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Yacon: Phytochemical Diversity and Antioxidant Potency Across Plant Parts

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Abstract

This study characterized the phytochemical composition and antioxidant capacity of yacon (*Smallanthus sonchifolius*) organs cultivated in Doalnara Aposkahoy, Claveria, Misamis Oriental, Philippines. Recognized as a functional food, yacon was analyzed for key phytochemicals—including alkaloids, flavonoids, phenolics, tannins, saponins, triterpenoids, steroids, and cardiac glycosides—and antioxidant properties via DPPH radical scavenging, ferric reducing antioxidant power (FRAP), total phenolic content, and total flavonoid content assays.

Plant parts were screened for alkaloids, phenolics, tannins, saponins, triterpenoids, steroids, and cardiac glycosides. Antioxidant potential was measured by DPPH radical-scavenging, ferric-reducing antioxidant power (FRAP), and total phenolic content assays. Results revealed trace to moderate alkaloids across various parts of yacon and variable distributions of tannins, phenolics, and saponins, indicating potential nutritional and therapeutic value. Antioxidant activity was highest in stems, flowers, and leaves, while tubers showed comparatively lower activity—contrasting some previous reports and offering new insights into organ-specific bioactivity. Overall, findings support yacon's potential as a functional food and highlight heterogeneous phytochemical and antioxidative profiles among organs. Further work is recommended to isolate bioactive constituents and assess broader nutraceutical and pharmacological applications.

Keywords: *Smallanthus Sonchifolius*, Antioxidant Activity, Phytochemical Composition, Alkaloids, Phenolics

1. Introduction

Yacon (*Smallanthus sonchifolius*) has gained increasing recognition as a functional food due to its diverse phytochemical composition and notable antioxidant properties (Pereira et al., 2025). The tuber is particularly valued for its high content of fructooligosaccharides (FOS) and inulin, which exhibit prebiotic effects, modulate gut microbiota, and contribute to the regulation of blood glucose levels (Choque Delgado, da Silva Cunha Tamashiro, Maróstica Junior, and Pastore, 2013). Additionally, the presence of phenolic compounds further enhances its potential health benefits.

The phytochemical composition of yacon varies considerably across different plant tissues. Major bioactive constituents include phenolic acids (such as chlorogenic, caffeic, and ferulic acids), flavonoids, terpenoids, sesquiterpene lactones, and FOS, all of which contribute to its antioxidant, anti-inflammatory, antidiabetic, and antimicrobial activities (Marcon et al., 2019; Ojansivu, Ferreira, and Salminen, 2011). Notably, leaves and peels generally contain higher concentrations of total phenolics and flavonoids than

the tuber flesh, resulting in greater antioxidant capacity as demonstrated by ABTS, DPPH, and FRAP assays (Khajehei, Merkt, Claupein, and Graeff-Hoenninger, 2018; Pereira et al., 2016). Furthermore, peels from various cultivars exhibit elevated phytochemical levels alongside low sugar content, making them suitable for low-glycemic applications (Khajehei et al., 2018). Leaf extracts are especially rich in caffeic acid derivatives, luteolin glycosides, and sesquiterpene lactones—including sonchifolin, uvedalin, and enhydrin—which have been shown to possess strong radical-scavenging, cytoprotective, and anti-inflammatory properties (Russo et al., 2014).

Despite these findings, comprehensive comparative analyses encompassing multiple anatomical parts—such as flowers, stems, tubers, and peels—remain limited. This gap restricts a complete understanding of the relative distribution of phytochemicals and antioxidant potential across the plant.

The present study addresses this limitation by systematically evaluating both qualitative and quantitative phytochemical profiles, with emphasis on total phenolics and other secondary metabolites, alongside antioxidant capacities measured through DPPH and FRAP assays in yacon leaves, flowers, stems, tubers, and peels. By delineating the distribution of bioactive compounds, the study aims to identify high-value plant fractions for applications in nutraceuticals, functional foods, and related industries, while also supporting the sustainable utilization of yacon by-products.

The findings are expected to enhance current understanding of the phytochemical diversity of yacon, reinforce its potential as a functional food and nutraceutical source, clarify the bioactive compounds responsible for its health-promoting effects, and contribute to the development of plant-based therapeutic applications as well as broader dietary integration.

