105

# STUDIES ON THE NUTRITIONAL AND ANTI-NUTRITIONAL PROPERTIES OF TRIBAL FOOD PLANTS OF KANYAKUMARI DISTRICT, TAMIL NADU

THESIS SUBMITTED TO THE **MANONMANIAM SUNDARANAR UNIVERSITY**, TIRUNELVELI IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

**DOCTOR OF PHILOSOPHY**

(IN BOTANY)

**S.SHANTHAKUMARI**

REG.NO: 1194

P.G. & RESEARCH DEPARTMENT OF BOTANY
ST.XAVIER'S COLLEGE
MANONMANIAM SUNDARANAR UNIVERSITY
TIRUNELVELI-627 012
INDIA

AUGUST 2005

**Dr.V.R.Mohan**
**(Guide)**
Reader
P.G. Department of Botany
V.O.Chidambaram College
Tuticorin – 628 008

**Dr.A.John De Britto**
**(Co-Guide)**
Reader
Research Department of Botany
St.Xavier's College
Palayamkottai-627 002

# CERTIFICATE

This is to certify that the thesis entitled, **"STUDIES ON THE NUTRITIONAL AND ANTI-NUTRITIONAL PROPERTIES OF TRIBAL FOOD PLANTS OF KANYAKUMARI DISTRICT, TAMIL NADU"** submitted by **S.Shanthakumari** for the award of **Degree of Doctor of Philosophy in Botany** of Manonmaniam Sundaranar University is a record of bonafide research work done by her and it has not been submitted for the award of any degree, diploma, associateship, fellowship of any university/ institution.

Place: Tuticorin

Date: August, 2005

**(Guide)**

**(Co-Guide)**

Dr. A. JOHN DE BRITTO,
M.A.,M.Sc.,M.Phil.,Ph.D.,PGDCA.,
Reader in Botany
St. Xavier's College (Autonomous)
Palayamkottai - 627 002.
Tamil Nadu, India.

**S.Shanthakumari**
Lecturer (S.S.)
Department of Botany
Sarah Tucker College
Tirunelveli-627 007.

## DECLARATION

I hereby declare that the thesis entitled, **"STUDIES ON THE NUTRITIONAL AND ANTI-NUTRITIONAL PROPERTIES OF TRIBAL FOOD PLANTS OF KANYAKUMARI DISTRICT, TAMIL NADU"** submitted by me for the **Degree of Doctor of Philosophy in Botany** is the result of my original and independent research work carried out under the guidance of **Dr.V.R.Mohan**, Reader, P.G. Department of Botany, V.O. Chidambaram College, Tuticorin and co-guidance of **Dr.A.John De Britto**, Reader, P.G. Department of Botany, St.Xavier's College, Palayamkottai, and it has not been submitted for the award of any degree, diploma, associateship, fellowship of any University or Institution.

Place: Tirunelveli

Date : August 2005

(**Shanthakumari.S**)

# ACKNOWLEDGEMENT

## ACKNOWLEDGEMENT

First and foremost I humbly thank the Almighty God for His guiding presence, sustaining grace and sufficient wisdom throughout my research. To Him be all praise and glory.

My sincere and heartfelt thanks are due to my much respected guide Dr.V.R.Mohan, Reader, P.G. Department of Botany, V.O.Chidambaram College, Tuticorin, for his systematic and meticulous guidance, scholarly insight, critical interest and all his humanistic and friendly concern.

I also express my gratitude to Dr.A.John de Britto, Reader, St.Xavier's College (Autonomous), Palayamkottai, for his valuable guidance, useful suggestions and constant encouragement.

I sincerely thank Dr.G.Padmaja, Head, Division of Crop Utilization and Biotechnology, Central Tuber Crops Research Institute, Sreekariyam, Trivandrum, and Dr.S.Edison, Director, CTCRI, Trivandrum, for providing laboratory facilities and offering training in their institute.

My thanks are also due to Dr.A.G.Panduranagan, Head, Division of Plant Systematics & Evolutionary Science, Tropical Botanic Garden and Research Institute, Palode, for giving me valuable information and suggestions.

I express my thanks to the authorities of Tamil Nadu Agricultural University, Bharathiar University, Coimbatore, TBGRI, Palode, CTCRI, Trivandrum and the University of Kerala, Trivandrum, for providing me with all possible library facilities.

I extend my thanks to the Secretary and Principal of St.Xavier's College (Autonomous), Palayamkottai, and the Secretary and Principal, V.O. Chidambaram College, Tuticorin, for providing necessary laboratory facilities.

I thank Dr.V.Chelladuarai, Research Officer, Survey of Medicinal Plant Unit, Govt. Siddha College, Palayamkottai, for helping me in identifying the plants selected for the study.

I am thankful to Mr.Israel, Assistant Director of Horticulture, Mr.Ashok Macrin, Horticultural Officer, Petchiparai, and Mr.George, Assistant Horticultural Officer, Kanyakumari district, and Mr.Jeganathan Kani of Arukani village, for their constant help and providing necessary facilities for research work during my field study.

I extend my thanks to Mr.R.Shanmugasundaram, H.O.D. Mr.A.S.Karunakaran, Mr.Venkatraman Kumar, Dr.M.Paramaraj, Mr.C.Lakshmanan, Mr.Chidambaram Pillai, Mr.Pugazhendi, Mr.N.Suresh, and all the non-teaching staff of Botany Department, V.O.C. College, Tuticorin, for their encouragement and helpful advice during the course of my research. I specially thank Mr.N.Suresh, Lecturer (S.S.) in Botany, V.O.C. College, Tuticorin, for proof reading the thesis thoroughly.

My sincere thanks are due to Mr.J.Kingsly, Librarian, Bishop Stephen Neil Study Centre, Palayamkottai, for his invaluable help at various levels in completing my thesis.

I sincerely thank, Dr.Pauline, Reader, Dept. of English, St.Pope's College, Sawyerpuram, and Dr.Janet Wilson, Reader, Dept. of English, Sarah Tucker College, Tirunelveli, for assisting in proof reading.

I also thank all the faculty of Botany and Maths Department, Sarah Tucker College, Tirunelveli, for their scholarly interest and encouragement.

I express my deep gratitude to my husband, Mr.D.Kenneth and children-Finney and Sankey, my parents and my family members, but for whose permanent support, total dedication and full co-operation I would not have completed my research work. They have been a wonderful source of inspiration and a real blessing to me throughout my research experience.

Finally I thank, Mr.Sankar, artist, CBB Lab, St.Xavier's College, for his aid in photography and Mr.P.Sushil Kumar for the neat execution of my thesis.

## CONTENTS

# INTRODUCTION

# INTRODUCTION

One of the most challenging tasks facing mankind today is to provide sufficient food for the teeming millions. It is a recognized fact that the carbohydrates play a central role in human nutrition providing the largest single component in man's diet and the main source of energy. Apart from cereals, root crops form the most important staple food in the tropics (Oyenuga, 1959).

The wild relatives of cultivated crops are actively considered for genetic improvement because they have beneficial genes for tolerance to environmental stress, resistance against pests and insects and higher levels of nutrients, while cultivated species often have a very narrow genetic base and lack genes for resistance to certain diseases. Wild species of several cultivated plants act as reservoirs for crop improvement including developing resistance to pests and pathogens (Ignacimuthu and Babu, 1987; Babu *et al.*, 1988).

The tribals in particular have their own culture, religious rites, food habits and a rich knowledge of plant genetic resources in their surroundings. Unfortunately this indigenous knowledge on the properties, utilization and conservation aspects of plant resources available with them is on the verge of depletion due to various developmental activities which are adversely affecting their cultural and traditional life. It is essential that the knowledge available with these people must be properly documented

and integrated with modern scientific values before it gets entombed with culture that gave its birth.

Conservation and use of bio-diversity must be concerned not only with genes, genotypes, species and ecosystems, but also with the traditional knowledge that has helped to produce and maintain this diversity. The tribals derive very basic needs for survival from the bio-diversity. In turn, they protect the forest, conserve its bio-diversity and also enrich its fertility through their various cultural activities, beliefs and practices.

The ethnic people use a wide variety of wild plants and plant products as their food. Studies of nutritional value of wild plant food are of considerable significance since they may help to identify long forgotten food resources. According to Irvine (1952), nutritive value of wild plants will also help to throw some light on the origin of man's food habits and his agriculture.

India, being one of the bio-diversity centres, has contributed to world agriculture atleast 167 plant species (Khoshoo, 1991; Zeven and dewet, 1982). India ranks tenth among the species rich countries of the world and sixth among the centres of diversity (Gadgil, 1996). Plant genetic resources provide the biological basis for world food security and directly or indirectly support the livelihoods of every person on the earth (Anon, 1996). The plant genetic diversity is now under threat because of several factors and much of the world's food supply is based on genetically uniform crops.

Agricultural production in the country has substantially decreased due to erratic monsoons and frequent occurrence of drought in certain areas. Tubers can face adverse climatic conditions. The knowledge about the tubers grown in different areas of the country is very poor and hence ethnobotanical studies on tubers is necessary. Along with the crop plant the ethnic societies of India still depend upon several wild species for their food. The wild fruits, seeds, pods, leaves, tubers, corms and rhizomes are used by the tribals (Ravishankar, 1996). Tamil Nadu is rich in tropical tuberous species though temperate root crops are also cultivated at higher elevations in the Nilgiris and Anamalais. The semi evergreen and wet evergreen forests are abundant in plants with tuberous roots and corms. The ethnic communities generally prefer to eat wild varieties of food plants.

During stress conditions when there is scarcity of food, inhabitants of forests exploit their environment to assuage their hunger and wild food helps them to survive (Santapau, 1953; Vartak, 1959, 1982; Gunjatkar and Vartak, 1982) The survey of ethnobotanical nature has shown a large number of edible species being exploited by the tribal communities and the consumption of tubers were maximum as compared to leaves, seeds and flowers (Nilegaonkar *et al.*, 1985).

Tuber crops play a vital role in the dietary pattern of many developed countries where the per capita consumption ranges anywhere from 117g to 383 g per day (Amla and Shankar, 1975). Dietary surveys carried out in places where Pacific Islanders follow traditional eating patterns show that roots, tubers and fruits usually provide 75-85 per cent of the total energy.

In these situations the staple food also provides people with a high proportion of all the other necessary nutrients and it is important that the chosen food should contain high amounts of protein, vitamins and minerals. This is illustrated in surveys carried out amongst the Chimbu people of Papua New Guinea by Venkatachalan, 1962 and Lambert, 1975. They found that starchy roots and tubers had provided the greater part of the diet of the people.

Dye (1976) showed that 60 per cent of the energy came from roots and tubers. In Western Samoa, Wilkins (1963) found that the percentage of total energy derived from roots and tubers varied greatly between rural and urban areas. People living near the town obtained 37-50 per cent of their energy from these foods; those living in more remote villages depended on roots and tubers for 50-64 per cent of their total energy.

Information regarding the chemical and nutritional content of Indian wild edible tubers, corms and rhizome is meagre (Coursey, 1967; Gopalan *et al.*, 1976; Anon, 1976; Cock, 1985; Bradbury and Holloway, 1988; Babu *et al.*, 1990; Mitra *et al.*, 1990; Nair and Nair, 1992; Rajyalakshmi and Geervani, 1994 and Balagopalan, 2000). Therefore, in the present study, an attempt is being made to estimate the proximate and mineral profiles, soluble proteins, starch, sugar content, *in vitro* protein digestibility and *in vitro* starch digestibility of the collected wild edible tubers, corm and rhizome consumed by the tribal Kanikkars of the Kanyakumari district.

Apart from nutrients, plants contain secondary chemicals/ anti-nutrients such as protease inhibitors, haemagglutins, allergens, alkaloids,

hormones, vitamin antagonists (Leopard and Ardrey, 1972). Some of these constituents have been found to be harmful if plants are consumed in raw form or processed incompletely. Hence, certain anti-nutritional substances like total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor and trypsin inhibitor activity are also quantified.

Over the years, tribals have evolved methods of food processing and food preparation to render the plant free from toxic substances and bitter ingredients. Various processing treatments were done to eliminate or understand the extent of reduction of anti-nutritional substances in the investigated samples.

It is hoped that this study will provide ample information for the researchers dealing with nutritional studies on the indigenous wild edible plants particularly tubers, corms and rhizomes which are a cheap source of carbohydrates, fats and minerals.

# REVIEW OF LITERATURE

## REVIEW OF LITERATURE

### I. Wild Edible Plants

New sources of plant food from the wild has come to light through the ethnobotanical knowledge gained from the indigenous people. The primitive cultivars and wild relatives of crop plants preserved by the indigenous people may hold the 'genetic key' of many valuable miracle crops of the future. There is a vast treasure of "gene pools" available in wild species for developing resistance for both biotic and abiotic stresses.

Over 9500 wild plant species used by Indian tribals for meeting their varied requirements have been recorded so far. Out of 3900 or more wild plant species used as food by the tribals, about 800 are new data and atleast 250 from them are worthy of being developed as alternative source of nutritive food that the civilizations would need in the near future (GOI, 1994). The indigenous people have helped to conserve unique biodiversity which has come as great ecological legacy to the modern civilization. About 250 samples of rare cultivars collected from the tribal belts of India are deposited in the National Bureau of Plant Genetic Resources (NBPGR), New Delhi.

Tribals living in the undisturbed forest and with traditional food habits are found to be healthy and free from most diseases. The wild yam (*Dioscorea deltoidea*) eaten by tribals in Kashmir region have high nutritional value (Sinha and Sinha, 2001). Tribal societies also use lower groups of plants—mosses, ferns, lichens as food and medicine.

Genetic variability of nature, underutilized species of food crops, fruits, medicinal, aromatic and other economic plants should be documented on priority (Paroda and Arora, 1991). Collecting and conserving the gene pools of wild species and crop related wild species at any cost for future food and agriculture related activities is an urgent need at present or in the near future (Frankel and Hawkes, 1975; Gadgil, 1996).

The tubers of wild forms of *Dioscorea* species are used throughout Africa in times of famine as an emergency food (Irvine, 1952). In India, studies on wild food plants have been carried out by several workers (Jain, 1963; Arora, 1985; Singh and Singh, 1985; Egbe and Akinyele, 1990; Jain, 1991; Mary Josephine and Janardhanan, 1992; Mohan and Janardhanan, 1993a,b; Radhakrishnan *et al.*, 1996; Vadivel and Janardhanan, 2000; 2001; Ofori *et al.*, 2001; Arinathan, 2002). Bedi (1978) reported that the aboriginal tribes of Ratan Mahal and surrounding hills of Gujarat use wild edible plants for their food. The Mikiris in Karbi-Anglong district of North-Eastern India depend on the natural plant resources of their neighbouring forests for their food (Jain and Borthakur, 1980).

The wild edible plants used by the tribals in Andaman and Nicobar Islands were surveyed by Thothathri (1980). Singh and Singh (1981) enumerated 97 wild plants belonging to 75 genera and 49 families used by the tribals of Eastern part of Rajasthan. The various tribal pockets of Cannanore district, Kerala State and Coimbatore district were surveyed by Ramachandran and Nair (1981). Gunjatkar amd Vartak (1982) has

recorded wild plants used as food in their floristic work from Pune and neighbouring districts of Maharashtra state.

The Onge tribe of the Andaman and Nicobar Islands use 21 wild edible food plants (Bhargava, 1983). One of the primitive hill tribes of Northern Kerala, the Nayadis, utilize about 15 wild plants as food (Prasad and Abraham, 1984). Pal (1984) enumerated the wild edible plants used by the tribals of Subansiri, Arunachalpradesh. Malayalis eat tubers of *Dioscorea oppositifolia* and *D.pentaphylla* (Jain, 1984). The people living in the remote areas of Ladakh, North-west and Trans Himalaya region, use wild plants as food (Kaul *et al.*, 1985; Bhattacharyya, 1991). Singh and Singh (1985) recorded 30 wild plants used as vegetables by the indigenous people of Manipur. A distinct tribe inhabiting the southern-most portion of Jaintia hills in Meghalaya called War Jainta use 24 wild edible food plants (Kumar *et al.*, 1987).

The tribals of Subansiri district, Arunachalpradesh use 31 wild edible plants as food (Thothathri and Pal, 1987). The wild edible plants used by the tribals of Sikkim were enumerated by Krishna and Singh (1987) Chakrabarty and Rao (1988) enumerated 27 wild edible plants eaten by the Shompen tribe inhabiting the Great Nicobar Island. The Jaunsaries, Kinnauris, Bhotiyas, Marchas, Tolchyas, Bokshas, Gujars and Goddis tribes of Uttar Pradesh used 50 wild edible species belonging to 40 genera and 30 families (Negi, 1988).

The Tangkhul Naga tribe of Ukhrul district, Manipur, use certain wild plants as their food (Elangbam *et al.*, 1989). Sebastian and Bhandari

(1990) reported a number of edible plants used by the tribals and local inhabitants of Mt.Abu area, Sirohi district and different parts of Udaipur and Banswara districts, Rajasthan. *Dioscorea wallichi* tubers were collected and eaten by Nallamalais and Upper Godavari tribes (Brahman and Saxena, 1990). Pollock, 1990 reported the uses of arrowroot from *Tacca leontopetaloides* by the people of Pacific Islands. Ao and Angami, the two distinct Naga tribes consume 56 wild edible plants as their food (Rao and Jamir, 1990). Aminuddin and Girach (1991) reported the wild edible plants eaten by the Bondo tribe of Koraput district Orissa. Maximum number of wild edible plants are used as food by the Great Andamanese of the Negrito Island of the Andamans (Awasthi, 1991). The primitive tribe, the Irulas in the coastal regions of Thanjavur district, use 53 wild edible plant species as their food (Pagupathy and Mahadevan, 1991). The tribals of North-Eastern India used native food plants (Arora, 1990).

The dominant tribals like the Bhuinya and the Juang in Keonjhar district of Orissa are known to use 31 wild edible plants (Mondal and Mukherjee, 1992). Manandhar (1997) reported 56 species of less known wild food plants of Nepal. Pedralli (1994) enumerated 81 wild relatives of yam in the Espim baccorange, Brazil. Rajendran and Henry (1994) listed the wild food plants of the Kadar tribe of Anamalai hills in Coimbatore district, Tamil Nadu. Singh (1995) reported 27 species consumed by the ethnic groups of Sikkim, Himalayas. Lesser known edible tubers of *Typhonium trilobatam*, corms of *Alocasia indica*, *A. macrorrhiza*, *Eleocharis dulcis* and rhizomes of *Canna edulis*, *Curcuma angustifolia*, *Tacca leontopetaloides*, *Costus speciosus*, *Maranta arundinacea*, *Hedychium*

*cornarium* and *Nelumbo nucifera* distributed in different parts of India were studied by Vimala (1995).

One hundred and ninety seven species and varieties of traditional edible plants including tubers of *Dioscorea arachnida, D. esculenta, Manihot esculenta* and corms of *Colocasia esculenta, C. tanoima, Amorphophallus esculentus, A.yuloensis, A.yunnanesis* and *A.ximengensis* are used by the Jinuo (Chun-lin and Jieru, 1995). Singh *et al.*, (1995) enumerated 55 wild edible plants in and around the Government garden, Chaubattia district, Uttar Pradesh. Vartak and Suryanarayana (1995) recorded 131 wild edible plant species in the Susala Island, Pune district, Maharashtra. Radhakrishnan *et al.*, (1996) reported 31 wild edible plants and tubers of *Dioscorea esculenta, D. oppositifolia, D. pentaphylla, D. wallichi*and *Utleria salicifolia* used by the tribals inhabiting Western Ghats of Kerala. Manandhar (1997) observed 31 species of unreported wild food plants used by tribal communities in different parts of Nepal. Das (1997) enumerated 153 wild edible plants of backward aboriginal Karauli and Sawari Madhopur districts, Rajasthan.

Thirty-seven wild edible plants and tubers of *Dioscorea alata* and *D. hirsuta* supplement the main diet of Tripuri tribes of Tripura (Singh *et al.*, 1999). The tribes of Rampa grow tuber crops like *Ipomoea batatus, Dioscorea anguina, D. hispida, D. alata, D. bulbifera, D. glabra, D. tomentosa* and *D. oppositifolia* and *Manihot esculenta* (Prasad *et al.*, 1999). Viswanathan (1999) enumerated 33 species of wild edible plants

from Ladakh. Bhattacharyya (1999) reported fifteen wild edible plant species used by the people of Druk-Yul, Bhutan.

The Onges and the Negrito tribes, settled in the little Andaman Island in the Andaman & Nicobar group of Islands use twenty wild edible plants (Awasthi and Goel, 1999). Dash and Misra (1999) enumerated 24 edible plants of the tribals of Narayanapatna hills of Koraput in Orissa. The tribes of Chittoor district (Andhra Pradesh) use 67 wild plant species as food (Sudhakar and Vedavathy, 1999). Singh (1999) reported 25 wild tribe food plants used by the Tharu, of Sub-Himalayan region of Eastern Uttar Pradesh. Kothari and Rao (1999) enumerated 30 plant species used as food by the Warli tribe and other local people especially from Mayavanshi in Thane district, Maharashtra. The Tripuri tribes of Tripura use 37 wild edible plants belonging to 30 genera and 24 families inclding corms of *Alocasia fornicata* and *Colocasia macrorrhiza* and tubers of *Dioscorea alata* and *D. hirsuta* (Singh *et al.*, 1999) Maikhuri *et al.*, (2000) observed that three tribal subsects of the Central Himalayas, India use wild edible plants. The tribals inhabiting the Uttar Pradesh, Himalaya, the Eastern most part of the Western Himalaya use 188 wild edible plants (Joshi and Tewari, 2000). The tribals of Rajasthan use 38 species of wild plants as food at the time of scarcity and during normal days (Tripathi 2000).

Naqshi and Aman (2001) enumerated 156 species of wild food plants used by the tribals, Gujjars and Shepherds of Kashmir Himalaya. Pandey and Singh (2001) observed nearly 17 wild edibles from the upper Luni Basin forests in Rajasthan. About 37 species of wild bulbous plants of

Shevaroy Hills are used by the tribals (Subramaniam and Dwarakan, 2002). The Maohi rely on more than 47 species of wild plants including tubers of *Dioscorea alata, D. bulbifera, D. esculenta, D. pentaphylla, D.nummularia,* and corms of *Alocasia macrorrhiza, Amorphophalus paeoniifolius* and *Colocasia esculenta* as food (Lepofsky, 2003). Mayadevi (2003) enumerated 156 species of wild edible plants of Sonitpur district, The Malayalis of Eastern Ghats especially Kolli Hills, Pachamalai, Sheveroys and Kalrayans consume *Manihot esculenta* as food (Unnikrishnan *et al.*, 2004). Ethno-botanically important edible plants of Tamil Nadu belonging to 416 species, 149 genera and 74 families were reported by Viswanathan (2004).

A review of Literature reveals that till date a detailed enumeration of wild edible plants particularly wild edible tubers/ corms/ rhizomes are not carried out among the tribal Kanikkars inhabiting the South-Eastern slopes of Western Ghats, Kanyakumari distrct, India. Hence, in the present study an attempt is made for collection and enumeration of wild edible tubers/ corms/ rhizomes in the above said area for their chemical analysis.

**II. Chemical and Nutritive Evaluation**

Several tribal communities traditionally use a wide variety of wild plants as food. Many workers have enumerated and documented the information regarding wild edible plant species being used as food. (Jain, 1981, 1991; Katiyar *et al.*, 1990 ; Pramila *et al.*, 1991 ; Rai, 1994; Manandhar, 1995 ; Mohan and Janardhanan, 1995 ; Radhakrishnan *et al.*, 1996 ; Prakash, 1988 ; Dahal *et al.*, 2003). However, the information on

nutritional evaluation and chemical composition of wild food plants is meagre (Prakash and Misra, 1987; Parkinson, 1984; Murugesan and Ananthalakshmi, 1991; Babu *et al.*, 1990; Rajyalakshmi and Geervani, 1994; Aggarwal *et al.*, 1999; Perumalsamy and Ignacimuthu, 2000).

**Proximate composition**

Proximate composition provides information about the contents of crude protein, crude lipid, crude fibre, ash and Nitrogen Free Extractives (NFE), for all food substances. In view of this, the collected plant parts have been subjected for proximate composition in the present study.

A considerable number of analyses for proximate composition have been carried out in the tubers of *Dioscorea alata, D. cayenensis, D. esculenta* and *D. rotundata* (Oyenuga, 1959; Coursey *et al.;* 1960, Mitra *et al.*, 1990; Balagopalan 2000); *Dioscorea alata* and *D. trifida* (Martin and Thompson, 1971) *Dioscorea bulbifera* (Umbreit *et al.*, 1972); *Dioscorea rotundata* (Francis *et al.*, 1975; Aduayi, 1979); *Dioscorea alata* (Ferguson *et al.*, 1980; Parkinson, 1984; Abraham and Nair, 1984); corm of *Amorphophallus paeoniifolius* (Parkinson, 1984; Seralathan and Thirumaran, 1999; Nair *et al.*, 1999); *Colocasia esculenta* (Hossain *et al.*, 1983; Parkinson, 1984; Pramila *et al.*, 1991; Seralathan and Thirumaran, 1999 Aggarwal *et al.*, 1999; Bala Gopalan, 2000; Dahal *et al.*, 2003); tubers of *Dioscorea cayenensis* and *D. rotundata* (Kabeerathumma *et al.*, 1985); *Dioscorea pentaphylla, D. esculenta, D. bulbifera, D. oppositifolia* (Nilegaonkar *et al.*, 1985); *Dioscorea alata, D. dumetorum* and *D. rotundata* (Lape and Treche, 1994); various *Dioscorea* sp. (Murugesan and

Ananthalakshmi, 1991; Pramila *et al.*, 1991; Rajyalakshmi and Geervani, 1994); corms of *Alocasia macrorrhiza, A. indicus* (Murugesan and Ananthalakshmi, 1991; Pramila *et al.*, 1991; Aggarwal *et al.*, 1999); corm of *Xanthosoma sagittifolium* (Parkinson, 1984; Seralathan and Thirumaran, 1999; Balagopalan, 2000); tubers of *Ipomoea batatus* (Limaye and Kore, 1978; Parkinson, 1984; Bradbury *et al.*,1985); *Manihot esculenta* (Longe, 1978; Maini, 1978; Parkinson, 1984; Bala Gopalan, 2000) ; rhizomes of *Sagittaria sagittifolia, Canna edulis* and tubers of *Typhonium trilobatum* (Vimala, 1995).

**Soluble Protein, Starch and Sugars**

The energy value of food is estimated based on its protein, fat and carbohydrate contents (Atwater and Bryant, 1900). Carbohydrates such as soluble sugars and starch are the main energy yielding substances of the diet.

Soluble protein content of *Dioscorea* species namely *Dioscorea bulbifera* (Umbreit *et al.*, 1972); *Dioscorea alata* (Parkinson, 1984; Abraham and Nair, 1984); *Dioscorea rotundata, D. dumetorum, D. alata* (Lape and Treche, 1994, Balagopalan, 2000) were studied.

Starch content was observed in aroids like *Colocasia, Alocasia* and *Xanthosoma* sp. by Ramaswamy *et al.*, 1982; Hossain *et al.*, 1983; Parkinson, 1984; Rajyalakshmi and Geervani, 1994; Ghosh *et al.*, 1988; Moorthy and Padmaja, 1990; Aggarwal *et al.*, 1999; Balagopalan 2000 and Dahal *et al.*, 2003. Tubers of *Manihot esculenta* was subjected to total

starch analysis by Maini, 1978; Longe, 1978; Babu *et al.*, 1990 and Sundaresan *et al.*, 1990; *Ipomoea batatus* by Babu *et al.*, 1990; *Dioscorea bulbifera* by Umbreit *et al.*, 1972, Raghunandan and Jolly, 1987 and Mulla and Kulkarni, 1994.

Total Sugar content was observed in *Colocasia* (Yamashita and Yoshikawa, 1973); Cassava varieties (Longe, 1978; Maini and Balagopal, 1978); and *Dioscorea dumetorum* and *D. rotundata* (Lape and Treche, 1994).

**Mineral composition**

Presence of mineral elements in the diet is necessary for life. Some of them are essential for the formation of structural components of the body and some act as catalysts in many body reactions (Mertz, 1981).

The mineral profiles of the tubers and corms were carried out by several workers. *Dioscorea alata* (Ferguson *et al.*, 1980; Parkinson, 1984); *Dioscorea rotundata* (Aduayi, 1979); *Dioscorea dumetorum* and *D. rotundata* (Lape and Treche, 1994) *Dioscroea esculenta, D. alata, D. rotundata* (Mitra *et al.*, 1990); *Dioscorea oppositifolia, D. pentaphylla, D. bulbifera* and *D. hispida* (Rajyalakshmi and Geervani, 1994); corm of *Colocasia esculenta* and *Alocasia* (Mandal *et al.*, 1982; Parkinson, 1984; Kabeerathumma *et al.*, 1985; Sen and Roychoudhury, 1988; Pramila *et al.*, 1991; Aggarwal *et al.*, 1999; Balagopalan, 2000) and tubers of *Manihot esculenta* (Maini, 1978; Balagopalan, 2000).

**_In vitro_ protein digestibility and _in vitro_ starch digestibility**

_In vitro_ protein digestibility was observed in the corm of _Colocasia_ by Dahal _et al.,_ 2003. _In vitro_ starch digestibility was studied in the tuber crops by Moorthy and Padmaja, 1990; and Rajyalakshmi and Geervani, 1994; In the tubers of _Dioscorea dumetorum_ and _D. rotundata_ _in vitro_ starch digestibility was observed by Lape and Treche, 1994.

