

## PROXIMATE ANALYSIS AND PHYTOCHEMICAL AND MINERAL CONSTITUENTS IN FOUR CULTIVARS OF YAMS AND TUBER CROPS IN SRI LANKA

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### ABSTRACT

A study was carried out to determine the levels of starch, protein, crude fat, crude fibre, ash and a few phytochemical constituents (saponins, flavanoids and alkaloids) and mineral elements (Calcium, Magnesium, Iron, Potassium and Zinc) in four cultivars of yams and tubers cultivated under similar agro-climatic conditions in Sri Lanka. Tubers of *Dioscorea alata* (Rajala and Hingurala), *Dioscorea esculenta* (Kukulala) and *Xanthosoma sagittifolium* (Kiriala) were subjected to the above analyses. The total starch percentage in crude flours ranged between  $74.66 \pm 0.66$  to  $80.46 \pm 0.62\%$  on dry weight basis and no significant difference found in total starch ( $P < 0.05$ ) between the studied varieties. The protein level ranged from  $2.66 \pm 0.21$  to  $10.16 \pm 0.64\%$  whereas *D. alata* was found to contain a higher protein level. The crude fat levels in tubers varied ranging from  $1.5 \pm 0.2$  to  $2.3 \pm 0.1\%$  and the highest level was observed in *Xanthosoma* sp. The crude fibre content in tubers was found to range from  $1.8 \pm 0.1$  to  $2.33 \pm 0.15\%$  and the highest level was observed in *D. esculenta* and the ash level ranged from  $1.66 \pm 0.21$  to  $2.33 \pm 0.21\%$ . There was no significant difference ( $P < 0.05$ ) between the total starch in the extracted starch from the tubers and ranged from  $86.3 \pm 1.2$  to  $89.85 \pm 1.11\%$ . Crude saponin levels were significantly higher ( $P < 0.05$ ) in yams while *D. alata* and *X. sagittifolium* contained a level which was comparable ( $P > 0.05$ ;  $12.98 \pm 0.61$  and  $13.11 \pm 0.52$  mg/100g). High amount of flavonoids were observed in *D. esculenta* and *X. sagittifolium* ( $12.4 \pm 0.46$  and  $11.26 \pm 0.46$  mg/100g). A considerable level of alkaloids was present in *D. alata* and *D. esculenta* ( $1.64 \pm 0.04$  mg/100g and  $1.89 \pm 0.02$  mg/100g). All three cultivars of yams were rich in Calcium and Iron while a high level of Magnesium was observed in *Xanthosoma* sp ( $45.27 \pm 0.31$  mg/100g). High levels of Potassium were observed in all the samples.

**Key words:** Chemical composition, *Dioscorea*, Starch, Phytochemical, Yams, *Xanthosoma* sp

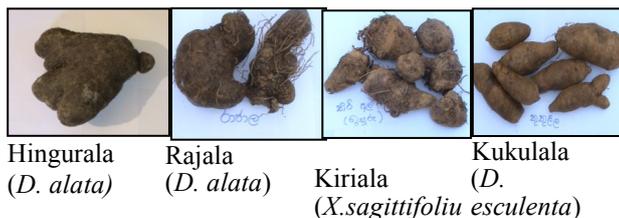
### INTRODUCTION

Yams and tuber crops are efficient solar energy transferors and a very good source of starch which can be cultivated under less favourable conditions with minimum amount of agricultural inputs. These crops are grown in the tropical regions and consumed as primary, secondary or supplementary staple. Yams and tuber crops can be eaten boiled, roasted, fried or cooked. *Dioscorea alata* and *Dioscorea esculenta* are the two main yam species commonly found in Sri Lanka while *Xanthosoma sagittifolium* (Kiriala) species is also commonly consumed since its availability throughout the year. Although *Dioscorea* (Family: Dioscoreaceae) is a genus consisting of 630 identified species, nearly about 40 *Dioscorea* varieties are grown in Sri Lanka (Jayasuriya, 1995).

The base of the *Dioscorea esculenta* (Kukulala) stem contains a large number of tubers which are generally ovoid and cylindrical (Fig. 1). Kukulala is widely cultivated in Sri Lanka, due to its flavour and short maturity period. The fleshy underground stem of *Dioscorea alata* (Rajala and Hingurala) contains only a single large tuber per vine. *Dioscorea* are seasonal crops and generally planted in the end of March to April. With the signs of yellowing leaves and withered vines mature crop is usually ready to harvest around December to February.

