Research Article

Proximate Biochemical Composition and Antinutritional Analyses of the Selected Parts of Yacon (*Smallanthus Sonchifolius*)

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ABSTRACT

Aim/Background: Yacon (*Smallanthus sonchifolius*) is an herbaceous and tuberous perennial plant that belongs to the sunflower family. This study aimed to determine the proximate biochemical and anti-nutritional compositions of the selected parts of mature yacon plants grown in Doalnara Aposkahoy Claveria, Misamis Oriental. **Materials and Methods:** For the biochemical composition, the selected parts of yacon were analyzed in terms of dry ash (using a furnace), crude lipid (using the Soxhlet extraction method), crude protein (using the Kjeldahl technique), and carbohydrate (calculating the percent difference) using the AOAC methods of proximate analyses. Meanwhile, the antinutritional composition determines alkaloids (using the alkaline precipitation gravimetric technique), oxalates (using the titration method), and phytates (using the Lucas and Markaka procedure) contents. **Results:** Findings of the overall biochemical composition indicated that carbohydrates came out as the highest (77.97%) followed by ash (9.96%), protein (8.91%), and lipid (3.18%). Comparing the different plant parts, the flowers and leaves registered the higher proteins and lipids contents while tubers showed the highest carbohydrate content and the leaves the highest ash content. Results also showed significant differences in protein, lipid, ash, and carbohydrate contents on the selected parts of yacon. These differences in the biochemical composition of the different parts may be due to the differences in biological functions. On the other hand, the anti-nutritional analyses indicated that oxalates had the highest concentration followed by alkaloids and lastly phytates. The flowers of yacon have shown the highest oxalate content while stems, tubers and tuber peels displayed higher alkaloid contents. **Conclusion:** Overall, the yacon parts that have promising biochemical and antinutritional compositions are the flowers in terms of protein, lipid, and oxalate contents; leaves for the ash and phytate contents; tubers for the carbohydrate contents; and stems for the alkaloid contents.

Keywords: Alkaloids, Oxalates, Phytates, Proximate biochemical composition, Antinutritional analysis.

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INTRODUCTION

Plants are one of the dietary sources that nourish and maintain the human body's health. Food plants are those plants that generate food in diverse forms. Many food products that we eat are produced from the stems, leaves, roots, and other components of different plants or trees. These plants are good sources of macromolecules such as carbohydrates, proteins, lipids, and minerals. They are known for their nutritional value. However the nutrients in plants are combined with anti-nutrients that reduce nutrient bioavailability.[1] The composition of anti-nutritional substances in plants protects them from being eaten by predators.[2] These plants frequently produce a variety of secondary metabolites as a defence against herbivores, insects, and diseases or as a way to survive in unfavourable growth environments.[3] These secondary metabolites refer to anti-nutritional substances. When consumed in high dietary concentrations, untreated

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anti-nutrients typically cause anorexia, stunted development, and low conversion efficiency.[4] Like other plants, root crops have trace levels of possible poisons and anti-nutritional compounds. Yacon (*Smallanthus sonchifolius*) is a plant belonging to the Asteraceae family, which includes sunflowers, that may reach heights of 1.5 to 2.5 m. Its huge tuberous roots exhibit diverse tissue colours, including white, yellow, orange, and purple.[5] It is a perennial herb native to the South American Andes.[6,7] Yacon also grows in the Central Andean regions and it is particularly grown in nations like Bolivia, Peru, Ecuador, and Argentina.[8] It is also currently cultivated in numerous countries in Europe and Asia for its medicinal and nutritious properties which have a high concentration of Fructooligosaccharide (FOS), a prebiotic component that may encourage immunological responses with anti-inflammatory properties.[9-13] Moreover, yacon is now being cultivated in some parts of the Philippines, including Claveria, and Misamis Oriental. This plant is considered important since the plant tubers can be a source of food and the other parts of yacon may have medicinal value which can prevent and cure sicknesses or diseases.

In this study, flowers stems, and tuber peels are included aside from the above-mentioned parts of yacon since these parts could have a good potential for food and medicine. There were limited studies on some plant parts, especially on biochemical and anti-nutritional compositions. However, it is also necessary to study the other parts of yacon to find out its nutritive and pharmacological value which can boost people's health and may cure illness. Hence, the study's objective is to evaluate the biochemical and antinutritional contents of the selected parts of *Smallanthus sonchifolius* to find out more potentials in plants as food and supplement through its biochemical and anti-nutritional composition.