2. Materials and Methods

2.1 Plant Sample Collection and Preparation

Yacon plants (*Smallanthus sonchifolius*) used in this study were sourced from Doalnara, Aposkahoy, Claveria, Misamis Oriental, Philippines (Figure 1). Samples were collected via purposive sampling, selecting only fully mature plants aged four to five months post-planting.

Harvested plants were sectioned, thoroughly washed, and wiped to facilitate drying. Aerial parts (flowers, leaves, and stems) were air-dried at room temperature in an air-conditioned environment. Tubers and tuber peels were oven-dried at low temperature under a nitrogen gas blanket to minimize oxidation.

Dried materials were pulverized into fine powder using a laboratory blender, then stored in sealed containers in a freezer to preserve integrity until extraction and analysis.

2.2 Phytochemical Screening

Test for Alkaloids

Alkaloids were evaluated by Wagner's test. A 50 mg sample was stirred in 2 mL of 2N HCl, filtered, and a few drops of Wagner's reagent added to 2 mL of the filtrate. Formation of a precipitate or turbidity confirmed the presence of alkaloids.

Test for Phenolics and Tannins

Phenolics and tannins were detected via the ferric chloride test. A 500 mg sample was boiled in 30 mL distilled water, filtered, and 2 mL of filtrate combined with 5% $FeCl_3$ solution. Development of a blue, green, or violet color indicated the presence of phenolics and tannins.

Test for Saponins

Saponins were confirmed through two complementary tests (foam and olive oil). The foam test entailed boiling 1 g of powder in 10 mL distilled water for 15 minutes, cooling, agitating vigorously, and observing

persistent honeycomb-like foam after 30 minutes. The olive oil test involved boiling 2 g of powder in 20 mL water, filtering, foaming 10 mL of filtrate with additional water, and shaking with three drops of olive oil; emulsion formation confirmed saponins.

Test for Triterpenoids

Triterpenoids were identified using the *Salkowski test*: 0.6 g of sample was extracted with 30 mL chloroform, filtered, and 2 mL of filtrate treated with concentrated sulfuric acid. A yellow color in the lower layer indicated presence.

Test for Steroids

Steroids were detected by the Liebermann-Burchard test (2 mL chloroform filtrate mixed with acetic anhydride and concentrated H_2SO_4 produced a blue-green ring) and the Salkowski test (red color in the lower layer).

Test for Cardiac Glycoside

Cardiac glycosides were evaluated with the Keller-Kiliani test: 500 mg of sample was boiled in 30 mL distilled water, filtered, and 2 mL of filtrate mixed with glacial acetic acid, 5% $FeCl_3$, and concentrated H_2SO_4. A green-blue color confirmed their presence.

These standardized procedures provided reliable qualitative detection of bioactive secondary metabolites in yacon plant parts.

2.3 Determination of Antioxidant Activity

Extraction for Antioxidant Assay

Approximately 20 g of dried sample was macerated in 100 mL of 95% ethyl acetate for 48 h. The mixture was filtered, and the marc was washed three times with 100 mL portions of fresh ethyl acetate with occasional shaking; all washings were combined with the initial filtrate and the total solvent volume recorded. The combined filtrate was concentrated under reduced pressure at 50°C (below the solvent's boiling point) using a rotary evaporator, and the residue was discarded. The resulting extract was transferred to a tightly stoppered vial and stored at 0–5°C until analysis; the procedure was repeated using hexane and water as solvents.

Determination of Crude Extract Concentration

Approximately 10mL of the extract was transferred using a pipette into a previously weighed empty dish. It was then placed in the oven at less than 50°C for one hour, cooled, and weighed. The process was repeated until constant weight was obtained. The concentration was calculated using the equation given below:

$$Concentration = \frac{(Weight_{extract + dish} - Weight_{empty\ dish})\ \underline{1000mg}}{Volume\ of\ crude\ extract\ in\ mL} \quad (1)$$

DPPH In vitro Antioxidant Assay

The sample extract (0.2 mL) was diluted with methanol, and 2 mL of 0.5 mM DPPH (2,2-diphenyl- 1-picrylhydrazyl) solution is added. After 30 min, the absorbance was recorded at 517 nm. The percentage of the DPPH radical scavenging was calculated using the equation as given below:

$$\%DPPH\ Radical\ inhibition = \frac{(A_{control} - A_{extract})}{A_{control}} \times 100 \quad (2)$$

The IC50 is a measure of the potency of a substance in inhibiting a specific biological or biochemical function. IC50 is a quantitative measure that indicates how much of a particular inhibitory substance (e.g. drug) is needed to inhibit, in vitro, a given biological process or biological component by 50%.

