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# NUTRITIONAL AND ANTINUTRITIONAL EVALUATION OF SOME UNCONVENTIONAL WILD EDIBLE PLANTS.

## [EVALUACIÓN NUTRICIONAL Y ANTINUTRICIONAL DE ALGUNAS PLANTAS SILVESTRES COMESTIBLES NO CONVENCIONALES]

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**SUMMARY**

The wild edible tubers, rhizome, corm, roots and stems were consumed by the tribal *Valaiyans* of Madurai district, Western Ghats, Tamil Nadu were analysed for proximate and mineral composition, starch, vitamins, *in vitro* protein (IVPD), *in vitro* starch (IVSD) digestibility and certain antinutritional factors. The tubers of *Kedrostis foetidissima* and stem of *Caralluma pauciflora* contain higher contents of crude protein. The tubers of *Decalepis hamiltonii* and stems of *Caralluma adscendens* var *attenuata* and *C. pauciflora* contain higher contents of crude lipids. All the presently investigated wild edible plants appeared to have a higher level of iron content compared to Recommended Dietary Allowances (RDA) of NRC/NAS (1980) for infants, children and adults. The tubers of *Cissus vitiginea, Dioscorea pentaphylla* var. *pentaphylla, D. oppositifolia* var. *oppositifolia, D. spicata, D. tomentosa, Kedrostis foetidissima, Parthenocissus neilgherriensis,* in the corm of *Colocasia esculenta,* in the rhizome of *Canna indica* and in the root of *Ipomoea staphylina* were formed to contain more starch. The tubers of *Cycas circinalis, Cyphostemma setosum, D. oppositifolia* var. *oppositifolia, Dioscorea pentaphylla* var. *pentaphylla, Kedrostis foetidissima, Parthenocissus neilgherriensis,* and in the stem of *Caralluma pauciflora* were found to be higher niacin content. All the investigated samples *in vitro* protein digestibility (IVPD) was found to be low. Antinutritional substances like total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase and trypsin inhibitor activity were also investigated.

**Key words:** Wild edible plants; proximate composition; vitamins; antinutritional factors; total oxalate.

**RESUMEN**

Los tubérculos, bulbos, rizomas, raíces, y tallos de plantas silvestres comestibles consumidos por las tribus Valaiyan del distrito Madurai, en los Ghats occidentales de la Tamil Nadu, India, fueron analizados en su composición proximal, mineral, almidón, vitaminas, digestibilidad *in vitro* de la proteína y almidón y algunos factores antinutricionales. Los tubérculos de *Kedrostis foetidissima* y los tallos de *Caralluma pauciflora* tuvieron los mayors contenidos de proteína. Los tubérculos de *Decalepis hamiltonii* y los tallos de *Caralluma adscendens* var *attenuata* y *C. pauciflora* contienen altos niveles de lípidos. Todas las plantas analizadas tuvieron niveles de hierro mayores a las recomendaciones diarias (RDA) de NRC/NAS (1980) para infantes, niños y adultos. Los tubérculos de *Cissus vitiginea, Dioscorea pentaphylla* var. *pentaphylla, D. oppositifolia* var. *oppositifolia, D. spicata, D. tomentosa, Kedrostis foetidissima, Parthenocissus neilgherriensis,* el bulbo de *Colocasia esculenta,* el rizoma de *Canna indica* y la raíz de *Ipomoea staphylina* tuvieron los mayores contenidos de almidón. El mayor contenido de niacina se encontró en los tubérculos de *Cycas circinalis, Cyphostemma setosum, D. oppositifolia* var. *oppositifolia, Dioscorea pentaphylla* var. *pentaphylla, Kedrostis foetidissima, Parthenocissus neilgherriensis* y en los tallos de *Caralluma pauciflora.* En todas las muestras se encontró una baja digestibilidad in vitro de la proteína. Se reportan los contenidos de sustancias antinutricionales como fenoles libre, taninos, cianuro de hidrógeno, oxalatos totales e inhibidores de amilasas y tripsina.

**Palabras clave:** Plantas silvestres comestibles; composición proximal; vitaminas; factores antinutricionales; oxalato total.

## INTRODUCTION

With ever-increasing population pressure and fast depletion of natural resources, it has become extremely important to diversify the present day agriculture in order to meet various human needs (Janardhanan *et al.*, 2003). The observed interest in search for alternative/ additional food and feed ingredients is of paramount importance mainly for two reasons, one is the low production of oil seeds and grains and another is the stiff competition between man and the livestock industry for existing food and feed materials (Siddhuraju *et al*., 2000). The ethnic people use a wide variety of wild plants and plant products as their food. India has one of the largest concentrations of tribal population in the world. The forest plays a vital role in the economy as well as daily needs of the tribals. In times of scarcity when the staple food is in short of supply tribals collect many types of wild roots and tubers to supplement their meager food available at home (Vidyarthi, 1987).

Information regarding the chemical and nutritional content of Indian wild edible tubers, rhizomes, corms, roots and stems is meager (Gopalan *et al.*, 1976; Babu *et al.*, 1990; Nair and Nair, 1992; Rajyalakshmi and Geervani, 1994; Shanthakumari *et al.*, 2008, Udensi *et al.*, 2008). Therefore, in the present investigation, an attempt has been made to understand the chemical composition and anti-nutritional factors of the wild edible tubers, rhizome, corm, roots, and stems consumed by the tribal *Valaiyans* of Madurai district, Western Ghats, Tamil Nadu. Studies on nutritional value of wild plant food are of considerable significance since it may help to identify long forgotten food resources.

## MATERIALS AND METHODS

Wild edible tubers, rhizome, corm, roots and stems (Table.1) grown in sandy loam soil consumed by the tribal *Valaiyans* were collected using multistage sampling technique in three consecutive rainy seasons (each seasons three samples- sample size 2 kg) during August and January (2007–2008) from the South-eastern slopes of Western Ghats, Madurai district, Tamil Nadu.

Table 1. Wild edible tubers, rhizome, corm, roots and stems.

| Botanical name | Plant parts used |
|---|---|
| *Aponogeton natans* (L.) Engler & k. | Tuber |
| *Boerhavia chinensis* (L.) Asch & Schweinf. | Root |
| *Caralluma adscendens* (Roxb.) Haw. var. *attenuata* (Wight) Grav. & Mayuranathan | Stem |
| *Caralluma pauciflora* (Wight) N.B.Br. | Stem |
| *Canna indica*L. | Stem |
| *Cissus quadrangularis* L. | Rhizome |
| *Cissus vitiginea*L. | Tuber |
| *Colocasia esculenta* (L.) Shott | Corm |
| *Cycas circinalis* L. | Tuber |
| *Cyphostemma setosum* (Roxb) Alston | Tuber |
| *Decalepis hamiltonii* Wight & Arn. | Tuber |
| *Dioscorea pentaphylla* L. var. *pentaphylla* | Tuber |
| *Dioscorea oppositifolia* L. var. *oppositifolia* | Tuber |
| *Dioscorea spicata* Roth. | Tuber |
| *Dioscorea tomentosa* Koen. Ex. Spreng. | Tuber |
| *Hemidesmus indicus* (L.) R. Br. var. *indicus* | Root |
| *Ipomoea staphylina* Roem & Schultes | Root |
| *Kedrostis foetidissima*(Jacq.) Cogn. | Tuber |
| *Maerua oblongifolia*(Forsk.) A. Rich | Tuber |
| *Momordica diocia* Roxb ex Willd | Tuber |
| *Nymphaea pubescens* Willd | Tuber |
| *Nymphaea rubra* Roxb ex Andrews | Tuber |
| *Parthenocissus neilgherriensis* (Wight) Planch. | Tuber |

**Proximate composition**

The moisture content was determined by drying 50 transversely cut seeds in an oven at 80°C for 24 hr and is expressed on a percentage basis. The air-dried samples were powdered separately in a Wiley mill (Scientific Equipment, Delhi, India) to 60-mesh size and stored in screw capped bottles at room temperature for further analysis.