MATERIALS AND METHODS

Sample Collection and Preparation

The yacon plant was taken from Doalnara Aposkahoy Claveria, Misamis Oriental, Philippines. In this study, purposive sampling was done for the collection of plant samples. This focuses on sampling methods in which the researcher's judgment is used to determine which units to examine. Only mature yacon plants were harvested and it is considered mature when the plant reaches 4-5 months from the time it was planted. The harvested plants were segregated by parts and were thoroughly washed, wiped, and reduced in size (smaller size) for faster drying. The tubers and tuber peels were dried at low temperatures in an oven with nitrogen gas blanketing to minimize oxidation. Other parts such as flowers, leaves, and stems were dried at room temperature in an air-conditioned room. The dried materials were ground in a laboratory blender and stored in a freezer while waiting for further testing. Until the moment of extraction, the samples were kept in powdered form and kept in airtight containers.

Proximate Biochemical Composition Analysis

Moisture content was determined by drying the material at 105°C±2°C until a consistent weight was reached, this was calculated using the moisture balance. The ash content analysis was conducted by the use of dry ashing.[14] 5g of each sample were placed in a furnace at 350°C within 30 min to 1hr for combustion. After combustion, the temperature was increased to 600°C for 6-20 hr for ashing the samples. Crude lipid was determined using the Soxhlet technique or semi-continuous solvent extraction method. Twenty-five grams (25g) of the sample was placed in the filter paper covered with thin cotton before placing it in the Soxhlet extractor. 150 mL of hexane was added to the condenser and heated for 6 hr. Then the solution in the extractor was drained in the flask and the sample was taken out in the Soxhlet extractor. The solution in the flask was allowed to run in 3 cycles for hexane recovery. Then the flask was placed in the water bath until all hexane was evaporated. The extracted crude lipid in the flask was placed in an oven @ 105°C for 3 hr before placing it in the desiccator for constant weighing. The crude lipid content was determined in terms of crude lipid percentage.[15] Kjeldahl method was used to determine crude protein in terms of percent nitrogen in samples. The crude protein was detected through the conversion of the nitrogen content using Kjeldahl's technique (Nx6.25). On the other hand, the total carbohydrate content for each sample was determined by difference. It is done by deducting 100 from the total of the contents of fat, protein, and ash.

Anti-nutritional Analysis

Alkaloid content was determined using the alkaline precipitation gravimetric technique.[16] 200 mL of 20% acetic acid in ethanol and 5 grams of the sample were placed into a 250 mL beaker, covered, and left to stand for 4 hr at 25°C. After filtering, the filtrate was then reduced to one-fourth of its initial volume using a water bath (memmert). Concentrated ammonium hydroxide was applied drop by drop to the extract until the precipitation was finished. After allowing the whole solution to settle, the precipitate was collected and cleaned with a weak NH_4OH solution. Then, it was filtered using filter paper that had been pre-weighed. The alkaloid residue was dried in the precision oven at 80°C. Then, the percentage of the weight of the sample analyzed was used to calculate the alkaloid content of the sample. Meanwhile, oxalate content was determined using the titration method.[17] 1g of the powdered sample was mixed with 75 mL of 3N H_2SO_4 and agitated intermittently for 1 hr using a magnetic stirrer. The mixture was then filtered through Whatman No. 1 filter paper (single layer). 25 mL of the filtrate was collected, boiled in a water bath for 5 min, and titrated against a solution of 0.05 M standard $KMnO_4$ until a very faint pink colour appeared and remained for 30 seconds. For phytate content, the method stated by Lucas and Markaka[18] was used. This involves weighing 2 g of each sample into a conical flask with a capacity of 250 mL. 50 mL of each sample's filtrate was placed into a 250-mL beaker along with 107 mL of distilled water to provide or increase the right acidity after the samples had been soaked in 100 mL of 2% conc HCl for 3 hr. Each sample solution received 10 mL of 0.3% ammonium thiocyanate solution as an indicator. The endpoint was indicated by a brownish-yellow coloration that remained for 4-5 min after titrating with a standard iron chloride solution, which contained 0.00181 g iron/mL. Then the phytic acid percentage was determined.[19]

Statistical Analysis

The data of the study were analyzed using IBM SPSS Statistic 22 and Microsoft Excel (2007). They were presented as the mean ± standard deviation.

