laboratory using biotechnological and selection methods. Plants were grown in a randomized complete block design with four replicates under

field conditions. Each plot received uniform agronomic practices, including irrigation, fertilization (NPK: 100:80:60 kg/ha), and pest management, to minimize environmental variability.

Sample Collection

Leaf samples were collected from the 3rd–4th leaves (counted from the growth point) during the vegetative growth phase (60–70 days post-planting) to ensure consistent physiological maturity. Approximately 10 g of fresh leaves per replicate were harvested, immediately stored at 4°C, and processed within 24 hours to prevent pigment degradation.

Pigment Extraction

Photosynthetic pigments (chlorophyll a, b, and carotenoids) were extracted using three standardized protocols to ensure robustness:

1. Ethanol-Based Extraction: 5 mg of leaf tissue was homogenized with $CaCO_3$ in 10 ml of 95% ethanol. The homogenate was incubated at 3–5°C for 24 hours in darkness to facilitate pigment extraction, then centrifuged at 10,000 rpm for 10 minutes. The supernatant was analyzed using a UV-1601 spectrophotometer (Shimadzu, Japan) at 662 nm (chlorophyll a), 644 nm (chlorophyll b), and 440 nm (carotenoids).
2. Acetone-Based Extraction (Method 1): 0.5 g of leaf tissue was homogenized in 10 ml of 80% acetone, centrifuged at 8,000 rpm for 10 minutes, and analyzed using an Agilent Cary 60 UV-Vis spectrophotometer at 663 nm (chlorophyll a), 645 nm (chlorophyll b), and 470 nm (carotenoids).
3. Acetone-Based Extraction (Method 2): Fresh leaves were homogenized in 85% acetone with Na_2CO_3 and quartz, filtered, and centrifuged at 5,000 rpm for 10 minutes. The supernatant was analyzed at 662 nm, 644 nm, and 440 nm.

Pigment Quantification

Pigment concentrations were calculated using the following equations (Lichtenthaler & Buschmann, 2001):

$$\text{Chlorophyll a (mg/g)} = \frac{(1{,}27 \times A_{662} - 2{,}69 \times A_{664}) \times V}{1000 \times V}$$

$$\text{Chlorophyll b (mg/g)} = \frac{(22{,}9 \times A_{664} - 4{,}68 \times A_{662}) \times V}{1000 \times V}$$

$$\text{Carotenoids (mg/g)} = \frac{1000 \times A_{440} - 1{,}82 \times C_a - 85{,}02 \times C_b}{198}$$

Where: (A) is absorbance at the specified wavelength, (V) is the extract volume (ml), (W) is the fresh weight of the sample (g), and (C_a) and (C_b) are chlorophyll a and b concentrations, respectively.

HPLC Analysis

High-performance liquid chromatography (HPLC) was performed to validate pigment quantification. Leaf samples (0.5 g) were frozen in liquid nitrogen, homogenized in a Teflon mortar, and extracted with 5 ml of acetone. The extract was centrifuged at 5,000 rpm for 10 minutes, diluted to 10 ml with acetone, and filtered. Analysis was conducted using an Agilent Technologies-1200 system with a diode array detector (DAD) at 445 nm. Chromatographic conditions included:

Column: Eclipse XDB C18 (5 µm, 150×4.6 mm)

Mobile phase: Acetonitrile: methanol: dichloromethane: distilled water (10:67:18:5)

Flow rate: 1 ml/min

Temperature: 30°C

Standards for chlorophyll (a, b) and β-carotene were sourced from Sigma-Aldrich (Buchs, Switzerland).

Statistical Analysis

Data were analyzed using Excel 2016 for descriptive statistics and Stat View 5.0 for analysis of variance (ANOVA). Significant differences between varieties were determined at $p<0.05$. Results are presented as mean ± standard error ($\chi \pm m$) based on four replicates.

Results. This study was designed to elucidate the physiological basis of varietal differences in sweet potato by quantifying photosynthetic pigments, which are critical for photosynthesis and nutritional quality. The results provide insights into the adaptability and productivity potential of sweet potato varieties under Samarkand's semi-arid conditions.

1. *Chlorophyll a:* Concentrations ranged from 14.16±0.37 mg/g (GulDU-1) to 17.93±0.18 mg/g (GulDU-2). GulDU-2's chlorophyll a content was significantly higher than all other varieties ($p<0.05$), indicating superior light absorption capacity. Xazina, Xazina-1, and Xazina-2 showed intermediate values, with no significant differences among them ($p>0.05$).
2. *Chlorophyll b:* Levels varied from 4.58±0.12 mg/g (GulDU-1) to 6.17±0.13 mg/g (Xazina). Xazina, Xazina-1, and Xazina-2 exhibited significantly higher chlorophyll b than GulDU-1 and GulDU-2 ($p<0.05$). GulDU-1's low

chlorophyll b suggests limited accessory pigment function.

