Evaluation of the effect of a whey-based biofertilizer on agronomic and biochemical parameters in sweet potato [*Ipomoea batatas* (L.) Lam.]

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ABSTRACT

Objective: To compare the effects of applying an organic biofertilizer (APIS®), formulated from whey, on agronomic and biochemical variables in sweet potato (*Ipomoea batatas*).

Design/Methodology/Approach: A randomized block design was implemented over a 1.5 ha open-field plot. Treatments included foliar applications of APIS®, Bayfolan Forte® (a commercial fertilizer), and water (as a control) at 35- and 65-days post-transplanting (dpt). Sampling was conducted at 35, 60, and 85 dpt to evaluate morphological parameters; quantification of total bacteria and filamentous fungi; elemental analysis; chlorophyll content; total protein; total polyphenols; soluble sugars; and hydrogen peroxide (H_2O_2) levels.

Results: The organic biofertilizer APIS® led to a higher number of tubers and, consequently, greater yield per hectare 22% and 32% higher compared to Bayfolan Forte® and the control, respectively. APIS® also enhanced microbial load during the second sampling, followed by a reduction in the third. No statistically significant differences were observed between the APIS® and control treatments regarding morphological parameters, chlorophyll content, total protein, polyphenols, soluble sugars, and H_2O_2. However, H_2O_2 concentrations increased in the Bayfolan Forte® treatment compared to the control.

Limitations/Implications: The study was conducted during a single agricultural cycle, which may limit broader generalizations.

Findings/Conclusions: APIS® demonstrates potential as a viable biofertilizer for sweet potato cultivation, showing comparable or superior performance to the commercial fertilizer.

Keywords: Elemental composition, total bacteria, chlorophyll content, filamentous fungi, total polyphenols.

INTRODUCTION

In agricultural production systems, it is essential to develop fertilization strategies that align with soil fertility, crop variety, and the production cycle (Aguilar, 2021). Based on this premise, enhancing soil fertility often involves the use of inorganic fertilizers,

which are the most commonly applied to meet the nutritional requirements of sweet potato crops. For instance, the recommended practice includes the application of 184 kg ha^{-1} of 10-30-10 (Nitrogen, Phosphorus, Potassium: N-P-K) at eight days and again at two months post-planting (Aguilar, 2021). However, the excessive and improper use of synthetic inputs has led to their accumulation in soil, water, and air, resulting in soil salinization and toxicity, disruption of biogeochemical cycles and trophic chains in agricultural zones, and increasing difficulties in pest, disease, and weed management all of which negatively affect agricultural productivity (Chávez-Díaz *et al.*, 2020; García-Galindo *et al.*, 2020; Andrade-Sifuentes *et al.*, 2022; García-De La Paz *et al.*, 2022). As a result, there is a pressing need to develop plant nutrition strategies that reduce reliance on synthetic fertilizers. This has driven interest in the use of organic amendments and biofertilizers, which not only supply essential nutrients for crop growth but also improve soil nutrition and increase organic matter reserves (Arreola *et al.*, 2020).

Biofertilizers are natural fertilizers containing living microorganisms that, when introduced into the soil, enhance nutrient availability to host plants, stimulate their development, and may promote the production of plant growth regulators and biocontrol agents (Nafi'Ah *et al.*, 2021). Recently, various types of biofertilizers have been developed using waste products from different industries. One such by-product, whey, is produced in large quantities by the cheese and yogurt industries and poses a significant environmental challenge due to its high organic load (Lizárraga-Chaidez *et al.*, 2023). Whey contains valuable nutrients for plants, including nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, as well as lactose, proteins, and minerals (Ahmed *et al.*, 2020). These components, combined with the activity of naturally occurring microorganisms, make whey a promising organic fertilizer for improving crop health and productivity (Akay & Sert, 2020). For example, the application of whey in agricultural soils improves physicochemical properties, enhances structural stability and aggregation, increases yields, and boosts N, P, and K content (Akay, 2020; Ahmed *et al.*, 2020). Furthermore, its content of water, proteins, lactose, fats, and vitamins promotes plant growth (Ahmed *et al.*, 2020). In this regard, the use of hydrolyzed whey in crops such as pea (*Pisum sativum* L.), wheat (*Triticum aestivum* L.), and sweet potato (*Ipomoea batatas* L.) has led to improvements in agronomic traits such as pod length and growth, dry weight, and nutrient uptake, ultimately enhancing crop yield (Sun *et al.*, 2024).