RESULTS

Proximate Biochemical Composition Analysis

Table 1 displays the selected yacon components and their related nearby biochemical compositions. The second greatest biochemical content in this research, after carbohydrate content, is crude protein content. As we know the main component of yacon is Fructooligosaccharides (FOS), a carbohydrate.[20] Yacon has a high concentration of FOS, a prebiotic ingredient that can favor anti-inflammatory immune responses.[12,13]

Table 1 shows that yacon flowers and leaves have high concentrations of crude protein with corresponding values of 16.650.049 and 16.250.035, respectively, indicating that yacon leaves and flowers are good food substitutes in the absence of meat and fish. Table 1 also shows significant differences among flowers, leaves, stems, tubers, and tuber peels of *Smallanthus sonchifolius* when compared to their crude protein content. Whereas, yacon tuber has the lowest protein content of 1.3800.000 indicating that it is poor in protein content.

In terms of crude lipids, Table 1 reveals that flowers and leaves have higher crude lipids compared to other parts of *Smallanthus sonchifolius*. Yacon flowers have the highest crude lipid value of 6.660.028 followed by leaves with a value of 5.570.355.

Table 1 further shows the results of ash content where leaves (14.610.102) had the highest rank among the selected parts of yacon and this is followed by the stem with corresponding values of 12.090.040.

In terms of carbohydrate content, tubers have the highest percentage among the selected parts of *Smallanthus sonchifolius* with a value of 95.090.012. This is followed by yacon tuber peels and stem which has a value of 83.660.032 and 80.000.278, respectively.

Anti-nutritional Composition Analysis

The anti-nutritional composition of the selected parts of S*mallanthus sonchifolius* was assessed in terms of its alkaloid content, oxalate content, and phytate content and summarized in Table 2.

As shown in Table 2, among the selected parts of yacon, the stem has the highest alkaloid content with corresponding values of 1.8280.172. This is followed by tubers and tuber peels with values of 1.764 0.076 and 1.5500.420, respectively.

Meanwhile, Table 2 also reveals that flowers have the highest oxalate content value of 18.515 0.049 among the

Table 1: Proximate biochemical composition of the Selected Parts of *Smallanthus Sonchifolius* and the Summary of One-Way ANOVA.

Parts of Yacon	%Crude Protein	%Crude Lipid	%Carbohydrate	%Ash
Flowers	16.65±0.049	6.660±0.028	67.53±0.245	9.34±0.017
Leaves	16.25±0.035	5.570±0.355	63.59±0.470	14. 61±0.102
Stem	7.18±.040	0.733±0.318	80.00±0.278	12.09±0.040
Tubers	1.38±0.000	0.130± 0.000	95.09±0.012	3.40±0.012
Tuber Peels	3.14±0.045	2.820±0.026	83.66±0.032	10.38±0.087
One Way ANOVA Summary (*p*)	$P < \alpha$	$P < \alpha$	$P < \alpha$	$P < \alpha$

Data represented as meanSD. p = p-value; α=0.05 level.

Table 2: Anti-nutritional Content of the Selected Parts of *Smallanthus Sonchifolius*.

Parts of Yacon	%Alkaloid	%Oxalate	%Phytate
Flowers	0.645±0.039	18.515±0.049	0.287±0.004
Leaves	0.687±0.073	2.191±0.056	0.348±0.007
Stem	1.828±0.172	0.767±0.027	0.298±0.007
Tubers	1.550±0.420	9.450±0.020	0.273±0.007
Tuber Peels	1.764±0.076	2.470±0.077	0.287±0.014
One-Way ANOVA Summary (*p*)	*P* < α	*P* < α	*P* < α

Data represented as meanSD. P = P-value; α=0.05 level.

selected parts of *Smallanthus sonchifolius*. This is followed by the tubers which have a value of 9.4500.020. On the other hand, the plant part which has the lowest oxalate content is the stem with a corresponding value of 0.767 0.027.

On the other hand, leaves had the highest phytate content among the selected parts of yacon and this is followed by stem as shown in Table 2. The phytate content values of the selected parts of *Smallanthus sonchifolius* are near to each other as compared to alkaloid and oxalate content values.