Total Antioxidant Assay: DPPH radical scavenging assay

A 0.1 mM DPPH solution was prepared by dissolving 4 mg of DPPH in 100 mL methanol. Ascorbic acid served as the positive standard, dissolved in methanol to produce a 100 ppm stock solution. The blank consisted of methanol alone, and the control comprised the 0.1 mM DPPH methanolic solution without sample or standard.

For each assay, the reaction mixture was vortexed thoroughly and incubated in the dark at room temperature for 30 minutes. Absorbance was measured at 517 nm using a spectrophotometer.

The percentage of DPPH radical scavenging activity was calculated as follows:

$$\% \text{ scavenging activity} = [(A_0 - A_1) / A_0] \times 100 \quad (3)$$

where:

A_0 = the absorbance of the control

A_1 = the absorbance of the sample extract or standard

Dose-response curves were generated by plotting percent inhibition against concentration, and the IC_{50} value (concentration required for 50% inhibition) was determined from the curve. All experiments were conducted in triplicate.

Total Antioxidant Assay: Ferric Reducing Antioxidant Power assay

The FRAP reagent was prepared by combining 50 mL of 0.3 mol·L^{-1} acetate buffer (pH 3.6), 5 mL of 10 mmol·L^{-1} TPTZ in 40 mmol·L^{-1} HCl, and 5 mL of 20 mmol·L^{-1} $FeCl_3$. For the assay, 200 µL of each extract was mixed with 3 mL of FRAP reagent and incubated at 37°C for 10 minutes. Absorbance was read at 593 nm on a UV–Vis spectrophotometer. A calibration curve was prepared using $FeSO_4 \cdot 7H_2O$ standards (125, 250, 500, 750, and 1000 µmol·L^{-1}). Ferric-reducing antioxidant power was calculated from the calibration curve and expressed as µmol Fe^{2+} equivalents per gram of dried sample.

Extraction was performed by macerating ~50 g of powdered yacon in 95% methanol (1:4 w/v) for 48 hours. The crude extract was filtered (Whatman), and the residue underwent two additional extractions with 100 mL methanol each, each shaken for 1 hour and filtered. Combined filtrates were concentrated under reduced pressure at 40°C using a rotary evaporator and stored at −20°C until analysis (adapted from Walag et al., 2017).

Total Flavonoids Assay: Aluminum Chloride Colorimetric Method

The total flavonoid content in methanolic and ethyl acetate extracts of yacon was quantified using the aluminum chloride colorimetric method (Ardekani et al., 2011). An aliquot (1 mL) of each extract (1000 ppm) was placed in a 10 mL volumetric flask and diluted with 4 mL of distilled water. Subsequently, 0.3 mL of 5% $NaNO_2$ was added, followed by a 5-minute incubation period. Then, 0.3 mL of 10% $AlCl_3$ was introduced, followed by the addition of 2 mL of 1 M NaOH and 2.4 mL of distilled water to reach a final volume of 10 mL. The mixture was vigorously shaken, and absorbance was measured at 415 nm using a Jenway 6051 colorimeter.

A standard calibration curve was prepared using quercetin solutions in ethanol at concentrations of 50, 100, 150, 200, and 300 ppm, with absorbance recorded at the same wavelength. Total flavonoid content was determined from the calibration curve and expressed as milligrams of quercetin equivalents per gram (mg/g) of dried sample.

Total Phenolic Assay: Folin-Ciocalteau Method

The total phenolic content (TPC) in crude methanolic and ethyl acetate extracts of yacon was quantified using the Folin-Ciocalteu method (Singleton and Rossi, 1965). An aliquot (1 mL) of each extract was placed in a 25 mL volumetric flask with 9 mL of distilled deionized water. A reagent blank containing only deionized water was prepared simultaneously. Then, 1 mL of Folin-Ciocalteu phenol reagent was added, and the mixture was shaken. After approximately 5 minutes, 10 mL of 7% Na_2CO_3 solution was added, and the volume was brought to 25 mL with deionized water. The solution was incubated at room temperature for 90 minutes. Absorbance was measured at 750 nm against the reagent blank using a UV-Vis spectrophotometer.