Sweet potato (*I. batatas*) is a high-potential crop with increasing economic relevance. It has been cultivated in Mexico since pre-Hispanic times and is currently grown in 21 states, with Michoacán, Veracruz, Guanajuato, and Chihuahua being the leading producers (Vidal *et al.*, 2018; Córdova *et al.*, 2022; SIAP, 2024). *I. batatas* adapts well to diverse edaphoclimatic conditions, is easily propagated, supports multiple production cycles per year, and serves various industrial purposes, including biofuel, paper, cosmetics, animal feed, and confectionery (Solís & Ruiloba, 2017; Salehin *et al.*, 2020; Montes-Sierra *et al.*, 2023; Gama *et al.*, 2023). Additionally, the tuber contains bioactive compounds with significant health benefits, provides essential nutrients, and exhibits nutraceutical properties (Vidal *et al.*, 2018). In response to the growing need for sustainable agricultural alternatives, a new organic biofertilizer APIS® has been

developed using whey, a by-product of the cheese-making industry. This formulation is enhanced with lactic acid bacteria, yeasts, and molasses. APIS® aims to reduce the environmental impact caused by agrochemicals while supporting crop nutrition. The primary aim of this study was to compare the effects of APIS® application on agronomic and biochemical variables in sweet potato plants relative to a commercial fertilizer. It is anticipated that whey will emerge as a viable nutritional alternative for agricultural crops, contributing to its revalorization.

MATERIALS AND METHODS

Field location

The study was conducted on private agricultural plots located in the community of San Nicolás de Los Agustinos (20.251640, −100.961281), in the municipality of Salvatierra, Guanajuato, Mexico.

Treatments

Sweet potato (*I. batatas*) plants were sown in January 2022. A randomized block design was employed over 1.5 hectares. Each experimental unit (EU) consisted of 10 ridges, each 1.6 m wide and 10.5 m long, with 15 cm spacing between plants and 90 cm between rows. Three EUs were used per treatment, at a planting density of 44,300 plants ha^{-1}. Four furrow irrigations were applied. No soil fertilization, insecticides, or fungicides were used. Weed control was performed mechanically and manually. Foliar fertilization was applied using a motorized backpack sprayer according to the manufacturer's recommendations for each of the following treatments: (1) Whey-based biofertilizer (APIS®, Irapuato, Gto.); (2) Commercial inorganic fertilizer Bayfolan Forte® (Bayer, Mexico) and (3) Water only (control).

All treatments included 100 mL ha^{-1} of the adjuvant Break Thru® (BASF de México).

The first foliar application was performed at 35 days post-transplanting (dpt): 4 L ha^{-1} of APIS® in 200 L of water, 4 L ha^{-1} of Bayfolan Forte® in 200 L of water, and 200 L ha^{-1} of water for the control. A second application at 65 dpt consisted of 5 L ha^{-1} of each fertilizer (APIS® and Bayfolan Forte®), while the control group received only water. For sampling, three ridges per treatment were randomly selected, and 21 plants were collected randomly from central rows at 35, 60, and 85 dpt. Samples were flash-frozen in dry ice, transported to the laboratory, and stored at −40.0 °C.

Morphological parameters

The following morphological variables were evaluated: root length (cm), total plant length (cm), number of leaves, fresh weight (g), dry weight (g), and yield (t ha^{-1}). Samples were first cleaned of residual substrate. Root and total length were measured with a measuring tape. Leaf number was counted manually. Fresh weight was recorded using an analytical balance (Sartorius), and samples were dried in a hot-air oven (Ecocell) at 75 °C for 72 hours or until constant weight. Final yield (t ha^{-1}) was reported by the grower at the end of the crop cycle.

Microbiological quantification

Colony-forming units (CFU) were quantified following Girón-Calva *et al.* (2012), with modifications. Five leaves per treatment were collected at each sampling time (30, 60, and 85 dpt), ground with 3 mL of phosphate buffer (137 mM NaCl, 2.7 mM KCl, 10 mM Na_2HPO_4, 1.8 mM KH_2PO_4), and centrifuged at 3,000 rpm for 3 min at room temperature. Serial dilutions (10^{-1}, 10^{-2}, and 10^{-3}) were plated on nutrient agar (NA) and incubated at 35 °C for 24 h to quantify total bacteria (TB). Simultaneously, dilutions were plated on potato dextrose agar (PDA) supplemented with benzylpenicillin (100 mg L^{-1}) and incubated at 28 °C for 7 days to quantify total filamentous fungi (TFF).

Elemental quantification

Carbon (C), hydrogen (H), nitrogen (N), and sulfur (S) were quantified based on Ma *et al.* (2017) and Easa *et al.* (2019), with slight modifications. Leaf samples from all three sampling times (30, 60, and 85 dpt) were dried in a convection oven at 45±3 °C to constant weight. Three milligrams of sample were combined with 10 mg of vanadium oxide (V_2O_5) in tin capsules. Elemental content was measured using a CHNS-O elemental analyzer (Thermo Fisher Scientific Inc., 2009), with a run time of 10 minutes per sample.