The nitrogen content was estimated by the micro Kjeldahl method (Humphries, 1956) and the crude protein content was calculated (N x 6.25). Crude lipid content was determined using Soxhlet apparatus (AOAC, 2005). The ash content was determined by heating 2g of dried sample in a silica dish at 600°C for 6hr (AOAC, 2005). Total dietary fibre (TDF) was estimated by the non-enzymatic-gravimetric method proposed by Li and Cardozo (1994). To determine the TDF, duplicate 500 mg ground samples were taken in separate 250 ml beakers. To each beaker 25 ml water was added and gently stirred until the samples were thoroughly wetted, (i.e. no clumps were noticed). The beakers were covered with Al foil and allowed to stand 90 min without stirring in an incubator maintained at 37°C. After that, 100 ml 95% ethanol was added to each beaker and allowed to stand for 1 hr at room temperature (25±2°C). The residue was collected under vacuum in a pre-weighed crucible containing filter aid. The residue was washed successively with 20 ml of 78% ethanol, 10 ml of 95% ethanol and 10 ml acetone. The crucible containing the residue was dried $\geq$2 hr at 105°C and then cooled $\geq$ 2 hr in a desiccator and weighed. One crucible containing residue was used for ash determination at 525°C for 5 hr. The ash-containing crucible was cooled for $\geq$ 2hr in a desiccator and weighed. The residue from the remaining duplicate crucible was used for crude protein determination by the micro-Kjeldahl method as already mentioned. The TDF was calculated as follows:

$$TDF\% = 100 \times \frac{Wr - [(P+A)/100]\,Wr}{Ws}$$

Where *Wr* is the mg residue, *P* is the % protein in the residue; *A* is the % ash in the residue, and *Ws* is the mg sample.

The nitrogen free extract (NFE) was obtained by difference (Muller and Tobin, 1980). The energy value of the seed (kJ) was estimated by multiplying the percentages of crude protein, crude lipid and NFE by the factors 16.7, 37.7 and 16.7, respectively (Siddhuraju *et al.*, 1996).

**Minerals and vitamins analysis**

Five hundred milligrams of the ground legume seed was digested with a mixture of 10ml concentrated nitric acid, 4ml of 60% perchloric acid and 1ml of concentrated sulphuric acid. After cooling, the digest was diluted with 50ml of deionised distilled water, filtered with Whatman No. 42 filter paper and the filtrates were made up to 100ml in a glass volumetric flask with deionised distilled water. All the minerals except phosphorus were analysed from a triple acid-digested sample by an atomic absorption spectrophotometer – ECIL (Electronic Corporation of India Ltd., India) (Issac and Johnson, 1975). The phosphorus content in the triple acid digested extract was determined colorimetrically (Dickman and Bray, 1940).

Ascorbic acid and niacin content were extracted and estimated as per the method given by Sadasivam and Manickam (1992). For the extraction of ascorbic acid, 3g air-dried powdered sample was ground with 25ml of 4% oxalic acid and filtered. Bromine water was added drop by drop to 10ml of the filtrate until it turned orange-yellow to remove the enolic hydrogen atoms. The excess of bromine was expelled by blowing in air. This filtrate was made up to 25ml with 4% oxalic acid and used for ascorbic acid estimation. Two millilitres of the extract was made up to 3ml with distilled $H_2O$ in a test tube. One millilitre of 2% 2, 4-dinitrophenyl hydrazine reagent and a few drops of thiourea were added. The contents of the test tube were mixed thoroughly. After 3hr incubation at 37°C, 7ml of 80% $H_2SO_4$ was added to dissolve the osazone crystals and the absorbance was measured at 540nm against a reagent blank.

For the extraction of niacin, 5g air-dried powdered sample was steamed with 30ml concentrated $H_2SO_4$ for 30min. After cooling, this suspension was made up to 50ml with distilled $H_2O$ and filtered. Five millilitres of 60% basic lead acetate was added to 25ml of the filtrate. The pH was adjusted to 9.5 and centrifuged to collect the supernatant. Two millilitres of concentrated $H_2SO_4$ was added to the supernatant. The mixture was allowed to stand for 1hr and centrifuged. The 5ml of 40% $ZnSO_4$ was added to the supernatant. The pH was adjusted to 8.4 and centrifuged again. Then the pH of the collected supernatant was adjusted to 7 and used as the niacin extract. For estimation, 1ml extract was made up to 6ml with distilled water in a test tube; 3ml cyanogen bromide was added and shaken well, followed by addition of 1ml of 4% aniline. The yellow colour that developed after 5min was measured at 420nm against a reagent blank. The ascorbic acid and niacin contents present in the sample were calculated by referring to a standard graph and expressed as milligrams per 100grams of powdered samples. Starch

content was determined by the method of Sadasivam and Manickam (1992).

**Analysis of antinutritional compounds**

The antinutritional compounds, total free phenolics (Bray and Thorne, 1954), tannins (Burns, 1971), hydrogen cyanide (Jackson, 1971) and total oxalate (AOAC, 1984) were quantified. Trypsin inhibitor activity was determined by the enzyme assay of Kakade *et al*. (1974) by using benzoil-DL-arginin-*p*-nitroanilide (BAPNA) as a substrate. One trypsin inhibitor unit (TIU) has been expressed as an increase of 0.01 absorbance units per 10ml of reaction mixture at 410nm. Trypsin inhibitor activity has been defined in terms of trypsin units inhibited per mg protein. Amylase inhibitor activity was determined by the method of Rekha and Padmaja (2002) by using 0.5% soluble starch as substrate. Porcine pancreatic α-amylase (Emerck, Germany) was used as the enzymatic source uniformly throughout the study. One α-amylase unit has been defined as one mg starch hydrolysed per minute at 30°C. One α-amylase inhibitor unit (AIU) has been defined as the amount of inhibitor that reduces the α-amylase activity by one unit. The specific amylase inhibitor unit is calculated as the AIU/mg soluble starch.

**Determination of *in vitro* protein digestibility**

This was determined using the multi-enzyme technique (Hsu *et al*., 1977). The enzymes used for IVPD were purchased from Sigma Chemical Co., St. Louis, MO, USA. Calculated amounts of the control (casein) and sample were weighed out, hydrated in 10ml of distilled water and refrigerated at 5°C for 1h. The samples containing protein and enzymes were all adjusted to pH 8.0 at 37°C. The IVPD was determined by the sequential digestion of the samples containing protein with a multi-enzyme mixture [trypsin (porcine pancreatic trypsin–type IX with 14190 BAEE unites per mg protein), ∝-chymotrypsin (bovine pancreatic chymotrypsin–type II, 60 units per mg powder) and peptidase (porcine intestinal peptidase–grade III, 40 units per g powder)] at 37°C followed by protease (type IV from *Streptomyces griseus*) at 55°C. The pH drop of the samples from pH 8.0 was recorded after 20min of incubation. The IVPD was calculated according to the regression equation $Y = 234.84 - 22.56X$, where $Y$ is the % digestibility and $X$ the pH drop.