A standard calibration curve was prepared using gallic acid solutions at concentrations of 20, 40, 60, 80, and 100 µg/mL. TPC was determined from the curve and expressed as milligrams of gallic acid equivalents (GAE) per gram of dried sample.

3. Results and Discussions

3.1 Phytochemical Analyses

The phytochemical composition of five yacon (*S. sonchifolius*) parts—flowers, leaves, stems, tubers, and tuber peels—was evaluated qualitatively (Table 1). Significant variations were observed in alkaloids, phenolics and tannins, saponins, triterpenoids, steroids, and cardiac glycosides across parts. Trace to moderate alkaloids were present in all parts. Saponins varied, absent in flowers and tubers. Phenolics and tannins occurred at trace to moderate levels in leaves, stems, and tuber peels. Triterpenoids were detected in leaves, stems, and tuber peels but absent in flowers and tubers. Steroids were limited to flowers and tuber peels. No cardiac glycosides were found in any part (Keller-Kiliani test negative).

These discrepancies with earlier studies reporting flavonoids, steroids, glycosides, and other bioactives in yacon leaves (e.g., Alvarez et al., 2008; Khajehei et al., 2018; Myint, Myint, and Than, 2021) may arise from genotypic, environmental, or methodological differences.

The findings indicate potential nutritional and medicinal value in various yacon parts, particularly due to phenolics, saponins, and triterpenoids with antioxidant properties. Further research is recommended to confirm the absence of cardiac glycosides and to elucidate influencing factors.

3.2 Antioxidant Activity

DPPH Radical Scavenging Assay

The DPPH (1,1-diphenyl-2-picrylhydrazyl) radical-scavenging assay measures antioxidant activity by electron or hydrogen donation to the stable DPPH radical, producing a color change quantified at 517 nm (Shahidi and Zhong, 2015).

Table 2 reports DPPH percent inhibition for yacon parts. One-way ANOVA (Table 3) indicated significant differences among parts. Percent inhibitions were: stems 93.35%, flowers 83.86%, leaves 72.80%, tuber peels 53.67%, and tubers 12.83%.

These findings indicate strong radical-scavenging capacity in stems, flowers, and leaves, with low within-group variability in absorbance. Results concur with total phenolic content (TPC) data—leaves, stems, flowers, and tuber peels exhibited comparable TPC—consistent with previous reports (Campos et al., 2018; Chessum et al., 2023; Ueda et al., 2019). The uneven distribution of phenolic and other bioactive compounds suggests multiple yacon parts are promising sources of natural antioxidants for functional food and pharmaceutical use. Further work is warranted to identify the specific compounds responsible for the observed inter-part differences.

FRAP Antioxidant Assay

The Ferric Reducing Antioxidant Power (FRAP) assay measures antioxidant capacity by reduction of the Fe^{3+}-TPTZ complex to Fe^{2+}-TPTZ, with increased absorbance at 593 nm indicating activity (Antolovich et al., 2002; Shahidi and Zhong, 2015).

Table 4 summarizes FRAP activities of yacon parts. One-way ANOVA (Table 5) showed significant differences among parts, consistent with reports of yacon's high antioxidant potential (Chessum et al., 2023; Ueda et al., 2019). Activities (mg Fe^{2+}/g) were: leaves 51.26, flowers 47.37, tuber peels 43.90, and tubers 0.00 (possible instrument detection limits). The tuber result contrasts with DPPH data and with Khajehei et al. (2018), who observed measurable FRAP activity in yacon tubers across cultivars. Pairwise comparisons confirmed significant inter-part differences. These results indicate variable antioxidant potential among yacon parts, with leaves exhibiting the greatest reducing capacity, and warrant further work to identify the bioactive compounds responsible.

Total Phenolics Content

The total phenolic content (TPC) quantifies phenolic compounds—major contributors to antioxidant capacity—and is typically reported as mg gallic acid equivalents (GAE) per g dry weight (Pękal & Pyrzynska, 2014). TPC is commonly determined by the Folin–Ciocalteu assay (Shahidi & Zhong, 2015).