Chlorophyll quantification

Following Arnon (1949), with modifications, 1 mL of 96% ethanol was added to 100 mg of fresh leaf tissue. Samples were incubated for 24 h at 4 °C, then centrifuged at 11,000 rpm for 15 min at 4 °C. Two hundred microliters of the supernatant were transferred to a microplate, and absorbance was measured at 645 nm and 663 nm (Multiskan™ Sky, Thermo Scientific).

Soluble protein quantification

Soluble protein content was determined using the Bradford method (Bradford, 1976). Dried leaf samples (100 mg) from each treatment and sampling time were homogenized in 250 μL of Tris-HCl buffer (0.05 M, pH 7.4), vortexed, and incubated at 4 °C for 15 min. Samples were centrifuged at 12,000 rpm for 15 min at 4 °C. In a 96-well microplate, 5 μL of extract, 5 μL of distilled water, and 200 μL of 1:5 diluted Bradford reagent were added per well. After 5 min of incubation at room temperature, absorbance was read at 595 nm. A bovine serum albumin (BSA) standard curve was used for quantification.

Total polyphenol quantification

Total polyphenols were measured in lyophilized and ground leaf tissue using the Folin-Ciocalteu method (Attard, 2013). A 100 mg sample was extracted with 500 μL of 70% methanol under agitation for 12 h, then centrifuged at 12,000 rpm for 5 min. In a microplate, 237 μL distilled water, 45 μL of 15% Na_2CO_3, 3 μL of extract, and 15 μL of 10% Folin-Ciocalteu reagent were mixed and incubated for 30 min at room temperature. Absorbance was read at 760 nm using a gallic acid calibration curve.

Total soluble sugar quantification

Total soluble sugars were quantified following Laurentin and Edwards (2003). One hundred milligrams of dried leaf tissue were extracted with 1.5 mL of 96% ethanol, centrifuged at 3,500 rpm for 10 min at 4 °C. Forty microliters of the supernatant were placed in a 96-well plate, mixed, and incubated at 4 °C for 15 min. Then, 100 μL of anthrone solution (2 g/12 mL H_2SO_4) was added. The plate was incubated in a water bath at 92 °C for 3 min, cooled to room temperature for 5 min, and then incubated at 45 °C for 15 min. Absorbance was read at 630 nm using a microplate spectrophotometer.

Hydrogen peroxide quantification

H_2O_2 concentration was determined using the Peroxide Assay Kit (Sigma-Aldrich®, 2019). A total of 100 mg of leaf tissue was mixed with 1 mL of distilled water, shaken at 1,500 rpm for 10 min, and centrifuged at 12,000 rpm for 15 min at 4 °C. The supernatant was collected. Quantification reagent (1:100 mixture of Reagents A:B) was prepared. In a 96-well plate, 40 μL of sample and 200 μL of reagent were added per well. After 30 min of incubation at room temperature, absorbance was measured at 585 nm. A standard curve was constructed using H_2O_2.

Statistical analysis

Data were analyzed using one-way ANOVA followed by Tukey's HSD multiple comparison test, both at a 5% significance level. Statistical analyses were performed using Minitab 20.3 software.

RESULTS AND DISCUSSION

Morphological Parameters

There is limited information on the application of biofertilizers in sweet potato plants, and to date, no studies have been reported using formulations based on whey. In this study, sweet potato plants were treated with a foliar application of a whey-based biofertilizer (APIS®) and compared to a commercial fertilizer (Bayfolan Forte®) and an untreated control. The results revealed statistically significant differences ($P \leq 0.05$) at 60 days post-transplant (dpt; second sampling) in the number of leaves between the APIS® and Bayfolan Forte® treatments (Figure 1a), as well as in root length (Figure 1c), stem length (Figure 1c), and number of tubers between the control and APIS® treatments (Figure 1d). Regarding tuber production, the average number of tubers recorded at the second sampling (60 dpt) was 4.6±0.9, 7.4±1.5, and 10.8±2.3 for the control, Bayfolan Forte®, and APIS® treatments, respectively (Figure 1d). A further increase in tuber count was observed in the third sampling (85 dpt) for the APIS® (12.3±0.6 tubers) and control (8±1.0 tubers) treatments. However, no increase was recorded for Bayfolan Forte® (7.3±5 tubers). At 85 dpt, no statistically significant differences ($P \leq 0.05$) were found among treatments in terms of number of leaves, fresh and dry plant weight, root length, stem length, or tuber weight (Figure 1a-e). García *et al.* (2022) evaluated the application of the APIS® biofertilizer in broccoli (*Brassica oleracea* var. *italica*) and reported significant improvements in axial and