DISCUSSION

Proximate Biochemical Composition

In the study, flowers and leaves of yacon have high concentrations of crude protein and crude lipids. The study of da Silva *et al*.[21] supports this results in which the yacon syrup has higher levels of amino acids, such as tryptophan, valine, and threonine. Results of the study of Lachman *et al*.[6] revealed that protein and lipid contents of yacon leaves (dry basis) got the highest value as compared to stem and flesh (refer to the Table 1). The study of Jain, Khatana and Vijayvergia[22] concluded that the root, stem, leaves, fruits, and flowers of various plants were found to possess secondary metabolites to show bioactivity. Thus, flowers and leaves have more crude protein content compared to stem, tuber, and tuber peels. In terms of crude lipids, fatty acids which are generated in the plastid and assembled by glycerolipids or triacylglycerols in the endoplasmic reticulum, make up the majority of lipids in plants. The study revealed that lipids provide plants with energy for their metabolic activities and cell-to-cell communication.[23] Along with the xylem, the phloem serves as the primary means of transport in plants. It includes lipids consisting of cholesterol, sitosterol, camposterol, stigmasterol, and a few other lipophilic hormones and compounds. Lipids serve as a portable energy source for seed germination and are an important part of biological membranes.[24,25] Dried leaves of yacon contained essential oils predominantly with β-pinene, caryophyllene and γ-cadinene using solid-phase microextraction fiber and semi-quantitative analysis in Gas Chromatography-Flame Ionization Detection (GC-FID).[26] In this study, lipid content results showed significant differences among flowers, leaves, stems, tubers, and tuber peels of *Smallanthus sonchifolius*.

Yacon tuber has the highest carbohydrate content. Studies reveal that yacon tuber has a high concentration of Fructooligosaccharides (FOS), a prebiotic ingredient that can possibly favor anti-inflammatory immune responses.[12,13] In addition, yacon contains carbohydrates in the form of β-(2→1) FOS, which aids in preventing constipation and lowering blood sugar and cholesterol levels.[27] The flour of yacon tuber has prebiotic activity due to its FOS content.[28] Aside, evaluation of the syrup from tubers resulted in higher levels of Fructooligosaccharide (FOS) and Chlorogenic Acid (CGA).[21,29] The study of Chessum *et al*.[29] on nutritional analysis of New Zealand yacon concentrate derived from the tuber roots revealed that the FOS content ranged from 17.6 to 52.7 g/100g while the major phenolic compounds are the chlorogenic acid and caffeic acid. The results further show that there is a significant difference among flowers, leaves, stems, tubers, and tuber peels of *Smallanthus sonchifolius* when compared to their crude protein content.

In the ash content, leaves got the highest among the selected parts followed by the stem, tuber peels, flowers, and tubers. This is consistent with the results of the study of Lachman *et al*.[6] with the highest value of leaves in terms of ash content. The high ash content of leaves, stems, and tuber peels imply good mineral components as compared to the other parts of yacon. It is an indication of high nutrient content as it contains minerals.[30,31] On the contrary, the lowest value of tubers indicates the minimal mineral content. This is supported by the results of the study of Choque Delgado *et al*.[32] which has a low ash value of the tubers. Also, tubers have high moisture content among the selected parts of yacon indicating its high percentage in water. Thus, the low ash content of the tuber is due to its high moisture content. In terms of significance, the study indicates a significant difference among the selected parts of the yacon in their ash contents.

Anti-nutritional Content

Stem has the highest alkaloid content followed by tubers and tuber peels. This signifies that stem, tubers, and tuber peels have a good amount of amino-containing organic compounds and can defend themselves from herbivores, insects, and disease attacks to thrive under unfavourable growth circumstances.[3,33] This study is consistent with the study of da Silva *et al*.[21] in which yacon syrup has higher levels of amino acids, such as tryptophan, valine, and threonine. The results also demonstrate that the per cent alkaloid content is significantly different from the selected parts of yacon.

Oxalate content results revealed that flowers got the highest followed by tubers. The results also indicated that plant parts vary differently in terms of their oxalate contents. The results were confirmed in the study of Prasad and Shivay[34] in which oxalic acid and oxalates are present in leaves, roots, stems, fruits and seeds of many plants. The oxalate content of plant tissues varies on plant species and plant tissues.[35,36] Nguyen and Savage[35] advised to decrease the consumption of higher oxalate-containing fruits to limit the intake of soluble oxalates. These oxalates deplete the minerals and vitamins in the human body. They have diverse unrelated roles in plant metabolism, including pH regulation in association with nitrogen metabolism, metal ion homeostasis and calcium storage.[37] That is why excessive ingestion of plant-derived oxalate is thought to be harmful to human health.