**Determining of *in vitro* starch digestibility**

Starch digestibility was assayed by the *in vitro* method described by Padmaja *et al*. (2001). One hundred mg of powdered sample was weighed and to this 10ml of the 0.02M sodium phosphate buffer (pH 6.9) was added and the contents were thoroughly mixed. Kept in boiling water bath and gelatinize the sample by stirring continuously, not allowing lump formation. The volume was made upto 20ml using the same buffer. Then 0.5ml of pancreatic alpha amylase solution was added to this and incubated at 30°C for 30 minutes. To nullify the effect of free reducing sugars, control flasks were also set up. For this, an identical flask containing sample as above was prepared and no enzyme is added and incubate for 30min at 30°C. Immediately after 30min the flasks were placed in a boiling water bath to inactivate the enzyme. On cooling, 0.2ml aliquots from each of the test as well as control were pipette out into separate test tubes. The contents of the tubes were then made up to 1.0ml using distilled water. The reducing sugars formed by the action of α-amylase on the starch were estimated by Nelson-Somogyi method and the absorbance was read at 520nm. A standard graph was prepared using D-maltose. The *in vitro* starch digestibility was expressed as mg reducing group formed 1h per g starch taken.

**Statistical analysis**

Proximate composition, minerals, vitamins (niacin and ascorbic acid), starch, antinutritional factors like total free phenolics, tannins, total oxalate and hydrogen cyanide were estimated in triplicate determinations. Data were analyzed using the statistical analysis system SPSS (SPSS software for windows release 11.5; SPSS Inc., Chicago IL, USA) Estimates of mean, standard error for aforesaid parameters were calculated.

## RESULTS AND DISCUSSION

**Proximate composition**

Data on proximate composition of the edible tubers, rhizome, corm, roots and stems are shown in Table 2. The proximate composition reveals that the tubers of *Kedrostis foetidissima* and stem of *Caralluma pauciflora* have more crude protein than the other investigated tubers, rhizome, corm, roots and stems. The crude protein content of the various species of *Dioscorea* tubers is found to be in agreement with the earlier studies in the species of Dioscorea tubers (Onyilagha and Lowe, 1985; Rajyalakshmi and Geervani, 1994; Akissoe *et al*., 2001). The crude lipid content of the tuber of *Decalepis hamiltonii* and the stems of *Caralluma adscendens* var. *attenuata* and *C. pauciflora* seem to be higher than those previously found for tubers such as *Dioscorea oppositifolia, D. bulbifera, D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. rotundata* (Akissoe *et al*., 2001); *D. bulbifera;* corms of *Colocasia esculenta* and *Alocasia macrorrhiza*

(Pramila *et al*., 1991); and *Dioscorea* spp. (Shanthakumari, *et al*., 2008). The presence of fiber in the diet is necessary for digestion and for elimination of wastes. The contraction of muscular walls of the digestive tract is stimulated by fiber, thus counteracting constipation (Narasinga Rao *et al.*, 1989). The World Health Organization (WHO) has recommended an intake of 22-23kg of fiber for every 1000 K.cal. of diet (Kanwar *et al*., 1997). The crude fibre content in the presently investigated tubers of *Cissus vitiginea*, *Dioscorea oppositifolia* var *oppositifolia*, *D. pentaphylla* var. *pentaphylla* and *Kedrostis foetidissima* is found to be more than that of earlier reports in certain tubers such as *D. bulbifera* (Pramila *et al.*, 1991), *D. oppositifolia, D. bulbifera, D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. rotundata* (Akissoe *et al*., 2001); *D. bulbifera* and *D. tomentosa* (Shanthakumari *et al*., 2008). The tubers, rhizome, corm, roots and stems presently investigated, contain high carbohydrates or Nitrogen Free Extractives (NFE) (70.33-85.09%). The presence of relatively high contents of total crude fat and NFE were found to be responsible for the stems of *Caralluma adscendens* var. *attenuata* and *C. pauciflora* as a good source of energy.

Table 2. Proximate composition of edible tubers, rhizome, corm, roots and stems (g $100g^{-1}$ )[a]

| Botanical Name | Moisture % | Crude Protein | Crude lipid | Crude fibre | Ash | N Free Extractives (NFE) | Calorific value (kJ $100g^{-1}$ DM) |
|---|---|---|---|---|---|---|---|
| *A. natans* | 9.28 | 5.25 ± 0.04 | 2.9 ± 0.01 | 3.92 ± 0.02 | 2.84 ± 0.03 | 85.09 | 1618.00 |
| *B. chinensis* | 79.63 | 6.12 ± 0.12 | 4.87 ± 0.02 | 3.04 ± 0.01 | 5.92 ± 0.04 | 80.04 | 1622.63 |
| *C. adscendens* | 91.47 | 7.0 ± 0.14 | 10.06 ± 0.18 | 2.38 ± 0.04 | 4.56 ± 0.01 | 76.00 | 1765.36 |
| *C. pauciflora* | 84.99 | 11.37 ± 0.07 | 11.22 ± 0.54 | 2.79 ± 0.07 | 4.28 ± 0.03 | 70. 33 | 1787.55 |
| *C. indica* | 89.01 | 6.34 ± 0.21 | 4.31 ± 0.11 | 5.78 ± 0.08 | 3.14 ± 0.01 | 80.43 | 1611.54 |
| *C. quadrangularis* | 89.19 | 6.12 ± 0.50 | 6.38 ± 0.32 | 3.48 ± 0.03 | 6.97 ± 0.70 | 77. 04 | 1629.46 |
| *C. vitiginea* | 87.65 | 3.93 ± 0.16 | 2.24 ± 0.04 | 4.48 ± 0.08 | 7.14 ± 0.02 | 82.20 | 1522.98 |
| *C. esculenta* | 38.34 | 4.37 ± 0.05 | 5.30 ± 0.03 | 3.78 ± 0.11 | 9.12 ± 0.11 | 77.42 | 1565.87 |
| *C. circinalis* | 63.47 | 9.18 ± 0.11 | 4.09 ± 0.11 | 3.93 ± 0.03 | 4.29 ± 0.12 | 78.50 | 1618.61 |
| *C. setosum* | 93.02 | 4.37 ± 0.11 | 5.77 ± 0.03 | 3.34 ± 0.02 | 9.86 ± 0.02 | 76.65 | 1570.73 |
| *D. hamiltonii* | 78.73 | 4.37 ± 0.09 | 10.24 ± 0.22 | 4.15 ± 0.03 | 8.7 ± 0.09 | 72.53 | 1670.44 |
| *D. pentaphylla* | 93.05 | 9.18 ± 0.18 | 4.8 ± 0.02 | 5.14 ± 0.11 | 4.64 ± 0.02 | 76.23 | 1607.47 |
| *D. oppositifolia* | 78.49 | 7.00 ± 0.07 | 6.92 ± 0.11 | 5.53 ± 0.13 | 6.38 ± 0.12 | 74.17 | 1616.42 |
| *D. spicata* | 89.26 | 6.38 ± 0.08 | 4.78 ± 0.12 | 4.67 ± 0.03 | 5.18 ± 0.01 | 78.99 | 1605.89 |
| *D. tomentosa* | 93.65 | 8.31 ± 0.12 | 6.84 ± 0.04 | 4.38 ± 0.18 | 6.53 ± 0.03 | 73.93 | 1631.44 |
| *H. indicus* | 19.40 | 4.37 ± 0.11 | 6.17 ± 0.07 | 3.15 ± 0.03 | 3.00 ± 0.12 | 83.30 | 1696.86 |
| *I. staphylina* | 66.74 | 5.25 ± 0.13 | 5.74 ± 0.02 | 4.13 ± 0.03 | 2.75 ± 0.12 | 82.13 | 1675.64 |
| *K. foetidissima* | 80.76 | 11.37 ± 0.03 | 5.09 ± 0.03 | 5.58 ± 0.06 | 7.36 ± 0.13 | 70.59 | 1560.79 |
| *M. oblongifolia* | 79.28 | 7.87 ± 0.06 | 7.83 ± 0.12 | 3.39 ± 0.05 | 3.73 ± 0.01 | 77.17 | 1715.52 |
| *M. dioica* | 77.78 | 3.5 ± 0.03 | 5.08 ± 0.03 | 4.14 ± 0.50 | 5.36 ± 0.01 | 81.92 | 1618.03 |
| *N. pubescens* | 87.55 | 9.62 ± 0.11 | 2.98 ± 0.01 | 3.15 ± 0.11 | 6.95 ± 0.04 | 77.29 | 1563.91 |
| *N. rubra* | 81.33 | 8.31 ± 0.12 | 5.05 ± 0.03 | 3.74 ± 0.09 | 3.80 ± 0.03 | 79.09 | 1650.13 |
| *P. neilgherriensis* | 79.29 | 5.25 ± 0.12 | 4.89 ± 0.01 | 3.44 ± 0.03 | 8.96 ± 0.11 | 77.46 | 1565.61 |