**Anti-nutritional factors**

Food particularly of plant origin contain a wide range of anti-nutritional factors which interfere with the assimilation of nutrients contained in them and cause adverse physiological effects. They interfere with the utilization of other nutrients like protein, minerals like iron, zinc, calcium and iodine.

The anti-nutritional factors are divided into two groups viz, heat labile anti-nutritional factors (Liener, 1980) and heat stable anti-nutritional factors (Nowacki, 1980).

Various anti-nutritional factors and their elimination have been carried out by several investigators (Liener, 1981; Kotaru _et al.,_ 1987. Thompson, 1988; Egbe and Akinyele, 1990; Babu _et al.,_ 1990; Mohan and Janardhanan, 1993a, b; Vijayakumari _et al.,_ 1995; Nagaraja, 2000; Arinathan, 2002; Rekha and Padmaja, 2002; Sasikiran and Padmaja, 2003).

**Total free phenolics and Tannins**

Plant secondary metabolites which have received the attention of nutritionists are phenolic compounds. Phenols have the aromatic ring, conferring acidic behaviour and offer resistance to pathogens and pests in plants.

Total phenol content was examined in tubers of *Dioscorea* sp. by Karnick, (1971); Osuji (1985) and Osagie and Opoku (1982) corm of *Colocasia esculenta*, tubers of *Ipomoea batatus*, and *Solanum tuberosum* (Adelusi and Ogundana, 1987); *Manihot esculenta* (Babu *et al.*, 1990; Sundaresan *et al.*, 1990; Arinathan, 2002).

Tannins are condensed polyphenolic compounds which are widely distributed in plants. They bind with iron irreversibly and interfere with iron absorption. They also bind with protein and reduce their availability (Radhika and Sreeja, 2004).

Tannins are reported to be present in various tubers of *Dioscorea alata, D. cayenensis, D. rotundata, D. esculenta* (Udoessien and Ifon, 1992) *Asparagus racemosus, Curculigo orchioides, Dioscorea bulbifera* var. vera, *D. oppositifolia* var. *dukhumensis, D. oppositifolia* var. *pentaphylla, D. tomentosa* and *Dolichos trilobus* (Arinathan, 2002).Tannins and phenols are present in the tubers of Coleus, aroids, yam (Balagopalan 2000).

**Total Oxalate**

Oxalic acid is a dicarboxylic acid which is seen widely distributed in plants along with its salts (oxalates) mostly calcium salts. Oxalates interfere with calcium by forming insoluble salts with calcium. Dietary oxalates are absorbed and contribute to increased excretion of oxalates in urine. High oxalate excretion may predispose to oxalate crystals leading to urinary stones (Radhika and Sreeja, 2004).

Presence of oxalate was detected in the edible parts of *Colocasia esculenta* (Mandal *et al.*, 1982); *Amorphophallus commautatus* and *Sauromatum pedatum* (Nilegaonkar *et al.*, 1985); *Dioscorea* sp., *Manihot esculenta*, *Colocasia esculenta* (Bradbury and Holloway, 1988). The intake of appreciable amount of oxalate (but not calcium oxalate) is known to produce chronic effects. Oxalate content was observed in the corms *Colocasia esculenta*, *Alocasia macrorrhiza*, *Xanthosoma sagittifolium*, *Amorphophallus campanulatus* (Sakai, 1983; Saha and Hussain, 1983; Tang and Sakai, 1983); *Colocasia esculenta* and *Amorphophallus paeoniifolius* (Balagopalan, 2000).

**Hydrogen cyanide**

The nutritive value of tubers and leaves is affected due to the presence of cyanogenic glycosides, linamarin and lotustralin which form highly toxic hydrogen cyanide on coming into contact (due to injury, infection, cutting, grinding, processing etc) with the enzyme linamarase (Balagopalan, 2000).

Hydrogen cyanide is present in the tubers of *Manihot esculenta* (Maini and Balagopal, 1978; Solomonson, 1981; Nambisan and Sundaresan, 1990; Nambisan and Malathi, 1993; Balagopalan 2000) Gibbs (1974) noted the occurrence of cyanogens in families like Rosaceae (150), Leguminosae (125), Graminae (100), Araceae (50), Compositae (50), Euphorbiaceae (50) and Passifloraceae (30).

**Trypsin and Amylase inhibitor**

Apart from the nutrients, plants contain secondary chemicals such as protease inhibitors, haemagglutins, allergens, alkaloids, hormones, vitamin antagonists (Leopard and Ardrey, 1972).

The enzyme inhibitors mainly trypsin and amylase inhibitors have been identified in many tubers. Proteinase inhibitor (Trypsin inhibitor) was observed in *Ipomoea batatus*, *Alocasia macrorrhiza*, *Colocasia esculenta* (Sumathi and Pattabiraman, 1977; Dickey, 1983; Ogato and Makisumi, 1984; Bradbury *et al.*, 1985; Hammer *et al.*, 1989; Sasikiran *et al.*, 1997a,b); *Solanum tuberosum* (Huang *et al.*, 1981; Bradbury and Holloway, 1988); *Dioscorea dumetorum* and *D. rotundata* (Lape and Treche, 1994); Sweet potato (Sugiura *et al.*, 1973); *Colocasia* and *Ipomoea batatus* (Sasikiran and Padmaja, 2003).

Root crops like *Colocasia esculenta* (Rao *et al.*, 1967; 1970; Rekha *et al.*, 1997; Rekha and Padmaja, 2002); *Ipomoea batatus* (Rekha and Padmaja, 2002); *Dioscorea alata* (Shivaraj *et al.*, 1979; Sharma and Pattabiraman, 1982; Rekha *et al.*, 1999) were found to contain amylase

inhibitors. Trypsin, chymotrypsin and amylase inhibitors have been identified and characterized from the tubers of sweet potato, *Colocasia* and yams (Balagopalan, 2000).

**Processing of tubers**

Studies have indicated that suitable processing techniques can reduce or eliminate the acridity, cyanide content, phenols, tannins, trypsin and amylase inhibitors. (Balagopalan, 2000).

Corms which are usually acrid, require cooking techniques before they can be used (Sakai, 1983). Hammer (1989) made a definitive study on the occurrence, chemistry and stability to heat of the proteinase inhibitors (Trypsin and chymotrypsin inhibitor) and found that the tubers are denatured on cooking and so do not seem to pose problems for digestion. If the uncooked tubers, leaves and corm are fed to animals, the difficulty of absorption of protein due to inactivation of gut proteinases by the inhibitors present pose problems for digestion.

Changes in Trypsin inhibitor during processing of tropical root crops (Bradbury and Holloway, 1988); Potatoes (Huang *et al.*,1981); sweet potato (Sasikiran and Padmaja, 2003) and amylase inhibitor changes during processing of sweet potato (*Ipomoea batatus*) and taro (*Colocasia esculenta*) (Rekha and Padmaja, 2002) were studied.

The cooking qualities and nutritive value of minor tubers like *Xanthosoma, Colocasia, Amorphophallus* etc. were studied by Seralathan and Thirumaran, (1999). *Manihot esculenta* (Cock, 1985; Padmaja, 1995;

Sheeba Ravi and Padmaja, 1997; Nambisan and Sundaresan, 1990) *Ipomoea batatus*, *Colocasia esculenta* (Rekha and Padmaja, 2002); *Colocasia esculenta* and *Amorphophallus paeoniifolius* (Balagopalan, 2000) were subjected to processing.

Processing of tubers, corms and rhizomes tend to increase the palatability and improve the digestibility by reducing or eliminating the anti-nutritional contents.

A review of literature thus reveals that till date a detailed study on the nutritional and anti-nutritional properties of wild tubers, corms and rhizomes and the elimination/ reduction of toxic substances by processing are not carried out among the tribal Kanikkars of Kanyakumari district, Tamil Nadu. Hence the present study is made on the nutritional and anti-nutritional properties of wild tubers, corms and rhizomes consumed by the tribal Kanikkars of Kanyakumari district, Tamil Nadu.

# WILD EDIBLE PLANTS AND THE KANIKKARS- AN INVESTIGATION

## WILD EDIBLE PLANTS AND THE KANIKKARS – AN INVESTIGATION

Wild edible plants are being used by the tribals particularly during scarcity and dry months (Maya Devi, 2003). Threats to destruction of wild species is largely due to over-exploitation, biotic and abiotic stresses. Many edible tubers/ corms/ rhizomes grow wild in the higher altitudes of the forest. The tribals collect and cook them for their food.

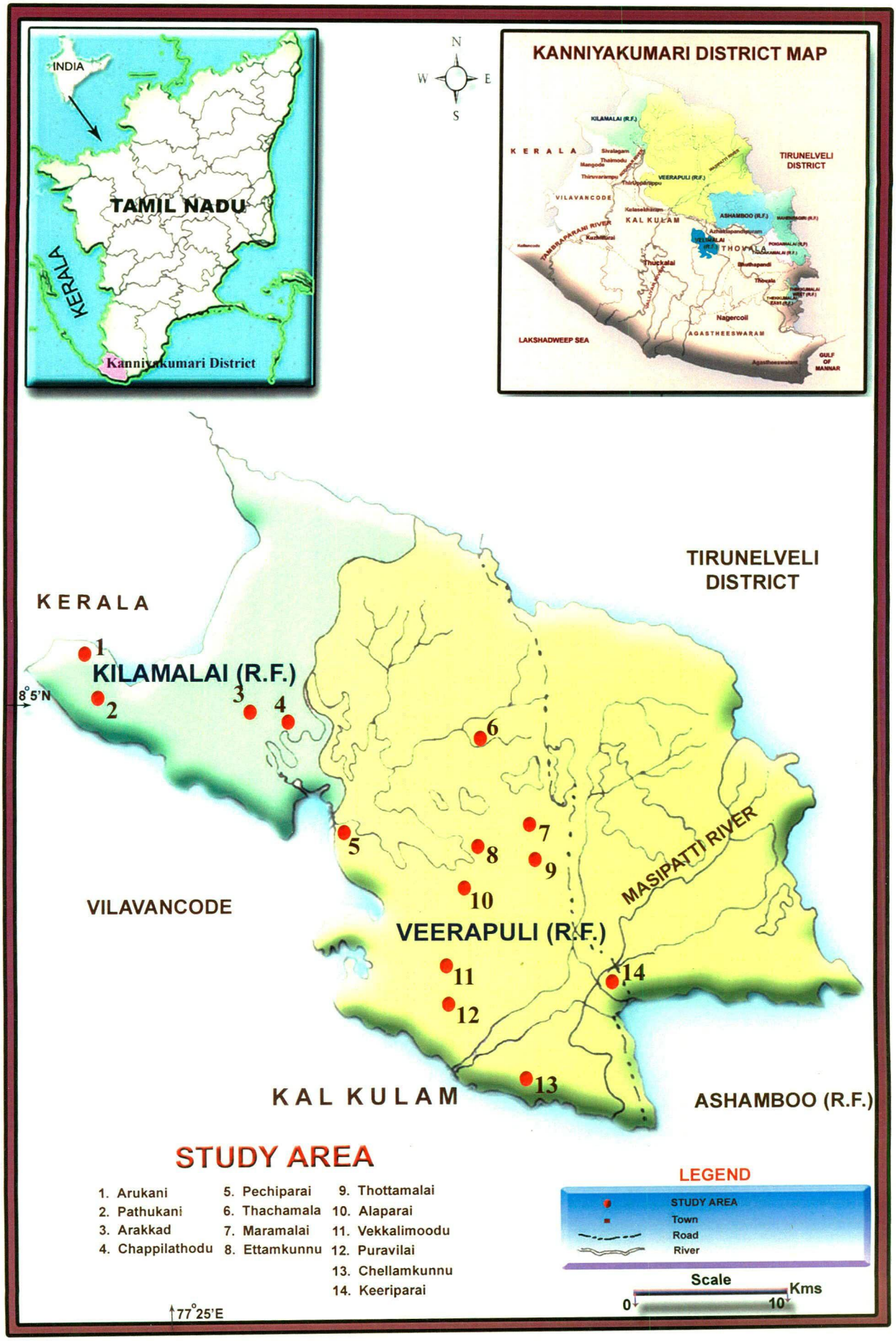
**Distribution**

Kanyakumari district constitutes the southern most tip of India, with Kerala on the west-north, Tirunelveli district in the north-east, Arabian sea in the south-west, the Bay of Bengal in the south-east and the Indian ocean in the south.

Forest division of Kanyakumari district is located between 77°10'—77°35' east longitude and 8°5'—8°35' north latitude. Due to its varying topography, diverse group of crops are being grown. Total area under forests in this district is 54,155 ha out of which the reserve forests occupy an area of 50,486 ha. There are 9 ranges under the control of this division.

The Kanikkars are distributed along the South-Eastern slopes of the Western Ghats, Tamil Nadu (Area map). There are about 47 Kanikkar settlements in Kanyakumari district, occupying an area of 1274 ha of reserve forests.

# STUDY AREA MAP




## STUDY AREA

1. Arukani
2. Pathukani
3. Arakkad
4. Chappilathodu
5. Pechiparai
6. Thachamala
7. Maramalai
8. Ettamkunnu
9. Thottamalai
10. Alaparai
11. Vekkalimoodu
12. Puravilai
13. Chellamkunnu
14. Keeriparai

**LEGEND**

- STUDY AREA
- Town
- Road
- River

Scale 0 — 10 Kms

Forty-seven settlements are situated within the catchment areas of Perunchani, Pechiparrai and Chittar Reservoir enclosed within the Veerapuli and Kilamalai Reserve forests in Kanyakumari division.

The forest lands are hilly and many places are very steep and rugged with prominent peaks. Various types of vegetation ranging from grasslands to luxuriant tropical wet evergreen forests occur in this region (Plate I).

Trees, shrubs, climbers, herbs, parasites, lianes, orchids, mosses, lichens and xerophytes are seen throughout the area. Wildlife in this region has been distributed and thrown out of its habitat. Its number is also very much reduced due to human interference in the form of conversion of natural forests into rubber and softwood plantations. Hunting and poaching is strictly prohibited throughout the region.

In the study area the Kanikkars live in several isolated pockets or in small villages. Their inhabitations are known by the following names:

1. Arukani
2. Pathukani
3. Arakkad
4. Chappilathodu
5. Pechiparai
6. Thachamalai
7. Maramalai
8. Ettamkunnu
9. Thottamalai
10. Alaparai
11. Vekkalimoodu
12. Puravilai
13. Chellamkunnu
14. Keeriparai

# PLATE I

## THE SOUTH EASTERN SLOPES OF WESTERN GHATS AREA SURVEYED

a. A view of Thalaikkumalai area.

b. Kallaravayal area in Pathukani region.

c. A view of Melamannadi area.

d. Keelmalai area of Kilamalai R.F.

e. Tholadi area of Kilamalai R.F.

f. Cherukidathukani
- a view from Orunooram vayal.

# LIFE STYLE OF THE KANIKKARS

## LIFE STYLE OF KANIKKARS

The Kanikkars (Kanis) are tribes living in the forest settlement of the low elevation hills of the South-Western Ghats limited to Thiruvananthapuram district of Kerala, Kanyakumari and Tirunelveli districts of Tamil Nadu. As per the 2002 census, there are 1575 families and the total population is 6158.

The government has allotted forest lands to persuade them to discard destructive shifting cultivation and adopt a settled agricultural life. The main occupation of Kanikkars are agriculture, horticulture and food gathering from the forests.

The tribals live in huts built by bamboo and reeds. They grow plantation crops, tubers, greens etc. in their settlement area (Plate II). Rubber, pepper, plantain, coconut, arecanut and tapioca are grown in the surrounding areas. The top soil in this area has more or less been washed away in soil erosion thus rendering the productivity low.

### Tribal organization

The Kanikkars have poor physique and are disease prone because of their scanty food and marriage among their close relatives. They are mostly illiterates. They have a head man and he is the law-giver, priest and protector. He settles all the disputes.

# PLATE II

## KANIKKARS OF KANYAKUMARI DISTRICT - A SURVEY

a. Sivaraman kani of Peanu village

b. A very old kani woman of Arukani.

c. A tribal man collecting tubers of *Xanthosoma violaceum* Schott.

d. A tribal woman holding *Dioscorea esculenta*(Lour) Burk. plant with its tubers.

e. An old tribal of Orunooramvayal listening to her fellow people .

f. A tribal hut in Arukani.

Their settlements are far from the tracks of elephants on steep hill slopes, which are terraced and planted with useful trees. The Kanis are peace loving people and they do not engage in petty quarrels.

Now, the Kanikkars have abandoned migratory cultivation because of forest rules. Forests may not be set fire to or trees felled at the unrestricted pleasure of individuals. Each settlement now has a forest block assigned to it fit for cultivation with which other tribes are not allowed to interfere. They do not pay anything as tax to the Government.

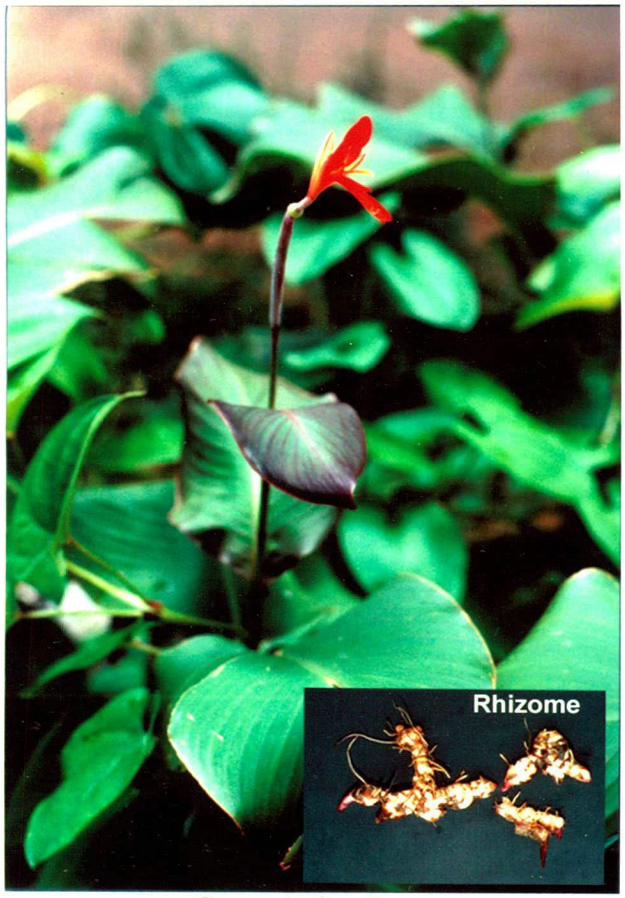
**Wild edible plants**

In India, certain wild tubers, root types, green leaves, flowers, unripe as well as ripe fruits and grain legumes including tribal pulses are known to be consumed by different tribal sects. Among the food plants, the tribal Kanikkars consume wild edible tubers/ corms/ rhizomes in large quantity.

The present investigation deals with the distribution of the tribal Kanikkars along the South Eastern slopes of Western Ghats and the ecological conditions, consumption pattern of different food plants and their nutritional potential. The present study focuses on the nutritive value of the wild edible tubers/ corms/ rhizomes consumed by the Kanikkars settled in the reserve forest area of Kanyakumari district (Plate III to V).

# PLATE III

## EDIBLE RHIZOME AND CORM IN THEIR NATURAL HABITAT.




a. *Canna indica* L.

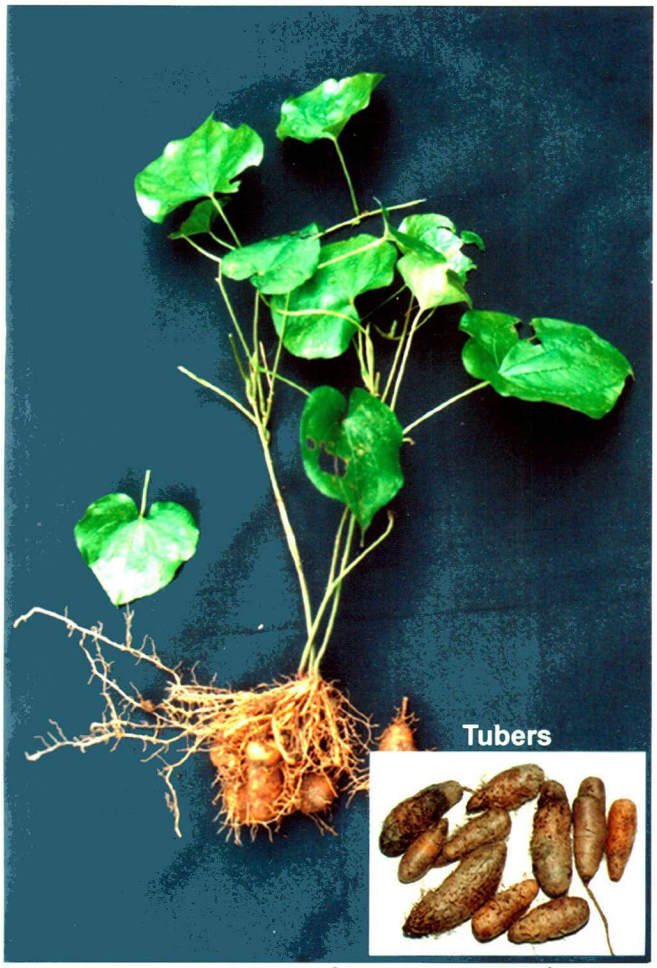

d. *Maranta arundinacea* L.


c. *Xanthosoma violaceum* Schott.


b. *Xanthosoma sagittifolium*(L.)Schott.

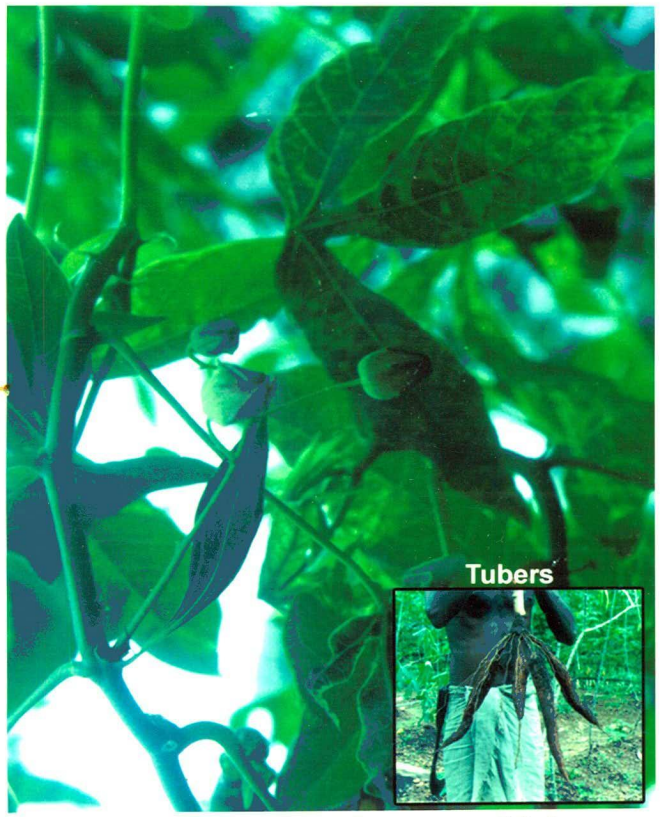
# PLATE IV

## EDIBLE TUBERS OF KANIKKARS




a. *Dioscorea esculenta* (Lour.)Burk.


b. *Manihot esculenta* Crantz var. H-226.




c. *Manihot esculenta* Crantz. var. M-4.

d. *Alocasia macrorrhiza* Schott.

# PLATE V

## EDIBLE TUBERS OF DIOSCOREA SPECIES.


a. *Dioscorea oppositifolia* L.


b. *Dioscorea pentaphylla* L.

c. *Dioscorea tomentosa* J. Konigex Spreng.

d. *Dioscorea alata* L. with aerial bulbils.

e. *Dioscorea wallichi* Hook.

f. *Dioscorea esculenta*(Lour.)Burk.

# MATERIALS AND METHODS

## MATERIALS AND METHODS

### I. Collection

Wild edible tubers, corms and rhizomes were collected from the Southern slope of Western Ghats, Kanyakumari district, Tamil Nadu (Vide area map). Field visits were made frequently. The data regarding the wild edibles mentioned above were collected by interviewing the Kanikkar tribals and their village leaders. Old experienced tribals were also interviewed. Specimens of tubers, corms and rhizomes were collected and brought to the laboratory for botanical identification and nutritive analysis. Voucher specimens were collected and deposited in the P.G. Department of Botany, V.O.Chidambaram College, Thoothukudi-8.

The specimens were identified using the following floras.

i) Flora of the Presidency of Madras, Vol.III. J.S.Gamble. and C.E.C.Fischer, (1915-1936).

ii) An excursion Flora of Central Tamil Nadu, India—K.M.Mathew 1991.

iii) Flora of British India, Vol.VI—J.D.Hooker, (1872-1897).

iv) Tropical crops—Monocotyledons, Vol.I&II—J.W.Purseglove, 1983.

The wild edible tubers, corms and rhizomes were photographed and the photographs are affixed in appropriate places in the section "Wild edible plants and the Kanikkars—an investigation.

## II. Chemical Analyses

### Chemicals

The chemicals used during the experiment were of BDH (AR) and Sigma Chemical Company, St.Louis, U.S.A. Casein and Poly Vinyl Pyrollidone (PVP) were purchased from SISCO Research Laboratories Pvt. Ltd. Bombay. Porcine pancreatic α-amylase was purchased from E Merck, Germany.

### Preparation of Samples

Wild edible samples washed free of dirt were chopped and about 50 g of each were weighed, dried and powdered in a Willey mill (Scientific Equipment Works, New Delhi, India) 60 mesh size. The powdered samples were stored in screw cap bottles at room temperature for further analysis.

### Proximate analysis

### Determination of Moisture content (AOAC, 1975)

The samples were weighed, chopped and incubated in a hot-air-oven at 80°C for 24 hours. Then the samples were cooled in a desiccator and weighed again. The loss in the weight of the sample was calculated as the moisture content and the average value of triplicate determinations are expressed on percentage basis.

**Determination of Crude protein content**

**Digestion**

The nitrogen content of the dried, powdered sample was determined by micro-kjeldahl method (Humphries, 1956). To 100 mg of the dried powdered sample taken in a microkjeldahl digestion flask, 2 ml of digestion mixture (5% (w/v) Salicylic acid in Con. $H_2SO_4$) was added and mixed well. After 20 min. 0.3 g of Sodium thio sulphate was added and heated gently until fumes disappeared. The contents of the flask were cooled and 60 mg of catalyst (a mixture of 1 g $CuSO_4$, 8g $K_2SO_4$ and 1 g Selenium dioxide) followed by 1 ml of Con. $H_2SO_4$ were added. The contents were digested until they turned apple green in colour. The flask was cooled and the contents were made upto a known volume.

**Distillation**

10 ml of the digested solution from the volumetric flask was transferred to Paranas microkjeldahl distillation flask. To this, 10 ml of 40% (w/v) NaOH and 2ml of distilled water were added and heated using Bunsen burner. The ammonia from the sample was steam-distilled for 5 min. into a receiver flask, which contained 5 ml of 2% (w/v) boric acid solution and indicator (83.3 mg of bromocresol green + 16.6 mg of methyl red dissolved in 10 ml of 95% ethanol).

The ammonia in the receiving flask produced by the breakdown of organic nitrogen-containing compounds in the sample was titrated against N/50 Sulphuric acid. A blank was run simultaneously using all the reagents and the value of the blank was deducted from the value of the

sample before calculation. One ml of N/50 $H_2SO_4$ equaled 0.00028 g of N, which forms the basis for calculation of N content in the sample.

The crude protein content, which is hereafter called simply the protein content was calculated by the equation.

Protein content (%)=% nitrogen x 6.25.

**Crude Lipid (AOAC 1970)**

Dried powdered sample (2g) was extracted with ether in a Soxhlet apparatus for 16 hrs. The ether was evaporated and the residue was weighed. The average value of triplicate experiments was expressed as percentage of ether extract or total crude lipid content on dry weight basis.

**Determination of Crude fibre content (AOAC, 1970)**

The left-out residue after extraction with ether was successively digested with 0.225N $H_2SO_4$ solution and 0.313N NaOH solution. After digestion, the sample was washed with boiling water followed by absolute ethanol in a Gooch crucible. The content of the crucible was dried to constant weight, cooled, weighed and ignited in an electric muffle furnace for 30 min. at 600°C. The contents were reweighed after cooling. The loss in weight was expressed as percentage of crude fibre on dry weight basis.

**Ash Analysis (AOAC, 1970)**

Two g of dried powdered sample was placed in a pre-weighed crucible and ignited at 600°C for 2 h. The contents of the crucible were cooled in a desiccator and weighed. The difference in weight of the crucible gives the

ash content. The ash content was expressed as percentage on dry weight basis.

**Determination of Nitrogen Free Extractives (NFE) Or Total Crude Carbohydrate content determination (Muller and Tobin, 1980)**

The carbohydrate content was obtained by the difference method: that is, by subtracting the sum of the protein, fat, ash and fibre from the total dry matter.

% NFE = 100 – (CP%+EE%+CF%+Ash%)

where CP=Crude Proten; EE=Ether Extract; CF=Crude Fibre

**Calorific value determination**

The calorific values of the investigated samples were determined in KJ by multiplying the percentage of crude protein, crude lipid and NFE by the factors 16.7, 37.7 and 16.7 respectively.

**Soluble proteins**

**Extraction**

One g of the dried, powdered sample was extracted with 10 ml of 0.1N NaOH (The extract was slightly heated in a water bath by shaking the tubes) 2 replications of each sample were prepared and 2 aliquots from each replica were used for analysis.