In phytate content, leaves got the highest followed by stem. However, the values are near to one another. This implies that the selected parts of yacon have almost similar phytate contents which are in minimal percentage. This indicates that the low concentrations of phytate in the selected parts have low amounts of phosphorous and thereby not harmful to the human body. According to the study of Manzoor *et al*.,[38] phytates are complex naturally occurring molecules that modify the features of foods based on their nutritional and functional qualities that are relevant to human health and nutrition. It may be possible to use the phytic acid found in plants to reduce the issue of zinc and iron deficiency, which is thought to be a significant public health concern.

Overall, a high intake of these parts of yacon which have a good amount of antinutrients may harm a living organism. Some of these antinutrients which are present in most plants, may either be hazardous to health or, if ingested in moderation, be beneficial to both human and animal health.[39] The study of Joshi and Abrol[4] indicated that the presence of anti-nutrients in untreated foodstuffs normally results in anorexia, reduced growth and poor food conversion efficiency when used at high dietary concentrations. They can cause micronutrient malnutrition and mineral deficiencies.[1] On the positive aspect, anti-nutrients have beneficial effects and therapeutic potential on some illnesses.[40] Gemede *et al*.[39] emphasized that phytate, lectins, tannins, amylase inhibitors, and saponins can lessen blood glucose and insulin responses to starchy meals, as well as plasma cholesterol and triglyceride levels when administered at low doses. Thus, moderate intake of yacon is recommended.

CONCLUSION

Among the selected parts of *Smallanthus sonchifolius* commonly known as yacon, flowers are rich in protein which can be a good alternative food or beverage for humans and animals alike. The crude protein in yacon flowers is due to the seeds present in the flowers and most proteins are stored in the seeds of the plant. Similarly, yacon flowers got the highest lipid content among the selected parts of yacon though lipid content is the lowest among the biochemical composition. The lipid content in flowers may be due to the seeds in the flowers which are the storehouse of oils. However, carbohydrate content is the highest among the biochemical composition and yacon tuber has the highest carbohydrate content among the selected parts of yacon. The ash content is the second lowest among the biochemical composition. Meanwhile, yacon leaves got the highest ash content among the selected parts of yacon which indicates its higher mineral content compared to other parts.

In terms of anti-nutritional content, the selected parts of *Smallanthus sonchifolius* that have greater alkaloid contents are stem, tubers, and tuber peels. These plant parts have a good amount of nitrogen-containing organic compounds and could form derivatives of different amino acids. These alkaloid contents are beneficial to the plant since they will serve as protection for plants and regulate plant growth. On the other hand, flowers are rich in oxalates. The oxalate content in yacon flowers may be due to the presence of seeds. The oxalate stored in yacon flowers may cause minerals and vitamin depletion which is not beneficial to the body. On the contrary, phytate is the lowest among the anti-nutrient results which has a very minimal value of all the selected yacon parts which implies that the selected plant parts have a lower amount of phosphorous. Further, antinutrients which are present in most plants, may either be hazardous to health or, if ingested in moderation, be beneficial to both human and animal health. In terms of significant difference, the selected parts of yacon differ from each other in their proximate biochemical components and anti-nutritional contents.

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CONFLICT OF INTEREST

There is no conflict of interest, according to the authors.

ABBREVIATIONS

AOAC: Association of Official Analytical Chemists; **FOS:** Fructooligosaccharides; **CGA:** Chlorogenic Acid.

SUMMARY

The selected parts of yacon have significant values in terms of their proximate biochemical composition and antinutritional contents. Findings show that the selected parts of yacon differ in their biochemical compositions as well as in their antinutritional contents. Flowers of yacon have the highest contents in terms of protein, lipid, and oxalates. This may be due to the seeds in the flowers which are the storehouse of oils. Yacon leaves have the highest ash content and phytate content. On the other hand, yacon tubers have the greatest value in terms of their carbohydrate contents. Lastly, stems of yacon have greater alkaloid values compared to the other selected parts.

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