Starch is the main component in the yams (60-85% dry basis) and forms an important component in the diet of individuals living in rural areas of Sri Lanka (Jayakody et al, 2007). *Xanthosoma* spp are commonly known as new cocoyams (Kiriala) and the immature stems of the studied variety contains a red line on the

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**Figure 1: Morphology of yams and *Xanthosoma* spp**

either side of the stem and the leaves contain blue- green pigments. A corm is produced at the base of the plant and this bears 10 to 15 lateral cormels (Kay, 1973)

After harvesting, these tuber crops upon passing a certain dormancy period may make sprouts if favourable conditions are met. This will bring a considerable amount of dry matter and water loss (Onwueme, 1982). However, if the tubers are properly stored these tubers can be made available throughout the year.

Yams (*Dioscorea* sp) and *Xanthosoma sagittifolium* (Kiriala) can be considered as nutritionally important tuber crops because of their high energy contribution as in the form of starch and raw yam provides about 494 KJ (118 Kcal/100 g serving) (USDA Nutrient Database). These yams and tubers also contain various types of phytochemicals. The most predominant phytochemical characteristic of yam is the diosgenin saponin and dioscorine alkaloid. Although dioscorine and diosgenin are considered as toxic, such toxicity can be removed by washing, boiling and cooking (Eka, 1998). Diosgenin saponin can be used in the production of important steroids for human. The bitterness and toxicity of various wild yams are believed to be due to the alkaloid content. Certain flavonoids in these tubers may sometimes act as antioxidants and can oxidize LDL (Low Density Lipoprotein), prevent incidents of arteriosclerosis and heart disease.

Efficient supply of nutrients (macro and micro) in human diet is essential in maintaining the healthy lifestyle of man. This study was aimed to assess the chemical composition of crude flours and starches and to investigate the availability of some phytochemicals (saponin, flavanoid and alkaloid) and a few mineral constituents in four different cultivars; two species of *Dioscorea* (*D. alata* and *D. esculenta*) and *Xanthosoma sagittifolium*

cultivated under similar agro – climatic conditions in Sri Lanka. Flour and starch samples were prepared two days after harvesting in order to understand the nutritional significance, but for a more conclusive study further examination of various samples of these cultivars cultivated under similar conditions from different regions and sites of Sri Lanka would need to be examined.

## MATERIALS AND METHODS

**Materials:** Matured tubers of *Dioscorea alata* (Rajala and Hingurala), *Dioscorea esculenta* (Kukulala) and *Xanthosoma sagittifolium* (Kiriala) samples were randomly selected from the fields of the Horticultural Crop Research & Development Institute, Gannoruwa, Sri Lanka. Flour and starch samples were prepared two days after harvesting.

**Flour preparation:** About 5kg of the tubers were washed, hand peeled and trimmed to remove defective parts. Then the tubers were grated into thin chips (~ 5mm) and dried in an air convection oven at 40°C for 30h up to 14% moisture. The dried chips were powdered using a laboratory scale grinder (Sumeet CM/L 2128945) and sifted through 300µm sieve. The flour samples were sealed and packed in air tight containers for further analysis. (Maria et al, 2002)

**Starch extraction:** Starch separation was carried out according to the method described by Gunaratne (2007). Nearly about 3kg of fresh tubers and yams were washed, peeled and diced and dipped in ice water containing 100ppm sodium metabisulphite to avoid browning. Homogenized at low speed in a laboratory scale blender (Sumeet CM/L 2128945). The slurry was filtered through a filtering cloth using a small amount of water. Filtrate was centrifuged at 3,000 x g for 10 minutes. The supernatant and the amber brown layer of protein on the surface of the sediment were removed and further purification was achieved by repeated suspension in water and centrifugation. The purified starch was dried at 35°C for 30h, sealed and packed for analysis.