Table 6 shows TPC (mg GAE/g): tuber peels 5.57, leaves 2.97, stems 2.17, flowers 2.05, tubers 0.00. These results indicate substantial phenolic content in peels, leaves, stems, and flowers, consistent with previous reports of elevated phenolics in yacon leaves and flowers (Campos et al., 2018; Cruz et al., 2019; de Andrade et al., 2014). The absence of detectable phenolics in tubers contrasts with other studies reporting low but measurable TPC in tubers (Campos et al., 2018), which may reflect cultivar, climate, soil, or agronomic differences at the Philippine site. One-way ANOVA (Table 7) indicated significant differences among plant parts, aligning with de Andrade et al. (2014). Targeted analysis is recommended to identify the individual phenolic compounds responsible for these differences.

Total Flavonoids Content

The total flavonoid content (TFC) of yacon extracts was quantified using the aluminum chloride colorimetric assay at 415 nm (Chandra et al., 2014; Sembiring, Elya, and Sauriasari, 2018). Flavonoids, characterized by a C6-C3-C6 backbone with diverse substitution patterns yielding subclasses such as flavonols, flavones, isoflavones, catechins, and related phenolics, serve as scavengers of reactive oxygen species (ROS) to mitigate oxidative stress (Dias, Pinto, and Silva, 2021; Karak, 2019).

Table 8 presents TFC values for various yacon parts. One-way ANOVA (Table 9) indicated significant differences among parts. Leaves exhibited the highest TFC (42.68 mg GAE/g sample), followed by flowers (33.50 mg GAE/g), stems (8.88 mg GAE/g), and tuber peels (3.48 mg GAE/g). Tubers showed a negligible or slightly negative value, denoting undetectable or trace levels.

These results demonstrate uneven flavonoid distribution, with leaves and flowers as particularly rich sources, supporting their potential bioactivity and therapeutic value. This aligns with prior studies reporting elevated TFC in yacon aerial parts and select underground tissues (Aguilar and Bonilla, 2009; Chessum et al., 2021; Ferraz et al., 2020; Ghabru and Rana, 2019; Hackova et al., 2021; Khajehei et al., 2018).

The findings enhance understanding of yacon's phytochemical profile and underscore the utility of specific parts in antioxidant-rich functional foods or nutraceuticals.

4. Conclusions

The findings indicate that the analyzed parts of yacon exhibit substantial medicinal and nutritional potential, attributable chiefly to the presence of phenolics, tannins, saponins, alkaloids, triterpenoids, and steroids. The absence of cardiac glycosides in the present study—contrary to certain prior reports—warrants additional investigation to verify these observations and to determine whether environmental conditions, genetic variation, or methodological differences influence the phytochemical profile of yacon. Overall, yacon stems, flowers, and leaves demonstrated greater antioxidant capacity than tuber peels and tubers, as evidenced by higher DPPH radical-scavenging activity and elevated ferric-reducing antioxidant power (FRAP). The leaves exhibited the highest total flavonoid content, underscoring their prominent role in flavonoid-mediated antioxidant activity.

5. Recommendations

The study recommends the incorporation of additional analytical techniques and more advanced instrumentation—such as HPLC, LC-MS/MS, and HPTLC—to obtain more accurate quantification and enhanced sensitivity in phytochemical and antioxidant profiling. Complementary detectors and modernized equipment will improve compound identification and reduce analytical uncertainty, while consideration of alternative extraction solvents alongside methanol may broaden analyte recovery and improve assay robustness.

For sample processing and laboratory practice, adopt freeze-drying to increase extraction efficiency and ensure consistent sample quality. Use a well-calibrated, contemporary UV–Vis spectrophotometer or other appropriate detectors, and establish standard operating procedures, quality-control protocols, and comprehensive researcher training in laboratory techniques and instrument operation to strengthen data validity and reliability.