**Estimation (Lowry *et al.*, 1951)**

0.5 ml of extract was pipetted out into the test tubes and made upto 1 ml with distilled water. 5ml of alkaline $CuSO_4$ reagent was added mixed

well and kept for 10 minutes at room temperature. 0.5 ml of diluted Folin ciocalteau reagent was added. The absorbance was measured after 30 minutes at 660 nm.

**Calculation**

The process was standardized using a bovine serum albumin standard and the factor was calculated to be 1.0 mg. The soluble protein (g $100g^{-1}$) was calculated according to the formula.

Soluble proteins=2 x T for an aliquot of 0.5 ml.

Where T is the OD value for the corresponding sample.

**Starch and sugars (Moorthy and Padmaja, 2002)**

**Extraction and Estimation**

To 1 g of the dried powdered sample, 20 ml of 80% ethanol was added and left overnight to extract the sugars.

The extracted sugars were separated from the residue by filtration with Whatman No.1 filter paper. The filtrates were collected separately for sugar estimation. The residue was transferred back into the conical flask using 20 ml of 2N HCl.

The starch in the residue was then hydrolysed, cooled, and the volume was increased to 100 ml using distilled water. This supernatant was then directly used for titration.

The alcoholic sugar filtrate was treated with 1 ml Con.HCl and heated (100°C). The volume of the sugar extract was raised to 50 ml with distilled water and used for titration.

Four replicas of each sample were taken and 2 aliquots were taken from each replica for analysis.

**Titrimetric assay**

10 ml 1% potassium ferricyanide was pipetted and 5 ml NaOH (2.5 N w/v) was added and mixed. The contents were boiled and 3 drops of dilute methylene blue was added. The solution immediately turned blue green. The starch hydrolysate was taken in a 2 ml blow pipette and added drop by drop. The end point is the change of colour to golden yellow. The titre value is noted.

For sugar estimation, the sugar extract was taken in a 10 ml blow pipette and added drop by drop to boiling reagent. The end point is the rapid disappearance of violet colour. At this stage, the titre reading was noted.

**Calculation**

Each lot of Potassium ferricyanide was calibrated using Std. Glc. solution and the relation.

10 mg of Glc.=10 ml of Potassium ferricyanide.

The starch content was calculated by the formula.

$$\text{Starch (g } 100g^{-1} \text{ DM)} = \frac{\text{Starch content}}{\text{DM\%}}$$

$$= \frac{10^a \times 100^b \times 0.9^c \times 100}{T \times 2^d \times 1000}$$

a- Titre obtained for ferricyanide reagent against Glc. Std.

b-Total volume of starch hydrolysate

c-Morris factor for converting sugar to starch.

d-Weight of sample (g)

T-Titre value for starch hydrolysate.

The sugar content was calculated as

$$\text{Sugar (g100g - 1)} = \frac{10^a \times 50^b \times 100}{T \times 2^c \times 1000}$$

a—Titre obtained for ferricyanide reagent against Glc. solution.

b—Total volume of hydrolysate.

c—Weight of the sample (g).

T—Titre value for sugar hydrolysate.

**Mineral Analysis**

**Sample Digestion**

Five-hundred mg of dried powdered sample was mixed with 10ml of Con. $HNO_3$, 4 ml of 60% perchloric acid and 1 ml of Con. $H_2SO_4$ and the contents were kept undisturbed overnight.

After that it was heated on a hot plate containing Con. $H_2SO_4$ in a beaker until the brown fumes ceased coming out and then allowed to cool. After cooling it was filtered through Whatman No.42 filter paper. After filtration the filtrate was made upto 100 ml with distilled water.

**Estimation of Sodium and Potassium**

Sodium and Potassium were estimated by using Flame Photometer (Model Elico). The sodium and potassium contents were calculated by

referring to the calibration curves of sodium and potassium respectively and expressed as mg 100 $g^{-1}$ of powdered samples.

**Estimation of Calcium and Magnesium (Jackson, 1973)**

**Calcium**

Five ml of triple acid digested extract was taken in a china dish. To this 10 ml of 10% (w/v) NaOH and 0.1 g of murexide indicator powder [40 g of potassium sulphate or potassium chloride was added and ground with 10g ammonium chloride and 0.2 g of murexide (ammonium purpurate)]. The solution was then titrated against 0.02 N versenate (19g of EDTA was dissolved in 5 litres of distilled water) and standardized against 0.2 N $Na_2CO_3$ solutions and adjusted until the colour changed from red to violet.

**Calcium and Magnesium**

Five ml of triple acid digested extract was taken in a china dish. To this 10 ml of ammonium chloride—ammonium hydroxide buffer (pH 10) and a few drops of Erichrome black T indicator (0.1g of Erichrome black T dissolved in 25ml of methanol containing 1g of hydroxylamine hydrochloride) were added and titrated against 0.02N versenate solution until the colour changed from red to blue.

**Calculation**

Percentage of calcium in the sample=Titre value of

Calcium x 100/5 x 100/0.5 x 0.0004

Percentage of magnesium = Titre value of calcium+ magnesium-Titre value of calcium

or

Titre value of calcium+magnesium x 0.96

Calcium and Magnesium contents were expressed as mg $100g^{-1}$ of sample .

**Estimation of Phosphorus (Dickman and Bray, 1940)**

One ml of triple acid digested extract was pipetted into 100ml volumetric flask. To this 50 ml of distilled water was added, followed by 5 ml ammonium molybdate-sulphuric acid reagent (Solution A: 25g of ammonium molybdate dissolved in 100ml of distilled water. Solution B: 280 ml of Con. $H_2SO_4$ diluted to 800 ml. Solution A was added slowly with constant stirring to solution B and the volume was made upto 1000 ml with distilled water). Blue colour developed after adding 6 drops of 2.5% (w/v) stannous chloride solution. The total volume was made upto 100 ml. The intensity of the blue colour was measured at 650 nm in a Spectrophotometer. The phosphorus content present in the sample was calculated by referring to a standard graph of phosphorus using potassium dihydrogen phosphate ($KH_2PO_4$) as standard and expressed as mg $100g^{-1}$ of powdered samples.

**Estimation of Micronutrients by Atomic Absorption Spectrophotometer (Issac and Johnson, 1975)**

By feeding the sample on an Atomic Absorption Spectro-photometer ECIL (Electronic Corporation of India Ltd.) the following elements were estimated with appropriate wavelengths.

| Name of the Mineral | Wavelength used for estimation |
|---|---|
| Iron | 248.3 nm |
| Copper | 324.5 nm |
| Zinc | 213.9 nm |
| Manganese | 279.4 nm |

The mineral contents were expressed as mg $100g^{-1}$ powdered samples.

***In vitro* protein digestibility determination (Padmaja, 2001)**

100g of the dried powdered sample was weighed and 10 ml distilled water was added. The sample was allowed to hydrate for 1 hour and equilibrated to pH 8.0 at 37°C.Panzynorm-N (Enzyme tablet) was dissolved in 5 ml of 0.02 M sodium phosphate buffer solution (pH 6.9) 1ml of enzyme solution was added and incubated at 37°C for 1 hr. The reaction was stopped by heating to 100°C. Control was run without the sample. The aminoacids released were estimated by Lowry's method (1951).

**Calculation**

The process was standardized using a bovine serum albumin standard and the factor was calculated to be 1mg.

*In vitro* protein digestibility was calculated as

Protein liberated in test sample as a result of enzyme digestion= T x F mg

T = Test OD—Control OD

F= Factor (1 mg)

***In vitro* starch digestibility determination (Padmaja, 2001)**

100 mg of powdered sample was weighed and 10 ml of the buffer (0.02 M Sodium phosphate buffer) was added. The volume was then made upto 20 ml using the buffer after the samples were homogenized over a boiling water bath.

**Colorimetric assay**

To nullify the effect of free reducing sugars, controls were set up 0.2ml of the samples were pipetted out and the volume was made to 1.0 ml

using distilled water. To the remaining sample 0.5 ml of pancreatic amylase was added and incubated at room temperature for 30 seconds. The flasks were placed in a boiling water bath immediately to inactivate the enzyme. On cooling 0.2 ml aliquots from each sample were pipetted out to obtain the test values. The reducing sugars formed by the action of α-amylase on the starch were estimated by Nelson-Somogyi's method and the absorbance was read at 520 nm.

The *in vitro* starch digestibility was expressed as mg reducing group formed/hr/g starch taken.

**Calculation**

*In vitro* digestibility units = T x 407.33 units

where 100 mg of the sample was used

T=Test OD value – Control OD value

**Anti-nutritional components**

**Extraction and Estimation of Total free phenolics**

**Extraction (Maxon and Rooney, 1972)**

Five hundred milligram of air-dried powdered sample was taken in a 100 ml flask, to which 50 ml of 1% (v/v) HCl in methanol was added. The samples were shaken on a reciprocating shaker for 24 hrs. at room temperature. The contents were centrifuged at 10,000 x g for 5 minutes. The supernatant was collected separately and used for further analysis.

**Estimation of Total free phenolics (Sadasivam and Manickam, 1996)**

One ml of aliquot of the above extract was pipetted into different test tubes to which 1ml of Folin-ciocalteu's reagent followed by 2 ml of 20% (w/v) $Na_2CO_3$ solution were added and the tubes were shaken and placed in a boiling water bath for exactly 1 min. The test tubes were cooled under running tap water. The resulting blue solution was diluted to 25 ml with distilled water and the absorbance was measured at 650 nm with the help of a Spectrophotometer. If precipitation has occurred, it was removed by centrifugation at 5000 x g for 10 min. before measuring the absorbance. The amount of phenolics present in the sample was determined from a standard curve prepared with catechol. A blank containing all the reagents minus plant extract was used to adjust the absorbance to zero. Average value of triplicate estimation was expressed as g $100g^{-1}$ of powdered sample on dry weight basis.

**Estimation of Tannins (Burns, 1971)**

From suitable aliquots of the above extract tannin content was quantified by the Vanillin-HCl method of Burns (1971) using phloroglucinol as a standard at 500nm with a Spectrophotometer. The average values of triplicate estimates of all samples were expressed as g $100g^{-1}$ powdered samples on dry weight basis.

**Extraction and Estimation of Hydrogen cyanide (Jackson, 1967)**

**Extraction**

Three gms of air-dried powdered sample was mixed thoroughly with 62.5ml of distilled water and 3 to 4 drops of chloroform in a distillation flask. The above suspension was steam distilled. The delivery end of the condenser was kept below the surface of 5 ml of 2% KOH solution in a beaker. Approximately 30 ml of distillate was collected and it was used as the source material.

**Estimation**

Five ml of aliquots of the above extract was pipetted into different test tubes and 5 ml of alkaline picrate solution was added to each test tube. The contents of the test tubes were mixed and digested in boiling water bath for 5 min. and the absorbance was measured at 520 nm against a reagent blank. The Hydrogen cyanide content present in the sample was calculated by referring to a standard graph of potassium cyanide as standard and expressed as mg $100g^{-1}$ of powdered samples.

**Total oxalate estimation (AOAC, 1984)**

One gm dried powdered sample was extracted twice with 0.25 N HCl in a water bath (60°C) for 1 hour each. The centrifugate was collected in a conical flask. This extract was precipitated by adding 5ml tungstophosphoric acid kept overnight and centrifuged. Then it was neutralized with 1:1 dil. ammonium solution. It was precipitated overnight by adding 5 ml of acetate buffer with $CaCl_2$ (pH 4.5). The precipitate was centrifuged and washed

twice with wash liquid (Dilute acetic acid + Calcium oxalate, decanted and filtered).

The precipitate was then dissolved in 15 ml 2 N $H_2SO_4$ and titrated against 0.01 N $KMnO_4$ solution at 60°C.

**Calculation**

$$\text{Total oxalate (\%) (dry weight)} = \frac{0.063 \times \text{vol. of } 0.01 \text{ N } KMnO4}{\text{Weight of sample (gm)}}$$

**Trypsin inhibitor assay (Sasikiran and Padmaja, 2003)**

Caseinolytic assay was used for the study of trypsin inhibitor. Three types of assay systems were used. The control system consisted of casein (2%, 2.0ml), trypsin inhibitor extract (0.3 ml) and 1.7ml sodium phosphate buffer (0.01 M, pH 8.0) ,trypsin (0.2 ml from a 1mg/10ml stock). In the inhibited system, trypsin (0.2 ml) and the inhibitor extract (0.3 ml) were pre-incubated for 30 min. for maximum inhibitor response. To this, casein (2.0 ml) was added followed by 1.5ml buffer. The system was incubated for 15 min. at 30°C and the reaction was stopped by adding 4.0 ml of 10% TCA. The TCA system was kept for one hour to complete protein precipitation and the precipitate was centrifuged off at 1000 x g for 10 min. One ml of the supernatant was used for the quantification of TCA soluble peptide fragments by the method of Lowry *et al.*, (1951).

**Calculation of trypsin inhibitor activity**

A calibration curve was prepared using bovine serum albumin (BSA) as standard. One unit of trypsin activity is defined as one mg peptide fragments released per minute at 30°C under the assay conditions.

Trypsin inhibitor unit (TIU) is defined as the number of trypsin units inhibited and is expressed on a dry weight basis. The effect of free amino acids in the inhibitor was nullified by subtracting the readings of control system from the inhibited system readings.

**Assay of amylase inhibitor (Rekha and Padmaja, 2002)**

The amylase inhibitor activity was studied using 0.5 % soluble starch as substrate. Porcine pancreatic α-amylase (Emerck, Germany) was used as the enzymatic source uniformly throughout the study. Three assay systems were used to quantify the amylase inhibitor activity. The control system consisted of starch (0.5 ml) and 0.02 M sodium phosphate buffer pH 6.9 (2.25 ml). In the uninhibited system, 0.5 ml starch and 2.0 ml buffer were allowed to react with α-amylase (0.25 ml from a solution containing 100 μg porcine pancreatic α-amylase/ ml). After incubation for 10 min. the reaction was stopped by adding 1.0ml of 0.1N HCl. In order to elicit maximum inhibitor response, the inhibitor extract (0.5 ml) was pre-incubated with the buffer (1.5 ml) and α-amylase (0.25 ml) for 30 min. at room temperature (30±2°C). To this inhibited system, 0.5 ml starch was added to initiate enzyme action. After incubation for 10 min, the reaction was terminated by adding 1.0 ml 1 N HCl.

The residual starch in the uninhibited and inhibited system as well as the starch in the control system was quantified by the method of

Mohammed and Sharma (1985) using iodine reagent (0.5 ml of an iodine solution containing 0.2 g iodine crystals and 2g potassium iodide in 100 ml distilled water). The volume was increased to 20ml with distilled water and the absorbance of the blue colour was measured at 620 nm in an ATI-Unicam UV—Vis Spectrophotometer.

**Calculation of amylase inhibitor activity**

A calibration curve was prepared using soluble starch (500-3000 μg), phosphate buffer and iodine reagent.

One α-amylase unit is defined as one μg starch hydrolysed per minute at 30°C under the assay conditions.

One α-amylase inhibitor unit (AIU) is defined as the amount of inhibitor that reduces the α-amylase activity by one unit.

The amount of starch hydrolyzed in the uninhibited system was computed by subtracting the respective readings from the control system readings.

Three replications were maintained for each sample and duplicate anaylsis was performed for each replicate.

**Treatments/ Processing**

**Soaking**

The tubers were peeled and cut into small pieces and were soaked in distilled water and 0.02% (w/v) sodium bicarbonate ($NaHCO_3$) solution (pH 8.6) for 3, 6 and 9 hrs. in the ratio of 1:10 (w/v). The water was drained off, and the samples were dried at 55°C.

**Cooking**

Separate batches of the sample were cooked in distilled water (100°C) in the ratio of 1:10 (w/v) for 30, 60 and 90 min. The cooked samples were rinsed and dried at 55°C.

**Autoclaving**

The samples were autoclaved at 15 lb pressure (121°C) in distilled water (1:10 w/v) for 15, 30 and 45 min. The samples were rinsed with distilled water and dried at 55°C.

All the treated as well as raw samples were powdered in a Willey mill to 60 mesh size.

**Statistical analysis**

Proximate analysis, mineral analysis, soluble protein, starch, sugars, and anti-nutritional factors like total free phenolics, tannins, hydrogen cyanide and total oxalate were estimated on triplicate determinations. Estimates of mean and standard error for the above stated parameters were calculated.

Mean was calculated by using the formula

$$\overline{X} = \Sigma x / N$$

Where $\overline{X}$ = Mean

$\Sigma$ = Summation

$X$ = Observations

$N$ = Number of observations

Standard error was calculated by using the formula

$$S.E. = SD/\sqrt{N}$$

Where

S.D. = Estimates of Standard Deviation

N = Number of observations.

# RESULTS

## RESULTS

Sixteen wild edible tubers/ corms/ rhizomes were identified as being eaten by the Kanikkar tribals of the South-Eastern slopes of the Western Ghats, Kanyakumari District, Tamil Nadu, India. They are tabulated alphabetically with botanical name, family name, vernacular name (used by the Kanikkars) habit and habitat (Table 1).

Table-2 shows the consumption pattern of the wild edible tubers/corms/rhizomes by the Kanikkar tribals.

### CHEMICAL ANAYLSES

Proximate Composition

#### Crude protein

Proximate composition (Table 3) reveals that the tubers of *Dioscorea alata, D.bulbifera, D. esculenta, D.oppositifolia, D. wallichi* and rhizome of *Maranta arundinacea* contain more than 10% of crude protein.

#### Crude lipid

The corms of *Amorphophallus campanulatus, Xanthosoma sagittifolium* and tubers of *Dioscorea bulbifera*, and *D. oppositifolia*, contain more than 5% of crude lipid content.

#### Crude fibre

Crude fibre content was found to be relatively high in the tubers of *Dioscorea esculenta, D. oppositifolia, D. pentaphylla, D. wallichi* and corm of *Xanthosoma sagittifolium.*

## Table 1 -- List of Plants Collected

| Sl. No | Botanical Name | Family | Vernacular Name | Habit | Habitat |
|---|---|---|---|---|---|
| 1. | ***Alocasia macrorrhiza*** Schott.<br>*Arum odorum* Roxb | Araceae | Maraan Cheambu | Robust herb | Evergreen forest |
| 2. | ***Amorphophallus campanulatus*** (Roxb.) Blume ex Dene.<br>*Amorphophallus paeoniifolius* (Dennst) Nicolson | Araceae | Kaattu Chenai | Perennial herb | Evergreen forest |
| 3. | ***Canna indica*** Linn. | Cannaceae | Vaazhai Koovai | Herb | Evergreen forest |
| 4. | ***Dioscorea alata*** Linn.<br>*Dioscorea globosa* Roxb. | Dioscoreaceae | Kaattu Kaychil | Climbing herb | Tropical wet evergreen |
| 5. | ***Dioscorea bulbifera*** Linn. | Dioscoreaceae | Thambai Kilangu | Climbing shrub | Tropical wet evergreen |
| 6. | ***Dioscorea esculenta*** (Lour.) Burk.<br>*Dioscorea spinosa* Roxb. | Dioscoreaceae | Sirukizhangu | Twining shrub | Deciduous forest |
| 7. | ***Dioscorea oppositifolia*** Linn. | Dioscoreaceae | Kavalai | Climbing herb | Moist deciduous forest |
| 8. | ***Dioscorea pentaphylla*** Linn. | Dioscoreaceae | Nooran | Twining herb | Tropical wet evergreen |
| 9. | ***Dioscorea tomentosa*** J. Konigex Spreng. | Dioscoreaceae | Nooli | Twining herb | Tropical wet evergreen |
| 10. | ***Dioscorea wallichi*** Hook.<br>*Dioscorea aculeata* L. | Dioscoreaceae | Neduvai | Woody climbing herb | Deciduous forest |
| 11. | ***Manihot esculenta*** Crantz | Euphorbiaceae | Adukkumuttan | Tuberous shrub | Cultivated in hilly areas. |
| 12. | ***Manihot esculenta*** Crantz **var. M-4** | Euphorbiaceae | Noorumuttan | Tuberous shrub | Cultivated in hilly areas. |
| 13. | ***Manihot esculenta*** Crantz **var. H-226** | Euphorbiaceae | Pulokkuvellai | Tuberous shrub | Cultivated in hilly areas. |
| 14. | ***Maranta arundinacea*** Linn. | Marantaceae | Koovai Kilangu | Mesophytic herb | Moist deciduous forest. |
| 15. | ***Xanthosoma sagittifolium*** (L.) Schott.<br>*Arum sagittifolium* L. | Araceae | Paalcheambu | Tall herbaceous plant | Tropical semi evergreen |
| 16. | ***Xanthosoma violaceum*** Schott. | Araceae | Neela Cheambu | Tall herbaceous plant. | Tropical semi evergreen |

## Table 2 -- Consumption pattern of edible tubers, corms and rhizomes by the Kanikkar tribals

| Sl. No. | Botanical Name | Family | Vernacular Name | Plant Part Used | Mode Of Use | Consumption Period |
|---|---|---|---|---|---|---|
| 1. | ***Alocasia macrorrhiza*** Schott.<br>*Arum odorum* Roxb. | Araceae | Maraan Cheambu | Corm | Boiled | January |
| 2. | ***Amorphophallus campanulatus*** **(Roxb.) Blume ex Dene.**<br>*Amorphophallus paeoniifolius* (Dennst) Nicolson | Araceae | Kaattu Chenai | Corm | Boiled / Roasted | June, July |
| 3. | ***Canna indica*** Linn. | Cannaceae | Vaazha Koovai | Rhizome | Boiled/ Roasted | October-December |
| 4. | ***Dioscorea alata*** Linn.<br>*Dioscorea globosa* Roxb. | Dioscoreaceae | Kaatu Kaychil | Tuber | Boiled | August |
| 5. | ***Dioscorea bulbifera*** Linn. | Dioscoreaceae | Thambai Kilangu | Tuber | Boiled/ Roasted | January-February |
| 6. | ***Dioscorea esculenta*** (Lour.) Burk.<br>*Dioscorea spinosa* Roxb. | Dioscoreaceae | Sirukizhangu | Tuber | Boiled/ Roasted | January |
| 7. | ***Dioscorea oppositifolia*** Linn. | Dioscoreaceae | Kavalai | Tuber | Boiled/ Roasted | January |
| 8. | ***Dioscorea pentaphylla*** Linn. | Dioscoreaceae | Nooran | Tuber | Boiled/ Roasted | January |
| 9. | ***Dioscorea tomentosa*** J. Konigex Spreng. | Dioscoreaceae | Nooli | Tuber | Boiled/ Roasted | August |
| 10. | ***Dioscorea wallichi*** Hook.<br>*Dioscorea aculeata* L. | Dioscoreaceae | Neduvai | Tuber | Boiled/ Roasted | August |
| 11. | ***Manihot esculenta*** Crantz | Euphorbiaceae | Adukkumuttan | Tuber | Boiled/ Roasted | January-April |
| 12. | ***Manihot esculenta*** Crantz. **var. M-4** | Euphorbiaceae | Noorumuttan | Tuber | Boiled/ Roasted | January-April |
| 13. | ***Manihot esculenta*** Crantz. **var. H-226** | Euphorbiaceae | Pulokkuvellai | Tuber | Boiled/ Roasted | January-April |
| 14. | ***Maranta arundinacea*** Linn. | Marantaceae | Koovaikilangu | Rhizome | Boiled/ Roasted | January-April |
| 15. | ***Xanthosoma sagittifolium*** (L.) Schott.<br>*Arum sagittifolium* L. | Araceae | Paalcheambu | Corm | Boiled/ Roasted | January-April |
| 16. | ***Xanthosoma violaceum*** Schott. | Araceae | Neela Cheambu | Corm | Boiled/ Roasted | January-April |

## Table 3--Proximate composition of edible tubers, corms and rhizomes (g $100g^{-1}$)[a]

| Sl. No. | Botanical Name | | Moisture | Crude Protein (Kjeldahl Nx6.25) | Crude Lipid | Crude Fibre | Ash | Nitrogen Free Extract (NFE) | Calorific value (KJ-$100g^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | ***Alocasia macrorrhiza*** | (Corm) | 89.04 | 3.47±0.03[b] | 2.38±0.03 | 3.45±0.03 | 2.16±0.01 | 88.54 | 1626.29 |
| 2. | ***Amorphophallus campanulatus*** | (Corm) | 80.00 | 8.75±0.12 | 5.35±0.05 | 6.25±0.14 | 3.18±0.02 | 76.47 | 1624.87 |
| 3. | ***Canna indica*** | (Rhizome) | 90.21 | 5.25±0.05 | 3.42±0.02 | 5.38±0.05 | 2.54±0.03 | 83.41 | 1609.56 |
| 4. | ***Dioscorea alata*** | (Tuber) | 87.72 | 10.73±0.13 | 2.50±0.02 | 6.48±0.12 | 8.50±0.04 | 71.79 | 1472.33 |
| 5. | ***Dioscorea bulbifera*** | (Tuber) | 92.48 | 15.75±0.08 | 8.13±0.01 | 3.92±0.03 | 2.86±0.02 | 69.34 | 1727.50 |
| 6. | ***Dioscorea esculenta*** | (Tuber) | 86.67 | 10.50±0.05 | 2.58±0.01 | 7.82±0.05 | 6.17±0.11 | 72.93 | 1490.55 |
| 7. | ***Dioscorea oppositifolia*** | (Tuber) | 88.93 | 13.54±0.11 | 6.43±0.12 | 8.47±0.11 | 6.09±0.03 | 65.47 | 1561.88 |
| 8. | ***Dioscorea pentaphylla*** | (Tuber) | 90.13 | 5.68±0.11 | 4.01±0.04 | 7.10±0.07 | 2.68±0.11 | 80.53 | 1590.89 |
| 9. | ***Dioscorea tomentosa*** | (Tuber) | 87.60 | 5.25±0.04 | 2.86±0.01 | 3.21±0.03 | 2.48±0.14 | 86.20 | 1635.04 |
| 10. | ***Dioscorea wallichi*** | (Tuber) | 71.06 | 10.50±0.06 | 1.18±0.01 | 9.23±0.15 | 8.42±0.07 | 70.67 | 1400.03 |
| 11. | ***Manihot esculenta*** | (Tuber) | 65.95 | 3.50±0.05 | 2.44±0.03 | 2.47±0.03 | 4.31±0.14 | 87.28 | 1608.01 |
| 12. | ***Manihot esculenta* var. M-4** | (Tuber) | 65.80 | 3.50±0.03 | 3.12±0.05 | 5.68±0.04 | 2.18±0.01 | 85.52 | 1604.26 |
| 13. | ***Manihot esculenta* var. H-226** | (Tuber) | 65.15 | 5.25±0.03 | 1.32±0.01 | 4.76±0.06 | 3.47±0.04 | 85.20 | 1560.28 |
| 14. | ***Maranta arundinacea*** | (Rhizome) | 78.08 | 13.13±0.06 | 1.12±0.01 | 6.48±0.11 | 2.10±0.01 | 77.17 | 1550.23 |
| 15. | ***Xanthosoma sagittifolium*** | (Corm) | 69.33 | 8.75±0.21 | 7.42±0.12 | 7.48±0.03 | 4.53±0.01 | 71.82 | 1625.25 |
| 16. | ***Xanthosoma violaceum*** | (Corm) | 90.75 | 6.78±0.13 | 3.42±0.03 | 4.51±0.06 | 3.46±0.03 | 81.83 | 1608.72 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Ash**

The ash content ranged between 2.10% and 8.50% in different plant samples currently investigated. The tubers of *Dioscorea alata* exhibits around 8% of ash content.

**NFE (Nitrogen Free Extractive) or Total Crude Carbohydrates**

The content of the total crude carbohydrates of all the investigated samples ranged between 65.47% and 88.54%. The NFE values of tubers of *Dioscorea pentaphylla, D. tomentosa, Manihot esculenta, M. esculenta var.* M-4, *M. esculenta var* M-226 and corms of *Alocasia macrorrhiza* and *Xanthosoma violaceum* are found to exceed 80%.

**Calorific value**

The calorific value of the presently investigated corms of *Amorphophallus campanulatus, Xanthosoma sagittifolium, X. violaceum, Alocasia macrorrhiza* and tubers of *Dioscorea bulbifera, D. tomentosa, Manihot esculenta* and *M. esculenta* var. M-4 is found to exceed 1600KJ100$^{-1}$DM.

**Mineral composition**

The data on the mineral profiles are furnished in Table 4. The tuber of *Dioscorea esculenta* and corms of *Xanthosoma sagittifolium* and *X. violaceum* exhibited high level of potassium. The tubers of *Dioscorea pentaphylla*, corms of *Alocasia macrorrhiza, Xanthosoma sagittifolium* and *X. violaceum* exhibited high content of iron.