[a] All the values are means of triplicate determinations expressed on dry weight basis, ± denotes standard error.

**Mineral composition**

The mineral analysis (Table. 3) reveals that the corm of *Colocasia esculenta* and the tuber of *Cycas circinalis* appear to be rich sources of potassium when compared with the Recommended Dietary Allowances (RDA) of NRC/NAS (1989) for infants and children. Robinson (1987) reported that a diet that meets two-thirds of the Recommended Dietary Allowances (RDA) values is considered to be adequate for an individual. The high content of Potassium can be utilized beneficially in diets of people who take diuretics to control hypertension and suffer from excretion of potassium through the body fluid (Siddhuraju *et al.*, 2001). The calcium content in the corm of *Colocasia esculenta*, the tubers of *Cycas circinalis, Dioscorea oppositifolia* var. *oppositifolia* and *D. pentaphylla* var *pentaphylla* and in the root of *Ipomoea staphylina* is found to be higher than an earlier study in the corms of *Colocasia esculenta* and *Alocasia macrorrhiza* (Pramila *et al*.,1991; Agarwal *et al*., 1999); in the tubers of *D. oppositifolia, D. pentaphylla, D. bulbifera* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. alata, D. bulbifera, D. esculenta, D. oppositifolia, D. pentaphylla* and *D. tomentosa* (Shanthakumari *et al.*, 2008) and also higher than that of RDA's of NRC/NAS (1980) for infants and children. The micro

element, iron content in the corm of *Colocasia esculenta*, tubers of *Decalepis hamiltonii* and *Dioscorea pentaphylla* var. *pentaphylla* and stem of *Caralluma adscendens* var. *attenuata* is found to be higher when compared with the earlier reports in the tubers of *D. oppositifolia, D. pentaphylla, D. bulbifera* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. pentaphylla* and *D. oppositifolia* (Murugesan and Ananthalakshmi, 1991). All the presently investigated tubers, rhizome, corm, roots and stems have higher iron content compared to infants, children and adults RDA's of NRC/NAS (1980). The copper content, in the corm of *Colocasia esculenta*, the tubers of *Cycas circinalis* and *D. pentaphylla* var. *pentaphylla* appears to be higher when compared with Estimated Safe and Adequate Daily Dietary Intakes of Minerals (ESADDI) of infants and adults (NRC/NAS, 1989).

Table 3. Mineral composition of edible tubers, rhizome, corm, roots and stems (mg $100g^{-1}$)[a]