3. *Total Chlorophyll*: Total chlorophyll ranged from 18.74±0.32 mg/g (GulDU-1) to 23.16±0.27 mg/g (GulDU-2). GulDU-2's total chlorophyll was significantly higher than all others ($p<0.05$), while GulDU-1's was the lowest. Xazina (22.49±0.37 mg/g) outperformed Xazina-1 and Xazina-2 ($p<0.05$).

4. *Carotenoids:* Carotenoid content ranged from 3.72±0.07 mg/g (Xazina-2) to 5.04±0.19 mg/g (GulDU-2). GulDU-2's carotenoid levels were significantly higher than all other varieties ($p<0.05$), followed by Xazina (4.35±0.08 mg/g) and Xazina-1 (4.20±0.06 mg/g). Xazina-2 and GulDU-1 showed the lowest values, with no significant difference between them ($p>0.05$).

capacity, potentially limiting tuber yield under local stresses such as water scarcity.

Chlorophyll b levels were highest in Xazina (6.17±0.13 mg/g), consistent with its role as a stable, high-yielding variety. The chlorophyll a/b ratio, an indicator of photosynthetic adaptation, ranged from 2.65 (Xazina) to 3.43 (GulDU-2). Higher ratios, as in GulDU-2, suggest adaptation to high-light environments, common in Samarkand's summer months (Lichtenthaler, 1987). Xazina, Xazina-1, and Xazina-2's similar chlorophyll profiles (21.40–22.49 mg/g total chlorophyll) indicate genetic stability, likely due to their shared breeding origin.

Carotenoid content, particularly in GulDU-2 (5.04±0.19 mg/g), highlights its nutritional superiority, as β-carotene is a critical dietary component. Compared to reported values (3–5 mg/g in orange-fleshed sweet potatoes), GulDU-2's carotenoid levels are at the upper end, reinforcing its potential for addressing vitamin A deficiency [1]. Xazina-2's low carotenoid content (3.72±0.07 mg/g) may limit its nutritional value, despite adequate chlorophyll levels.

Table 1.

Chlorophyll and Carotenoid Content in Sweet Potato Leaves

Varieties	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Carotenoids (mg/g)
Khazina	16.32±0.36	6.17±0.13	22.49±0.37	4.35±0.08
Khazina-1	15.12±0.37	6.08±0.22	21.60±0.59	4.20±0.06
Khazina-2	15.29±0.27	6.12±0.34	21.40±0.45	3.72±0.07
GulDU-1	14.16±0.37	4.58±0.12	18.74±0.32	3.77±0.28
GulDU-2	17.93±0.18	5.22±0.18	23.16±0.27	5.04±0.19

HPLC analysis confirmed spectrophotometric results, with β-carotene being the dominant carotenoid across all varieties. Statistical analysis (ANOVA) revealed significant varietal effects on pigment content ($p<0.05$), underscoring genetic influences on photosynthetic efficiency.

Discussion. The significant variations in chlorophyll and carotenoid content reflect genetic differences among sweet potato varieties, with implications for photosynthetic efficiency and nutritional quality. GulDU-2's high chlorophyll a (17.93±0.18 mg/g) and total chlorophyll (23.16±0.27 mg/g) align with studies linking elevated chlorophyll levels to enhanced photosynthetic rates and biomass accumulation [3]. Compared to global benchmarks (e.g., 15–20 mg/g total chlorophyll in high-yielding sweet potato varieties), GulDU-2's performance is exceptional, suggesting its suitability for Samarkand's semi-arid conditions (Porra, 2002). Conversely, GulDU-1's low chlorophyll content (18.74±0.32 mg/g total chlorophyll) may indicate reduced photosynthetic

These results align with global research emphasizing the role of photosynthetic pigments in crop productivity and stress tolerance [2]. The observed differences suggest that GulDU-2's high pigment content enhances its photosynthetic efficiency, potentially increasing tuber yield and quality. However, GulDU-1's poor performance warrants further investigation into its genetic and physiological limitations. Future studies should explore correlations between pigment content, tuber yield, and environmental stress responses to guide breeding programs.

Conclusion. Under Samarkand's soil-climate conditions, GulDU-2 exhibited the highest photosynthetic pigment content, with 17.93±0.18 mg/g chlorophyll a, 23.16±0.27 mg/g total chlorophyll, and 5.04±0.19 mg/g carotenoids,

indicating superior photosynthetic efficiency and nutritional quality. Xazina (22.49±0.37 mg/g total chlorophyll, 4.35±0.08 mg/g carotenoids), Xazina-1, and Xazina-2 showed comparable chlorophyll levels but varied in carotenoids, while GulDU-1 had the lowest pigment content (18.74±0.32 mg/g total chlorophyll, 3.77±0.28 mg/g carotenoids). These findings highlight the influence of genetic variation on pigment accumulation, with GulDU-2 emerging as a promising candidate for high-yield, nutrient-rich sweet potato cultivation in Uzbekistan.

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