## Table 4 – Mineral composition of edible tubers, corms and rhizomes (mg100 $g^{-1}$)[a]

| Sl. NO | Botanical Name | Sodium | Potassium | Calcium | Magnesium | Phosphorous | Zinc | Manganese | Iron | Copper |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | **Alocasia macrorrhiza** (Corm) | 196.01±0.06 | 1941.36± 0.82 | 580.48±0.16 | 154.10±0.04 | 89.60±0.12 | 2.20±0.02 | 3.34±0.03 | 72.74±0.06 | 7.26±0.02 |
| 2. | **Amorphophallus campanulatus** (Corm) | 21.50±0.04 | 1015.38±0.62 | 536.00±0.05 | 98.60±0.12 | 134.40±0.11 | 6.58±0.04 | 5.96±0.03 | 34.60±0.08 | 3.20±0.01 |
| 3. | ***Canna indica*** (Rhizome) | 22.05±0.03 | 948.03±0.54 | 130.20±0.11 | 144.10±0.11 | 69.00±0.06 | 1.10±0.01 | 1.48±0.01 | 10.34±0.00 | 2.34±0.02 |
| 4. | ***Dioscorea alata*** (Tuber) | 32.00±0.06 | 1551.00±1.21 | 338.10±0.12 | 506.10±0.14 | 110.10±0.03 | 1.26±0.01 | 5.36±0.03 | 33.10±0.02 | 8.30±0.02 |
| 5. | ***Dioscorea bulbifera*** (Tuber) | 63.38±0.01 | 1548.00±0.82 | 228.15±0.08 | 440.17±0.10 | 120.50±0.06 | 1.30±0.01 | 10.60±0.03 | 3.90±0.12 | 2.64±0.02 |
| 6. | ***Dioscorea esculenta*** (Tuber) | 51.68±0.08 | 1638.00±0.13 | 238.10±0.06 | 330.00±0.12 | 126.30±0.12 | 1.48±0.02 | 4.54±0.04 | 9.38±0.09 | 1.34±0.03 |
| 7. | ***Dioscorea oppositifolia*** (Tuber) | 113.00±0.14 | 1460.41±0.13 | 240.00±0.03 | 548.33±0.11 | 98.40±0.08 | 1.20±0.06 | 8.84±0.24 | 28.10±0.12 | 6.58±0.03 |
| 8. | ***Dioscorea pentaphylla*** (Tuber) | 83.24±0.11 | 1230.60±0.62 | 560.10±0.12 | 430.10±0.10 | 136.00±0.08 | 3.32±0.03 | 2.22±0.01 | 78.10±0.11 | 14.10±0.09 |
| 9. | ***Dioscorea tomentosa*** (Tuber) | 25.54±0.10 | 1335.41±0.54 | 220.30±0.11 | 219.00±0.00 | 78.68±0.06 | 5.20±0.01 | 1.10±0.01 | 22.00±0.09 | 1.34±0.01 |
| 10. | ***Dioscorea wallichi*** (Tuber) | 54.36±0.04 | 1241.60±0.12 | 660.00±0.09 | 618.10±0.03 | 96.40±0.04 | 4.44±0.01 | 2.58±0.01 | 18.12±0.09 | 3.54±0.01 |
| 11. | ***Manihot esculenta*** (Tuber) | 33.18±0.10 | 940.00±0.10 | 420.14±0.07 | 310.10±0.07 | 82.00±0.03 | 8.00±0.07 | 9.10±0.03 | 28.20±0.02 | 1.20±0.01 |
| 12. | ***Manihot esculenta* Var. M-4** (Tuber) | 31.40±0.03 | 828.18±0.78 | 540.00±0.03 | 408.12±0.03 | 76.15±0.02 | 7.94±0.03 | 12.80±0.06 | 20.15±0.07 | 1.42±0.03 |
| 13. | ***Manihot esculenta* Var. H-226** (Tuber) | 23.00±0.04 | 968.10±0.72 | 520.14±0.03 | 416.00±0.11 | 86.10±0.03 | 12.30±0.03 | 13.48±0.03 | 32.20±0.03 | 1.32±0.03 |
| 14. | ***Maranta arundinacea*** (Rhizome) | 22.40±0.03 | 880.10±0.68 | 440.20±0.11 | 312.00±0.10 | 54.00±0.06 | 3.60±0.03 | 7.54±0.04 | 18.30±0.05 | 1.26±0.01 |
| 15. | ***Xanthosoma sagittifolium*** (Corm) | 168.10±0.03 | 2016.00±0.71 | 670.10±0.07 | 186.48±0.03 | 108.00±0.07 | 2.10±0.01 | 3.18±0.01 | 72.00±0.03 | 5.94±0.01 |
| 16. | ***Xanthosoma violaceum*** (Corm) | 194.00±0.01 | 1948.10±0.68 | 658.40±0.12 | 177.10±0.08 | 102.10±0.02 | 2.28±0.03 | 4.34±0.03 | 84.70±0.14 | 6.60±0.03 |

a- Values are the mean of triplicate determinations expressed on dry weight basis.
b± Standard error

**Soluble Protein, Starch and Total Sugars**

The data on the soluble protein, starch and total sugars of the investigated samples are presented in Table 5.

The soluble protein of the investigated samples ranged between 0.44% and 3.12%. The starch content of the investigated samples ranged between 20.93% and 69.23%. The tubers of *Dioscorea alata, D. esculenta, D. oppositifolia, Manihot esculenta* and *M. esculenta* var M-4, rhizome of *Maranta arundinacea* and corm of *Xanthosoma violaceum* exhibited more than 60% of starch.

The total sugar of the currently investigated samples ranged between 1.00% and 9.09%. The content of total sugars of the rhizome of *Canna indica* and tubers of *Manihot esculenta* var H-226 is found to exceed 8%.

## *In vitro* Protein digestibility and *In vitro* Starch disgestibility

The *in vitro* protein digestibility of the investigated samples ranged between 3.78 units and 6.74 units.

The *in vitro* starch digestibility of the investigated sample ranged between 6.12 units and 176.37 units. The tubers of *Dioscorea bulbifera* and *Manihot esculenta* var. H-226 exhibited high *in vitro* starch digestibility.

**Table 5 -- Soluble protein, starch, sugar content, *in vitro* protein digestibility and *in vitro* starch digestibility of edible tubers, corms and rhizomes[a]**

| Sl. No. | Botanical Name | Soluble protein g100g$^{-1}$ | Starch g100g$^{-1}$ | Total Sugar g100g$^{-1}$ | *In vitro* protein digestibility units[c] | *In vitro* starch digestibility units[d] |
|---|---|---|---|---|---|---|
| 1. | ***Alocasia macrorrhiza*** (Corm) | 3.12±0.14[b] | 56.25±0.31 | 1.10±0.12 | 3.78 | 72.10 |
| 2. | ***Amorphophalluscampanulatus*** (Corm) | 1.43±0.22 | 50.00±0.28 | 6.67±0.13 | 5.28 | 53.36 |
| 3. | ***Canna indica*** (Rhizome) | 1.34±0.09 | 36.00±0.14 | 9.09±0.18 | 5.55 | 78.21 |
| 4. | ***Dioscorea alata*** (Tuber) | 1.29±0.14 | 64.29±2.23 | 1.19±0.11 | 6.02 | 30.14 |
| 5. | ***Dioscorea bulbifera*** (Tuber) | 2.16±0.31 | 42.86±1.13 | 2.70±0.03 | 4.83 | 157.64 |
| 6. | ***Dioscorea esculenta*** (Tuber) | 1.12±0.04 | 60.00±0.48 | 5.0±0.12 | 6.74 | 44.40 |
| 7. | ***Dioscorea oppositifolia*** (Tuber) | 1.67±0.18 | 64.29±0.51 | 5.49±0.48 | 5.93 | 120.16 |
| 8. | ***Dioscorea pentaphylla*** (Tuber) | 1.18±0.04 | 61.26+0.52 | 3.28±0.14 | 5.86 | 38.21 |
| 9. | ***Dioscorea tomentosa*** (Tuber) | 1.22±0.14 | 56.25±0.14 | 6.02±0.04 | 4.64 | 87.60 |
| 10. | ***Dioscorea wallichi*** (Tuber) | 1.22±0.09 | 56.25±0.34 | 3.57±0.14 | 5.17 | 57.84 |
| 11. | ***Manihot esculenta*** (Tuber) | 0.44±0.11 | 64.29±1.38 | 1.00±0.08 | 5.36 | 54.18 |
| 12. | ***Manihot esculenta* var. M-4** (Tuber) | 0.80±0.04 | 69.23±2.14 | 4.55±0.11 | 6.03 | 74.95 |
| 13. | ***Manihot esculenta* var. H-226** (Tuber) | 0.68±0.04 | 52.94±1.14 | 8.47±0.36 | 5.57 | 176.37 |
| 14. | ***Maranta arundinacea*** (Rhizome) | 1.24±0.13 | 64.29±1.34 | 3.27±0.41 | 4.38 | 6.12 |
| 15. | ***Xanthosoma sagittifolium*** (Corm) | 2.14±0.23 | 20.93±1.24 | 4.76±0.38 | 5.09 | 118.94 |
| 16. | ***Xanthosoma violaceum*** (Corm) | 1.21±0.12 | 60.00±1.25 | 3.45±0.03 | 5.69 | 97.35 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error
c 1 Unit = g amino acid released per 100 g tuber (DM)
d 1 Unit = mg reducing groups / hr/ g sample

## Anti-nutritional Factors

The data on antinutritional factors, total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor and trypsin inhibitor are presented in Table 6.

### Total free phenolics

In the investigated samples, the content of total free phenolics ranged from 0.03% to 1.40%. In the corm of *Amorphophallus campanulatus* and the tuber of *Dioscorea bulbifera* the total free phenolics is found to be more than 1%.

### Tannins

The tannin content of all the investigated samples ranged from 0.02% to 1.59%. In the corm of *Amorphophallus campanulatus* and the tubers of *Dioscorea bulbifera*, the tannin content is found to be above 1%. In all the other investigated samples tannin content is found to be less than 1%.

### Hydrogen Cyanide

In the investigated sample hydrogen cyanide content is found to be negligible.

### Total Oxalate

The total oxalate content of all the investigated samples except the tubers of *Manihot esculenta* and *M. esculenta* var. H-226 ranged from

## Table 6 – Anti-nutritional factors of edible tubers, corms and rhizomes[a]

| Sl. No. | Botanical Name | | Total free phenolics g100g$^{-1}$ | Tannin g100g$^{-1}$ | Hydrogen cyanide mg100g$^{-1}$ | Total oxalate g100g-1 | Amylase inhibitor AIU | Trypsin inhibitor TIU |
|---|---|---|---|---|---|---|---|---|
| 1. | ***Alocasia macrorrhiza*** | (Tuber) | 0.83±0.003[b] | 0.62±0.013 | 0.13±0.012 | 0.93±0.003 | 10.80 | 12.31 |
| 2. | ***Amorphophallus campanulatus*** | (Corm) | 1.19±0.015 | 1.34±0.012 | 0.12±0.002 | 2.39±0.012 | 6.08 | 0.28 |
| 3. | ***Canna indica*** | (Rhizome) | 0.50±0.004 | 0.03±0.003 | 0.02±0.001 | 3.15±0.039 | 3.04 | 1.20 |
| 4. | ***Dioscorea alata*** | (Tuber) | 0.49±0.003 | 0.51±0.015 | 0.15±0.006 | 0.63±0.002 | 8.11 | 2.75 |
| 5. | ***Dioscorea bulbifera*** | (Tuber) | 1.40±0.012 | 1.59±0.014 | 0.12±0.003 | 0.98±0.001 | 1.01 | 0.87 |
| 6. | ***Dioscorea esculenta*** | (Tuber) | 0.56±0.011 | 0.11±0.003 | 0.19±0.001 | 0.23±0.001 | 14.50 | 2.92 |
| 7. | ***Dioscorea oppositifolia*** | (Tuber) | 0.28±0.006 | 0.15±0.009 | 0.11±0.003 | 0.31±0.003 | 1.69 | 23.70 |
| 8. | ***Dioscorea pentaphylla*** | (Tuber) | 0.41±0.002 | 0.06±0.001 | 0.17±0.004 | 0.33±0.001 | 1.85 | 2.56 |
| 9. | ***Dioscorea tomentosa*** | (Tuber) | 0.61±0.005 | 0.10±0.001 | 0.14±0.002 | 0.30±0.004 | 3.04 | 1.47 |
| 10. | ***Dioscorea wallichi*** | (Tuber) | 0.22±0.003 | 0.02±0.003 | 0.15±0.012 | 0.10±0.002 | 5.07 | 2.10 |
| 11. | ***Manihot esculenta*** | (Tuber) | 0.46±0.002 | 0.14±0.003 | 0.29±0.001 | ND | 2.36 | 1.39 |
| 12. | ***Manihot esculenta* var. M-4** | (Tuber) | 0.52±0.003 | 0.06±0.004 | 0.30±0.001 | 0.13±0.003 | 1.35 | 2 .77 |
| 13. | ***Manihot esculenta* var. H-226** | (Tuber) | 0.03±0.001 | 0.07±0.003 | 0.28±0.003 | ND | 1.35 | 0.21 |
| 14. | ***Maranta arundinacea*** | (Rhizome) | 0.09±0.001 | 0.76±0.013 | 0.05±0.004 | 0.43±0.008 | 1.69 | 4.40 |
| 15. | ***Xanthosoma sagittifolium*** | (Corm) | 0.16±0.002 | 0.13±0.002 | 0.11±0.001 | 1.60±0.002 | 3.04 | 13.88 |
| 16. | ***Xanthosoma violaceum*** | (Corm) | 0.03±0.001 | 0.31±0.004 | 0.06±0.003 | 0.83±0.001 | 0.18 | 2.40 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error
ND-Not Detected.

0.10% to 3.15%. In the corm of *Amorphophallus campanulatus* and the rhizome of *Canna indica*, the oxalate content is found to be above 2%.

**Amylase inhibitor**

The amylase inhibitor activity of the currently investigated samples ranged from 0.18 units to 14.50 units. In the tubers of *Dioscorea alata*, *D. esculenta* and *D. wallichi* and corms of *Alocascia macrorrhiza* and *Amorphophallus campanulatus*, the amylase inhibitor activity is found to be more than 5 units.

**Trypsin inhibitor**

The trypsin inhibtor activity of the investigated samples ranged from 0.21 units to 23.70 units in the tubers of *Dioscorea oppositifolia* and in the corms of *Alocasia macrorrhiza* and *Xanthosoma sagittifolium*, the trypsin inhibitor activity is found to be more than 10 units.

## Treatments/ Processing

Sixteen different tubers/ corms/ rhizomes of the present investigation were subjected to various processing to understand to what extent the studied anti-nutritional factors, total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitors and trypsin inhibitors get reduced in different time intervals. The data on the effect of soaking in distilled water and sodium bicarbonate solution, and cooking and autoclaving on the levels of the above said anti-nutrients in *Alocasia macrorrhiza*, *Amorphophallus campanulatus*, *Canna indica*, *Dioscorea alata*, *D. bulbifera*, *D. esculenta*, *D. oppositifolia*, *D. pentaphylla*, *D. tomentosa*,

*D. wallichi, Manihot esculenta, Manihot esculenta* var. M-4, *Manihot esculenta* var. H-226, *Maranta arundinacea, Xanthosoma sagittifolium* and *Xanthosoma violaceum* are presented (Tables 7-38).

**Soaking**

The data on the effect of soaking in distilled water and sodium bicarbonate solution in different time intervals on the levels of the selected anti-nutrients in *Alocasia macrorrhiza, Amorphophallus campanulatus, Canna indica, Dioscorea bulbifera, D. esculenta, D. oppositifolia, D. pentaphylla, D. tomentosa, D. wallichi, Manihot esculenta, Manihot esculenta* var. M-4, *Manihot esculenta* var. H-226, *Maranta arundinacea, Xanthosoma sagittifolium and Xanthosoma violaceum* are presented in tables 7-22 respectively.

Soaking in distilled water for 9 hours showed above 45% reduction in the level of total free phenolics in the presently investigated samples of *Canna indica, Dioscorea wallichi* and *Maranta arundinacea.*

Soaking in sodium bicarbonate solution (0.02% w/v) for 9 hours showed 50% reduction in the level of phenolic content of *Canna indica, Dioscorea wallichi* and *Xanthosoma violaceum.*

Soaking in distilled water for 9 hours showed above 40% decrease in tannin content level in *Dioscorea oppositifolia, D. pentaphylla, D. tomentosa, D. wallichi* and *Manihot esculenta* var. M-4 whereas soaking in Sodium bicarbonate (0.02% w/v) for 9 hours showed above 50% decrease in the level of tannin in *Dioscorea pentaphylla, D. tomentosa,*

**Table 7** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Alocasia macrorrhiza*[a]**

| Time interval (hrs.) | Total free phenolics g100g$^{-1}$ | % loss | Tannins g100g$^{-1}$ | % loss | Hydrogen cyanide 100g$^{-1}$ | % loss | Total oxalate g 100g$^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.83±0.003[b] | | 0.62±0.013 | | 0.13±0.012 | | 0.93±0.003 | | 10.80 | 12.31 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.75±0.003 | 10 | 0.61±0.003 | 3 | 0.10±0.003 | 27 | 0.63±0.006 | 32 | 10.71 | 12.28 |
| 6 | 0.77±0.009 | 7 | 0.59±0.002 | 6 | 0.09±0.002 | 35 | 0.59±0.007 | 36 | 10.70 | 12.19 |
| 9 | 0.63±0.002 | 24 | 0.50±0.000 | 21 | 0.07±0.000 | 50 | 0.52±0.005 | 44 | 10.52 | 12.08 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.80±0.002 | 4 | 0.62±0.002 | 2 | 0.13±0.000 | 8 | 0.71±0.000 | 24 | 10.75 | 12.30 |
| 6 | 0.79±0.003 | 5 | 0.60±0.002 | 5 | 0.11±0.003 | 20 | 0.68±0.003 | 27 | 10.70 | 12.26 |
| 9 | 0.73±0.002 | 12 | 0.57±0.003 | 9 | 0.09±0.003 | 35 | 0.63±0.002 | 32 | 10.65 | 12.15 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 8** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Amorphophallus campanulatus*[a]**

| Time interval (hrs.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg$100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 1.19±0.015[b] | | 1.34±0.012 | | 0.12±0.002 | | 2.39±0.012 | | 6.08 | 0.28 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 1.19±0.003 | 1 | 1.30±0.003 | 4 | 0.12±0.002 | 0 | 2.12±0.009 | 11 | 6.01 | 0.28 |
| 6 | 1.17±0.002 | 3 | 1.28±0.006 | 5 | 0.10±0.003 | 16 | 2.10±0.006 | 12 | 5.06 | 0.25 |
| 9 | 1.10±0.002 | 9 | 1.08±0.003 | 20 | 0.07±0.002 | 41 | 2.09±0.003 | 13 | 5.05 | 0.21 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 1.17±0.002 | 3 | 1.33±0.002 | 1 | 0.11±0.000 | 10 | 1.98±0.006 | 17 | 6.02 | 0.26 |
| 6 | 1.11±0.003 | 8 | 1.30±0.012 | 3 | 0.10±0.000 | 18 | 1.88±0.013 | 21 | 6.00 | 0.25 |
| 9 | 1.09±0.006 | 9 | 1.29±0.002 | 4 | 0.08±0.003 | 32 | 1.76±0.015 | 26 | 5.02 | 0.20 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 9** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Canna indica*[a]**

| Time interval (hrs.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.50±0.004[b] | | 0.03±0.003 | | 0.02±0.001 | | 3.15±0.039 | | 3.04 | 1.20 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.30±0.006 | 39 | 0.02±0.003 | 30 | 0.02±0.001 | 0 | 2.88±0.003 | 10 | 3.03 | 1.18 |
| 6 | 0.29±0.003 | 42 | 0.02±0.003 | 39 | 0.01±0.000 | 52 | 2.56±0.002 | 20 | 3.00 | 1.16 |
| 9 | 0.26±0.003 | 48 | 0.02±0.000 | 39 | 0.01±0.000 | 52 | 2.33±0.002 | 27 | 2.91 | 1.12 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.33±0.003 | 34 | 0.02±0.002 | 33 | 0.02±0.000 | 5 | 2.34±0.012 | 26 | 3.01 | 1.20 |
| 6 | 0.21±0.003 | 58 | 0.03±0.003 | 0 | 0.01±0.002 | 43 | 2.24±0.012 | 29 | 2.98 | 1.15 |
| 9 | 0.15±0.002 | 70 | 0.02±0.002 | 33 | 0.01±0.000 | 52 | 2.24±0.016 | 29 | 2.88 | 1.10 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 10** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea alata*[a]**

| Time interval (hrs.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.49±0.003[b] | | 0.51±0.015 | | 0.15±0.006 | | 0.63±0.002 | | 8.11 | 2.75 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.45±0.002 | 8 | 0.48±0.013 | 6 | 0.13±0.006 | 13 | 0.61±0.002 | 3 | 8.09 | 2.71 |
| 6 | 0.44±0.002 | 10 | 0.40±0.011 | 22 | 0.10±0.003 | 34 | 0.61±0.002 | 3 | 8.02 | 2.65 |
| 9 | 0.39±0.003 | 20 | 0.32±0.010 | 37 | 0.10±0.001 | 35 | 0.58±0.001 | 8 | 8.00 | 2.60 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.48±0.003 | 2 | 0.50±0.011 | 05 | 0.14±0.003 | 8 | 0.60±0.001 | 5 | 8.10 | 2.74 |
| 6 | 0.40±0.002 | 18 | 0.44±0.010 | 14 | 0.11±0.005 | 26 | 0.58±0.003 | 8 | 8.06 | 2.70 |
| 9 | 0.35±0.002 | 29 | 0.43±0.013 | 16 | 0.09±0.001 | 42 | 0.56±0.001 | 11 | 8.01 | 2.59 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 11** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea bulbifera*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 1.40±0.012[b] | | 1.59±0.014 | | 0.12±0.003 | | 0.98±0.001 | | 1.01 | 0.87 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 1.40±0.009 | 0.21 | 1.56±0.013 | 2 | 0.12±0.003 | 0 | 0.91±0.003 | 7 | 1.00 | 0.86 |
| 6 | 1.35±0.006 | 4 | 1.40±0.009 | 12 | 0.10±0.002 | 17 | 0.88±0.001 | 10 | 0.97 | 0.82 |
| 9 | 1.33±0.003 | 6 | 1.38±0.006 | 14 | 0.08±0.001 | 34 | 0.86±0.001 | 12 | 0.91 | 0.79 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 1.39±0.009 | 0.92 | 1.54±0.003 | 4 | 0.11±0.003 | 8 | 0.94±0.002 | 4 | 1.01 | 0.85 |
| 6 | 1.30±0.003 | 8 | 1.50±0.003 | 6 | 0.10±0.002 | 17 | 0.90±0.001 | 8 | 0.99 | 0.84 |
| 9 | 1.28±0.003 | 9 | 1.45±0.004 | 9 | 0.09±0.003 | 24 | 0.87±0.001 | 11 | 0.95 | 0.80 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 12** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea esculenta*[a]**

| Time interval (hrs.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.56±0.011[b] | | 0.11±0.003 | | 0.19±0.001 | | 0.23±0.001 | | 14.50 | 2.92 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.55±0.010 | 2 | 0.11±0.003 | 0 | 0.17±0.001 | 10 | 0.22±0.001 | 4 | 14.48 | 2.90 |
| 6 | 0.52.±0.010 | 7 | 0.10±0.002 | 10 | 0.15±0.002 | 20 | 0.21±0.002 | 8 | 14.35 | 2.56 |
| 9 | 0.51±0.009 | 9 | 0.08±0.002 | 27 | 0.11±0.002 | 41 | 0.19±0.000 | 18 | 14.29 | 2.49 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.52±0.011 | 7 | 0.10±0.003 | 9 | 0.10±0.002 | 5 | 0.22±0.001 | 4 | 14.49 | 2.81 |
| 6 | 0.50±0.003 | 7 | 0.09±0.001 | 19 | 0.11±0.001 | 42 | 0.21±0.002 | 8 | 14.35 | 2.76 |
| 9 | 0.48±0.008 | 8 | 0.05±0.000 | 56 | 0.09±0.001 | 52 | 0.18±0.001 | 22 | 14.25 | 2.54 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 13** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea oppositifolia*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.28±0.006[b] | | 0.15±0.009 | | 0.11±0.003 | | 0.31±0.003 | | 1.69 | 93.73 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.27±0.003 | 5 | 0.11±0.006 | 27 | 0.09±0.003 | 18 | 0.31±0.002 | 0.32 | 1.69 | 93.70 |
| 6 | 0.25±0.005 | 11 | 0.09±0.003 | 42 | 0.09±0.001 | 19 | 0.28±0.001 | 10 | 1.66 | 93.61 |
| 9 | 0.19±0.006 | 31 | 0.08±0.002 | 48 | 0.05±0.003 | 53 | 0.24±0.002 | 23 | 1.59 | 93.52 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.22±0.003 | 22 | 0.13±0.005 | 15 | 0.08±0.001 | 28 | 0.30±0.003 | 3 | 1.67 | 93.71 |
| 6 | 0.21±0.002 | 26 | 0.11±0.003 | 29 | 0.05±0.002 | 54 | 0.27±0.002 | 13 | 1.62 | 93.65 |
| 9 | 0.15±0.005 | 46 | 0.08±0.003 | 48 | 0.01±0.001 | 90 | 0.25±0.002 | 19 | 1.56 | 93.60 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 14** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea pentaphylla*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.41±0.002[b] | | 0.06±0.001 | | 0.17±0.004 | | 0.33±0.001 | | 1.85 | 2.56 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.41±0.002 | 0 | 0.04±0.001 | 33 | 0.15±0.003 | 12 | 0.31±0.001 | 6 | 1.80 | 2.54 |
| 6 | 0.38±0.002 | 7 | 0.02±0.002 | 64 | 0.11±0.004 | 34 | 0.30±0.001 | 9 | 1.71 | 2.50 |
| 9 | 0.37±0.003 | 9 | 0.01±0.001 | 82 | 0.10±0.001 | 42 | 0.28±0.002 | 15 | 1.62 | 2.48 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.40±0.001 | 3 | 0.06±0.000 | 2 | 0.16±0.004 | 6 | 0.30±0.002 | 9 | 1.83 | 2.53 |
| 6 | 0.35±0.002 | 15 | 0.04±0.001 | 33 | 0.13±0.003 | 24 | 0.27±0.001 | 18 | 1.79 | 2.51 |
| 9 | 0.29±0.003 | 29 | 0.01±0.001 | 82 | 0.10±0.003 | 41 | 0.26±0.001 | 21 | 1.61 | 2.48 |

a Values are the mean of triplicate determinations expressed on dry weight basis

b ± Standard error

**Table 15** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea tomentosa*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.61±0.005[b] | | 0.10±0.001[b] | | 0.14±0.002 | | 0.30±0.004 | | 3.04 | 1.47 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.60±0.003 | 2 | 0.09±0.001 | 10 | 0.11±0.002 | 21 | 0.28±0.001 | 8 | 3.01 | 1.44 |
| 6 | 0.55±0.004 | 10 | 0.05±0.002 | 49 | 0.09±0.001 | 36 | 0.26±0.001 | 14 | 2.91 | 1.40 |
| 9 | 0.53±0.001 | 14 | 0.02±0.001 | 79 | 0.08±0.001 | 43 | 0.22±0.003 | 27 | 2.86 | 1.38 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.60±0.004 | 2 | 0.06±0.001 | 40 | 0.12±0.002 | 14 | 0.29±0.000 | 5 | 3.00 | 1.46 |
| 6 | 0.58±0.001 | 6 | 0.03±0.001 | 69 | 0.11±0.002 | 21 | 0.26±0.002 | 14 | 2.98 | 1.41 |
| 9 | 0.52±0.002 | 15 | 0.01±0.002 | 88 | 0.08±0.001 | 43 | 0.21±0.001 | 31 | 2.82 | 1.32 |

a Values are the mean of triplicate determinations expressed on dry weight basis

b ± Standard error

**Table 16** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea wallichi*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.22±0.003[b] | | 0.02±0.003 | | 0.15±0.012 | | 0.10±0.002 | | 5.07 | 2.10 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.22±0.003 | 0 | 0.01±0.003 | 43 | 0.13±0.010 | 14 | 0.10±0.001 | 1 | 5.04 | 2.09 |
| 6 | 0.11±0.001 | 50 | 0.01±0.003 | 43 | 0.11±0.011 | 25 | 0.08±0.001 | 21 | 5.01 | 2.01 |
| 9 | 0.09±0.002 | 59 | 0.007±0.003 | 57 | 0.09±0.010 | 38 | 0.07±0.002 | 29 | 4.95 | 1.91 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.18±0.001 | 19 | 0.01±0.001 | 52 | 0.12±0.012 | 19 | 0.09±0.002 | 10 | 5.01 | 2.06 |
| 6 | 0.11±0.003 | 49 | 0.008±0.003 | 57 | 0.11±0.011 | 25 | 0.08±0.001 | 21 | 4.91 | 2.03 |
| 9 | 0.10±0.003 | 54 | 0.005±0.002 | 70 | 0.08±0.011 | 44 | 0.08±0.001 | 21 | 4.45 | 1.95 |

a Values are the mean of triplicate determinations expressed on dry weight basis

b ± Standard error

**Table 17** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.46±0.0.002[b] | | 0.14±0.003 | | 0.29±0.001 | | ND | 2.36 | 1.39 |
| Soaking in distilled water | | | | | | | | | |
| 3 | 0.44±0.002 | 4 | 0.11±0.003 | 21 | 0.25±0.001 | 14 | ND | 2.31 | 1.38 |
| 6 | 0.39.±0.001 | 15 | 0.10±0.001 | 29 | 0.20±0.002 | 31 | ND | 2.29 | 1.30 |
| 9 | 0.35±0.001 | 24 | 0.05±0.003 | 63 | 0.18±0.001 | 38 | ND | 2.20 | 1.28 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | |
| 3 | 0.41±0.002 | 11 | 0.13±0.002 | 8 | 0.28±0.001 | 3 | ND | 2.34 | 1.32 |
| 6 | 0.38±0.000 | 18 | 0.11±0.001 | 22 | 0.26±0.000 | 11 | ND | 2.30 | 1.28 |
| 9 | 0.32+0.002 | 30 | 0.09±0.001 | 36 | 0.19±0.001 | 34 | ND | 2.28 | 1.16 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error
ND Not detected