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Figure

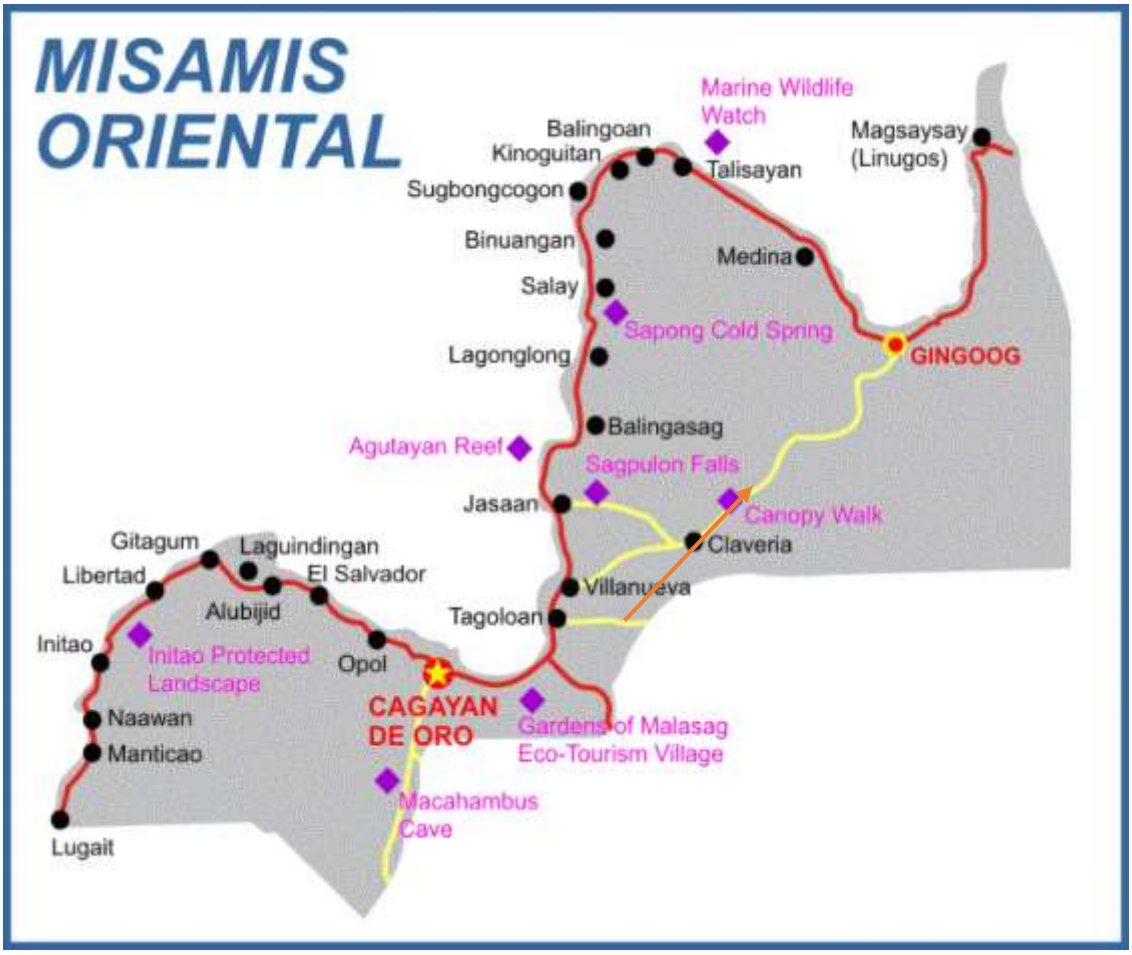

Figure 1. Political Map of Claveria, Misamis Oriental (PhilAtlas, n.d.)

Table

Table 1. Phytochemicals Present in the various Parts of Yacon

Photochemical	Test	Flowers	Leaves	Stems	Tubers	Tuber Peels
Alkaloids	Wagner's test	+	+ +	+	+ +	+
Phenolics and Tannins	Ferric chloride test	+ +	+ + +	+ + +	+ +	+ +
Saponins	Foam test	–	+	+	–	+
	Olive Oil test	–	+ + +	+ + +	–	+ + +
Triterpenoids	Salkowski's test	–	+ +	+ +	–	+ +
Steroids	Liebermann-Burchard test	+ + +	–	–	–	–

	Salkowski's test	+ + +	–	–	–	+ + +
Cardiac glycosides	Keller-Kiliani's test	–	–	–	–	–

Table 2. DPPH Radical Quenching Activities of the various Parts of Yacon

Yacon Parts	Sample Code	Absorbance	% Inhibition	Average %Inhibition ±SD
Flowers	MS31	0.079	83.298	83.862±0.646
	MS32	0.073	84.566	
	MS33	0.077	83.721	
Leaves	MS51	0.127	73.150	72.797±0.323
	MS52	0.130	72.516	
	MS53	0.129	72.727	
Stems	MS21	0.033	93.209	93.347±0.119
	MS22	0.032	93.416	
	MS23	0.032	93.416	
Tubers	MS11	0.431	11.317	12.826±1.323
	MS12	0.419	13.786	
	MS13	0.421	13.374	
Tuber peels	MS41	0.219	53.699	53.699±0.000
	MS42	0.219	53.699	
	MS43	0.219	53.699	