**Chemical analysis of extracted components:** Moisture, lipid, protein (N x 6.25), ash and

fibre were determined according to AOAC (1980) methods. Starch content was estimated by complete acid hydrolysis method. Flour sample of 2.5g was suspended in a mixture of 200 ml of water and 20ml of HCl acid. (Sp. Gravity 1.125) The mixture was heated in a flask provided with a reflux condenser for 2.5 hours. Contents were cooled, neutralized with NaOH (5 N). Volume was made to 250ml and the sugar formed was determined as dextrose by Lane and Eynon reducing sugar estimation method. The dextrose multiply by 0.9 was taken as starch.

**Mineral composition and starch granular structure:** Mineral elements (Ca, Mg, Fe, K and Zn) were determined by dry ashing method, (AOAC 1980) followed by elemental analysis by Atomic Absorption Spectrophotometer (GBC Avanta Ver 1.33). Structure of starch granules were observed under (10 X 100) light microscope (Magnus MLX-DX).

**Phytochemical composition:** Phytochemicals were determined gravimetrically with slight modifications to the methods described by Okwu D.E and C. U Nadu (2006).

**Crude saponin determination:** A sample of 2.5g of flour was dispersed in 25ml of 20% ethanol. The suspension was heated over a hot water bath at 55°C for 4h with continuous stirring. The mixture was filtered and the residue re- extracted twice with another 25ml of ethanol. The combined extracts were reduced to one quarter of the total volume by heating over a water bath maintained at 90°C (Okwu D.E, 2006). The aqueous portion of the concentrate was extracted thrice with 20 ml of diethyl ether by using a 250ml separating funnel. The extract was purified further with 40ml of n-butanol and washed thrice with 5% aqueous NaCl. The remaining solution was evaporated at 95°C over a water bath until obtaining a constant weight. The saponin content was calculated on dry basis.

**Crude flavonoid determination:** A sample of 1 g flour sample was mixed with 20ml of 80% aqueous methanol and extracted flavonoids at room temperature by using an ultra sonic bath for 30 minutes. The solution was filtered through Whatman filter paper No. 42 (12mm).

The filtrate was evaporated on a boiling water bath until a constant weight was obtained. The flavonoids were calculated on dry matter basis (Okwu D.E, 2006).

**Crude alkaloid determination:** A sample of 1 g flour was taken to 100ml beaker and 50ml of 20% acetic acid in ethanol was added and covered to stand for 4h. Contents were filtered and concentrated using a water bath at 100°C until one – quarter of its original volume. Concentrated Ammonium was added drop wise until a maximum precipitate was achieved. Contents were dried at 70°C until obtaining a constant weight. Alkaloid content was calculated on dry matter basis (Okwu, 2006).

**Statistical analysis:** Samples were analysed in replicates of three (3) and values were evaluated using the One – Way ANOVA Tukey's test ( $P < 0.05$ ).

## RESULTS AND DISCUSSION

**Proximate analysis of flours:** The results indicate that the *Xanthosoma* sp (Kiriála) is slightly richer in starch than the studied yam varieties (Table 1). From the three yam varieties though Hingurala contained a higher level of starch on dry weight basis there was no significant difference ( $P < 0.05$ ) in the starch content of the studied cultivars. Yams contained a higher level of proteins compared to the *Xanthosoma* sp. *Dioscorea alata* (Rajala) contained the highest level of proteins ( $10.16 \pm 0.64\%$ ). Crude fat content was higher in the *Xanthosoma* sp ( $2.3 \pm 0.1\%$ ) while there was no significant difference ( $P > 0.05$ ) in the crude fat content of yams.

Crude fibre levels were comparatively high in kukulala and Kiriála while Hingurala contained the lowest. Kiriála and Hingurala indicated a higher level of ash while Rajala contained a lower level. This study showed that the fat and ash contents for all the flours tested were higher than those have been reported in the literature. i.e.: ash and fat contents in different varieties of *D. alata* 0.19 - 0.51% and 0.5-0.73% respectively (Riley et al, 2006). However, these differences can be expected due to varietal and geographical differences. High amounts of fat can be one of the reasons for the feeling of satiety once consumed these