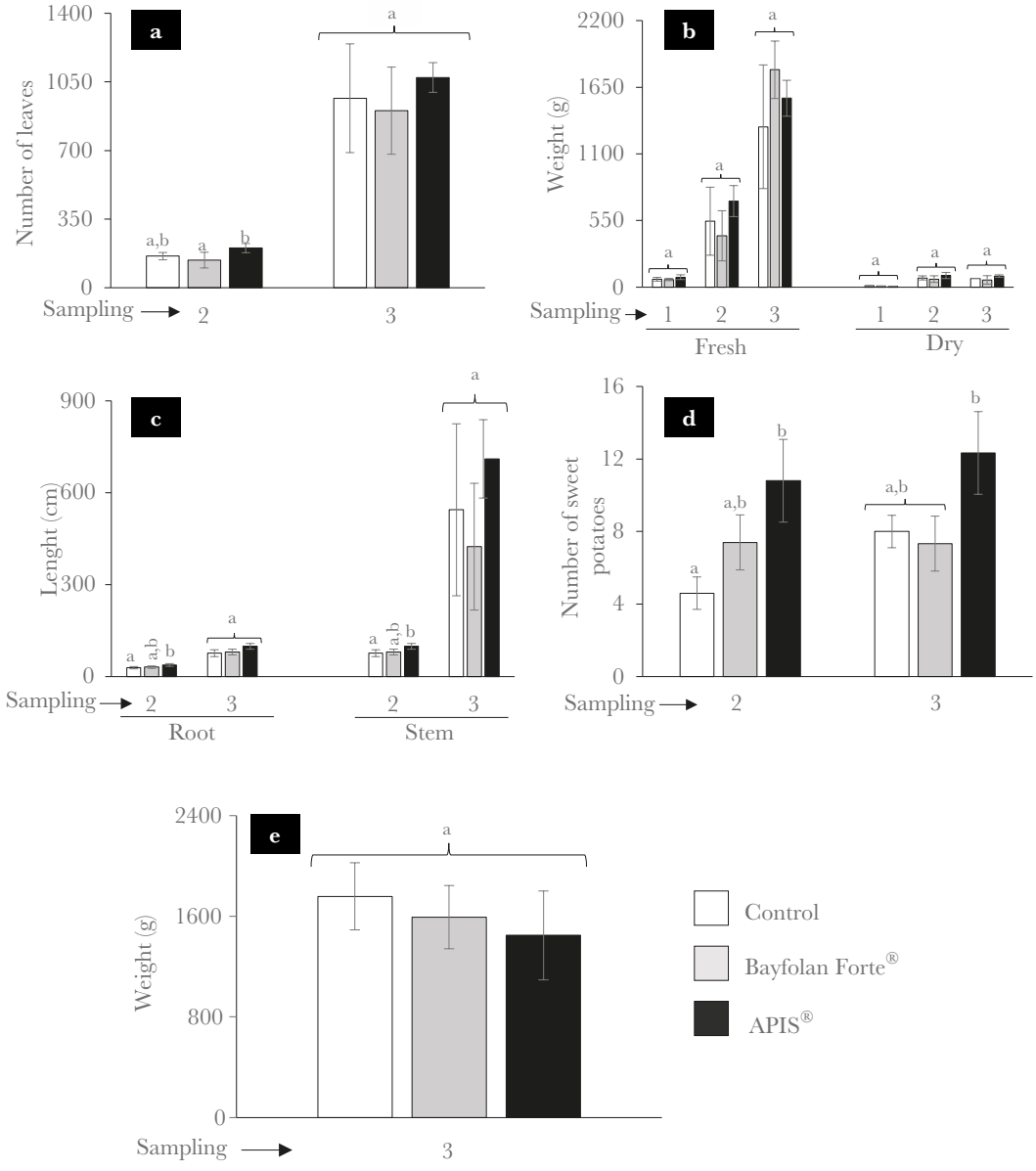

Figure 1. Morphological parameters of sweet potato (*I. batatas*) plants treated with a biofertilizer. (a) Number of leaves; (b) fresh and dry weight; (c) root and stem length; (d) number of tubers per plant; and (e) total tuber weight per plant at different sampling times (35, 60, and 85 days post-transplant, dpt). Bars represent the mean ± standard deviation (n=5). Different letters indicate statistically significant differences according to Tukey's test ($P \leq 0.05$).

longitudinal length, stem length, leaf count, and floret diameter compared to both the control and Bayfolan Forte® treatments.

Although the control treatment produced the lowest number of tubers compared to the APIS® treatment (Figure 1d), the tubers harvested from the control group showed a trend toward a higher average weight, although no statistically significant differences were detected among treatments (Figure 1e). Notably, the tuber weights obtained in this study exceeded those reported by Sakamoto and Suzuki (2020), who evaluated sweet potato

production under hydroponic conditions with varying conductivity levels (0.8, 1.4, and 2.6 dS m^{-1}), achieving an average tuber weight of 1,300 g.