**Table 18** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta* var M-4[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Cyanogens mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.52±0.0.003[b] | | 0.06±0.004 | | 0.30±0.001 | | 0.13±0.003 | | 1.35 | 2.77 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.51±0.003 | 2 | 0.05±0.002 | 19 | 0.27±0.002 | 10 | 0.11±0.001 | 17 | 1.33 | 2.76 |
| 6 | 0.48±0.002 | 8 | 0.01±0.003 | 80 | 0.25±0.000 | 17 | 0.10±0.002 | 23 | 1.31 | 2.71 |
| 9 | 0.44±0.000 | 16 | 0.01±0.003 | 80 | 0.20±0.002 | 33 | 0.09±0.002 | 31 | 1.28 | 2.62 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.50±0.03 | 4 | 0.06±0.003 | 2 | 0.25±0.001 | 17 | 0.12±0.001 | 9 | 1.31 | 2.74 |
| 6 | 0.49±0.002 | 6 | 0.04±0.002 | 34 | 0.23±0.002 | 23 | 0.11±0.001 | 17 | 1.28 | 2.70 |
| 9 | 0.38+0.003 | 27 | 0.01±0.003 | 80 | 0.20±0.001 | 33 | 0.11±0.000 | 17 | 0.19 | 2.68 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 19** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta* var H-226[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.03±0.001[b] | | 0.07±0.003 | | 0.28±0.003 | | ND | 1.35 | 0.21 |
| Soaking in distilled water | | | | | | | | | |
| 3 | 0.03±0.001 | 0 | 0.06±0.003 | 14 | 0.25±0.003 | 11 | ND | 1.30 | 0.19 |
| 6 | 0.01.±0.001 | 65 | 0.04±0.002 | 42 | 0.20±0.001 | 29 | ND | 1.26 | 0.10 |
| 9 | 0.008±0.004 | 61 | 0.01±0.002 | 84 | 0.16±0.003 | 42 | ND | 1.21 | 0.08 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | |
| 3 | 0.02±0.001 | 68 | 0.05±0.003 | 27 | 0.21±0.003 | 25 | ND | 1.33 | 0.20 |
| 6 | 0.01±0.001 | 65 | 0.03±0.001 | 58 | 0.09±0.004 | 95 | ND | 1.31 | 0.18 |
| 9 | 0.01+0.000 | 68 | 0.01±0.001 | 85 | 0.11±0.003 | 60 | ND | 1.26 | 0.11 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error
ND Not detected

**Table 20** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Maranta arundinacea*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.09±0.0.001[b] | | 0.76±0.013 | | 0.05±0.004 | | 0.43±0.008 | | 1.69 | 4.40 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.09±0.001 | 0 | 0.76±0.013 | 0 | 0.04±0.003 | 20 | 0.40±0.008 | 7 | 1.61 | 4.31 |
| 6 | 0.08.±0.000 | 12 | 0.73±0.010 | 4 | 0.02±0.001 | 61 | 0.38±0.006 | 12 | 1.58 | 4.28 |
| 9 | 0.05±0.001 | 44 | 0.69±0.009 | 10 | 0.01±0.003 | 76 | 0.31±0.003 | 29 | 1.45 | 4.01 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.09±0.001 | 0 | 0.75±0.013 | 1 | 0.03±0.004 | 37 | 0.41±0.006 | 5 | 1.66 | 4.36 |
| 6 | 0.09±0.000 | 1 | 0.71±0.010 | 7 | 0.01±0.003 | 76 | 0.39±0.003 | 10 | 1.51 | 4.21 |
| 9 | 0.06±0.000 | 34 | 0.68±0.011 | 11 | 0.009±0.001 | 81 | 0.37±0.006 | 14 | 1.42 | 4.18 |

a Values are the mean of triplicate determinations expressed on dry weight basis

b ± Standard error

**Table 21** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Xanthosoma sagittifolium*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.16±0.002[b] | | 0.13±0.002 | | 0.11±.001 | | 1.60±0.002 | | 3.04 | 13.88 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.13±0.002 | 19 | 0.11±0.002 | 15 | 0.10±0.000 | 10 | 1.58±0.003 | 1 | 3.01 | 13.81 |
| 6 | 0.11.±0.001 | 31 | 0.10±0.001 | 23 | 0.08±0.003 | 25 | 1.56±0.002 | 3 | 2.96 | 13.65 |
| 9 | 0.10±0.000 | 38 | 0.08±0.001 | 39 | 0.05±0.005 | 50 | 1.50±0.002 | 6 | 2.82 | 13.49 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.16±0.002 | 0 | 0.12±0.002 | 8 | 0.10±0.001 | 9 | 1.58±0.004 | 1 | 3.02 | 13.78 |
| 6 | 0.13±0.003 | 18 | 0.10±0.001 | 23 | 0.06±0.001 | 45 | 1.55±0.001 | 3 | 2.91 | 13.61 |
| 9 | 0.12±0.001 | 25 | 0.09±0.000 | 32 | 0.05±0.003 | 52 | 1.49±0.002 | 7 | 2.85 | 13.52 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 22** **Effect of soaking on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Xanthosoma violaceum*[a]**

| Time interval (hrs) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.03±0.001[b] | | 1.31±0.004 | | 0.06±.003 | | 0.83±0.001 | | 0.18 | 2.40 |
| Soaking in distilled water | | | | | | | | | | |
| 3 | 0.03±0.001 | 0 | 1.30±0.004 | 1 | 0.04±0.002 | 33 | 0.80±0.001 | 4 | 0.17 | 2.35 |
| 6 | 0.02.±0.000 | 35 | 1.28±0.001 | 3 | 0.03±0.003 | 48 | 0.79±0.001 | 5 | 0.12 | 2.31 |
| 9 | 0.02±0.001 | 32 | 1.27±0.001 | 3 | 0.01±0.001 | 83 | 0.75±0.000 | 10 | 0.09 | 2.28 |
| Soaking in Sodium bicarbonate solution | | | | | | | | | | |
| 3 | 0.02±0.00 | 32 | 0.29±0.003 | 78 | 0.03±0.003 | 48 | 0.81±0.001 | 2 | 0.16 | 2.38 |
| 6 | 0.01±0.001 | 65 | 0.25±0.001 | 81 | 0.01±0.001 | 83 | 0.79±0.001 | 5 | 0.14 | 2.31 |
| 9 | 0.008±0.001 | 71 | 0.24±0.001 | 82 | 0.009±0.001 | 84 | 0.78±0.002 | 6 | 0.11 | 2.26 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

*D. wallichi, Xanthosoma violaceum* and *Manihot esculenta* var. M-4 when compared with raw samples.

Soaking in distilled water for 9 hours showed above 50% reduction in the level of hydrogen cyanide content in the currently investigated samples of *Alocasia macrorrhiza, Canna indica, Dioscorea esculenta, D. oppositifolia, Maranta arundinacea, Xanthosoma sagittifolium* and *X. violaceum* whereas soaking in sodium bicarbonate solution (0.02 % w/v) for 9 hours with above 80% reduction in the content of cyanogens was reported in *Dioscorea oppositifolia, Maranta arundinacea* and *Xanthosoma violaceum.*

25 % reduction in total oxalate content was observed while soaking in distilled water for 9 hours in *Alocasia macrorrhiza, Canna indica, Dioscorea tomentosa, D. wallichi* and *Manihot esculenta* var. $M_4$. Soaking in Sodium bicarbonate solution (0.02% w/v) for 9 hrs. showed 25% decrease in the total oxalate content in *Alocasia macrorrhiza, Amorphophallus campanulatus, Canna indica* and *Dioscorea tomentosa.*

Soaking in distilled water and $NaHCO_3$ solution (0.02% w/v) in all the presently investigated samples showed only slight decrease in the level of amylase and trypsin inhibitor content.

**Cooking and autoclaving**

The data on the effect of cooking and autoclaving in different time intervals on the levels of the selected anti-nutrients in *Alocasia macrorrhiza, Amorphophallus campanulatus, Canna indica, Dioscorea alata, D. bulbifera,*

*D. esculenta, D. wallichi, Manihot esculenta, M. esculenta* var. M-4, *M. esculenta* var H-226, *Maranta arundinacea, Xanthosoma sagittifolium* and *Xanthosoma violaceum* are presented in tables (23-38) respectively.

Cooking for 90 minutes showed 80% decrease in total free phenolics content in *Amorphophallus campanulatus, Dioscorea oppositifolia, D. wallichi, Maranta arundinacea* and *Xanthosoma violaceum.*

Autoclaving for 45 minutes showed 90% reduction in total free phenolics content in *Amorphophallus campanulatus, Canna indica* and *Xanthosoma violaceum.*

Cooking for 90 minutes showed 80% reduction in the tannin content in *Amorphophallus campanulatus, Dioscorea pentaphylla, D. tomentosa, D. wallichi, Manihot esculenta, M. esculenta* var H-226, *Xanthosoma sagittifolium* and *X. violaceum.* Autoclaving for 45 minutes showed 90% decrease in tannin content in *Dioscorea esculenta, D. tomentosa, Manihot esculenta* var. M-4, *Xanthosoma sagittifolium* and *X. violaceum.*

Cooking for 90 minutes showed 80% reduction in the hydrogen cyanide content of *Amorphophallus campanulatus, Dioscorea oppositifolia* and *Xanthosoma violaceum.*

Autoclaving for 45 minutes showed 90% decrease in the hydrogen cyanide content in *Alocasia macrorrhiza, Amorphophallus campanulatus, Dioscorea bulbifera, D. oppositifolia* and *D. wallichi.*

**Table 23** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Alocasia macrorrhiza*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 0.83±0.003[b] | | 0.62±0.013 | | 0.13±0.012 | | 0.93±0.003 | | 10.80 | 12.31 |
| Cooking | | | | | | | | | | |
| 30 | 0.69±0.002 | 17 | 0.58±0.003 | 8 | 0.10±0.000 | 30 | 0.56±0.004 | 40 | 10.76 | 12.28 |
| 60 | 0.61±0.002 | 27 | 0.50±0.001 | 21 | 0.06±0.006 | 54 | 0.42±0.003 | 55 | 10.72 | 12.20 |
| 90 | 0.56±0.000 | 33 | 0.48±0.002 | 24 | 0.01±0.003 | 91 | 0.33±0.000 | 65 | 10.61 | 12.16 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.70±0.003 | 16 | 0.51±0.004 | 19 | 0.08±0.004 | 41 | 0.53±0.006 | 43 | 10.73 | 12.29 |
| 30 | 0.60±0.002 | 28 | 0.42±0.002 | 33 | 0.02±0.002 | 85 | 0.40±0.000 | 57 | 10.63 | 12.19 |
| 45 | 0.49±0.000 | 41 | 0.38±0.000 | 40 | 0.009±0.000 | 94 | 0.31±0.001 | 67 | 10.59 | 12.10 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 24** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Amorphophallus campanulatus*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 1.19±0.015[b] | | 1.34±0.012[b] | | 0.12±0.002 | | 2.39±0.012 | | 6.08 | 0.28 |
| Cooking | | | | | | | | | | |
| 30 | 1.15±0.009 | 4 | 1.30±0.011 | 3 | 0.09±0.001 | 25 | 2.35±0.011 | 2 | 6.06 | 0.25 |
| 60 | 0.10±0.011 | 91 | 1.25±0.012 | 7 | 0.06±0.010 | 43 | 2.34±0.012 | 2 | 6.00 | 0.22 |
| 90 | 0.08±0.009 | 93 | 0.20±0.010 | 84 | 0.01±0.004 | 89 | 2.30±0.004 | 4 | 5.91 | 0.19 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.15±0.011 | 87 | 1.29±0.012 | 4 | 0.06±0.001 | 50 | 2.38±0.011 | 0.5 | 6.07 | 0.27 |
| 30 | 0.09±0.009 | 92 | 1.24±0.011 | 7 | 0.03±0.000 | 75 | 2.34±0.002 | 3 | 6.02 | 0.21 |
| 45 | 0.05±0.008 | 95 | 1.19±0.001 | 12 | 0.009±0.001 | 92 | 2.31±0.004 | 4 | 6.00 | 0.18 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 25** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Canna indica*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 0.50±0.004[b] | | 0.03±0.003 | | 0.02±0.001 | | 3.15±0.039 | | 3.04 | 1.20 |
| Cooking | | | | | | | | | | |
| 30 | 0.21±0.001 | 58 | 0.02±0.001 | 36 | 0.02±0.000 | 5 | 3.10±0.003 | 3 | 3.01 | 1.18 |
| 60 | 0.20±0.000 | 60 | 0.02±0.001 | 39 | 0.01±0.003 | 38 | 3.08±0.012 | 3 | 2.98 | 1.12 |
| 90 | 0.15±0.003 | 70 | 0.01±0.000 | 67 | 0.006±0.000 | 71 | 3.08±0.010 | 3 | 2.92 | 1.00 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.18±0.004 | 63 | 0.02±0.003 | 30 | 0.01±0.001 | 48 | 3.11±0.001 | 2 | 3.03 | 1.16 |
| 30 | 0.07±0.001 | 86 | 0.01±0.001 | 67 | 0.009±0.001 | 52 | 3.08±0.030 | 2 | 3.00 | 1.11 |
| 45 | 0.03±0.001 | 94 | 0.01±0.000 | 70 | 0.006±0.002 | 62 | 3.02±0.010 | 5 | 2.91 | 1.08 |

a Values are mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 26** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea alata*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 049±0.003[b] | | 0.51±0.015 | | 0.15±0.006 | | 0.63±0.002 | | 8.11 | 2.75 |
| Cooking | | | | | | | | | | |
| 30 | 0.44±0.002 | 10 | 0.46±0.014 | 8 | 0.11±0.000 | 29 | 0.61±0.003 | 3 | 8.09 | 2.71 |
| 60 | 0.20±0.001 | 59 | 0.40±0.009 | 22 | 0.09±0.002 | 41 | 0.58±0.005 | 7 | 8.00 | 2.65 |
| 90 | 0.19±0.002 | 61 | 0.36±0.010 | 30 | 0.04±0.001 | 74 | 0.52±0.002 | 17 | 7.89 | 2.51 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.40±0.003 | 18 | 0.44±0.001 | 16 | 0.13±0.002 | 15 | 0.60±0.002 | 4 | 8.10 | 2.70 |
| 30 | 0.18±0.002 | 63 | 0.40±0.004 | 23 | 0.08±0.004 | 46 | 0.56±0.000 | 11 | 8.05 | 2.59 |
| 45 | 0.16±0.001 | 67 | 0.31±0.010 | 39 | 0.02±0.001 | 87 | 0.55±0.002 | 13 | 7.91 | 2.45 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 27** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea bulbifera*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 1.40±0.012[b] | | 1.59±0.014 | | 0.12±0.003 | | 0.98±0.001 | | 1.01 | 0.87 |
| Cooking | | | | | | | | | | |
| 30 | 1.35±0.010 | 4 | 1.52±0.010 | 5 | 0.09±0.001 | 26 | 0.95±0.003 | 3 | 1.00 | 0.81 |
| 60 | 0.60±0.004 | 57 | 1.48±0.004 | 7 | 0.08±0.004 | 32 | 0.91±0.001 | 7 | 0.88 | 0.80 |
| 90 | 0.38±0.001 | 73 | 1.42±0.012 | 11 | 0.03±0.001 | 75 | 0.82±0.001 | 16 | 0.81 | 0.78 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.99±0.004 | 30 | 1.49±0.010 | 6 | 0.06±0.004 | 48 | 0.92±0.001 | 6 | 0.99 | 0.84 |
| 30 | 0.50±0.010 | 64 | 1.43±0.004 | 11 | 0.02±0.002 | 82 | 0.89±0.000 | 9 | 0.87 | 0.78 |
| 45 | 0.35±0.001 | 75 | 1.39±0.001 | 13 | 0.008±0.001 | 93 | 0.80±0.003 | 18 | 0.80 | 0.75 |

a Values are the mean of triplicate determinations expressed on dry weight basis

b ± Standard error

**Table 28** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea esculenta*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.56±0.011[b] | | 0.11±0.003 | | 0.19±0.001 | | 0.23±0.001 | | 14.50 | 2.92 |
| Cooking | | | | | | | | | | |
| 30 | 0.41±0.012 | 26 | 0.09±0.006 | 15 | 0.17±0.002 | 10 | 0.20±0.002 | 13 | 14.47 | 2.90 |
| 60 | 0.26±0.009 | 53 | 0.05±0.001 | 55 | 0.12±0.001 | 37 | 0.16±0.006 | 28 | 14.42 | 2.88 |
| 90 | 0.16±0.006 | 71 | 0.03±0.010 | 65 | 0.09±0.007 | 49 | 0.09±0.001 | 61 | 14.38 | 2.75 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.30±0.001 | 47 | 0.06±0.009 | 39 | 0.09±0.002 | 52 | 0.19±0.001 | 17 | 14.46 | 2.89 |
| 30 | 0.24±0.002 | 58 | 0.03±0.003 | 71 | 0.06±0.003 | 67 | 0.12±0.001 | 48 | 14.41 | 2.81 |
| 45 | 0.19±0.010 | 65 | 0.01±0.000 | 91 | 0.03±0.001 | 84 | 0.08±0.000 | 65 | 14.36 | 2.78 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 29** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea oppositifolia*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 0.28±0.006[b] | | 0.15±0.009 | | 0.11±0.003 | | 0.31±0.003 | | 1.69 | 93.73 |
| Cooking | | | | | | | | | | |
| 30 | 0.22±0.002 | 22 | 0.13±0.005 | 15 | 0.08±0.001 | 28 | 0.29±0.001 | 7 | 1.67 | 93.70 |
| 60 | 0.08±0.006 | 70 | 0.09±0.002 | 42 | 0.02±0.003 | 80 | 0.22±0.004 | 28 | 1.60 | 93.68 |
| 90 | 0.05±0.001 | 82 | 0.06±0.002 | 61 | 0.009±0.002 | 90 | 0.19±0.001 | 39 | 1.52 | 93.61 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.14±0.003 | 50 | 0.11±0.003 | 29 | 0.06±0.002 | 45 | 0.30±0.003 | 3 | 1.69 | 93.71 |
| 30 | 0.09±0.005 | 67 | 0.08±0.001 | 49 | 0.03±0.001 | 73 | 0.22±0.002 | 29 | 1.61 | 93.62 |
| 45 | 0.06±0.001 | 79 | 0.05±0.000 | 69 | 0.006±0.001 | 94 | 0.18±0.000 | 42 | 1.59 | 93.58 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 30** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea pentaphylla*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 0.41±0.002[b] | | 0.06±0.001 | | 0.17±0.004 | | 0.33±0.001 | | 1.85 | 2.56 |
| Cooking | | | | | | | | | | |
| 30 | 0.35±0.002 | 15 | 0.02±0.002 | 64 | 0.13±0.003 | 24 | 0.30±0.002 | 9 | 1.80 | 2.54 |
| 60 | 0.26±0.001 | 37 | 0.01±0.001 | 82 | 0.09±0.004 | 46 | 0.21±0.005 | 35 | 1.73 | 2.48 |
| 90 | 0.24±0.007 | 41 | 0.008±0.002 | 84 | 0.02±0.002 | 87 | 0.20±0.001 | 39 | 1.70 | 2.45 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.33±0.004 | 19 | 0.03±0.001 | 49 | 0.12±0.004 | 29 | 0.32±0.001 | 3 | 1.82 | 2.55 |
| 30 | 0.19±0.002 | 53 | 0.01±0.001 | 82 | 0.05±0.001 | 71 | 0.28±0.004 | 14 | 1.76 | 2.48 |
| 45 | 0.15±0.001 | 63 | 0.006±0.002 | 87 | 0.03±0.002 | 81 | 0.21±0.002 | 36 | 1.60 | 2.41 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 31** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea tomentosa*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.61±0.005[b] | | 0.10±0.001 | | 0.14±0.002 | | 0.30±0.004 | | 3.04 | 1.47 |
| Cooking | | | | | | | | | | |
| 30 | 0.56±0.003 | 8 | 0.08±0.001 | 20 | 0.12±0.003 | 13 | 0.26±0.003 | 13 | 3.00 | 1.44 |
| 60 | 0.48±0.002 | 22 | 0.03±0.002 | 68 | 0.10±0.003 | 27 | 0.22±0.001 | 27 | 2.95 | 1.40 |
| 90 | 0.44±0.005 | 28 | 0.01±0.001 | 89 | 0.05±0.002 | 63 | 0.20±0.001 | 34 | 2.91 | 1.38 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.52±0.003 | 15 | 0.06±0.002 | 39 | 0.13±0.001 | 8 | 0.25±0.002 | 17 | 3.03 | 1.46 |
| 30 | 0.40±0.001 | 35 | 0.03±0.004 | 66 | 0.06±0.00 | 56 | 0.20±0.001 | 34 | 3.00 | 1.41 |
| 45 | 0.32±0.007 | 47 | 0.01±0.000 | 90 | 0.02±0.001 | 85 | 0.18±0.001 | 40 | 2.98 | 1.35 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 32** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Dioscorea wallichi*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Sample | 0.22±0.003[b] | | 0.02±0.003 | | 0.15±0.012 | | 0.10±0.002 | | 5.07 | 2.10 |
| Cooking | | | | | | | | | | |
| 30 | 0.11±0.008 | 47 | 0.009±0.001 | 57 | 0.12±0.010 | 20 | 0.08±0.006 | 16 | 5.03 | 2.08 |
| 60 | 0.06±0.004 | 71 | 0.005±0.010 | 35 | 0.09±0.012 | 37 | 0.02±0.001 | 79 | 5.00 | 2.06 |
| 90 | 0.03±0.001 | 86 | 0.002±0.002 | 83 | 0.05±0.004 | 67 | 0.007±0.002 | 91 | 4.97 | 2.00 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.10±0.001 | 55 | 0.01±0.003 | 43 | 0.13±0.012 | 12 | 0.07±0.004 | 27 | 5.01 | 2.06 |
| 30 | 0.05±0.004 | 76 | 0.004±0.005 | 61 | 0.09±0.006 | 41 | 0.04±0.002 | 59 | 4.98 | 2.00 |
| 45 | 0.03±0.002 | 86 | 0.001±0.003 | 83 | 0.01±0.001 | 93 | 0.009±0.003 | 88 | 4.91 | 1.98 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 33** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg/$100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.52±0.003[b] | | 0.06±0.004 | | 0.30±0.001 | | 0.13±0.003 | | 1.35 | 2.77 |
| Cooking | | | | | | | | | | |
| 30 | 0.48±0.001 | 8 | 0.03±0.001 | 52 | 0.25±0.006 | 15 | 0.11±0.001 | 17 | 1.30 | 2.74 |
| 60 | 0.25±0.005 | 51 | 0.01±0.003 | 80 | 0.19±0.003 | 36 | 0.08±0.003 | 38 | 1.27 | 2.68 |
| 90 | 0.15±0.007 | 70 | 0.006±0.001 | 89 | 0.10±0.001 | 66 | 0.01±0.006 | 88 | 1.24 | 2.61 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.46±0.002 | 12 | 0.05±0.003 | 17 | 0.24±0.001 | 20 | 0.09±0.003 | 30 | 1.34 | 2.76 |
| 30 | 0.22±0.001 | 58 | 0.03±0.002 | 50 | 0.15±0.003 | 49 | 0.03±0.001 | 77 | 1.31 | 2.71 |
| 45 | 0.13±0.006 | 73 | 0.01±0.004 | 78 | 0.09±0.000 | 70 | 0.009±0.002 | 92 | 1.28 | 2.68 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 34** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta* var M-4[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.46±0.002[b] | | 0.14±0.003 | | 0.29±0.001 | | ND | 2.36 | 1.39 |
| Cooking | | | | | | | | | |
| 30 | 0.36±0.002 | 22 | 0.11±0.003 | 21 | 0.25±0.010 | 11 | ND | 2.36 | 1.38 |
| 60 | 0.29±0.004 | 36 | 0.08±0.001 | 43 | 0.18±0.009 | 35 | ND | 2.32 | 1.33 |
| 90 | 0.19±0.002 | 58 | 0.02±0.011 | 78 | 0.10±0.003 | 65 | ND | 2.24 | 1.30 |
| Autoclaving | | | | | | | | | |
| 15 | 0.32±0.001 | 31 | 0.10±0.007 | 26 | 0.21±0.010 | 24 | ND | 2.33 | 1.37 |
| 30 | 0.28±0.010 | 37 | 0.06±0.003 | 56 | 0.15±0.003 | 47 | ND | 2.30 | 1.31 |
| 45 | 0.16±0.006 | 64 | 0.009±0.001 | 93 | 0.12±0.001 | 58 | ND | 2.26 | 1.28 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

ND-Not detected.

**Table 35** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Manihot esculenta* var H-226[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g$100g^{-1}$ | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.03±0.001[b] | | 0.07±0.003 | | 0.28±0.003 | | ND | 1.35 | 0.21 |
| Cooking | | | | | | | | | |
| 30 | 0.02±0.010 | 3 | 0.04±0.002 | 42 | 0.24±0.002 | 14 | ND | 1.33 | 0.20 |
| 60 | 0.01±0.002 | 61 | 0.006±0.003 | 88 | 0.21±0.003 | 25 | ND | 1.30 | 0.18 |
| 90 | 0.004±0.009 | 58 | 0.002±0.001 | 96 | 0.18±0.010 | 33 | ND | 1.28 | 0.11 |
| Autoclaving | | | | | | | | | |
| 15 | 0.01±0.001 | 65 | 0.03±0.001 | 58 | 0.20±0.006 | 27 | ND | 1.34 | 0.19 |
| 30 | 0.006±0.002 | 74 | 0.01±0.003 | 82 | 0.16±0.003 | 42 | ND | 1.31 | 0.17 |
| 45 | 0.002±0.006 | 74 | 0.006±0.002 | 89 | 0.12±0.00 | 57 | ND | 1.28 | 0.10 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

ND-Not detected.

**Table 36** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Maranta arundinacea*[a]**

| Time interval (in min.) | Total free phenolics g/100g$^{-1}$ | % loss | Tannins g/100g$^{-1}$ | % loss | Hydrogen cyanide mg/100g$^{-1}$ | % loss | Total oxalate g/100g$^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.09±0.001[b] | | 0.76±0.013 | | 0.05±0.004 | | 0.43±0.008 | | 1.69 | 4.40 |
| Cooking | | | | | | | | | | |
| 30 | 0.05±0.003 | 42 | 0.72±0.010 | 6 | 0.03±0.006 | 33 | 0.39±0.006 | 10 | 1.64 | 4.38 |
| 60 | 0.04±0.002 | 54 | 0.69±0.007 | 10 | 0.02±0.002 | 59 | 0.33±0.010 | 22 | 1.60 | 4.34 |
| 90 | 0.01±0.001 | 88 | 0.56±0.001 | 27 | 0.01±0.001 | 80 | 0.28±0.002 | 36 | 1.57 | 4.28 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.06±0.001 | 33 | 0.62±0.009 | 19 | 0.04±0.011 | 6 | 0.33±0.008 | 23 | 1.66 | 4.40 |
| 30 | 0.03±0.000 | 67 | 0.60±0.006 | 22 | 0.02±0.002 | 59 | 0.28±0.002 | 36 | 1.62 | 4.36 |
| 45 | 0.01±0.002 | 87 | 0.52±0.002 | 32 | 0.01±0.001 | 80 | 0.20±0.000 | 54 | 1.58 | 4.31 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 37** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Xanthosoma sagittifolium*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.16±0.002[b] | | 0.13±0.002 | | 0.11±0.001 | | 1.60±0.002 | | 3.04 | 13.88 |
| Cooking | | | | | | | | | | |
| 30 | 0.12±0.002 | 25 | 0.09±0.002 | 30 | 0.09±0.010 | 10 | 1.29±0.001 | 19 | 3.00 | 13.84 |
| 60 | 0.06±0.001 | 62 | 0.03±0.003 | 75 | 0.07±0.006 | 32 | 1.21±0.006 | 24 | 2.91 | 13.81 |
| 90 | 0.04±0.003 | 73 | 0.01±0.004 | 89 | 0.03±0.004 | 69 | 1.10±0.003 | 31 | 2.86 | 13.75 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.13±0.001 | 20 | 0.10±0.010 | 17 | 0.09±0.006 | 14 | 1.50±0.002 | 6 | 3.01 | 13.87 |
| 30 | 0.10±0.002 | 37 | 0.07±0.002 | 45 | 0.05±0.002 | 53 | 1.20±0.005 | 25 | 2.99 | 13.80 |
| 45 | 0.05±0.000 | 69 | 0.01±0.001 | 92 | 0.01±0.004 | 87 | 1.09±0.001 | 32 | 2.84 | 13.71 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

**Table 38** **Effect of cooking and autoclaving on the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity in *Xanthosoma violaceum*[a]**

| Time interval (in min.) | Total free phenolics g $100g^{-1}$ | % loss | Tannins g $100g^{-1}$ | % loss | Hydrogen cyanide mg $100g^{-1}$ | % loss | Total oxalate g $100g^{-1}$ | % loss | Amylase inhibitor activity AIU | Trypsin inhibitor activity TIU |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw sample | 0.03±0.001[b] | | 1.31±0.004 | | 0.06±0.003 | | 0.83±0.001 | | 0.18 | 2.40 |
| Cooking | | | | | | | | | | |
| 30 | 0.01±0.002 | 61 | 1.25±0.001 | 5 | 0.03±0.001 | 51 | 0.79±0.003 | 5 | 0.16 | 2.31 |
| 60 | 0.008±0.001 | 71 | 0.19±0.003 | 85 | 0.01±0.004 | 78 | 0.68±0.001 | 18 | 0.12 | 2.28 |
| 90 | 0.005±0.001 | 81 | 0.12±0.004 | 91 | 0.006±0.003 | 86 | 0.59±0.006 | 28 | 0.09 | 2.21 |
| Autoclaving | | | | | | | | | | |
| 15 | 0.02±0.001 | 32 | 0.29±0.002 | 78 | 0.05±0.002 | 17 | 0.76±0.001 | 8 | 0.18 | 2.38 |
| 30 | 0.008±0.002 | 68 | 0.15±0.004 | 88 | 0.02±0.003 | 63 | 0.70±0.005 | 15 | 0.16 | 2.35 |
| 45 | 0.002±0.001 | 90 | 0.11±0.001 | 92 | 0.003±0.000 | 52 | 0.62±0.006 | 25 | 0.10 | 2.29 |

a Values are the mean of triplicate determinations expressed on dry weight basis
b ± Standard error

*Alocasia macrorrhiza*, *Dioscorea esculenta*, *D. wallichi* and *Manihot esculenta* showed 60% reduction in total oxalate content when cooked for 90 minutes.