**Table 1: Chemical composition of flours and starches of yams and *Xanthosoma* sp (% dry weight basis)**

Source	Total starch	Protein*	Crude fat	Crude fibre	Ash
<b>Flours</b>					
<i>D. alata</i> (Rajala)	75.86±2.01 <sup>a</sup>	10.16±0.64 <sup>a</sup>	1.53±0.31 <sup>b</sup>	2.0±1 <sup>b</sup>	1.66±0.21 <sup>b</sup>
<i>D. alata</i> (Hingurala)	78.32±1.14 <sup>a</sup>	6.24±0.26 <sup>b</sup>	1.56±0.25 <sup>b</sup>	1.8±1 <sup>b</sup>	2.33±0.15 <sup>a</sup>
<i>D. esculenta</i> (Kukulala)	74.66±0.66 <sup>a</sup>	9.02±0.65 <sup>c</sup>	1.5±0.2 <sup>b</sup>	2.33±0.15 <sup>a</sup>	2.1±0.2 <sup>a</sup>
<i>X. sagittifolium</i> (Kiriala)	80.46±0.62 <sup>a</sup>	2.66±0.21 <sup>d</sup>	2.3±0.1 <sup>a</sup>	2.13±0.15 <sup>b</sup>	2.33±0.21 <sup>a</sup>
<b>Starch</b>					
<i>D. alata</i> (Rajala)	86.81±1.83 <sup>c</sup>	2.1±0.09 <sup>f</sup>	0.43±0.06 <sup>i</sup>	n.dt	0.33±0.01 <sup>k</sup>
<i>D. alata</i> (Hingurala)	86.61±1.56 <sup>c</sup>	2.02±0.11 <sup>f</sup>	0.41±0.02 <sup>i</sup>	n.dt	0.41±0.01 <sup>j</sup>
<i>D. esculenta</i> (Kukulala)	86.3±2 <sup>c</sup>	1.2±0.01 <sup>g</sup>	0.42±0.01 <sup>i</sup>	n.dt	0.25±0.01 <sup>l</sup>
<i>X. sagittifolium</i> (Kiriala)	89.85±1.11 <sup>e</sup>	1.12±0.01 <sup>g</sup>	0.63±0.04 <sup>h</sup>	n.dt	0.31±0.02 <sup>k</sup>

N\* X 6.25, Data represent the mean of three replicates. Values followed by the different superscript in each column are significantly different (P<0.05) n.dt = not determined

cultivars compared to other root and tuber crops such as cassava, potato and sweet potatoes.

The highest level of extracted starch was observed in Kiriala and more protein was observed in Rajala and Hingurala (2.1 ± 0.09 and 2.02 ± 0.11% respectively). This may be probably due to the presence of mucilaginous material in starch. Fat content in Kiriala starch was comparatively higher (P<0.05) than in yams while more ash was observed in Hingurala.

**Phytochemical composition:** The phytochemical composition of yams and *Xanthosoma* sp are shown in Table 2. The saponin and alkaloid contents are considered important due to their toxicity in certain yams and tubers. *D. esculenta* had the highest saponin content of 20.01± 0.46 mg/100g while *D. alata* (Rajala) contained the lowest level of saponin (12.98 ± 0.61 mg/100g). High amount of flavonoids were observed in *D. esculenta* and *X. sagittifolium* (Table 2). Although *D. alata* contained purple pigments low levels of flavonoid were observed compared to the other white varieties. In this study crude levels of flavonoids were measured and the molecular weights of the extracted flavonoids from white cultivars may be higher compare to the purple

yam. Considerable level of alkaloids was present in Hingurala and Kukulala (1.64 ± 0.04 and 1.89 ± 0.02 mg/ 100g). The lowest level was in Rajala (0.94 ± 0.04 mg/100g). The

**Table 2: Phytochemical composition of yams and *Xanthosoma* sp on dry weight basis (mg/100g)**

Botanical name	Local name	Saponins	Flavonoids	Alkaloids
<i>D. alata</i>	Rajala	12.98±0.61 <sup>c</sup>	5.19±0.15 <sup>d</sup>	0.94±0.04 <sup>c</sup>
<i>D. alata</i>	Hingurala	18.24±0.15 <sup>b</sup>	9.84±0.26 <sup>c</sup>	1.64±0.04 <sup>b</sup>
<i>D. esculenta</i>	Kukulala	20.01±0.26 <sup>a</sup>	12.4±0.46 <sup>a</sup>	1.89±0.02 <sup>a</sup>
<i>X. sagittifolium</i>	Kiriala	13.11±0.52 <sup>c</sup>	11.3±0.46 <sup>b</sup>	0.99±0.01 <sup>c</sup>

Data represent the mean of three replicates, Values followed by the different superscript in each column are significantly different (P<0.05)

availability of high levels of alkaloids in tubers causes itchiness, bitterness and/or sometimes toxicity (Oliver- Bever 1989).