Fertilization plays a critical role in sweet potato cultivation, as it can influence either vegetative growth or tuber production (Sakamoto & Suzuki, 2020). In this study, the application of APIS® resulted in a higher number of tubers per plant, translating into a commercial yield of 26.4 t ha^{-1}, compared to 21.6 t ha^{-1} for Bayfolan Forte® and 20 t ha^{-1} for the control (Table 1).

It has been reported that the average yield of sweet potato crops in Mexico is approximately 21.13 t ha^{-1} (SIAP, 2025). In this context, the application of APIS® resulted in a 24.7% increase in yield, while Bayfolan Forte® yielded a 2.3% improvement. Similarly, Rodríguez *et al.* (2023) reported a commercial yield of 26.44 t ha^{-1} using clones derived from stem cuttings of orange-fleshed tuber-producing plants, planted at a density of 50,000 plants ha^{-1} and fertilized with a 60-40-100 N-P-K formulation. Furthermore, Elwaziri *et al.* (2023) documented that foliar application of 0.2% milk protein hydrolysate increased yield from 24 to 32 t ha^{-1} compared to the control. Notably, the combined application of 240 kg ha^{-1} of K_2O with 0.2% milk protein hydrolysate produced yields of up to 36 t ha^{-1}, surpassing the 29 t ha^{-1} obtained with the control treatment. The findings of the present study suggest that applying APIS® could enhance the economic returns for sweet potato producers in Mexico. Based on the minimum market prices reported by the León, Guanajuato central wholesale market on August 11, 2025, projected revenues would be approximately $527,140 MXN ha^{-1} for APIS®, $432,160 MXN ha^{-1} for Bayfolan Forte®, and $399,120 MXN ha^{-1} for the control (SNIIM, 2024). Consequently, the use of APIS® could result in additional earnings of $94,890 MXN compared to Bayfolan Forte® and $128,020 MXN compared to the untreated control.

Microbial load

Regarding microbial load results obtained from the different sweet potato leaf samplings, no statistically significant differences ($P \leq 0.05$) were observed among treatments in the first and third sampling points (Figures 2a and 2b). However, during the second sampling, leaves from plants treated with APIS® exhibited significantly higher levels of both total bacteria and filamentous fungi compared to the control and Bayfolan Forte® treatments ($P \leq 0.05$). This increase may be attributed to the biological nature of APIS®, which is formulated with lactic acid bacteria and yeasts microorganisms that are likely to be isolated and quantified in greater abundance, particularly during the mid-stage of plant development. Additionally, it has been reported that whey contains bioactive peptides with antimicrobial and antioxidant properties, which may play a role in modulating microbial populations (Carrasco & Guerra, 2010). Kalla *et al.* (2021) further observed that exposure of milk to

Table 1. Commercial yield of sweet potato (*I. batatas*) following foliar fertilization treatments.

	Treatment		
	Control	**Bayfolan Forte®**	**APIS®**
Performance (t ha^{-1})	20.0	21.6	26.4

t: tonne; ha: hectare.

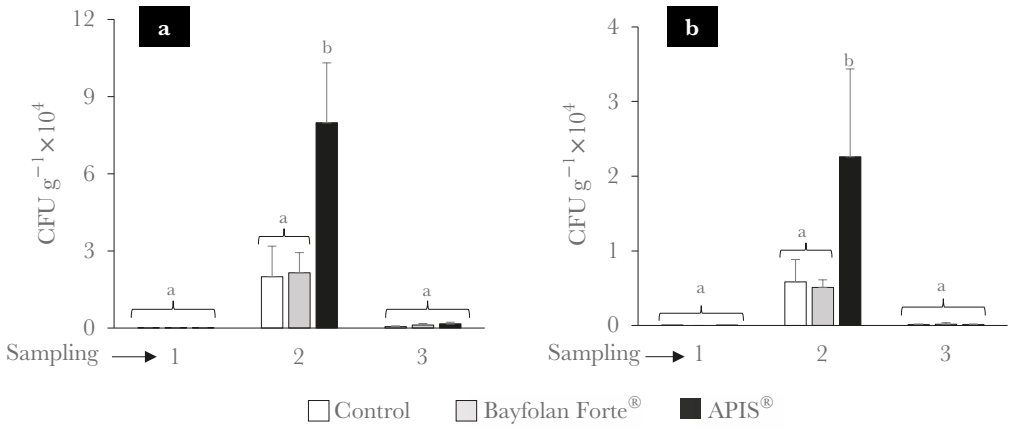

Figure 2. Microbial load in sweet potato leaves. (a) Total bacteria and (b) total fungi at different sampling points (35, 60, and 85 days post-transplanting, dpt). Bars represent the mean ± standard deviation (n=3). Different letters indicate statistically significant differences according to Tukey's test (P≤0.05).

solar ultraviolet radiation generates superoxide anions $\left(O_2^{-2}\right)$ and reactive oxygen species, which can disrupt the cell membranes of fungal pathogens such as *Phytophthora infestans*. Similarly, Chee *et al.* (2018) reported that the application of anhydrous milk fat effectively controlled downy mildew caused by *Sphaerotheca fuliginea* in various squash cultivars, outperforming commercial fungicides such as Bravo® 720 (Syngenta) and Kumulus®. These findings may explain the subsequent decline in microbial load both bacterial and fungal observed during the third sampling (Figure 2).