Autoclaving for 45 minutes showed 65% decrease in total oxalate content in *Alocasia macrorrhiza*, *Dioscorea esculenta*, *D. wallichi* and *Manihot esculenta.*

It was found that the tubers of *Manihot esculenta* var. M-4 and *M.esculenta* var H-226 do not have oxalates.

Cooking and autoclaving of all the investigated samples showed only slight reduction in the level of amylase inhibitor and trypsin inhibitor activity.

*In vitro* protein digestibility and *in vitro* starch digestibility in the raw and treated samples are presented in tables (39-54).

Autoclaving for 45 minutes showed increased rate of the *in vitro* protein digestibility and *in vitro* starch digestibility of all the presently investigated samples than other treatments.

**Table 39** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Alocasia macrorrhiza***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 3.78 | -- | 72.10 | -- |
| Soaking in distilled water for 9 hours | 3.89 | 3 | 75.00 | 4 |
| Soaking in $NaHCO_3$ solution for 9 hours | 3.90 | 3 | 78.80 | 8 |
| Cooking in boiling water for 90 min. | 4.22 | 12 | 83.60 | 16 |
| Autoclaving for 45 min. | 4.50 | 19 | 85.72 | 19 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 40** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Amorphophallus campanulatus***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.28 | | 53.36 | -- |
| Soaking in distilled water for 9 hours | 6.15 | 16 | 55.10 | 3 |
| Soaking in $NaHCO_3$ solution for 9 hours | 7.08 | 34 | 59.08 | 11 |
| Cooking in boiling water for 90 min. | 7.38 | 39 | 63.00 | 18 |
| Autoclaving for 45 min. | 7.97 | 51 | 70.10 | 31 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 41** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Canna indica***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.55 | | 78.21 | |
| Soaking in distilled water for 9 hours | 5.92 | 7 | 81.90 | 5 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.35 | 14 | 85.00 | 9 |
| Cooking in boiling water for 90 min. | 8.28 | 49 | 88.12 | 13 |
| Autoclaving for 45 min. | 9.00 | 62 | 90.00 | 15 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 42** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea alata***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 6.02 | | 30.14 | |
| Soaking in distilled water for 9 hours | 6.59 | 9 | 32.08 | 6 |
| Soaking in $NaHCO_3$ solution for 9 hours | 7.21 | 20 | 35.12 | 17 |
| Cooking in boiling water for 90 min. | 9.86 | 64 | 46.59 | 55 |
| Autoclaving for 45 min. | 10.63 | 77 | 60.20 | 100 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 43** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea bulbifera***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 4.83 | | 157.64 | |
| Soaking in distilled water for 9 hours | 5.25 | 9 | 162.00 | 3 |
| Soaking in $NaHCO_3$ solution for 9 hours | 5.92 | 23 | 185.20 | 17 |
| Cooking in boiling water for 90 min. | 7.08 | 47 | 197.18 | 25 |
| Autoclaving for 45 min. | 8.95 | 85 | 205.85 | 31 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 44** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea esculenta***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 6.74 | | 44.40 | |
| Soaking in distilled water for 9 hours | 7.00 | 4 | 45.20 | 2 |
| Soaking in $NaHCO_3$ solution for 9 hours | 8.65 | 28 | 50.60 | 14 |
| Cooking in boiling water for 90 min. | 9.28 | 38 | 59.82 | 35 |
| Autoclaving for 45 min. | 10.02 | 49 | 60.28 | 36 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 45** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea oppositifolia***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of Protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.93 | | 120.16 | |
| Soaking in distilled water for 9 hours | 7.21 | 22 | 128.01 | 7 |
| Soaking in $NaHCO_3$ solution for 9 hours | 7.88 | 33 | 157.25 | 31 |
| Cooking in boiling water for 90 min. | 9.26 | 56 | 182.61 | 52 |
| Autoclaving for 45 min. | 10.70 | 80 | 190.50 | 59 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 46** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea pentaphylla***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of Protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.86 | | 38.21 | |
| Soaking in distilled water for 9 hours | 6.00 | 2 | 40.60 | 6 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.85 | 17 | 42.92 | 12 |
| Cooking in boiling water for 90 min. | 8.62 | 47 | 50.01 | 31 |
| Autoclaving for 45 min. | 9.10 | 55 | 58.95 | 54 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 47** ***In vitro*** **protein digestibility and** ***in vitro*** **starch digestibility in raw and treated samples of** ***Dioscorea tomentosa***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 4.64 | | 87.60 | |
| Soaking in distilled water for 9 hours | 5.00 | 8 | 89.22 | 2 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.08 | 31 | 90.80 | 4 |
| Cooking in boiling water for 90 min. | 7.62 | 64 | 95.00 | 8 |
| Autoclaving for 45 min. | 9.18 | 98 | 99.08 | 13 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 48** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Dioscorea wallichi***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.17 | | 57.84 | |
| Soaking in distilled water for 9 hours | 6.63 | 28 | 60.12 | 4 |
| Soaking in $NaHCO_3$ solution for 9 hours | 8.90 | 72 | 69.03 | 19 |
| Cooking in boiling water for 90 min. | 10.65 | 106 | 76.22 | 32 |
| Autoclaving for 45 min. | 11.20 | 117 | 79.60 | 38 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 49** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Manihot esculenta***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.36 | | 54.18 | |
| Soaking in distilled water for 9 hours | 6.28 | 17 | 56.22 | 4 |
| Soaking in $NaHCO_3$ solution for 9 hours | 7.60 | 42 | 60.10 | 11 |
| Cooking in boiling water for 90 min. | 10.82 | 102 | 66.12 | 22 |
| Autoclaving for 45 min. | 11.36 | 112 | 75.29 | 39 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 50** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Manihot esculenta* var. M-4**

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 6.03 | | 74.95 | |
| Soaking in distilled water for 9 hours | 7.00 | 16 | 78.20 | 4 |
| Soaking in $NaHCO_3$ solution for 9 hours | 7.93 | 32 | 80.80 | 8 |
| Cooking in boiling water for 90 min. | 8.56 | 42 | 88.65 | 18 |
| Autoclaving for 45 min. | 10.68 | 77 | 93.26 | 24 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Ttable 51** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Manihot esculenta* var. H-226**

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.57 | | 176.37 | |
| Soaking in distilled water for 9 hours | 5.98 | 7 | 178.03 | 1 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.60 | 18 | 181.00 | 3 |
| Cooking in boiling water for 90 min. | 9.28 | 67 | 195.35 | 11 |
| Autoclaving for 45 min. | 10.00 | 80 | 208.50 | 18 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 52** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Maranta arundinacea***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 4.38 | | 6.12 | |
| Soaking in distilled water for 9 hours | 4.98 | 14 | 7.00 | 14 |
| Soaking in $NaHCO_3$ solution for 9 hours | 5.60 | 28 | 7.63 | 25 |
| Cooking in boiling water for 90 min. | 6.25 | 43 | 8.15 | 33 |
| Autoclaving for 45 min. | 7.00 | 60 | 9.92 | 62 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 53** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Xanthosoma sagittifolium***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility units[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.09 | | 118.94 | |
| Soaking in distilled water for 9 hours | 6.00 | 18 | 120.26 | 1 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.52 | 28 | 122.67 | 3 |
| Cooking in boiling water for 90 min. | 8.08 | 59 | 158.82 | 34 |
| Autoclaving for 45 min. | 8.75 | 72 | 169.96 | 43 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

**Table 54** ***In vitro* protein digestibility and *in vitro* starch digestibility in raw and treated samples of *Xanthosoma violaceum***

| Treatment | *In vitro* protein digestibility units[a] | Percentage increase of protein digestibility | *In vitro* starch digestibility unit[b] | Percentage increase of starch digestibility |
|---|---|---|---|---|
| Raw | 5.69 | | 97.35 | |
| Soaking in distilled water for 9 hours | 6.28 | 10 | 99.52 | 2 |
| Soaking in $NaHCO_3$ solution for 9 hours | 6.87 | 21 | 108.03 | 11 |
| Cooking in boiling water for 90 min. | 7.29 | 28 | 125.58 | 29 |
| Autoclaving for 45 min. | 8.00 | 41 | 129.07 | 33 |

a -1Unit = g aminoacid released per 100 g tubers (DM basis)

b -1 Unit = mg reducing groups/hr/g sample.

# DISCUSSION

# DISCUSSION

## I. Wild Edible Plants

The present study indicates the nutritional value of the wild edible tubers/ corms/ rhizomes used by the Kanikkar tribals in South-Eastern slopes of the Western Ghats (Vide area Map), Tamil Nadu, India. Various ethological and anthropological surveys conducted in India has brought to light a number of wild plant species which are used by the various ethnic societies of India, but their edible properties and nutritional requirements were not known to the modern civilization. Against this backdrop, in the present study 16 wild edible tubers/ corm/ rhizome were collected and subjected to chemical analyses (Table 1).

Among the 16 edible plants there are 11 tubers, 3 corms and 2 rhizomes consumed by the tribal Kanikkars (Table 2). The tubers/corms/rhizomes are known to be consumed not only by the Kanikkars but also by several other tribals. *Dioscorea bulbifera* and *D. pentaphylla* are consumed by the tribes of Ratan Mahal Hills, Gujarat (Bedi, 1978). The tubers of *Dioscorea bulbifera*, *D. oppositifolia* and *D. pentaphylla* are consumed by the Bhuinya and Juang tribes of Orissa (Mondal and Mukherjee, 1992) and the tribes of Western Maharashtra (Nilegaonkar *et al.*, 1985). The tubers of *Dioscorea oppositifolia* and *D. pentaphylla* are consumed by the tribals of Susala Island, Pune district, Maharashtra (Vartak and Suryanarayana, 1995). The tubers of *Dioscorea esculenta* is consumed by Jinuo tribes of China (Chun-lin and Jieru, 1995). The tubers of *Dioscorea alata*, *D. bulbifera*, *D. oppositifolia*,

*D. pentaphylla* and *D. tomentosa* and the rhizome of *Canna indica* are used by the tribes of Andaman and Nicobar Islands (Ravishankar, 1996). The tubers of *Dioscorea bulbifera*, *D. tomentosa*, *D. alata* and *D. oppositifolia* are eaten by the tribes of Rampa Agency, Andhrapradesh (Krishna Prasad *et al.*, 1999). The corm and tubers of *Alocasia macrorrhiza*, *Dioscorea alata*, *D. esculenta*, *D.bulbifera* and *D.pentaphylla* are consumed by the Maohi tribes of the Society Islands (Lepofsky, 2003).

Tribal beliefs and practices have helped to preserve flora and fauna in their pristine glory, representing a great ecological heritage for modern civilization. The traditional knowledge of the wild food plants has to be preserved and utilized for agricultural development.

**II. Chemical Analyses**

In recent years, the Kanikkars of the Western Ghats, Kanyakumari district, depend on wild food plants particularly wild tubers, corm and rhizomes as their subsidiary food in recent years.

Tuber crops are rated as one of the richest sources of energy because of the high photosynthetic efficiency and the subsequent synthesis of carbohydrates, besides being a treasure house which provides vitamins and minerals (Balagopalan, 2000).

**Proximate composition**

**Crude protein**

*Dioscorea bulbifera* has more crude protein than the other investigated tubers, corms and rhizomes. The crude protein content recorded in the present study for *Dioscorea bulbifera* (15.75 g $100g^{-1}$) and

for the tubers of various species of the genus *Dioscorea*, is tabulated below along with the values of the related species of the same genus.

**Table 1. Data on the crude protein content of the different species including the investigated species of the genus *Dioscorea*.**

| **Name of the species** | **Crude protein (% on Dry weight basis)** |
|---|---|
| *Dioscorea rotundata*[a] | 8.55 |
| *D. rotundata* (Nwopoko)[b] | 4.80 |
| *D. cayenensis* (EKO)[a] | 10.88 |
| *D. hispida*[c] | 5.20 |
| *D. alata* | 10.73 |
| *D. bulbifera* | 15.75 |
| *D. esculenta* | 10.50 |
| *D. pentaphylla* | 5.68 |
| *D. oppositifolia* | 13.54 |
| *D. tomentosa* | 5.25 |
| *D. wallichi* | 10.50 |

Source of information

a. Onyilagha and Lowe, 1985

b. Akissoe *et al.*, 2001.

c. Rajyalakshmi and Geervani, 1994.

The crude protein content of the tubers of *Dioscorea alata*, *D. esculenta* and *D. wallichi* investigated in the present study is found to be in agreement with the earlier investigations in the tubers of *Dioscorea cayenensis* (EKO) (Onyilagha and Lowe, 1985).

The crude protein content of the corms of *Amorphophallus campanulatus, Xanthosoma sagittifolium* is found to be higher than that of the earlier reports in *Colocasia esculenta* (Mandal *et al.* 1982; Pramila *et al.* 1991; Aggarwal *et al.*, 1999; Balagopalan 2000).

**Crude lipid**

Fat is a concentrated source of energy and supplies per unit weight more than twice the energy furnished by either proteins or carbohydrates. Presence of fat in the diet is important for the absorption of fat soluble vitamins like vitamin A and carotene. Fats provide 'Essential Fatty Acids' (EFA) which perform vitamin-like functions in the body (Narasinga Rao *et al.*, 1989).

The content of the crude lipids in the investigated tubers, corms and rhizomes reveals that the tubers of *Dioscorea oppositifolia, D. bulbifera* and corms of *Amorphophallus campanulatus, Xanthosoma sagittifolium* exhibit more crude lipid content than the earlier reports in tubers of *Dioscorea oppositifolia, D. bulbifera* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. rotundata* (Akissoe *et al.*, 2001); *D. bulbifera* and in the corms of *Colocasia esculenta* and *Alocasia macrorrhiza* (Pramila *et al.*, 1991).

**Crude fibre**

Fibre in diet comes from complex carbohydrates available in whole grains, fruits and vegetables.

The crude fibre content in the tubers of *Dioscorea esculenta*, *D.oppositifolia*, *D.pentaphylla*, *D.wallichi* and corm of *Xanthosoma sagittifolium* is found to be more than that of the earlier reports in certain tubers such as *Dioscorea bulbifera* (Pramila *et al.*, 1991); *Dioscorea oppositifolia*, *D.bulbifera*, *D.pentaphylla*, *D.hispida* (Rajyalakshmi and Geervani, 1994) *D.rotundata* (Akissoe *et al.*, 2001); *D.oppositifolia* and *D. pentaphylla* (Murugesan and Anantha Lakshmi, 1991); corms of *Colocasia esculenta* and *Alocasia* sp. (Aggarwal *et al.*, 1991) and *Alocasia indicus*, *Alocasia* sp. (Murugesan and Ananthalakshmi, 1991).

**Ash**

Relatively high content of ash (above 6%) is detected in the tubers of *Dioscorea alata*, *D.esculenta*, *D.oppositifolia* and *D.wallichi*. This value is found to be higher than that of the earlier reports in the tubers of various species of *Dioscorea* (Rajyalakshmi and Geervani, 1994); *Dioscorea bulbifera* (Pramila *et al.*, 1991); *D. rotundata* (Akissoe *et al.*, 2001).

**Nitrogen Free Extractives (NFE)**

In the present study the NFE content in the tubers of *D.pentaphylla*, *D.tomentosa*, *Manihot esculenta*, *Manihot esculenta* var.M-4, *M. esculenta* var. H-226; corm of *Alocasia macrorrhiza*, *Xanthosoma violaceum* and rhizome of *Canna indica* is found to be higher (above 80%). This value is found to be higher than that of some previous studies in the tubers of *Dioscorea* species (Rajyalakshmi and Geervani, 1994); *D.rotundata* (Akissoe *et al.*, 2001); *D.bulbifera* and corms of *Colocasia esculenta* and *Alocasia*

*macrorrhiza* (Pramila *et al.*, 1991); in the tubers of *Dioscorea* species and in the corm of *Alocasia indicus* (Murugesan and Ananthalakshmi, 1991).

**Calorific value**

The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition and level of physical activity, consistent with long term good health and that will allow for maintenance of economically necessary and socially desirable activity. In the case of children and pregnant as well as lactating women, the energy requirement includes the energy needs associated with the deposition of tissues or the secretion of milk at rate consistent with good health (FAO/WHO/UNU, 1985).

In the present study the calorific values (energy) of the tubers of *Dioscorea bulbifera, D. tomentosa, Manihot esculenta* var. M-4 and corm of *Alocasia macrorrhiza, Amorphophallus campanulatus, Xanthosoma sagittifolium, X.violaceum* and rhizome of *Canna indica* are found to be in the range of 1604.26-1727.50 KJ $100g^{-1}$ dry matter respectively.

## Mineral composition

The essentiality of a number of minerals has been known for many years and estimated dietary requirements for five of them (Calcium, phosphorus, iron, copper and iodine) have been proposed in the 1939 "Year book of food and life" (Sherman *et al.*, 1939). The third edition of the Recommended Dietary Allowance (RDA), published in 1953 includes RDA's for only two minerals, viz., calcium and iron, although phosphorus, copper

and iodine are recognized as essential minerals (Bogert, 1954). The number of elements with dietary recommendations has expanded to twelve by the National Research Council (NRC/ NAS, 1980) and has remained at twelve when the most recent edition of the RDA was published (NRC/ NAS, 1989). The 1980 recommendations include six minerals with RDA's and six with Estimated Safe and Adequate Daily Dietary Intakes (ESADDI), while the 1984 recommendations include seven with RDA's and five with ESADDI (Turnlund 1994).

The sodium content of the currently investigated corms of *Alocasia macrorrhiza, Xanthosoma sagittifolium* and *X. violaceum* is found to be higher than that of the earlier report in *Colocasia esculenta* (Aggarwal *et al.*, 1999). Among the investigated samples, the corm of *Xanthosoma sagittifolium* registers the highest level of Potassium (2060 mg 100g-1). This highest value seems to be higher than that of other earlier reports in the corms of *Alocasia macrorrhiza, Amorphophallus campanulatus, Colocasia esculenta* and *Xanthosoma sagittifolium* (Parkinson, 1984). The calcium content in the corms of *Alocasia* macrorrhiza, *Amorphophallus campanulatus, Xanthosoma sagittifolium, X. violaceum* and in the tubers of *Dioscorea pentaphylla, D. wallichi, Manihot esculenta* var. M-4 is found to be higher than earlier studies in the corm of *Colocasia esculenta* and *Alocasia* sp. (Pramila *et al.*, 1991; Aggarwal *et al.*, 1999); in the tubers of *Dioscorea oppositifolia, D. pentaphylla, D. bulbifera* and *D. hispida* (Rajyalakshmi and Geervani, 1994).

The magnesium content in the tubers of *Dioscorea alata, D. bulbifera, D. esculenta, D. oppositifolia, Manihot esculenta* var. M-4 and *M.esculenta*

var. H-226 is found to be more than that of an earlier report in the corm of *Colocasia esculenta* and *Alocasia* sp. (Aggarwal *et al.*, 1999); in the tubers of *Manihot esculenta*, (Oke, 1975). Among the investigated samples, the corms of *Amorphophallus campanulatus*, *Alocasia macrorrhiza*, *Xanthosoma sagittifolium* and *X. violaceum* are found to have more phosphorus content than the earlier reports in the corms of *Amorphophallus paeoniifolius*, *Alocasia indica*, *Xanthosoma sagittifolium*, *Colocasia esculenta*. (Balagopal, 2000). Microelement zinc content in the corms of *Amorphophallus campanulatus* and the tubers of *Manihot esculenta* var. M-4 and *M. esculenta* var. H-226 is found to be higher when compared to the zinc content in the corms of *Colocasia esculenta* and *Alocasia* sp. (Aggarwal *et al.*, 1999).

The iron content in the corms of *Alocasia macrorrhiza*, *Xanthosoma sagittifolium*, *X. violaceum* and the tubers of *Dioscorea pentaphylla* is found to be higher when compared with the earlier reports in the corm of *Colocasia*, *Amorphophallus*, *Xanthosoma* and *Alocasia* (Balagopalan, 2000); in the tubers of *Dioscorea oppositifolia* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *D. pentaphylla*, *D. oppositifolia* (Murugesan and Ananthalakshmi, 1991). Among the investigated samples, *D. pentaphylla* (14.10mg 100g-1) exhibit the highest content of copper when compared with that of the earlier reports in *Colocasia esculenta* and *Alocasia* (Aggarwal et.al., 1999) and *Asparagus* (Cosano and Rojas, 1990). When compared with RDA's of NRC/ NAS (1980) all the investigated samples, indeed exhibit deficiency in sodium content. Among the currently investigated plant parts the tubers of *Dioscorea alata* and *D. esculenta*,

corms of *Xanthosoma sagittifolium* and *X. violaceum* are found to contain more than the adequate level of potassium compared to RDA's of infants and children (NRC/ NAS, 1980).

In the present study, the corm of *Alocasia macrorrhiza*, *Amorphophallus campanulatus*, *Xanthosoma sagittifolium* and *X. violaceum* and the tubers of *Dioscorea pentaphylla*, *D. wallichi*, *Manihot esculenta*, *M. esculenta* var. M-4, *M. esculenta* var. H-226 and *Maranta arundinacea* are found to contain higher calcium content than that of RDA's of NRC/ NAS (1980) for infants.

Most of the investigated plant parts are found to contain higher Magnesium content than that of RDA's of NRC/NAS for infants and children (1980). The phosphorus content in all the investigated plant parts is found to be deficient compared to RDA's of NRC/NAS (1980). The corm of *Amorphophallus campanulatus* and the tubers of *Dioscorea tomentosa*, *Manihot esculenta*, *M. esculenta* var. M-4 and *M. esculenta* var H-226 are found to contain a high range of zinc content compared with RDA's of NRC/ NAS (1980) infants. All the investigated plant parts appear to have a higher level of manganese content compared to ESADD1 of infants, children and adults (NRC/ NAS, 1989).

In the present study, all the investigated plant parts except the tubers of *Dioscorea bulbifera* have higher iron content compared to infants, children and adults RDA's of NRC/ NAS, 1980. All the investigated plant parts appear to have a higher level of copper content compared to ESADD1 of infants, children and adults (NRC/ NAS, 1989). For ready and easy

comparison, the RDA's and ESADD1 values of NRC/ NAS (1980, 1989) are tabulated below.

**Table II. Recommended Dietary Allowances of Minerals**

| Category[a] | Age (years)[a] or conditoin | Weight[a] (Kg) | Height[a] (cm) | Na[b] (mg) | K[b] (mg) | Ca[b] (mg) | Mg[b] (mg) | P[b] (mg) | Fe[b] (mg) | Zn[b] (mg) |
|---|---|---|---|---|---|---|---|---|---|---|
| Infants | 0.0-0.5 | 6 | 60 | -- | -- | 400 | 40 | 300 | 6 | 5 |
| | 0.5-1.0 | 9 | 71 | 500 | 1100 | 600 | 60 | 500 | 10 | 5 |
| Children | 1-3 | 13 | 90 | -- | -- | 800 | 80 | 800 | 10 | 10 |
| | 4-6 | 20 | 112 | 900 | 1550 | 800 | 120 | 800 | 10 | 10 |
| | 7-10 | 28 | 132 | -- | -- | 800 | 170 | 800 | 10 | 10 |
| Males | 11-14 | 45 | 157 | | | 1200 | 270 | 1200 | 12 | 15 |
| | 15-18 | 66 | 176 | | | 1200 | 400 | 1200 | 12 | 15 |
| | 19-24 | 72 | 177 | | | 1200 | 350 | 1200 | 10 | 15 |
| | 25-50 | 79 | 176 | | | 800 | 350 | 800 | 10 | 15 |
| | 51+ | 77 | 173 | | | 800 | 350 | 800 | 10 | 15 |
| Females | 11-14 | 46 | 157 | | | 1200 | 280 | 1200 | 15 | 12 |
| | 15-18 | 55 | 163 | | | 1200 | 300 | 1200 | 15 | 12 |
| | 19-24 | 58 | 164 | | | 1200 | 280 | 1200 | 15 | 12 |
| | 25-50 | 63 | 163 | | | 800 | 280 | 800 | 15 | 12 |
| | 51+ | 65 | 160 | | | 800 | 280 | 800 | 15 | 12 |
| Pregnant | 1st 6months | | | | | 1200 | 320 | 1200 | 30 | 15 |
| Lactating | | | | | | 1200 | 355 | 1200 | 15 | 19 |
| | 2nd 6months | | | | | 1200 | 340 | 1200 | 15 | 16 |

Source: a-NRC/NAS-1989

b-NRC/NAS-1980

**Table III. Estimated Safe and Adequate Daily Dietary Intake of Minerals**

| Category | Age (years) | Cu (mg) | Mn(mg) |
|---|---|---|---|
| Infants | 0.0-0.5 | 0.4-0.6 | 0.3-0.6 |
| | 0.5-1.0 | 0.6-0.7 | 0.6-1.0 |
| Children and Adolescents | 1-3 | 0.7-10 | 1.0-1.5 |
| | 4-6 | 1.0-1.5 | 1.5-2.0 |
| | 7-10 | 1.0-2.0 | 2.0-3.0 |
| | 11+ | 1.5-2.5 | 2.0-5.0 |
| Adults | | 1.5-3.0 | 2.0-5.0 |

Source: NRC/NAS-1989

**Starch**

In the present study, all the investigated tubers, corms and rhizomes are found to contain more starch than that of earlier reports in the tubers of *Dioscorea 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); the corm of *Amorphophallus paeoniifolius* (Moorthy *et.al.*, 1994; Balagopal, 2000); *Colocasia* (Balagopal, 2000). Among the investigated tubers *Dioscorea esculenta* seems to be more or less identical with that of an earlier report in the same species of *Dioscorea esculenta* (Sundaresan *et al.*, 1990).

The *in vitro* starch digestibility (IVSD) of the raw samples are found to be very high except *Maranta arundinacea.*

**Anti-nutritional factors**

The anti-nutritional factors include protease inhibitors, phytate, lectins, total free phenolics, tannins, cyanogenic glucosides, alkaloids, non-protein aminoacids, flatulence factors, saponins and allergins (Liener, 1994). The anti-nutritional factors in the legume seeds adversely affect the protein digestibility (Gupta, 1987). These substances, unless destroyed by heat or some other suitable treatment, can exert adverse physiological effects when ingested by man and animals (Liener, 1980). On the contrary, it has been suggested that consumption of low level of certain anti-nutrients may produce health benefits while avoiding some of the adverse effects associated with their large intake (Thompson, 1988).

**Total Free Phenolics and Tannins**

Polyphenols are present in almost all parts and they are common in most food plant (Bravo *et al.*, 1994). Polyphenols have different effects in the intestine depending on their solubilities. Extractable polyphenols appear to be absorbed from the digestive tract and produce systemic effects such as reduction of the metabolic utilization of absorbed aminoacids and elevate plasma levels of growth hormone (Martin-Tanguy *et al.*, 1976; Barry *et al.*, 1986). Non-extractable polyphenols not absorbed in the intestine are recovered quantitatively in faeces (Bravo *et al.*, 1992; 1993).

Phenolic compounds inhibit the activity of digestive as well as hydrolytic enzymes such as amylase, trypsin, chymotrypsin and lipase (Salunkhe *et al.*, 1982). Polyphenols decrease the digestibility of carbohydrates, the availability of vitamins and minerals (Rao and Deosthale, 1982) and interact with proteins rendering them insoluble (Singh, 1984).

Among the tubers of various species of *Dioscorea*, the tubers of *Dioscorea bulbifera* contain more total free phenolics (1.40%). This value is found to be higher than that of the earlier studies in the tubers of *Dioscorea cayenensis*, *D. alata*, *D. dumetorum* and *D. bulbifera* (Osagie and Opoku, 1982); *Ipomoea batatas* (Adelusi and Ogundana, 1987); *Dioscorea esculenta*, *D. alata*, *D. rotundata* (Babu *et al.*, 1990; Sundaresan *et al.*, 1990); and *Manihot esculenta*, *Ipomoea batatas* (Babu *et al.*, 1990).

Among the currently investigated tubers of *Dioscorea* species, the tubers of the species *D. bulbifera* contain more tannin when compared with other earlier reports in the tubers of *Dioscorea alata*, *D. cayenensis*, *D. rotundata* and *D. esculenta* (Esuabana, 1982; Udoessien and Ifon, 1992).

The tannins and phenolics are water soluble compounds (Uzogara *et al.*, 1990) and as such can be eliminated by decortication and soaking (Singh, 1988; 1993; Kataria *et al.*, 1989; Singh and Singh, 1992).

It seems that polyphenols may not pose a serious constraint particularly to people in regions where pulses are consumed after decortification. Soaking (water discarded) followed by cooking before consumption is recommended as a means of removing harmful effects of

polyphenolic compounds in the regions where pulses are consumed as whole seeds (Rao and Deosthale, 1982).