| Botanical Name | Sodium | Potassium | Calcium | Magnesium | Phosphorus | Zinc | Manganese | Iron | Copper |
|---|---|---|---|---|---|---|---|---|---|
| *A. natans* | 43.1 | 1038 | 312.3 | 134.0 | 68.0 | 2.20 | 3.34 | 30.10 | 1.50 |
| | ±0.14 | ±1.24 | ±0.44 | ±0.31 | ±0.21 | ±0.04 | ±0.01 | ±0.44 | ±0.01 |
| *B. chinensis* | 24.3 | 735 | 224.2 | 99.0 | 59.1 | 1.60 | 2.94 | 23.10 | 1.80 |
| | ±0.08 | ±0.84 | ±0.12 | ±0.12 | ±0.33 | ±0.01 | ±0.03 | ±0.24 | ±0.03 |
| *C. adscendens* | 24.3 | 946 | 120.3 | 138.1 | 134.0 | 6.80 | 6.48 | 52.00 | 1.40 |
| | ±0.08 | ±1.02 | ±0.54 | ±1.01 | ±0.72 | ±0.24 | ±0.33 | ±0.32 | ±0.03 |
| *C. pauciflora* | 34.1 | 938 | 110.1 | 124.0 | 120.0 | 5.48 | 7.34 | 48.00 | 1.10 |
| | ±0.12 | ±1.18 | ±1.04 | ±1.11 | ±0.18 | ±0.33 | ±0.08 | ±0.24 | ±0.01 |
| *C. indica* | 21.1 | 979 | 154.1 | 134.1 | 89.0 | 0.89 | 1.21 | 11.53 | 3.36 |
| | ± 0.28 | ± 0.17 | ±0.13 | ±0.08 | ±0.03 | ±0.01 | ±0.04 | ±0.12 | ±0.08 |
| *C. quadrangularis* | 44.2 | 1034 | 94.0 | 150.0 | 118.1 | 3.24 | 2.10 | 34.00 | 1.10 |
| | ± 0.11 | ±1.2 | ±0.62 | ±1.18 | ±0.12 | ±0.41 | ±0.01 | ±0.11 | ±0.01 |
| *C. vitiginea* | 18.2 | 638 | 316.1 | 88.3 | 38.1 | 1.75 | 2.54 | 26.08 | 1.56 |
| | ±0.11 | ±0.54 | ±0.03 | ±0.09 | ±0.18 | ±0.01 | ±0.01 | ±0.11 | ±0.04 |
| *C. esculenta* | 189.1 | 2024 | 538.3 | 197.4 | 112.1 | 1.98 | 4.24 | 62.16 | 7.91 |
| | ±0.24 | ±1.38 | ±0.06 | ±1.03 | ±1.06 | ±0.06 | ±0.11 | ±1.01 | ±0.11 |
| *C. circinalis* | 94.1 | 1548 | 418.3 | 138.1 | 102.0 | 1.48 | 5.54 | 31.00 | 5.24 |
| | ±0.34 | ±1.42 | ±0.04 | ±0.62 | ±1.01 | ±0.01 | ±0.13 | ±0.78 | ±0.08 |
| *C. setosum* | 54.3 | 934 | 346.1 | 124.0 | 44.0 | 1.40 | 3.16 | 28.00 | 2.24 |
| | ±0.11 | ±0.68 | ±0.11 | ±0.66 | ±0.42 | ±0.02 | ±0.03 | ±0.33 | ±0.01 |
| *D. hamiltonii* | 64.0 | 1134 | 386.1 | 104.0 | 46.0 | 2.18 | 5.44 | 51.10 | 1.34 |
| | ±0.14 | ±0.92 | ±0.48 | ±0.34 | ±0.04 | ±0.03 | ±0.04 | ±0.12 | ±0.01 |
| *D. pentaphylla* | 95.2 | 1322 | 632.1 | 380.0 | 96.1 | 3.10 | 1.32 | 103.48 | 12.60 |
| | ±0.12 | ±2.40 | ±0.22 | ±0.74 | ±0.06 | ±0.01 | ±0.01 | ±0.94 | ±0.14 |
| *D. oppositifolia* | 102.2 | 1431 | 680.6 | 432.5 | 78.2 | 3.24 | 6.34 | 22.00 | 2.74 |
| | ±0.54 | ±1.56 | ±0.82 | ±1.11 | ±0.08 | ±0.08 | ±0.01 | ±0.08 | ±0.03 |
| *D. spicata* | 52.2 | 1255 | 172.0 | 112.4 | 86.1 | 4.18 | 0.98 | 22.36 | 0.78 |
| | ±0.11 | ±0.48 | ±0.21 | ±0.32 | ±0.11 | ±0.13 | ±0.14 | ±0.38 | ±0.21 |
| *D. tomentosa* | 32.2 | 1354 | 272.1 | 120.4 | 96.1 | 5.20 | 1.32 | 24.56 | 1.34 |
| | ±0.18 | ±1.34 | ±1.01 | ±0.08 | ±0.04 | ±0.03 | ±0.04 | ±0.04 | ±0.01 |
| *H. indicus* | 26.1 | 1065 | 432.0 | 94.0 | 54.0 | 2.18 | 1.46 | 44.10 | 1.12 |
| | ±0.11 | ±0.74 | ±0.32 | ±0.12 | ±0.12 | ±0.02 | ±0.01 | ±0.08 | ±0.11 |
| *I. staphylina* | 23.5 | 520 | 524.2 | 396.1 | 74.5 | 14.60 | 12.80 | 25.20 | 1.62 |
| | ±0.06 | ±0.26 | ±0.11 | ±0.11 | ±0.14 | ±0.33 | ±0.24 | ±0.11 | ±0.12 |
| *K. foetidissima* | 41.0 | 732 | 371.0 | 156.2 | 88.0 | 1.76 | 1.54 | 34.00 | 1.74 |
| | ±0.06 | ±0.44 | ±0.33 | ±0.18 | ±0.18 | ±0.01 | ±0.04 | ±0.12 | ±0.01 |
| *M. oblongifolia* | 66.0 | 843 | 218.1 | 118.2 | 76.0 | 1.44 | 1.32 | 29.10 | 1.10 |
| | ±0.13 | ±0.36 | ±0.17 | ±0.14 | ±0.11 | ±0.04 | ±0.03 | ±0.08 | ±0.03 |
| *M. dioica* | 85.0 | 938 | 234.0 | 112.0 | 64.0 | 1.24 | 1.58 | 34.14 | 1.10 |
| | ±0.14 | ±0.28 | ±0.11 | ±0.33 | ±0.08 | ±0.04 | ±0.01 | ±0.31 | ±0.01 |
| *N. pubescens* | 56.1 | 768 | 326.1 | 96.1 | 54.1 | 1.34 | 1.38 | 32.10 | 1.16 |
| | ±0.22 | ±0.48 | ±0.17 | ±0.14 | ±0.11 | ±0.01 | ±0.02 | ±0.11 | ±0.05 |
| *N. rubra* | 34.1 | 734 | 354.1 | 104.0 | 76.3 | 1.64 | 1.34 | 28.14 | 1.12 |
| | ±0.36 | ±0.74 | ±0.18 | ±0.06 | ±0.06 | ±0.01 | ±0.01 | ±0.24 | ±0.01 |
| *P. neilgherriensis* | 48.0 | 968 | 372.0 | 104.1 | 72.1 | 1.04 | 1.64 | 29.00 | 1.14 |
| | ±0.26 | ±0.85 | ±0.08 | ±0.26 | ±0.08 | ±0.01 | ±0.03 | ±0.03 | ±0.01 |

[a] All the values are means of triplicate determinations expressed on dry weight basis, ± denotes standard error.

**Starch and Vitamins**

The contents of starch and vitamins (niacin and ascorbic acid) are shown in Table 4. The rhizome of *Canna indica*, the tubers of *Cissus vitiginea*, *Colocasia esculenta*, *Dioscorea pentaphylla* var. *pentaphylla*, *D. oppositifolia* var. *oppositifolia*, *D. spicata*, *D. tomentosa*, *Kedrostis foetidissima*, *Parthenocissus neilgherriensis* and the root of *Ipomoea staphylina* are found to contain more starch contents than that of earlier reports in the tubers of *D. oppositifolia*, *D. bulbifera*, *D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. alata* (Abraham and Nair, 1984); *Ipomoea batatus* (Nair and Nair, 1992); *Manihot esculenta* (Maini and Balagopal, 1978), and the corm of *Amorphophallus paeoniifolius* (Moorthy *et al.*, 1994). The vitamin niacin content in the tubers of *Cycas circinalis*, *Cyphostemma setosum*, *Dioscorea oppositifolia* var. *oppositifolia*, *D. pentaphylla* var. *pentaphylla*, *Kedrostis foetidissima* and *Parthenocissus neilgherriensis* and the stem of *Caralluma pauciflora* is found to be higher than that of earlier reports in the tubers of *Dioscorea* spp, the pith of *Caryota urens* and shoot of *Bambusa arundinacea* (Rajyalakshmi and Geervani, 1994). The tuber of *Decalepis hamiltonii* are found to contain more ascorbic acid content than the earlier report in the tubers of *Dioscorea alata* (Udensi *et al*., 2008); corms of *Colocasia esculenta* and *Alocasia macorrhiza* (Pramila *et al.*, 1991).

***In vitro* protein and starch digestibility:**

Table 5 are shown the *in vitro* protein digestibility and *in vitro* starch digestibility. All the presently investigated samples, the *in vitro* protein digestibility (IVPD) is found to be very low. However, *in vitro* starch digestibility (IVSD) of the tubers of *Aponogeton natans*, *Cissus vitiginea*, *Decalepis hamiltonii*, *Cyphostemma setosum*, *Dioscorea pentaphylla* var *pentaphylla*, *D. spicata*, *Kedrostis foetidissima* and *Maerua oblongifolia* is found to be higher than that *of D. oppositifolia*, *D. bulbifera*, *D. pentaphylla*, *D. hispida* and the pith of *Caryota urens* (Rajyalakshmi and Geervani, 1994).

Table 4. Starch, vitamins (niacin and ascorbic acid) content of edible tubers, rhizome, corm, roots and stems[a]