Elemental Parameters

Whey is an excellent source of macro- and micronutrients that can be utilized as a biofertilizer to support plant development (Akay & Sert, 2020). The elements carbon, hydrogen, oxygen, nitrogen, and sulfur (CHONS) are essential to all life forms and constitute the fundamental biomolecules required for plant growth, development, and reproduction (Monib *et al.*, 2023). For instance, carbon serves as a structural component in plants and is involved in the biosynthesis of defense-related compounds such as phenols and terpenes (Xing *et al.*, 2021). Nitrogen is vital for physiological processes including photosynthesis and biomolecule synthesis (Xing *et al.*, 2021). Sulfur, although required in smaller quantities, is essential for chlorophyll formation, protein synthesis, oil production, and amino acid biosynthesis (Monib *et al.*, 2023). The analysis of these elemental components and their interactions is critical for understanding plant nutrition and implementing effective crop management practices. In the present study, the concentrations of carbon (C), hydrogen (H), nitrogen (N), and sulfur (S) in sweet potato leaves did not show statistically significant differences (P≤0.05) among the experimental treatments applied (Figures 3a-d). Carbon and hydrogen levels remained relatively stable across the three sampling periods. In contrast, some variation was observed in nitrogen and sulfur concentrations over time, although these were not statistically significant (P≤0.05). Garcia *et al.* (2022), in their study applying APIS® to broccoli plants at various phenological stages, reported that C and H concentrations remained constant over time,

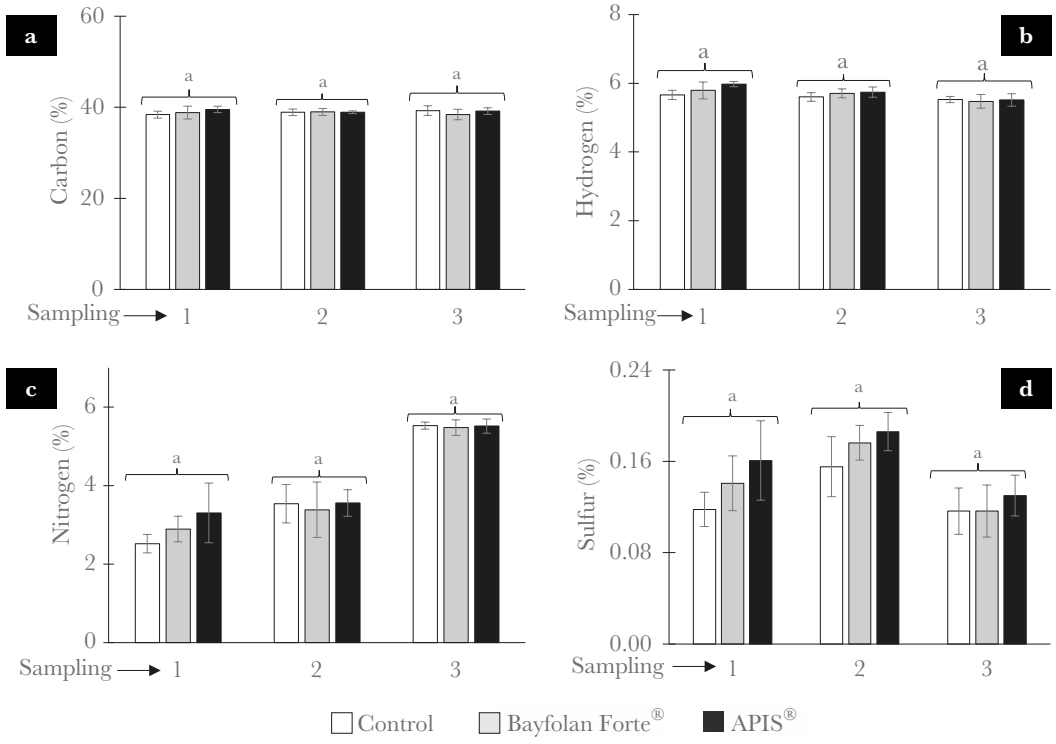

Figure 3. Elemental composition (%) in sweet potato leaves. (a) Carbon, (b) Hydrogen, (c) Nitrogen, and (d) Sulfur at different sampling times (35, 60, and 85 days post-transplanting, dpt). Bars represent the mean ± standard deviation (n=3). Different letters indicate statistically significant differences according to Tukey's test (P≤0.05).

while statistically significant differences (P≤0.05) were observed in N and S content across the three sampling periods.