Improvement of protein digestibility by reducing the levels of total free phenolics and tannins has been well documented in some tribal pulses (Siddhuraju *et al.*, 1996 a, b; Vijaya Kumari *et al.*, 1995; 1996; 1997 a, b).

**Hydrogen cyanide**

The content of hydrogen cyanide level in the tubers; rhizome and corms 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 in the tubers of *Dioscorea alata, D. cayenensis, D. rotundata, D. esculenta* (Maini and Balagopal, 1978; Osagie and Opoku, 1982; Esuabana, 1982; Udoessien and Ifon, 1992).

**Total oxalate**

Oxalate is an end product or excretory product in metabolism and tends to accumulate in the plant with increasing age. Its concentration is higher in the levels which are lost at abscission and its toxicity is removed by deposition as calcium oxalate crystals (Smith, 1982).

Among the investigated plant parts, the corm of *Amorphophallus campanulatus* and rhizome of *Canna indica* contain more total oxalate when compared with other earlier reports in the tubers of *Manihot esculenta* (Raymond *et al.*, 1941; Oke, 1975); in the corms of *Alocasia macrorrhiza* and *Xanthosoma sagittifolium* (Chakraborty and Eka, 1977); *Colocasia* (Mandal *et al.*, 1982); in the tubers of *Dioscorea alata, D. cayenensis, D. rotundata* and *D. esculenta* (Esuabana, 1982).

**Amylase inhibitor activity**

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, corms and rhizomes are found to be in the range of 0.18 to 14.50 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).

**Trypsin inhibitor activity**

Trypsin inhibitor is believed to play a regulatory role in plant metabolism and many such storage proteins also have defensive role to protect the plants from the attack of insects and pathogens (Johnson *et al.*, 1989; Ryan 1990).

Among the investigated tubers of *Dioscorea* species, the tubers of the species *D. oppositifolia* (23.70 units) contain more trypsin inhibitor activity when compared with the earlier reports in the tubers of *D. dumetorum* and *D. rotundata* (Lape and Treche, 1994); *D. rotundata* (Sasikiran *et al.*, 1999).

**Processing/ Treatment**

Many foods including the root crops cannot be digested in their natural state and hence require cooking which increases the palatability, digestibility, the keeping qualities and the safety of the foods from potentially toxic substances (Bradbury and Holloway, 1988).

Soaking in water or in salt solution prior to household cooking also effects a significant reduction in tannin content, provided the cooking broth is discarded (Deshpande and Cheryan, 1983; Braham and Bressani, 1985). Soaking in sodium bicarbonate solution (0.02% w/v) for 9 hours reduces the concentration of total free phenolics to a maximum extent in the rhizome of *Canna indica* whereas the content of tannin is reduced to 88% by soaking in sodium bicarbonate solution for 9 hours in the tubers of *Dioscorea tomentosa.*

About 94% of the total free phenolics gets removed in the corm of *Amorphophallus campanulatus* when cooked for 90 minutes and autoclaved for 45 minutes where as in the rhizome of *Canna indica* mere autoclaving for 45 minutes showed reduction in the level of total free phenolic content. Autoclaving the rhizome of *Canna indica* for 45 minutes showed reduction in the level of total free phenolics content. Autoclaving the tubers of *Dioscorea tomentosa, D. esculenta, Manihot esculenta* and corm of *Xanthosoma sagittifolium* and *X. violaceum* for 90 minutes showed reduction in the content of tannin to a maximum (above 90%).

The loss of tannins may also be due to heat degradation of tannin molecules or formation of water soluble complexes. The loss of polyphenols by autoclaving may also be due to the interaction of polyphenols with other components of the plant parts such as protein to form insoluble tannin-protein complexes (Babar *et al.*, 1988).

The rate of reduction of tannin content is great in sodium bicarbonate solution soaking than distilled water soaking. Polyphenol compounds are of water soluble nature (Kumar *et al.*, 1979). Hence a

decrease in the free phenolics and tannin content in the rhizome of *Canna indica* and tubers of *Dioscorea tomentosa* during soaking may be due to leaching of the phenolic substance in soaking water under concentration gradient. Earlier, similar results have been observed in several legumes under such treatments (Laurena *et al.*, 1986; Kataria *et al.*, 1988).

Soaking for 24 hours followed by 10 minutes boiling has been reported to eliminate upto 60% of the total cyanide and remove the free cyanide completely. However, soaking alone is not effective in removing cyanide (Balagopal, 2000). The content of the hydrogen cyanide level in the raw samples of tubers, rhizome and corm is far below the lethal level, i.e., 36 mg $100g^{-1}$ (Oke, 1969). There seems to be a positive correlation between the reduction in the content of hydrogen cyanide and duration of soaking period in all investigated plant parts. Significant reduction has been observed when subjected to both distilled water as well as solution soaking. Endogenous and autolytic enzymes are inactive (Panasuik and Bills, 1984), but are activated by hydrolysis. The hydrogen cyanide produced during hydrolysis is water-soluble and this accounts for the decrease in hydrogen cyanide content during soaking. Similar results has been obtained earlier in *Manihot esculenta* (Bradbury and Holloway, 1988).

All the tubers tend to contain oxalic acid but high level of oxalate are known to be toxic to man and animals. The lethal dose of oxalate for man is reported to range from 2-5 g. It is also believed that the various methods of preparation of yam tubers for food tend to reduce the level of oxalate (Eka, 1967). The total oxalate content of all the investigated samples falls below the lethal range. Soaking, cooking, and autoclaving further reduced the

content of total oxalate. The edible aroids (corms) like *Colocasia*, *Xanthosoma*, *Alocasia*, *Cryptosperma* and *Amorphophallus* have been reported to be acrid; i.e., to cause a sharp irritation and burning of the throat and mouth on ingestion of uncooked material (Sakai, 1979). *Alocasia* and *Amorphophallus* are even more acrid and requires removal of a thick layer of skin and a long period of cooking to remove the acridity (Sakai, 1979; 1983). In the present study also cooking and autoclaving reduced the level of total oxalate content in most of the samples.

In the present investigation, slight reduction in the levels of amylase inhibitor and trypsin inhibitor activity during soaking, cooking and autoclaving were observed. Boiling for sufficient time makes the tubers/ corms/ rhizomes make them soft enough and inactivate all the trypsin inhibitor as reported by Bradbury and Holloway (1988) in sweet potato, taro and giant swamp taro. Rekha (2000) reported that various processing methods can detoxify amylase inhibitor in tuber crops.

The raw samples of tubers of *Dioscorea wallichi* exhibited 5% *in vitro* protein digestibility (IVPD). Cooking for 90 minutes increased the IVPD value to 11% (106% improvement) whereas autoclaving improved the digestibility of protein somewhat further. The increase in protein digestibility of the tubers on autoclaving may be attributed not only to the removal of the polyphenols but also to the structural disintegration of the native proteins including enzyme inhibitors.

The raw tubers of *Dioscorea alata* exhibited 30% *in vitro* starch digestibility. Autoclaving for 45 minutes increased the *in vitro* starch digestibility to 50% (100% improvement). This is in agreement with the

earlier reports in *Dioscorea dumetorum* and *D. rotundata.* It has been known for a long time that raw starch of certain tubers are poorly digestible (Langworthy and Devel, 1922; Booher *et al.*, 1951) and a very mild moist heat treatment, could render any starch completely digestible (Cummings *et al.*, 1986).

Based on the nutritive evaluation studies on the wild edible tubers, corms and rhizomes consumed by the tribal Kanikkars, it can be summarized that most of them are found to be good source of protein, lipid, crude-fibre, starch and minerals.

While considering the various processing methods, autoclaving seems to be the best for the removal / inactivation of the investigated anti-nutritional factors and it also improves the *in vitro* protein and *in vitro* starch digestibility.

# SUMMARY

## SUMMARY

In the present study, about 16 wild edible tubers/corms/rhizomes reported to be eaten by the tribal Kanikkars of Kanyakumari district, Western Ghats, were collected and documented. The collected 16 wild edible plants belong to 5 families. Among the edible plants collected, the tubers of *Dioscorea* species are harvested in large quantities and consumed almost all over the year.

The chemical analyses of the various edible parts reveal that most of them appear to be good sources of crude protein, crude lipid, crude fibre, NFE, starch and minerals like potassium, calcium, magnesium, zinc and iron. The anti-nutritional factors such as total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor and trypsin inhibitor activity were detected in all the collected samples.

The proximate composition reveals that most of the investigated plant parts appear to be good sources of crude protein and crude lipid. Among the investigated edible parts, the starch content is found to be high in the tubers of *Manihot esculenta* var. M-4. The maximum calorific value is registered by the tubers of *Dioscorea bulbifera*. The data on mineral profiles reveal that potassium is the predominant element in the tubers of *Dioscorea alata*, *Dioscorea esculenta* and corms of *Xanthosoma sagittifolium* and *X. violaceum* vis-à-vis RDA's value of NRC/NAS (1989). All the investigated plant parts exhibited *in vitro* protein and *in vitro* starch digestibility. Tubers of *Dioscorea bulbifera* and *Manihot esculenta* var. H-226 showed high *in vitro* starch digestibility.

Different processing methods of the edible parts showed that autoclaving for 45 minutes reduces the amount of anti-nutrients to a maximum level thus improving the *in vitro* protein and *in vitro* starch digestibility.

Based on the chemical evaluation of the wild edible plant parts used by the Kanikkars, the tubers of *Dioscorea esculenta, D.oppositifolia, D.wallichi;* corms of *Xanthosoma sagittifolium* and *X. violaceum* and rhizomes of *Maranta arundinacea* and *Canna indica* may be advocated for the popularization and large scale cultivation so that these excellent foods can be made readily available for the increasing population.

# BIBLIOGRAPHY

# BIBLIOGRAPHY


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

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

*Aduayi, E.A. 1979. *Comm. Soil Sci. Pl. Analysis.* **10**: 927-39.

Aggarwal, R.A.K., Arya, P.S. and Mahajan, N.C. 1999. Nutritional evaluation of vegetable *Colocasia. J. Fd. Sci. Technol.* **36**: 457-458.

Akissoe, H.N., Hounhouigan, D.J. Bricas, N., Vernier, P., Niago, C.M. and Olorunda, O.A. 2001. Physical, chemical and sensory evaluation of dried yam (*Dioscorea rotundata*) tubers, flour and 'amala', a flour-derived product. *Trop. Sci.* **41**: 151-155.

Aminuddin and Girach, R.D. 1991. Ethnobotanical studies on Bondo tribe of district Koraput (Orissa), India. *Ethnobotany.* **3**: 15-19.

Amla, B.L. and Shankar, J.V. 1975. Conservation of Potato and Tapioca in India. *J. Root Crops.* **2**: 24-38.

Anon, 1976. The Wealth of India. Publications and Information Directorate, CSIR, New Delhi. p.385.

Anon, 1996. The State of the World's Plant Genetic Resources for Food and Agriculture, FAO, Rome, Italy.

AOAC. 1970. Official Methods of Analysis (11th edn.). Association of Official Analytical Chemists, Washington, DC.

AOAC. 1975. Official Methods of Analysis (12th edn.). Association of Official Analytical Chemists, Washington, DC.

AOAC 1984. Official Methods of Analysis (14th edn.). Association of Official Analytical Chemists. Washington. DC.

Arinathan, V. 2002. Studies on Tribal Food Plants of South India, Ph.D., Thesis, Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu.

Arora, R.K. 1985. Genetic resources of less-known cultivated food plants. NBPGR: *Sci. Monogr.* 9. ICAR, New Delhi, India.

Arora, R.K. 1990. Native food plants of the Tribals in North-Eastern India. In: *Contributions to Ethnobotany of India.* (Ed.). Jain, S.K. Sci. Publishers, Jodhpur. pp.137-152.

Atwater, W.O. and Bryant, A.P. 1900. The availability and food values of food materials. Agricultural Experimental Station, Storrs. C.T.

Awasthi, A.K. 1991. Ethnobotanical Studies of the Negrito Islanders of Andaman Islands, India-The Great Andamanese. *J. Econ. Tax. Bot.* **45**: 274-280.

Awasthi, A.K. and Goel, A.K. 1999. Ethnobotanical studies on the tribe Onge from Little Andaman Island. *J. Econ Tax. Bot.* **23**: 569-575.

Babar, V.S., Chavan, J.K. and Kadam, S.S. 1988. Effects of heat treatments and germination on trypsin inhibitor activity and polyphenols in jack bean. (*Canavalia ensifomis* L. DC). *Plant Foods Hum. Nutr.* **38**: 319-324.

Babu,C.R., Sharma, S.K., Chatterjee,S.R. and Abrol, Y.P. 1988. Seed protein and aminoacid composition of wild *Vigna radiata* var. *sublobata* (Fabaceae) and two Cultigens. *V. mungo* and *V. radiata*. *Econ. Bot.* **42**: 54-61.

Babu, L., Nambisan, B. and Sundaresan, S. 1990. Comparative evaluation of Biochemical constituents of selected tuber crops. *J. Root. Crops*: 270-273.

Balagoplanan, C. (Ed.). 2000. Integrated Technologies for value addition and post harvest management in Tropical Tuber Crops. Central Tuber Crops Research Institute, Kerala, India.

Barry, T.N., Allsop, T.F. and Redekopp, C. 1986. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. 5. Effects on the endocrine system and on adipose tissue metabolism. *Brit. J. Nutr.* **56**: 607-614.

Bedi, S.J. 1978. Ethnobotany of the Ratan mahal hills, Gujarat, India. *Econ. Bot.* **32**: 278-284.

Bhargava, N. 1983. Ethnobotanical studies of the tribes of Andaman and Nicobar Islands, India. I. Onge. *Econ. Bot.* **37**: 110-119.

Bhattacharyya, A. 1991. Ethnobotanical observations in the Ladakh region of Northern Jammu and Kashmir state, India. *Econ. Bot.* **45**: 305-308.

Bhattacharyya, G. 1999. Ethnobotanical wealth of the "Druk-Yul" (Bhutan). *J. Econ. Tax. Bot.* **23**: 94-98.

Bogert, L.J. 1954. Nutrition and physical fitness. W.B. Saunder's company. Philadelphia.

Booher, L.E., Behan, I. and MacMeans,E. 1951. Biologic utilisation of unmodified and modified food starches. *J. Nutr.* **45**: 75-95.

Bradbury, J.H., Hammer, B., Nguyen, T., Anders, M. and Millar, J.S. 1985. Protein quantity and quality and Trypsin inhibitor content of Sweet potato cultivars from the highlands of Papua New Guinea. *J. Agric. Food Chem.* **33**: 281-285.

Bradbury, J.H. and 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.

Braham, J.E. and Bressani, R. 1985. Effect of bean broth on the nutritive value and digestibility of beans. *J. Sci. Food Agric.* **36**: 1028.

Brahmam, M. and Saxena, H.C. 1990. Ethnobotany of Gandhamardan Hills—Some Noteworthy Folk Medicinal Uses. *Ethnobotany* **2**: 71-79.

Bravo, L., Abia, R. and Saura—Calixto, F. 1994. Polyphenols as dietary fibre associated compounds. Comparative study on *in vivo* and *in vitro* properties. *J. Agric. Food Chem.* **42**: 1481-1487.

Bravo, L. Manas, E. and Saura—Calixto, F. 1993. Dietary non-extractable condensed tannins as indigestible compounds. Effects on faecal weight, protein and fat excretion. *J. Sci. Food Agric.* **63**: 63-68.

Bravo,L., Saura—Calixto, F. and Goni, I. 1992. Effects of dietary fibre and tannins from apple pulp on the composition of faeces in rats *Brit. J. Nutr.* **67**: 463-473.

Burns, R.B. 1971. Methods of estimation of tannin in the grain, *Sorghum. Agron. J.* **63**: 511-512.

*Chakraborty, R. and Eka, O.U. 1977. *West. Afr. Jour. Biol. Appl. Chem.* **21**: 43-52.

Chakrabarty, T. and Rao, M.K.V. 1988. Ethnobotanical studies on the Shompens of Great Nicobar Island. *J. Econ. Tax. Bot.* **12**: 39-54.

Chun-Lin, L. and Ji eru, W. 1995. Ethnobotany of Jinuo Nationality in Xishuangbanna, South-West China: I. Edible Plants. *Ethnobotany.* **7**: 39-49.

Cock, J.H. 1985. Cassava-New Potential for a Neglected crop. West View Press/ Boulder and London. pp.6-29.

Cosano, G.Z. and Rojas, R.M. 1990. Mineral elements in fresh and canned *Asparagus. Food Chem.* **38**: 113-118.

Coursey, D.G. 1967. Yams. Longmans Green, London, 172-230.

*Coursey, D.G., Nwankwo, F.I. and Enyeniti, L.U. 1960. *Note in Ann. Rep. West. Afr. Stored Prod. Res. Unit*, Lagos.

Cummings, J.H., Englyst, H.N. and Wiggins, H.S. 1986. The role of carbohydrates in lower gut function. *Nutr. Rev.* **44**: 50-54.

Dahal, N., Rao, E.R. and Swamylingappa, B. 2003. Biochemical and Nutritional Evaluation of Masyaura—A Legume-based traditional savoury of Nepal. *J. Fd Sci. Technol.* **40**: 17-22.

Das, S.N. 1997. A study on the Ethnobotany of Karauli and Sawai Madhopur Districts, Rajasthan. *J. Econ. Tax. Bot.* **21**: 587-605.

Dash, S.S. and Misra, M.K. 1999. Taxonomic survey and systematic census of economic plants of Narayana Patna Hills of Koraput District, Orissa. *J. Econ. Tax. Bot.* **23**: 473-498.

Deshpande, S.S. and Cheryan, M. 1983. Changes in the phytic acids, tannins and trypsin inhibitor activity of soaking of dry beans. (*P. vulgaris* L.). *Nutr. Rep. Int.* **27**: 371.

*Dickey, L.F. 1983. Trypsin Inhibitors in sweet potatoes. M.S. Thesis. North Carolina State Univ. Raleigh. N.C. 2750.

Dickman, S.R. and Bray, R.H. 1940. Colorimetric determination of Phosphate. *Ind. Eng. Chem. Anal. Ed.* **12**: 665-668.

*Dye, E. 1976. Masters degree Thesis. Univ. Hawaii.

Egbe, I.A. and Akinyele, I.O. 1990. Effect of cooking on the anti-nutritional factors of lima beans (*Phaseolus lunatus*). *Food Chem.* **35**:81-87.

Eka, O.U. 1967. The chemical composition of yam tubers. In: *Yams* (Ed.) Coursey, D.G. Tropical Products Institute, London, p.68.

Elangbam, J.S., Yadava, P.S. and Thingbaijam, B.S. 1989. Ethnobotanical study of the Tangkhul Naga tribe of Ukhrul, Manipur. *J. Econ. Tax. Bot.* **13**: 11-16.

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

FAO/ WHO/ UNU, 1985. Energy and Protein requirements. Report of a joint FAO/WHO/UNU expert consultation, WHO technical report series. 724. World Health Organization, Geneva, Switzerland.

*Ferguson, T.U., Haynes, P.H. and Spence, J.A., 1980. *Trop. Agric.* **57**: 61-70.

Francis, B.J., Halliday D. and Rebinson, J.M. 1975. Yams as a source of edible protein. *Trop. Sci.* **17**.

Frankel, O.A. and Hawkes, J.G. (Ed.) 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge, UK.

Gadgil, M. 1996. Documenting diversity: An experiment. *Crop. Sci.* **70**: 36-44.

Ghosh, S.P., Ramanujam, T., Jos, J.S. Moorthy, S.N. and Nair, R.G. 1988. Edible Aroids. In: *Tuber Crops*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. pp.226-302.

Gibbs, R.D. 1974. Occurrence of cyanogenesis. In: *Chemotaxonomy of Flowering plants*. Vol. I-IV. McGill Queen's University Press, Montreal.

Gopalan, C., Ramashastri, B.V. and Balasubramanian, S.C. 1976. Nutritive value of Indian Foods. I.C.M.R., New Delhi.

Government of India (GOI), 1994. Ethnobiology in India—A Status Report: Ministry of Environment and Forest, Govt. of India, New Delhi.

Gunjatkar, N. and Vartak, V.D. 1982. Enumeration of wild edible legumes from Pune district, Maharashtra state. *J. Econ. Tax. Bot.* **3**: 1-9.

Gupta, Y.P. 1987. Anti-nutritional and toxic factors in food legumes: A review: *Plant Foods Hum. Nutr.* **37**: 201-228.

Hammer, B.C. Shaw, D.C. and Bradbury, J.H. 1989. Trypsin inhibitor from *Colocasia esculenta, Alocasia macrorrhiza* and *Cyrtosperma chamissonis*. *Phytochemistry*. **28**: 3019-3027.

*Hossain, M.M., Mussain, M., Chowdhury, B., Hussain, A. and Rashid, M.M. 1983. *Bangaladesh Hort.* **11**: 15-24.

Huang, D.Y., Swanson, B.G. and Ryan, C.A. 1981. Stability of proteinase inhibitors in potato tubers during cooking. *J. Food. Sci.* **46**: 287-290.

Humphries, E.C. 1956. Mineral components and ash analysis. In: *Modern methods of plant analysis.* Vol.1 (Eds.) Paech, K. and Tracey, M.V. Springer—Verlag, Berlin, pp. 468-502.

Ignacimuthu, S. and Babu, C.R. 1987. *Vigna radiata* var. *sublobata* (Fabaceae) Economically useful wild relative of Urd and Mung bean. *Econ. Bot.* **41**: 418-422.

Irvine, F.R. 1952. Supplementary and emergency food plants of West Africa. *Eco. Bot.* **6**: 23-40.

Issac, R.A. and Johnson, W.C. 1975. Collaborative study of wet and dry ashing techniques for the elemental analysis of plant tissue by Atomic Absorption Spectrophotometer. *J. AOAC.* **58**: 436-440.

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

Jackson, M.L. 1973. Soil Chemical Analysis. Second Edition. Prentice Hall of India, Private Ltd., pp.326-337.

Jain, S.K. 1963. Studies in Indian Ethnobotany—Less known uses of fifty common plants from the tribal areas of Madhya Pradesh. *J. Bull. Bot. Surv. India.* **5**: 223-226.

Jain, S.K. (Ed.) 1981. Glimpses of Indian Ethnobotany. Oxford & IBM Publishing Co., New Delhi, India.

Jain, S.P. 1984. Ethnobotany of Morni and Kalesar (District Ambala, Haryana). *J. Econ. Tax. Bot.* **5**: 809-813.

Jain, S.K. (Ed.) 1991. Contributions to Ethnobotany of India.Scientific Publishers, Jodhpur, India.

Jain, S.K. and Borthakur, S.K. 1980. Ethnobotany of Mikirs of India. *Econ. Bot.* **34**: 264-272.

Johnson, R., Narva'en. J,G, An. and Ryan,C.A. 1989. Expressing of proteinase inhibitors I and II in transgenic tobacco plants; effects on natural defense against *Manduca sexta* larvae. *Proc. Natl. Acad. Sci.* **86**: 9871-9875.

Joshi, G.C. and Tewari, K.C. 2000. Wild edible plants diversity in Uttar Pradesh Himalaya. *J. Econ. Tax. Bot.* **24**: 433-443.

Kabeerathumma, S., Mohankumar, B. and Nair, P.G. 1985. Nutrient uptake by Taro (*Colocasia esculenta*) 2. Uptake pattern of secondary and micronutrients at different stages of growth. *J. Root Crops.* **11**: 51-56.

Karnick, C.R. 1971. Phytochemical investigation of some *Dioscorea* species and varieties found in India. *Quart. J. Crude Drug Res.* **11**: 1761-1773.

Kataria, A., Chauhan, B.M. and Gandhi,S. 1988. Effect of domestic processing and cooking on the anti-nutrients of black gram. *Food Chem.* **30**: 149-156.

Kataria, A., Chauhan, B.M. and Punia, D. 1989. Anti-nutrients and protein digestibility (*in vitro*) of mung bean as affected by domestic processing and cooking. *Plant Foods Hum. Nutr.* **3**: 9-17.

Kaul, M.K. Bhatia, A.K. and Atal, C.K. 1985. Ethnobotanic studies in North West and Trans-Himalaya-contribution to the wild food plants of Ladak. *J. Econ. Tax. Bot.* **6**: 523-527.

Katiyar, S.K., Sharma, K., Kumar, N. and Bhatia, A.K. 1990. Composition of some unconventional Himalayan Wild fruits. *J. Fd. Sci. Technol.* **27**: 309-310.

Khoshoo, T.N. 1991. Conservation of biodiversity in biosphere. In :*Indian Geosphere Biosphere Programme Some Aspects* (Eds.) Khoshoo, T.N. and Sharma, M. National Academy of Sciences, Allahabad, India. pp.178-233.

Kotaru, M., Ikenchi, T., Yoshikawa, H. and Ibuki, F. 1987. Investigation of anti-nutritional factors of the winged bean (*Psophocarpus tetragonolobus*). *Food Chem.* **24**: 279-286.

Kothari, M.J. and Rao,K.M. 1999. Ethnobotanical studies of Thane district, Maharashtra. *J. Econ. Tax. Bot.* **23**: 265-272.

Krishna Prasad, V., Rajagopal, T., Yogeshkant and Badarinath, K.V.S. 1999. Food Plants of Konda Reddis of Rampa Agency, East Godavari District, Andhra Pradesh—A Case Study *Ethnobotany.* **11**: 92-96.

Krishna, B. and Singh, S. 1987. Ethnobotanical observations in Sikkim. *J. Econ. Tax. Bot.* **9**: 1-7.

Kumar, N.R., Reddy, A.N. and Rao, K.N. 1979. Levels of phenolic substances in the leacheates in *Cicer* seed. *Indian J. Expt. Biol.* **17**: 114-116.

Kumar, Y., Scarlet, F. and Rao, R.R. 1987. Further contribution to the enthnobotany of Mehalaya: Plants used by "War Jainta" of Jaintia Hills district. *J. Econ. Tax. Bot.* **11**: 65-70.

*Lambert, J. 1975. A study of nutritional status and economic development in the chimbu district, Papua New Guinea. 1956-76. Master Degree Thesis, University of London.

Langworthy, C.F. and Devel, H.J. 1922. Digestibility of raw rice, arrowroot, *Canna*, cassava, taro, tree fern and potato starches. *J. Biol. Chem.* **52**: 251-261.

Lape, I.M. and Treche, S. 1994. Nutritional quality of yam (*Dioscorea dumetorum* and *D. rotundata*) flours for growing rats. *J. Sci. Food Agric.* **66**: 447-455.

Laurena, A.C., Garcia, V.V. and Mendoza, E.M.T. 1986. Effect of soaking in aqueous acidic and alkali solutions on removal of polyphenols and *in vitro* digestibility of cow pea. *Qual. Plant. Foods. Hum. Nutr.* **36**: 107-118.

Leopard, C. and Ardrey, R. 1972. Toxic substances in plants and food habits of early man. *Science.* **176**: 512-513.

Lepofsky, D. 2003. The Ethnobotany of cultivated plants of the Maohi of the Society Islands. *Econ. Bot.* **5**:73-92.

Liener, I.E. 1980. Heat-liable anti-nutritional factors. In: *Advances in Legume Science.* (Eds.) Summerfield, R.J. and Bunting, A.H., Kewi, Richmond, Survey, U.K. Royal Botanic Gardens. pp.157-170.

Liener, I.E. 1981. Factors affecting the nutritional quality of soya products. *Amer. Oil. Chem. Soc.* **58**: 406-415.

Liener, I.E. 1994. Implications of anti-nutritional components in soybean foods. CRC *Crit. Rev. Food Sci. Nutr.* **34**: 31-67.

Limaye, V.P. and Kore, V.N. 1978. Performance of high yielding sweet potato variety, Hybrid-268 under the Konkan (Maharashtra) conditions. *J. Root Crops* **4**: 43-45.

Longe, O.G. 1978. Carbohydrate constituents of different cassava varieties grown in Nigeria. *J. Root Crops* **4**: 1-8.

Lowry, O.H. Rosebrough, J.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with folin phenol reagent. *J. Biol. Chem.* **193**: 263-275.

Maikhuri, R.K., Nautiyal, S., Rao, K.S. and Semwal, R.L. 2000. Indigenous knowledge of medicinal plants and wild edibles among three tribal subcommunities of the central Himalayas, India. *J. Indigenous Knowledge Devt. Monitor.* **8**: 7-13.

Maini, S.B. 1978. Quality aspects of Cassava. Cassava Production Technology, CTCRI, Trivandrum (India). pp.49-57.

Maini, S.B. and Balagopal, C. 1978. Biochemical changes during post harvest deterioration of Cassava. *J. Root Crops.* **4**: 31-33.

Manandhar, N.P. 1995. A survey of medicinal plants of Jajarkot district, Nepal. *J. Ethnopharmacology.* **48**: 1-6.

Manandhar, N.P. 1997. Unreported wild food plants of Nepal. *Ethnobotany.* **9**: 97-100.

*Mandal, R.C., Singh, K.D. and Maini, S.D. 1982. *Veg. Sci.* **9**: 82-83.

Martin, F.W. and Thompson, A.E. 1971. Crude protein content of Yams. *Hort. Sci.* **6**: 545-546.

Martin-Tanguy, J., Vermorel, M., Lenoble, M., Martin, C. and Gallet, M. 1976. *Sorghum* tannins. Importance in nutritional nitrogen use in growing rats. *Ann. Biol. Anim. Biochem. Biophys.* **16**: 879-890.