| Botanical Name | Starch g 100g $^{-1}$ | Niacin mg 100g $^{-1}$ | Ascorbic acid mg 100g$^{-1}$ |
|---|---|---|---|
| *A. natans* | 7.64±0.11 | 7.06±0.03 | 6.56±0.03 |
| *B. chinensis* | 14.11±0.12 | 16.47±0.12 | 10.49±0.04 |
| *C. adscendens* | 6.76±0.14 | 10.59±0.12 | 5.25±0.15 |
| *C. pauciflora* | 5.58±0.17 | 20.00±0.21 | 8.53±0.13 |
| *C. indica* | 34.00 ± 0.14 | 9.34 ± 0.11 | 5.59 ± 0.24 |
| *C. quadrangularis* | 6.17±0.15 | 4.71±0.13 | 9.84±0.14 |
| *C. vitiginea* | 27.94±0.03 | 15.29±0.12 | 22.95±0.11 |
| *C. esculenta* | 13.52±0.03 | 9.41±0.11 | 1.97±0.01 |
| *C. circinalis* | 7.94±0.03 | 20.00±0.10 | 18.36±0.12 |
| *C. setosum* | 7.64±0.06 | 18.82±0.07 | 20.33±0.12 |
| *D. hamiltonii* | 12.35±0.03 | 11.76±0.12 | 30.16±0.12 |
| *D. pentaphylla* | 15.88±0.07 | 18.82±0.11 | 4.59±0.24 |
| *D. oppositifolia* | 9.41±0.04 | 18.82±0.03 | 26.23±0.12 |
| *D. spicata* | 49.36 ± 0.34 | 12.31 ± 0.07 | 21.23 ± 0.12 |
| *D. tomentosa* | 15.29±0.09 | 14.12±0.02 | 24.92±0.21 |
| *H. indicus* | 4.70±0.01 | 12.94±0.09 | 10.49±0.10 |
| *I. staphylina* | 7.35±0.02 | 17.65±0.09 | 7.21±0.11 |
| *K. foetidissima* | 29.41±0.11 | 18.82±0.11 | 7.87±0.02 |
| *M. oblongifolia* | 4.70±0.03 | 14.12±0.12 | 21.64±0.06 |
| *M. dioica* | 22.05±0.06 | 17.65±0.03 | 1.31±0.01 |
| *N. pubescens* | 8.73±0.06 | 9.41±0.01 | 19.02±0.06 |
| *N. rubra* | 13.52±0.09 | 5.88±0.01 | 14.43±0.03 |
| *P. neilgherriensis* | 27.94±0.02 | 18.82±0.02 | 17.05±0.03 |

[a] All the values are means of triplicate determinations expressed on dry weight basis; ±denotes standard error.

Table 5. *In vitro* protein digestibility (IVPD, %)and *in vitro* starch digestibility(IVSD, %) of edible tubers, rhizome, corm, roots and stems[a].

| Botanical name | IVPD | IVSD[b] |
|---|---|---|
| *A. natans* | 3.68 | 62.10 |
| *B. chinensis* | 3.78 | 23.15 |
| *C. adscendens* | 4.31 | 14.10 |
| *C. pauciflora* | 3.38 | 18.27 |
| *C. indica* | 5.45 | 68.20 |
| *C. quadrangularis* | 3.14 | 30.33 |
| *C. vitiginea* | 6.02 | 30.10 |
| *C. esculenta* | 4.03 | 42.40 |
| *C. circinalis* | 3.89 | 56.32 |
| *C. setosum* | 4.64 | 62.37 |
| *D. hamiltonii* | 5.86 | 66.30 |
| *D. pentaphylla* | 4.87 | 86.14 |
| *D. oppositifolia* | 5.29 | 39.21 |
| *D. spicata* | 5.27 | 76.34 |
| *D. tomentosa* | 4.98 | 56.84 |
| *H. indicus* | 5.30 | 25.00 |
| *I. staphylina* | 4.30 | 15.18 |
| *K. foetidissima* | 5.68 | 89.33 |
| *M. oblongifolia* | 5.06 | 67.12 |
| *M. dioica* | 4.87 | 13.14 |
| *N. pubescens* | 4.31 | 23.40 |
| *N. rubra* | 5.78 | 18.23 |
| *P. neilgherriensis* | 5.69 | 54.00 |

[a] means of two independent determinations. [b]1 unit = mg reducing groups / hr. / g sample.

**Antinutritional factors**

The problem of plant protein digestibility has been suggested to be because of the interplay of several factors such as protease inhibitors, amylase inhibitors, phytates, oxalates, lectins, goitrogens, hydrogen cyanide, total free phenolics, tannins and other antinutritional factors. For this reason a preliminary evaluation of some of these factors in raw tubers, rhizome, corm, roots and stems are made (Table. 6). Total free phenolic contents of all the presently investigated samples, except *Cissus vitiginea* are found to be low compared to earlier studies in the tubers of *Ipomoea batatus* (Adelusi and Ogundana, 1987); *Dioscorea esculenta, D. alata, D. rotundata,* (Babu *et al.*, 1990; Sundaresan *et al*., 1990) *Manihot esculenta* and *Ipomoea batatus* (Babu *et al.*, 1990). Phenolic compounds inhibit the activity of digestive as well as hydrolytic enzymes such as amylase, trypsin, chymotrypsin and lipase (Salunkhe, 1982). However, recent researchers report that the phenolic compounds are the main human dietary antioxidant and have a decreased incidence of chronic diseases. A number of polyphenolic compounds are present, which contribute towards the defense mechanism of plants. Although these are considered earlier as antinutritional compounds, under the present nomenclature phenols fall under the category of nutraceuticals, offering many nutritional advantages to man (Shanthakumari *et al*., 2008). The tannin content in the tubers of *Cissus vitiginea* are found to be more when compared with other earlier reports in the tubers of *Dioscorea alata, D. caryenensis, D. rotundata* and *D. esculenta* (Udoession and Iforn, 1992). Tannins are known to inhibit the activities of digestive enzymes (Jambunathan and Singh, 1981) and hence the presence of even a low level of tannin is not desirable from nutritional point of view. The content of hydrogen cyanide level in the tubers, rhizome, corm, roots and stems is found to be lower when compared with the earlier reports obtained in the tubers of *Manihot utilisima* and *M. palmate* (Oke, 1975); *M. esculenta* (Nambisan and Sundaresan, 1990) and *Dioscorea alata. D. caryenensis, D. rotundata, D. esculenta* (Esuabana, 1982; Udoessien and Ifon, 1992). A lot of HCN (known to inhibit the respiratory chain at the cytochrome oxidase level) is lost during soaking and cooking (Kay *et al*., 1977) so that its content in the tubers poses no danger of toxicity. Among the presently investigated plant parts, the rhizome of *Canna indica* contain more total oxalate when compared with other earlier report in the tubers of *Manihot esculenta* (Oke, 1975); *Dioscorea alata, D. caryenensis, D. rotundata, D. esculenta* (Esuabana, 1982).

Alpha-amylase inhibitors combine with alpha amylases and make them unavailable for starch digestion. Research has been carried out on the possible interference of these compounds with starch digestion in living organisms and on their physiological function (Rekha and Padmaja, 2002). The amylase inhibitor activity among the currently investigated tubers, rhizome, corm, roots and stems are found to be in the range of 1.01 to 9.23 units. This range is very low when compared with the earlier reports in the tubers of *Dioscorea oppositifolia, D. bulbifera, D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994). The presence of protease inhibitors such as trypsin and chymotrypsin inhibitors in the diet leads to the formation of irreversible trypsin enzyme- trypsin inhibitor complexs, causing a decrease in trypsin in the intestine and decrease in the digestibility of dietary protein, thus leading to slower animal growth. As a result, the secretary activity of the pancreas increases, which could cause pancreatic hypertrophy and hyperplasia (Liener, 1994). The tuber of *D, oppositifolia* var. *oppositifolia*, presently investigated; contain more trypsin inhibitors activity when compared with the

earlier reports in the tubers of *D. dumetorum* and *D. rotundata* (Lape and Treche, 1994) and *D. rotundata* (Sasikiran *et al*., 1999). Inhibitors of alpha amylases and protein digesting enzymes interfere with the digestion of starch and protein. Boiling for sufficient time makes the tubers soft enough and inactivates all the trypsin inhibitor (Bradbury and Holloway, 1988).