Total chlorophyll and soluble protein

Total chlorophyll content increased over time (Figure 4a), although no statistically significant differences were observed among treatments (P≤0.05). The APIS® treatment recorded the highest chlorophyll concentration, followed by Bayfolan Forte® and the control, with values of 206.0, 177.8, and 170.2 mg chlorophyll g^{-1} FW, respectively. Variations in chlorophyll levels among plants may be attributed to factors such as cultivar differences, altitude, fertilization type, and the crop›s nutrient assimilation efficiency (Milenković *et al.*, 2024). In contrast, soluble protein concentration declined at 60 dpt following the first sampling but increased again at 85 dpt, with no statistically significant differences among treatments (Figure 4b). Proteins are essential macromolecules composed of amino acids that play key roles in enzymatic activity, structural integrity, storage, photosynthesis, biosynthesis, transport, and in defense mechanisms against pathogens or abiotic stress factors (Rasheed *et al.*, 2020).

Total polyphenols, soluble sugars, and hydrogen peroxide

Previous studies have demonstrated that sweet potato leaves are an excellent source of antioxidant compounds, such as caffeic acid and caffeoylquinic acids, which not only

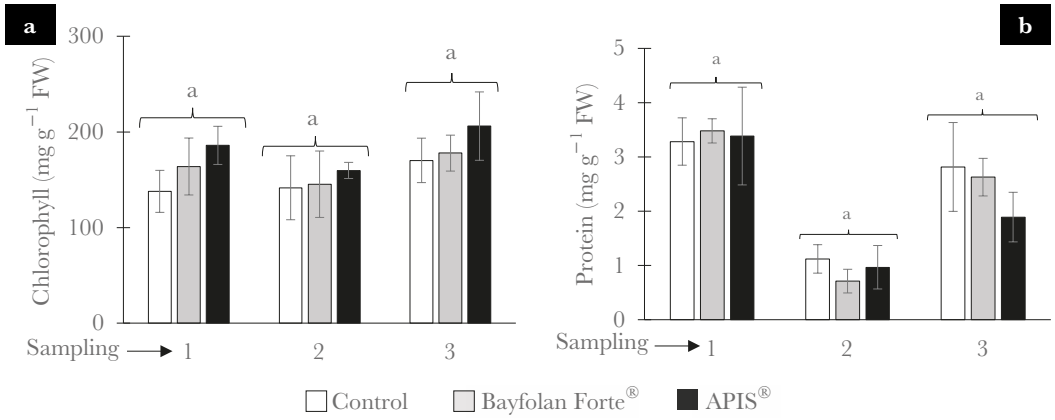

Figure 4. Concentration of biomolecules in sweet potato (*I. batatas*) leaves. (a) Total chlorophyll and (b) total protein at different sampling times (35, 60, and 85 days post-transplanting, dpt). Bars represent the mean ± standard deviation (n=3). Different letters indicate statistically significant differences according to Tukey's test (P≤0.05).

exhibit strong antioxidant capacity but also possess remarkable bioactive properties including anti-inflammatory, antimicrobial, hepatoprotective, cardioprotective, LDL oxidation-preventive, and neuroprotective effects (Sasaki *et al.*, 2015).

In the present study, the highest concentrations of total polyphenols were observed during the first and third sampling periods (Figure 5a). Notably, at 35 dpt, both nutrient treatments APIS® and Bayfolan Forte® led to significantly higher polyphenol levels compared to the untreated control (P≤0.05), whereas no significant differences were detected among treatments at 60 and 85 dpt. Ghasemzadeh *et al.* (2012) reported that total polyphenol content in leaves of six *I. batatas* varieties ranged from 4.47 to 8.11 mg gallic acid g^{-1} DW. In contrast, this study recorded higher concentrations, ranging from 9.44 to 20.28 mg gallic acid g^{-1} FW, induced by APIS® and Bayfolan Forte®, respectively.

Another class of biomolecules involved in cellular maintenance are soluble sugars (Figure 5b). These play multiple roles in plants, including energy storage, growth, nutrient signaling, membrane and macromolecule stability, osmotic potential regulation, chlorophyll pigment stabilization, and defense mechanisms, as well as the mitigation of reactive oxygen species (ROS) (Kitayama *et al.*, 2020; Savchenko & Tikhonov, 2021). The highest concentration of soluble sugars was recorded at the third sampling in plants treated with APIS® (24.62 mg g^{-1} FW), which was statistically higher (P≤0.05) than those of the control and Bayfolan Forte® treatments. Kitayama *et al.* (2020) reported total soluble sugar levels in leaves of *I. batatas* varieties "Japanese Yellow" and "Blackie" at 80 and 20 mg g^{-1} DW, respectively.