#### Mineral composition and starch granular structure:

All three varieties of yams were found to be rich in Calcium and Iron while a high level of Magnesium was observed in Kiriala (Table 3). High levels of Potassium were observed in all the samples. Usage of Potassium rich fertilizers can be of one of the causes to this. All the samples contained lower levels of Zinc compared to analyzed mineral matter. Literature reveals very low levels of

**Table 3: Mineral content of different varieties of yams and *Xanthosoma* sp on dry weight basis (mg 100g<sup>-1</sup>)**

Source	Calcium	Iron	Magnesium	Potassium	Zinc
<i>D. alata</i> (Rajala)	8.13±0.05 <sup>a</sup>	7.17±0.11 <sup>b</sup>	35.11±1.16 <sup>b</sup>	2.29±4.94 <sup>b</sup>	206.99±0.05 <sup>a</sup>
<i>D. alata</i> (Hingurala)	8.15±0.29 <sup>a</sup>	6.22±0.2 <sup>a</sup>	31.34±1.16 <sup>b</sup>	184.21±1.92 <sup>a</sup>	2.11±0.1 <sup>b</sup>
<i>D. esculenta</i> (Kukulala)	8.29±0.06 <sup>a</sup>	6.12±0.03 <sup>a</sup>	33.6±1.19 <sup>a</sup>	190.91±0.78 <sup>c</sup>	1.19±0.08 <sup>a</sup>
<i>Xanthosoma sagittifolium</i> (Kiriala)	6.36±0.31 <sup>b</sup>	6.21±0.31 <sup>a</sup>	45.27±0.31 <sup>c</sup>	184.15±1.6 <sup>a</sup>	1.16±0.15 <sup>a</sup>

Data represent the mean of three replicates, Values followed by the different superscript in each column are significantly different (P<0.05)

minerals in Nigerian varieties of *D. alata* species (Okwu et.al, 2006). But further studies concerning the phytochemicals and mineral constituents of these varieties cultivated in different sites and regions of Sri Lanka is needed to come to a more conclusive study. Light microscopic view of extracted starches

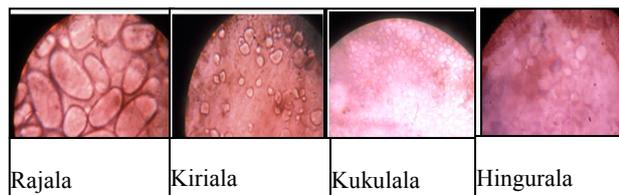


Figure 2: Light microscopic starch granular structure of yams and *Xanthosoma* spp (10 X 100)

(figure 2) showed that Kukulala contained comparatively smaller granules from the studied species and digestibility of starches with smaller granular sizes is fairly high (Szylit et al, 1978). Genetic variations and environmental conditions influence the structure and the properties of starch (Debon and Tester, 2000).

The starch granular shape of *Dioscorea esculenta* was polygonal and Rajala contained oval shaped granules. The largest granules were observed in Rajala while kukulala contained the smallest from the studied cultivars.

## CONCLUSION

Flours obtained from yams and *Xanthosoma* sp contained a considerable level of starch as the main constituent on dry matter basis. More purification was needed to ensure the purity of extracted starch. Results revealed the presence of significant quantity of protein in yam flours. A considerable amount of crude fat was observed in the yams and *Xanthosoma* sp (latter being the highest). These cultivars also contain a significant quantity of crude fibre and ash. From the phytochemical constituents studied in yams and *Xanthosoma* sp, Kukulala contained a higher levels of saponins, flavanoids and alkaloids while Rajala contained the lowest level. There was no significant difference in the Calcium, Magnesium and Iron levels in the studied yam varieties and a considerably higher amount of Potassium was observed in Rajala. Zinc content was higher in Hingurala compared to other studied tubers. Further studies concerning the digestibility and availability of these

nutrients and phytochemicals of these cultivars cultivated in different sites and regions of Sri Lanka is needed to come to a more conclusive study.

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