Table 6. Antinutritional factors of edible tubers, rhizomes, corm, roots and stems[a].

| Botanical name | Total free phenolics g $100g^{-1}$ | Tannins g $100g^{-1}$ | Hydrogen Cyanide mg $100g^{-1}$ | Total oxalate g $100g^{-1}$ | Amylase inhibitor[b] AIU/mg Soluble starch | Trypsin inhibitor[b] TIU/mg Protein |
|---|---|---|---|---|---|---|
| *A. natans* | 0.24±0.03 | 0.01±0.01 | 0.04±0.03 | 0.23± 0.04 | 9.23 | 11.34 |
| *B. chinensis* | 0.10±0.01 | 0.02±0.01 | 0.03±0.02 | 0.07± 0.01 | 2.14 | 0.58 |
| *C. adscendens* | 0.55±0.01 | 0.25±0.03 | 0.13±0.01 | 0.13± 0.11 | 2.3 | 1.26 |
| *C. pauciflora* | 0.24±0.03 | 0.09±0.03 | 0.13±0.01 | 0.09± 0.01 | 1.14 | 1.34 |
| *C. indica* | 1.47±0.12 | 1.83±0.11 | 0.03±0.01 | 0.94± 0.28 | 1.69 | 1.47 |
| *C. quadrangularis* | 0.08±0.02 | 0.14±0.01 | 0.15±0.02 | 0.04± 0.03 | 1.35 | 2.92 |
| *C. vitiginea* | 0.12±0.04 | 0.17±0.05 | 0.09±0.06 | 0.10± 0.13 | 2.04 | 0.333 |
| *C. esculenta* | 0.14±0.03 | 0.02±0.01 | 0.03±0.01 | 0.61± 0.14 | 4.04 | 2.44 |
| *C. circinalis* | 0.20±0.03 | 0.02±0.01 | 0.01±0.01 | 0.78± 0.08 | 2.36 | 1.47 |
| *C. setosum* | 0.41±0.06 | 0.64±0.05 | 0.03±0.02 | 0.65± 0.21 | 7.56 | 1.34 |
| *D. hamiltonii* | 0.27±0.05 | 0.02±0.01 | 0.04±0.02 | 0.28± 0.09 | 1.54 | 12.6 |
| *D. pentaphylla* | 0.75±0.06 | 0.44±0.06 | 0.09±0.03 | 0.31± 0.01 | 1.95 | 2.86 |
| *D. oppositifolia* | 0.28±0.03 | 0.10±0.04 | 0.14±0.02 | 0.38± 0.05 | 4.13 | 2.1 |
| *D. spicata* | 0.38±0.06 | 0.34±0.06 | 0.09±0.03 | 0.33± 0.03 | 3.34 | 1.39 |
| *D. tomentosa* | 0.23±0.10 | 0.07±0.48 | 0.05±0.01 | 0.03± 0.01 | 1.54 | 0.87 |
| *H. indicus* | 0.04±0.03 | 0.02±0.01 | 0.05±0.02 | 0.18± 0.01 | 2.36 | 1.04 |
| *I. staphylina* | 0.10±0.12 | 0.12±0.11 | 0.04±0.03 | 0.98± 0.38 | 7.54 | 2.36 |
| *K. foetidissima* | 0.12±0.01 | 0.02±0.01 | 0.05±0.03 | 0.08± 0.01 | 2.36 | 1.37 |
| *M. oblongifolia* | 0.10±0.02 | 0.02±0.01 | 0.09±0.03 | 0.26± 0.07 | 1.17 | 0.38 |
| *M. dioica* | 0.38±0.12 | 0.32±0.04 | 0.11±0.10 | 0.21± 0.11 | 4.07 | 2.66 |
| *N. pubescens* | 0.21±0.05 | 0.18±0.03 | 0.12±0.10 | 0.38± 0.06 | 3.86 | 2.41 |
| *N. rubra* | 0.20±0.01 | 0.11±0.03 | 0.04±0.01 | 0.42± 0.11 | 1.01 | 0.56 |
| *P. neilgherriensis* | 0.48±0.04 | 0.03±0.003 | 0.06±0.001 | 2.75±0.03 | 2.94 | 0.98 |

[a]all the values are means of triplicate determinations expressed on dry weight basis; ±denotes standard error. [b]Means of two independent determination.

## CONCLUSION

Based on the nutritive evaluation studies on the wild edible tubers, rhizome, corm, roots and stems consumed by the tribal *Valaiyans* it can be summarized that most of them are found to be a good source of protein, lipid, crude fibre, starch, vitamins and minerals. All the investigated samples exhibited variation in the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase and trypsin inhibitors. Except for phenolics, tannins, hydrogen cyanide and total oxalate these antinutritional can be inactivated by moist heat treatments. For phenolics, tannins, hydrogen cyanide and total oxalate can be eliminated by soaking (Water discarded) followed by cooking before consumption is recommended as a means of removing harmful effects of these antinutritionals.

## REFERENCES

Abraham, K., Nair, S.G. 1984. Studies on yield and tuber characters of Greater yam, *Dioscorea alata*, L. Journal of Root Crops, 10: 11 – 16.

Adelusi, A.A., Ogundana, S.K. 1987. Phenolics and ascorbic acid accumulation in some infected root crops. Journal of Root Crops, 13: 29 – 33.

Aggarwal, R.A.K., Arya, P.S., Mahajan, N.C. 1999. Nutritional evaluation of vegetable *Colocasia*. Journal of Food Science and Technology, 36: 457 – 458.

Akissoe, H.N., Hounhouigan, D.J., Bricas, N., Vernier, P., Niago, C.M., Olorunda O.A. 2001. Physical, Chemical and Sensory evaluation of dried yam (*Dioscorea rotandata*) tubers, flour and 'amala', a flour-derived product. Tropical science. 41: 151 – 155.

AOAC. 2005. Official Methods of Analysis (18th edn.). Association of Official Analytical Chemists. Washington. DC.

Babu, L., Nambisan, B., Sundaresan, S. 1990.Comparative evaluation of biochemical constituents of selected tuber crops. Journal of Root Crops. 17: 270 – 273.

Bradbury, J.H., Holloway, W.D. 1988. Chemistry of tropical root crops: Significance for nutrition and agriculture in the Pacific, Australian centre for International Agricultural Research, Canberra, pp. 89 – 133.

Bray, H.G., Thorne, W.V. 1954. Analysis of phenolic compounds methods. Biochemical. Analyst, 1: 27-52.

Burns, R.B. 1971. Methods of estimation of tannin in the grain, sorghum. Agronomy Journal. 63: 511 -512.

Dickman, S.R., Bray, R.H. 1940. Colorimetric determination of phosphate. Industrial and Engineering Chemistry Analytical Education, 12: 665-668.

Esuabana, N.J. 1982. The phenolic and toxic compound on four types yams. *Dioscorea* species. HND project, Polytechnic, Calabar.

Gopalan, C., Ramasastri, A.V., Balasubramanian, S.C. 1976. Nutritive value of Indian Foods. ICMR. New Delhi.

Hsu, H.W., Vavak, D.L., Satterlee, L.D., Miller, G.A. 1997. A multi-enzyme technique for estimating protein digestibility. Journals of Food Science, 42: 1269 – 1271.

Humphries, E.C. 1956. Mineral components and ash analysis. In: K.Paech and M.V. Tracey (eds.) Modern Methods of Plant Analysis, Vol. I. Springer verlag. Berlin: pp 468 -502.

Issac, R.A., Johnson, W.C. 1975. Collaborative study of wet and dry ashing techniques for the elemental analysis of plant tissue by Atomic Absorption Spectrophotometer. Journal of the Association of Official Analytical Chemists. 58: 436 – 440.