Finally, the highest concentration of hydrogen peroxide (H_2O_2) was observed in the third sampling for plants treated with Bayfolan Forte® (503.0 μM g^{-1} FW), followed by the control (402.06 μM g^{-1} FW) and APIS® (381.5 μM g^{-1} FW), though no statistically significant differences were found among treatments (Figure 5c). It is well-established that plant cells continuously generate basal levels of ROS, which are non-toxic and, in coordination with antioxidant molecules, participate in signaling processes that

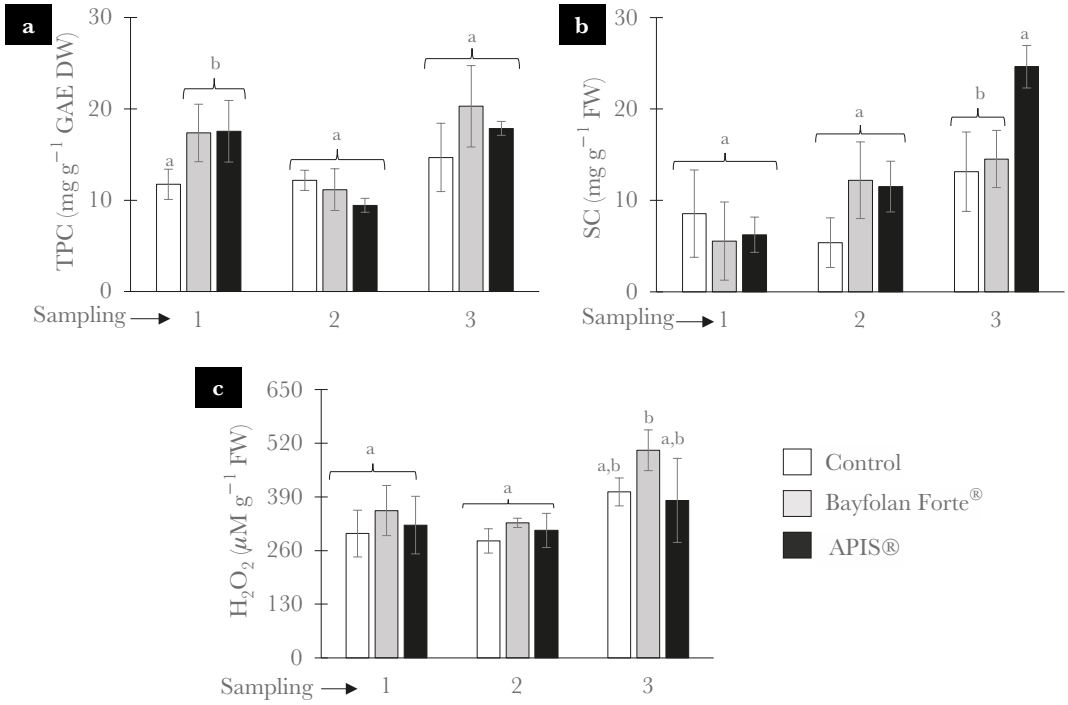

Figure 5. Biochemical stress markers in sweet potato (*I. batatas*). (a) Total polyphenols (TPC), (b) Sugar concentration (SC), and (c) Hydrogen peroxide (H_2O_2) at different sampling times (35, 60, and 85 days post-transplanting, dpt). Bars represent the mean ± standard deviation (n=3). Different letters indicate statistically significant differences according to Tukey's test ($P \leq 0.05$). Total Polyphenols Concentration (TPC) reported as Gallic Acid Equivalents (GAE) in Dry Weight (DW). Sugar Concentration (SC) from Fresh Weight (FW).

regulate gene expression under various biotic and abiotic stress conditions (Sperdouli *et al.*, 2022).

CONCLUSIONS

The whey-based biofertilizer demonstrated comparable effects to the commercial fertilizer Bayfolan Forte® in the morphological variables evaluated during the third sampling. The elemental composition (C, H, N, and S) was statistically similar between treatments with APIS® and Bayfolan Forte®. APIS® application contributed to increased tuber yield, while Bayfolan Forte® enhanced the number of tubers produced. The total bacterial and filamentous fungal load in sweet potato leaves treated with APIS® increased during the second sampling but declined by the third. Total chlorophyll and protein concentrations remained consistent across all treatments. However, polyphenol content was elevated in APIS® and Bayfolan Forte® treatments during the first sampling. The highest soluble sugar concentration was recorded in the APIS® treatment at the third sampling, while H_2O_2 levels remained statistically unchanged among treatments.

The APIS® biofertilizer is a viable alternative for sweet potato (*I. batatas*) cultivation, offering an environmentally friendly option that can contribute to reducing agricultural production costs. Further research is warranted to assess the combined use of whey-based biofertilizer with other organic and biological products.

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