Table 3. One-Way ANOVA of DPPH Radical Quenching of the various Parts of Yacon

Source of Variation	SS	Df	MS	F-value	P-value
Between groups	.288	4	0.072	6750.125	0.000*
Within groups	.000	10	0.000		
Total	.288	14			

*Statistically significant @ alpha 0.05

Table 4. FRAP Antioxidant Activity Results of the various Parts of Yacon

Yacon parts	Sample Code	mmol Fe^{2+}/L	mg Fe^{2+}/ g sample	Average mg Fe^{2+}/g sample ±SD
Flowers	MS31	441.21	46.66	47.37 ± 0.616
	MS32	454.07	47.77	
	MS33	450.50	47.68	
Leaves	MS51	474.07	51.35	51.26 ± 0.407
	MS52	481.93	51.62	
	MS53	472.64	50.82	

	MS21	230.50	29.49	
Stems	MS22	244.79	32.08	31.56±1.873
	MS23	249.79	33.13	
	MS11	-36.64	0.00	
Tubers	MS12	-38.79	0.00	0.00 ± 0.006
	MS13	-38.07	-0.01	
	MS41	109.79	47.11	
Tuber peels	MS42	97.64	42.06	43.90± 2.785
	MS43	98.36	42.55	

Table 5. One-Way ANOVA of Ferric Reducing Antioxidant Power (FRAP) of the various Parts of Yacon

Source of Variation	SS	df	MS	F-value	P-value
Between groups	5201.110	4	1300.276	550.413	0.000*
Within groups	23.624	10	2.362		
Total	5224.729	14			

*Statistically significant @ alpha 0.05

Table 6. Total Phenolics Content of the Various Parts of Yacon

Yacon parts	Sample Code	mg GAE/L	mg GAE/g sample	Average mg GAE/g sample ±SD
	MS31	18.17	1.92	
Flowers	MS32	19.65	2.07	2.05 ± 0.121
	MS33	20.39	2.16	
	MS51	27.80	3.01	
Leaves	MS52	27.43	2.94	2.97 ± 0.038
	MS53	27.43	2.95	
	MS21	18.91	2.42	
Stems	MS22	15.20	1.99	2.17± 0.225
	MS23	15.76	2.09	
	MS11	-3.87	0.00	
Tubers	MS12	-3.69	0.00	0.00 ± 0.000
	MS13	-1.65	0.00	
	MS41	12.24	5.25	
Tuber peels	MS42	12.98	5.59	5.57± 0.306
	MS43	13.54	5.86	

Table 7. One-Way ANOVA of Total Phenolic Content of the various Parts of Yacon

Source of Variation	SS	df	MS	F-value	P-value
Between groups	48.520	4	12.130	378.589	0.000*
Within groups	0.320	10	0.032		
Total	48.840	14			

*Statistically significant @ alpha 0.05

Table 8. Total Flavonoids Content of the various Parts of Yacon

Yacon Parts	Sample Code	mg GAE/L	mg GAE/g sample	Average mg GAE/g sample ±SD
	MS31	317.25	33.55	
Flowers	MS32	319.75	33.64	33.50 ± 0.171
	MS33	314.75	33.31	
	MS51	399.75	43.30	
Leaves	MS52	397.25	42.55	42.68±0.575
	MS53	392.25	42.17	
	MS21	69.75	8.92	
Stems	MS22	67.25	8.81	8.88±0.063
	MS23	67.25	8.92	
	MS11	-10.25	7.00	
Tubers	MS12	-10.25	-9.54	-4.01±9.538
	MS13	-10.25	-9.50	
	MS41	7.25	3.11	
Tuber peels	MS42	7.25	3.12	3.48±0.638
	MS43	9.75	4.22	

Table 9. One-Way ANOVA of Total Flavonoids Content of the various Parts of Yacon

Source of Variation	SS	df	MS	F-value	P-value
Between groups	4864.398	4	1216.099	66.279	0.000*
Within groups	183.483	10	18.348		
Total	5047.881	14			

*Statistically significant @ alpha 0.05