Jackson, M.L. 1967. Cyanide in Plant tissue. In: Soil Chemical Analysis. Asia Publishing House New Delhi India. p. 337.

Jambunathan, R., Singh, U. 1981. Grain quality of pigeon pea. IN: Proceeding of the International workshop on pigeon pea, vol 1, ICRISAT, Hydrabad, Andhrapradesh, India. pp 351 – 356.

Janardhanan, K., Vadivel, V., Pugalenthi, M. 2003. Biodiversity in India underexploited tribal pulses. In: PK Jaiwal & RP Singh (eds.) Improvement strategies for Leguminasae biotechnology, Great Britian: Kluwer, pp:353 – 405.

Kakade, M.L., Rackis, J.J., McGhce, J.E ., Puski, G. 1974. Determination of trypsin inhibitor activity of soy products: a collaborative analysis of an improved procedure. Cereal Chemistry, 51: 376 -382.

Kanwar, K.C., Kanwar, V., Shah, S. 1997. Friendly fibers. Science Reports, 34: 9 -14.

Kay, T., Ogunsona, V.A., Eka, O.U. 1977. The prevention of beany taste development and the elimation of bitter taste in preparing soybean food in the rural community in Nigeria. Samuru Agricultural News Letter. 19: 11.

Lape, I.M., Treche, S. 1994. Nutritional quality of yam (*Dioscorea dumetorum* and *D. rotundata*) flours for growing rats. Journals of Science Food and Agriculture. 66: 447 – 455.

Li, B.W, Cardozo, M.S. 1994. Determination of total dietary fiber in foods and products with little or no starch, non-enzymatic gravimetric method: collaborative study. Journal of Association of Official Analytical Chemists International. 77: 687 -689.

Liener, I.E. 1994. Implications of antinutritional compounds in soybean foods. CRC, Critical Review on Food Science and Nutrition, 34: 31 – 67.

Maini, S.B., Balagopalan, C. 1978. Biochemical changes during post harvest determination of Cassava. Journal of Root Crops, 4: 31 -33.

Moorthy, S.N., Unnikrishnan, M., Lakshmi K.R. 1994. The Physiochemical properties of starch of some accessions of *Amorphophallus paeoniifolius*. Tropical Science. 34: 371 – 376.

Muller, H.G., Tobin, G. 1980. Nutrition and food processing, London: Croom Helm Ltd. Murugesan, PT, Ananthalakshmi, A. 1991. Dietary practices of the *Palliyar* tribal group and the nutrient content of unconventional foods consumed. Indian Journal of Nutrition and Dietaries, 28: 297 – 301.

Murugasen, P.T., Ananthalakshmi, A. 1991. Dietary practices of the Palliyar tribal group and the nutrient content of unconventional foods consumed. Indian Journal of Nutrition Dietaries. 28: 297 – 301.

Nair, D.B., Nair, V.M. 1992. Nutritional studies in sweet potato. Journal of Root Crops. 18: 53 – 57.

Nambisan, B., Sundaresan, S. 1990. Distribution pattern of cyanoglucosidesin *Cassiva* tubers and leaves at different growth states. Journal of Root Crops. 17: 261 – 264.

Narasinga Rao, B.S., Deosthale, Y.G., Pant K.C. 1989. Nutritive value of Indian Foods. National institute of nutrition, Indian Council of Medical Research, Hyderabad, India.

NRC / NAS 1980. National Research Council Committee on Dietary Allowances. Recommended Dietary Allowances 9th edn. National Academy of Science Press. Washington, DC. USA.

NRC / NAS 1989. National Research Council Committee on Dietary Allowances. Recommended Dietary Allowances 10th edn. National Academy of Science Press. Washington, DC. USA.

Oke, O.L. 1975. The role of Cassava in the nutrition of Nigerian population. Journal of Root Crops, 1: 1 - 15.

Onyilogha, J.C., Lowe, J. 1985. Crude proteins of some Nigerian cultivars of *Dioscorea caryenensis* and *D. rotunda*t. Journal of Root Crops. 11: 61 – 63.

Padmaja, G., Moorthy, S.N., Nambisan, B., Babu, L., Sundaresan, S., Sajeev, M.S., Nanda, S.K., Susan John, K., Rajalakshmy, L., Sudha Devi, K.S., Manikantan Nair, M. 2001.Digestability of starch and protein. In: S.Edison (ed.) Analytical Metrologies for Tropical tubers crops. Published by Central tuber crops research institute. Thiruvananthapuram, Kerala, India, pp 34 - 38.

Pramila, S.S., Kumar, A., Raghuvanshi, R. 1991. Nutrient composition of some uncommon foods consumed by Kumaon and Garhwal hill subjects. Journal of Food Science and Technology. 28: 237 – 238.

Rajyalakshmi, P., Geervani, P. 1994. Nutritive value of the foods cultivated and consumed by the tribals South India. Plant Foods for Human Nutrition. 46: 53 -61.

Rekha, M.R, Padmaja, G. 2002. Alpha-amylase inhibitor changes during processing of sweet potato and taro tubers. Plant foods for Human Nutrition. 57: 285 – 294.

Robinson, D.R. 1987. Food Biochemistry and Nutritional value. Burn mill, Long-man scientific and technology, Haslow, England, pp 327 -328

Sadasivam, S., Manickam, A. 1992. Biochemical methods, New age International (P) limited publishers, New Delhi, India.

Salunkhe, D.K. 1982. Legumes in human nutrition: current status and future research needs. Current Science. 51: 387 -394.

Sasikiran, K., Padmaja, G., Easwari Amma, C.S., Sheela, M.N. 1999. Trypsin and Chymotrypsin inhibitor activities of sweet potato and yam tubers. Journal of Root Crops, 25: 195 -199.

Shanthakumari, S., Mohan, V.R., John de Britto. 2008. Nutritional evaluation and elimination of toxic principles in wild yam (*Dioscorea* spp.), Tropical and Subtropical Agroecosystem. 8: 313 -319.

Siddhuraju, P., Becker, K., Makker, H.S. 2001. Chemical composition, protein fractionation, essential amino acid potential and antimetabolic constituents of an unconventional legume, Gila bean (*Entada phaseoloides* Merrill.) seed kernel. Journal of Science Food and Agriculture, 82: 192 -202.

Siddhuraju, P., Becker, K., Makkar, H.P. 2000. Studies of the nutritional composition and antinutritional factors of three different germplasm seed materials of an underutilized tropical legume, *Mucuna pruriens* var. *utilis*. Journal of Agricultural and Food Chemistry, 48, 6048–6060.

Siddhuraju, P., Vijaykumari, K., Janardhanan, K. 1996. Chemical composition and protein quality of the little known legume, velvet bean [*Mucuna pruriens* (L.) DC.] Journals of Agricultural and Food Chemistry. 44: 2636 – 2641.

Sundaresan, S., Babu, L., Nambisan, B. 1990. Biochemical changes in Yam tubers during storage. Journal of Root Crops. 17: 265 – 269.

Udensi, E.A., Oselebe, H.O., Iweala, O.O. 2008. The investigation of chemical composition and functional properties of water yam (*Dioscorea alata*): Effect of varietals differences. Pakistan Journal of Nutrition. 7: 342 - 344.

Udoessien, E.I., Ifon, E.T. 1992. Chemical evaluation of some antinutritional constituents in four species of Yam. Tropical Science, 32: 115 – 119.

Vidyarthi, L.P. 1987. Role of forest in tribal life. Tribals and Foress. Ed. SP Sinha, Bihar Tribal Welfare Research Institute, Ranchi, p 323.

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