Mary Josephine, R. and Janardhanan, K. 1992. Studies on chemical composition and anti-nutritional factors in three germ plasm seed materials of the tribal pulse, *Mucuna pruriens* (L.) DC. *Food Chem.* **43**: 13-18.

Maxon, E.D. and Rooney, L.W. 1972. Two methods of tannin analysis for *Sorghum bicolor* (L.) Moench, grain. *Crop. Sci.* **12**: 253-254.

Maya Devi. 2003. Wild edible plants of Sonitpur District, Assam. *J. Econ. Tax. Bot.* **27**: 396-409.

Mertz, W. 1981. The essential trace elements. *Science* **213**: p.1332.

Mitra, S.K., Sadhu, M.K. and Bose, T.K. (Ed.) 1990. Nutrition of vegetable crops. pp.354-366.

Mohan, V.R. and Janardhanan, K. 1993a. Chemical and nutritional evaluation of raw seeds of the tribal pulses *Parkia roxburghii.* G. Don and *Entada phaseoloides* (L.). Merr. *Inter. J. Food Sci. Nutri.* **44**: 47-53.

Mohan, V.R. and Janardhanan, K. 1993b. Chemical composition and nutritional evaluation of two little known species of *Vigna*. *Food Chem.* **48**: 367-371.

Mohan, V.R. and Janardhanan, K. 1995. Chemical determination of nutritional and anti-nutritional properties in tribal pulses. *J. Fd. Sci. Technol.* **32**: 465-469.

Mondal, P. and Mukherjee, P.K. 1992. Notes on ethnobotany of Keonjhar district, Orissa. *J. Econ. Tax. Bot.* **10**: 7-16.

Moorthy, S.N. and Padmaja, G. 1990. Comparative study on digestibility of raw and cooked starch of different tuber crops. *J. Root Crops.* **17**: 255-258.

Moorthy, S.N. and Padmaja, G. 2002. A rapid titrimetric method for the determination of starch content of Cassava tubers. *J. Root Crops.* **28**: 31-38.

Moorthy, S.N. Unnikrishnan, M. and Lakshmi, K.R. 1994. The physiochemical properties of starch of some accessions of *Amorphophallus paeoniifolius*. *Trop. Sci.* **34**: 371-376.

Mulla, K.M. and Kulkarni, A.R. 1994. Starch from bulbils of *Dioscorea bulbifera*. L. *J. Econ. Tax. Bot.* **18**: 517-519.

Muller, H.G. and Tobin, G. 1980. Nutrition and Food Processing. Croom Helm Ltd., London.

Murugesan, P.T. and Ananthalakshmi, A. 1991. Dietary practices of the Palliyar tribal group and the nutrient content of unconventional foods consumed. *Ind. J. Nutr. Dietet.* **28**: 297-301.

Nagaraja, R. V. 2000. Biochemical Composition of cashew (*Anacardium occidentale*) kernal testa. *J. Fd. Sci. Technol.* **37** : 554-556.

Nair, D.B. and Nair, V.M. 1992. Nutritional studies in sweet potato. *J. Root Crops.* **18**: 53-57.

Nair, S.G., Unnikrishnan, M., Sheela, M.N., Abraham, K., Vimala, B., Sreekumari, M.T. and Easwari Amma, C.S. 1999. Tuber Crops varieties released by CTCRI (Ed.) Edison, S. CTCRI, Thiruvananthapuram, Kerala.

Nambisan, B. and Malathi, V.G. 1993. Studies on Cyanoglucosides in relation to Cassava mosaic disease. *J. Root Crop.* **19**: 122-126.

Nambisan, B. and Sundaresan, S. 1990. Distribution pattern of Cyanoglucosides in Cassava tubers and leaves at different growth states. *J. Root Crops.* **17**: 261-264.

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

Naqshi, A.R. and Aman, N. 2001. Principal wild food plants of Kashmir Himalaya. *J. Econ. Tax. Bot.* **25**: 324-335.

Negi, K.S. 1988. Some little known wild edible plants of U.P. hills. *J. Econ. Tax. Bot.* **12**: 345-360.

Nilegaonkar, S., Vartak, V.D. and Chitre, R.G. 1985. Nutritional evaluation of some wild food plants from Pune and neighbouring districts, Maharashtra State: Part –1. *J. Econ. Tax. Bot.* **6**: 629-635.

Nowacki, E. 1980. Heat-stable anti-nutritional factors in leguminous plants. In: *Advances in Legume Science.* (Eds.) Summerfield, R.J. and Bunting, A.H., Kew, Richmond, Surrey, U.K. Royal Botanical Gardens, pp.171-177.

NRC/NAS, 1980. National Research Council Committee on Dietary Allowances. Recommended Dietary Allowances. 10th 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.

Ofori, K., Kumaga, F.K. and Bimi, K.L. 2001. Variation in seed size, protein and tannin content of bambara ground nut (*Vigna subterranean*) *Trop. Sci.* **41**: 100-103.

Ogato, F. and Makisumi, S. 1984. Isolation and characterization of trypsin inhibitors from tubers of taro (*Colocasia antiquorum* var. *nymphifolia*). *J. Biochem.* **96** : 1565-1574.

Oke, O.L. 1969. The role of hydrocyanic acid in nutrition. *Wld. Rev. Nutr. Diet.* **11**: 118-147.

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

Onyilagha, J.C. and Lowe, J. 1985. Crude Proteins of some Nigerian Cultivars of *Dioscorea cayenensis* and *D. rotundata. J. Root Crops.* **11**: 61-63.

Osagie, A.U. and Opoku, A.R. 1982. Enzymatic browning of Yams. *Nig. Jour. Biochem.*

Osuji, G. (Ed.). 1985. The Biochemistry and Technology of the Yam tuber. In: *Advances in Yam Research.* Anambra State University of Technology.

Oyenuga, V.A. 1959. Nigeria's Food and Feeding Stuffs, Ibadan University Press, Ibadan, Nigeria, p.99.

Padmaja, G. 1995. Cyanide detoxification in Cassava for food and feed uses. *Crit. Rev. Food Sci. Nutr.* **35**: 299-340.

Padmaja, G. 2001. CTCRI. Trivandrum (Personal Communication). In : *Analytical Methodologies for tropical tuber crops.* 2005 (Ed.) Edison,S. CTCRI, Trivandrum. pp.34-38.

Pal, G.D. 1984. Observations on Ethnobotany of Tribals of Subansiri, Arunachal Pradesh. *J. Bull. Bot. Surv. India.* **26**: 26-37.

Panasuik, O. and Bills, D.D. 1984. Cyanide contents of *Sorghum* sprouts. *J. Food Sci.* **49**: 791-793.

Pandey, R.P. and Singh, N.P. 2001. Floristic studies of the upper Luni Basin in Rajasthan. *J. Econ. Tax. Bot.* **25**: 145-215.

Parkinson, S. 1984. The contribution of aroids in the nutrition of people in the South Pacific. In: *Edible aroids.* (Ed.). Chandra, S. Oxford Clarendon Press. pp.215-224.

Paroda, R.S. and Arora, R.K. 1991. Plant Genetic Resources: General Perspective. In: *Plant Genetic Resources Conservation and Management* (Ed.). Paroda, R.S. and Arora, R.K. IBPGP, New Delhi. pp.1-23.

Pedralli, G. 1994. Collecting wild relatives of Yam (*Dioscorea* spp.) in the Espinbacco range. Brazil. *Pl. Genet. Res. Newslett.* **97**: 51.

Perumalsamy, R. and Ignacimuthu, S. 2000. Anti-bacterial activity of some folklore medicinal plants used by tribals in Western Ghats of India. *J. Ethnopharmacology.* **69**: 63-71.

Pollock, N.J. 1990. Arrowroot as a Pacific food stuff. *Ethnobotany.* **2**: 1-10.

Prakash, V. 1988. Indian medicinal plants: Current Status-I. *Ethnobotany.* **10**: 112-121.

Prakash, D. and Misra, P.S. 1987. Protein and aminoacid composition of some wild leguminous seeds. *Plant Foods Hum. Nutr.* **37**: 29-32.

Pramila, S.S., Kumar, A. and Raghuvanshi, R. 1991. Nutrient composition of some uncommon foods consumed by Kumaon and Garhwal hill subjects. *J. Fd. Sci. Technol.* **28**: 237-238.

Prasad, P.N. and Abraham, Z. 1984. Ethnobotany of the Nayadis of North Kerala. *J. Econ. Tax. Bot.* **5**: 41-48.

Prasad, V.K., Rajagopal, T., Kant,Y. and Badarinath, K.V.S. 1999. Food plants of Konda Reddis of Rampa Agency, East Godavari district. Andhra Pradesh—A Case Study. *Ethnobotany.* **11**:92-96.

Radhakrishnan, K., Pandurangan, A.G. and Pushpagandan, P. 1996. Ethnobotany of Wild plants of Kerala, India. In: *Ethnobiology in Human Welfare* (Ed.) Jain, S.K. Deep Publications, New Delhi, India, pp.48-51.

Radhika, V.S. and Sreeja, M. 2004. Anti-nutritional factors in food. *Kisan World.* p.62.

Raghunandan, K.V. and Jolly, C.I. 1987. Starch from *Dioscorea bulbifera. Indian J. Pharm. Sci.* **49**:233-236.

Ragupathy, S. and Mahadevan, A. 1991, Ethnobotany of Kodiakkarai Reserve Forest, Tamil Nadu, South India. *Ethnobotany* **3**: 79-82.

Rai, M.K. 1994. Herbal Medicines in India: Retrospect and Prospect. *Fitoterapia.* **65**: 483-491.

Rajendran, A. and Henry, A.N. 1994. Plants used by the tribe Kadar in Anamalai Hills of Tamil Nadu. *Ethnobotany.* **6**: 19-24.

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

Ramachandran, V.S. and Nair, V.J. 1981. Ethnobotanical Studies in Cannanore district, Kerala state (India). *J. Econ. Tax. Bot.* 2 : 593-604.

*Ramaswamy, N., Muthukrishnan, U.R. and Suresh, M. 1982. *Madras Agric. J.*, **69**: 135-8.

Rao, P.U. and Deosthale, Y.G. 1982. Tannin content of pulses: Varietal differences and effects of germination and cooking. *J. Sci. Food Agric.* **33**: 1013-1016.

Rao, R.R. and Jamir, N.S. 1990.Ethnobotany of AO and Angami Nagas of Nagaland. *J. Econ. Tax. Bot.* **14**: 593-604.

Rao, M.N., Shurpalekar, K.S. and Sundravalli, O.E. 1967. An amylase inhibitor in *Colocasia esculenta*. *Ind. J. Biochem.* **4**: 185.

Rao, M.N., Shurpalekar, K.S. and Sundaravalli, D.E. 1970. Purification and properties of ∝-amylase inhibitor from colocasia (*Colocasia esculenta*) tubers. *Ind. J. Biochem.* **7**: 241-243.

Ravishankar, T. 1996. Role of Indigenous People in the Conservation of plant Genetic Resources: In: *Ethnobiology in Human Welfare.* (Ed.) Jain, S.K. pp.310-314.

*Raymond, W.D., Jojo,W. and Nicodemus, Z. 1941: Z.E. African *Agr. J.* **6**: 154-159.

Rekha, M.R. 2000. Biological variations, metabolic significance and kinetic properties of the Amylase inhibitor of Tuber crops. Ph.D. Thesis, University of Kerala, Trivandrum.

Rekha, M.R. and Padmaja, G. 2002. Alpha-amylase inhibitor changes during processing of sweet potato and taro tubers. *Plant Foods Hum. Nutr.* **57**: 285-294.

Rekha, M.R., Padmaja, G., Easwari Amma, C.S. and Sheela, M.N. 1999. Cultivar differences in the alpha-amylase inhibitor activity of sweet potato and yam tubers. *J. Root Crops.* **25**: 185-191.

Rekha, M.R., Padmaja, G. and Thankamma Pillai, P.K. 1997. Cultivar differences in the apparent amylase inhibitor activity of taro tubers. *J. Root Crops* **23**:39-44.

Ryan, C.A. 1990. Protease inhibitor in plants: Genes for improving defenses against insects and pathogens. *Ann. Rev. Phytopathol.* **28**: 425-449.

Sadasivam, S. and Manickam, A. (Eds.) 1996. Biochemical Methods. New Age International (P) Limited. Publishers. New Delhi. India. pp.1-250.

Saha, B.P. and Hussain, M. 1983. A study of the irritating principle of aroids. *Indian J. Agri. Sci.* **53**: 833-836.

Sakai, W.S. 1979. Aroid root crops, acridity and raphides. In: Tropical Foods: Chemistry and Nutrition. (Eds.) Inglett,G.E. and Charlambous.G. Academic Press, New York. pp.265-278.

Sakai. 1983. Aroid root crops: Alocasia, Cyrtosperma and Amorphophallus. In: *Hand book of Tropical Foods.* (Ed.) Chan, H.T., New York, Marcel Dekker, pp.29-83.

Salunkhe, D.K., Sathe, S.K. and Reddy, N.R. 1982. Legume Lipids. In: *Chemistry and Biochemistry of Legumes.* (Ed.) Arora, S.K. Oxford & IBH Publishing Co., New Delhi, India. pp.51-107.

Santapau, H. 1953. The flora of Khandala in Western Ghats of India (Eds. 1,2 and 3) *Rec. bot. Surv. India.* **16**: 1-372.

Sasikaran, K. and Padmaja, G. 2003. Inactivation of trypsin inhibitors in sweet potato and taro tubers during processing. Plant Foods *Hum. Nutr.* **58**: 153-163.

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

Sasikiran, K., Padmaja, G. and Thankamma Pillai, P.K. 1997a. Biological variations in the apparent proteinase inhibitory activities of root crops. I. Trypsin inhibitory activity of taro tubers. *J. Root Crops.* **23**: 45-50.

Sasikiran, K., Padmaja, G. and Thankamma Pillai, P.K. 1997b. Biological variations in the apparent proteinase inhibitory activities of root crops. II. Chymotrpsin inhibitor activity of taro tubers. *J. Root Crops* **23**: 51-56.

Sebastian, M.K. and Bhandari, M.M. 1990. Edible wild plants of the forest areas of Rajasthan. *J. Econ. Tax. Bot.* **14**: 689-694.

*Sen, H. and Roy Choudhury, N. 1988. *Environ. Ecol.* **6**: 431-3.

Seralathan, M.A. and Thirumaran, A.S. 1999. Studies on the Nutritive value and cooking qualities of Minor Tubers. In: *Tropical tuber crops.* (Eds.) Balagopalan, C., Nayar, T.V.R., Sundaresan, S., Premkumar, T. and Laskshmi, K.R. CTCRI, Trivandrum.

Sharma, K.K. and Pattabiranam, T.N. 1982. Natural plant enzyme inhibitors. Purification and properties of ∝-amylase inhibitors from yam (*Dioscorea alata*). *J. Sci. Food Agric.* **33**: 255-262.

Sheeba Ravi and Padmaja, G. 1997. Mechanism of cyanogens reduction in Cassava roots during cooking. *J. Sci. Food Agric.* **75**: 427-432.

Sherman, H.C., Dickson, M.A., Smith, M.C. and Daniel, E.P. 1939. Mineral requirements of man. In: *Food and Life*: Yearbook of Agriculture (University States Department of Agriculture), United States Government Printing Office, Washington, DC, USA. pp.187-221.

Shivaraj, B; Sharma, K.K. and Pattabiraman, T.N. 1979. Natural Plant enzyme inhibitor Part-VII—Alpha amylase inhibitors and amylases in plant tubers. *Ind. J. Biochem. Biophys.* **16**: 52-55.

Siddhuraju, P., Vijayakumari, K. and Janardhanan, K. 1996 a. Chemical Composition and Protein quality of the little-known legume, Velvet bean (*Mucuna pruriens* (L.) DC.) *J. Agric. Food Chem.* **44**: 2636-2641.

Siddhuraju, P., Vijayakumari, K. and Janardhanan, K. 1996 b. Chemical Compsition and nutritional evaluation of an under-exploited legume, *Acacia nilotica* (L.). *Del. Food Chem.* **57**: 385-391.

Singh, A.K. 1999. A contribution to the ethnobotany of sub-Himalayan region of Eastern Utter Pradesh. *J. Econ. Tax. Bot.* **23**: 237-246.

Singh, U. 1984. The inhibition of digestive enzymes by polyphenols of chickpea. (*Cicer arietinum* L.) and Pigeon pea (*Cajanus cajan* (L.) Millsp. *Nutr. Rep. Intanatl.* **29**: 745-753.

Singh, U. 1988. Anti-nutritional factors of chickpea and pigeon pea and their removal by processing. *Plant Foods Hum. Nutr.* **38**: 251-261.

Singh, U. 1993. Protein quality of pigeon pea *Cajanus cajan* (L.) Mills. as influenced by seed polyphenols and cooking process. *Plant Foods Hum. Nutr.* **38**: 251-261.

Singh, V. 1995. Lesser known wild edible of Sikkim Himalaya. *J. Econ. Tax. Bot.* **19**: 385-390.

Singh, H.B., Hynniewta, T.M. and Bora, P.J. 1999. An ethnobotanical note on wild edible plants of Tripura, India. *Ethnobotany* **11**: 26-28.

Singh, H., Gupta, L.K., Shah, S.C. and Bisht, G.S. 1995. Observation of wild edible plants growing around the Government garden, Chaubatti (Ranikhet) district. Almora, Uttra Pradesh. *J. Econ. Tax. Bot.* **19**: 325-330.

Singh, R.S. and Singh, N.I. 1985. A preliminary ethnobotanical studies on wild edible plants in the markets of Manipur-I. *J. Econ. Tax. Bot.* **6**: 699-703.

Singh, U. and Singh,B. 1992. Tropical grain legume as important human foods. *Econ. Bot.* **46**: 310-361.

Singh, V. and Singh, P. 1981. Edible wild plants of Eastern Rajasthan. *J. Econ. Tax. Bot.* **2**: 197-207.

Sinha, R.K. and Sinha, S. 2001. *Ethnobiology.* Surabhi Publications. Jaipur. India. pp.27-56.

Smith, D.L. 1982. Calcium oxalate and carbonate deposits in plant cells. In: *The Role of Calcium in Biological systems.* (Eds.) Anghileri, L.J. and Anghilai, A.M.T. RC Press, Florida, pp.253-261.

Solomonson, L.P. 1981. Metabolic inhibitor. In: *Cyanide in Biology.* (Eds.) Vennesland, B., Conn, E.E., Knowles,C.J., Westley, J. and Wissing, F. Academic Press, New York. 11.

Subramaniam, A. and Dwarakan, P. 2002. A Catalogue of indigenous bulbous plants from shevaroy hills of Salem district, Tamil Nadu. *J. Econ. Taxon. Bot.* **26**: 25-27.

Sudhakar, A. and Vedavathy, S. 1999. Wild edible plants used by the tribals of Chittoor district (Andra Pradesh), India. *J. Econ. Tax. Bot.* **23**: 321-329.

Sugiura, M., Ogiso, T., Takeuti, K., Tamura, S. and Ito, A. 1973. Studies on trypsin inhibitors of sweet potato. *Biochem. Biophys. Acta.* **328**: 407-417.

Sumathi, S. and Pattabiraman, T.N. 1977. Natural plant enzyme inhibitors V. A Trypsin/ Chymotrypsin inhibitor from *Alocasia macrorrhiza* tubers. *Biochem. Biophys. Acta.* **45**: 167-178.

Sundaresan, S., Babu, L. and Nambisan, B. 1990. Biochemical changes in yam tubers during storage. *J. Root Crops.* **17**: 265-269.

Tang, C. and Sakari, W.S. 1983. In: *Taro.* (Ed. Wang, J.K.) Univ. Hawaii Press, Honolulu, pp. 148-163.

Thompson, L.U. 1988. Anti-nutrients and blood glucose. *Food Technol.* **42**: 123-132.

Thothathri, K. 1980. Plant resources and their utilization in the Andaman and Nicobar Islands. *J. Econ. Tax. Bot.* **1**: 111-114.

Thothathri, K. and Pal, G.D. 1987. Further contribution to the Ethnobotany of tribals of Subansiri district, Arunachal Pradesh. *J. Econ. Tax. Bot.* **10**: 149-157.

Tripathi, Y.C. 2000. Promising resources of Rajasthan Forest. *Ad. Plant Sci.* **13**: 31-37.

Turnlund, J.R. 1994. Future directions for establishing mineral/ trace element requirements. *J. Nutr.* **124**: 17655-17705.

Udoessien, E.I. and Ifon, E.T. 1992. Chemical evaluation of some anti-nutritional constituents in four species of yam. *Trop. Sci.* **32**: 115-119.

Umbreit, W.W., Burries, R.S. and Stauffer, J.R. 1972. *Manometric biochemical technique: Manual of tissue metabolism.* Minneapolis Burgess.

Unnikrishnan, M., Edison, S. and Sheela, M.N. 2004. Tuber crops and their wild relatives. In: *Tamil Nadu Biodiversity strategy and Action Plan.* (Ed.) Annamalai, R. Tamil Nadu Forest Department. Government of Tamil Nadu. Chennai. pp.159-168.

Uzogara, S.G., Morton, I.D. and Daniel, J.W. 1990. Changes in some anti-nutrients of cowpeas (*Vigna unguiculata*) processed with 'Kanwa' alkaline salt. *Plant Foods Hum. Nutr.* **40**: 249-258.

Vadivel, V. and Janardhanan, K. 2000. Nutritional and anti-nutritional composition of velvet beans an under-utilized food legume in South India. *Int. J. Food Sci. Nut.* **51**: 279-287.

Vadivel, V. and Janardhanan, K. 2001. Nutritional and anti-nutritional attributes of the under-utilized food legume, *Cassia floribunda. Cav. Food Chem.* **73**: 209-215.

Vartak, V.D. 1959. Some edible plants of hilly regions of Poona district. Bombay State. *J. Bom. Nat. Hist. Soc.* **56**: 8-25.

Vartak, V.D. 1982. Observation on wild edible plants from hilly region of Maharashtra and Goa: *Resume and future prospects. Glimpses of Indian Ethnobotany.* pp.261-270.

Vartak, V.D. and Suryanarayana, M.L. 1995. Enumeration of wild edible plants from Susala Island. Mulshi Reservoir, Pune district. *J. Econ. Tax. Bot.* **19**: 555-569.

Venkatachalan, P.S. 1962. A study of the diet, nutrition and health of the people of the Chimbu area. Ph.D. Monograph No.4, Port Moresby Dept. Public Health, Port Moresby, Papua New Guinea.

Vijayakumari, K., Siddhuraju, P. and Janardhanan, K. 1995. Effects on various water or hydrothermal treatments on certain anti-nutritional compounds in the seeds of the tribal pulse, *Dolichos lab lab* var. *vulgaris* L. *Plant Foods Hum Nutr.* **48**: 17-29.

Vijayakumari, K., Siddhuraju, P. and Janardhanan, K. 1996. Effect of different post-harvest treatments on anti-nutritional factors in seeds of the tribal pulse, *Mucuna pruriens* (L.) DC. *Inter. J. Food Sci. Nutr.* **47**: 263-272.

Vijayakumari, K., Siddhuraju, U.P. and Janardhanan, K. 1997 a. Chemical composition aminoacid content and protein quality of the little known legume *Bauhinia purpurea* L. *J. Sci. Food Agric.* **73**: 279-286.

Vijayakumari, K., Siddhuraju, P. and Janardhanan, K. 1997b. Effect of domestic processing on the levels of certain anti-nutrients in *Prosopis chinensis* (Molina) Stunz seeds. *Food Chem.* **59**: 367-371.

Vimala, B. 1995. Lesser known edible tuber crops in India. A Review. *J. Root Crops* **21**: 51-64.

Viswanathan, M.B. 2004. Ethnobotanically important plants. In: *Tamil Nadu. Biodiversity strategy and Action Plan.* (Ed.) Annamalai, R. Tami Nadu Forst Department, Government of Tamil Nadu, Chennai. pp.170-231.

Viswanathan, M.V. 1999. Edible and medicinal plants of Ladakh (J.K.) *J. Econ. Tax. Bot.* **23**: 151-154.

Wilkins, R.M. 1963. Dietary survey in a Fijian village, Naduri, Nadroga, South Pacific Health Service Dept., Suva, Fiji.

Yamashita, E. and Yoshikowa, N. 1973. Studies on the mucilage in Sakoimo (*Colocasia antiquorum* Schott. var., *esculenta.* Eng.), *J. Jap. Soc-Food Nutr.* **26**: 303-307.

Zeven, A.C. and de Wet, J.M. J. 1982. *Dictionary of cultivated plants and their regions of Diversity.* ed. 2. PUDOC, Wageningen, The Netherlands.

* Original not seen.

# LIST OF PAPERS PRESENTED / PUBLISHED / COMMUNICATED

## LIST OF PAPERS PRESENTED/ PUBLISHED/ COMMUNICATED

1. **Shanthakumari, S.** 2004. Nutritional evaluation of the rhizome of *Maranta arundinacea* (abst), Paper presented in National Seminar on Rural Biotechnology for Sustainable Development, Gandhigram, 19-20. Feb. 2004.

2. **Shanthakumari, S.** 2004. Studies on the wild edible tubers of Kanyakumari district, Tamil Nadu (abst), Paper presented in Fourth National Conference on Siddha Medicine for All Ages—Friends of Siddha Medicine, Thoothukudi, 11-12 Dec. 2004.

3. **Shanthakumari, S.**, Mohan, V.R. and Britto, J.D. 2004. Chemical analysis of the rhizome of *Maranta arundinacea* (L.) *Journal of Eco. Tax. Bot.* (communicated).

4. **Shanthakumari, S.**, Mohan, V.R. and Britto, J.D. 2005. Nutritional quality and effect of various treatments on certain anti-nutritional compounds in wild yams. (abst.), Paper presented in 2nd National Seminar on Root and Tuber Crops (NSRTC-2) 'Achievements and Opportunities in Postharvest Management and Value Addition in Root and Tuber Crops'—Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 19-20 July, 2005.

5. **Shanthakumari, S.**, Mohan, V.R. and Britto, J.D. 2005. Chemical composition and nutritive value of tannia (*Xanthosoma sagittifolium* (L.) Schott.) (abst.), Poster presented on 2nd National Seminar on Root and Tuber Crops (NSRTC-2) 'Achievements and Opportunities in Postharvest Management and Value Addition in Root and Tuber Crops'—Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 19-20 July, 2005.

## 02-88 NUTRITIONAL EVALUATION OF THE RHIZOME OF *Maranta arundinacea* (L.)

*** Shanthakumari S, ** Mohan V.R and *** John De Britto**

* Department of Botany, Sarah Tucker College, Tirunelveli-627 007
** PG Department of Botany, VOC College, Thoothukudi-628 008
*** Department of Botany, St.Xavier's College (Autonomous), Palayamkottai-627 002

The rhizome of *Maranta arundinacea (L.)* has traditionally been eaten by the tribal Kanikars in Kanyakumari District. The data on the chemical composition, nutritional attributes and the anti-nutritional contents of the rhizome of *Maranta arundinacea (L.)* are not readily available. The proximate composition, total protein, total starch, total sugars, *in vitro* starch digestibility, *in vitro* protein digestibility and certain anti-nutritional contents of the rhizome of *Maranta arundinacea (L.)* have been analysed.

## 02-89 ANTI-INFLAMMATORY ACTIVITY OF *Abelmoschus ficulneus*

*** Sethuraman M.G and Vigneswari K**

* Department of Chemistry, The Gandhigram Rural Institute, Gandhigram – 624 302
Department of Bio-technology, Kamaraj College of Engineering and Technology, Virudunagar – 624 001

*Abelmoschus ficulneus* Weight. and Arn. (Syn: *Hibischus ficulneus)* Linn. is a herbaceous, prickly, annual bush, indigenous to the hotter parts of India. The flowers and dry pods of the plant have been taken up for the work and the polyphenolic constituents isolated were characterized by spectral studies such as UV, $^{1}H$ and $^{13}C$ NMR. The isolated flavonoids were tested for anti-inflammatory activity by both *in*

Fourth National Conference on

# Siddha Medicine for All Ages

**Thoothukudi, 11 - 12 December, 2004**

## *Honorary Patrons*

*Siddha Maruthuva Kavalar* **TMT. QUDSIA GANDHI,** IAS

**THIRU. M.F. FAROOQUI,** IAS

*Siddha Maruthuva Chemmal* **Dr.J.R.KRISHNA MOORTHY** GCIM

## *Organising Secretary*

**Dr. J. Joseph Thas,** BSc., MBBS., MSc. Ph.D. DSc.

President, FSM, Palayamkottai

## *Joint Secretaries*

**Thiru. V. Kanagavel,**

Secretary, Kamaraj collge, Thoothukudi

**Fr. Britto Vincent, SJ**

Director, FRRC, SXC, Palayamkottai

**Thiru S. Cletus Babu,** M.A. L.L.B.

Chairman, SCAD Group, Tirunelveli

**Thiru S.S. Vanangamudi** M.Sc. (Agri)

Managing Director, APEX Laboratries, Chennai

## 15. HERBS ARE NATURAL REMEDIES FOR GOOD HEALTH

*RANI VIJAYA, C.* and SARADA, T.

Dept. of Zoology, Sri Parasakthi College, Courtallam.

More and more people are curing their illnesses with the herbal treatments and natural preventives that have been effectively used for thousands of years. Herbs play a significant role, especially in modern times. When the damaging effects of food processing and over medication have assumed alarming proportions. most herbs have little or no harmful side effects.

*Allium sativum*: Garlic has been highly valued for centures all over the world for its health - building qualities. Hippocrates, the father of medicine (460-357 B.C.) recommended the use of this herb in infectious disease, and intestinal disorders. In herbal medicine, garlic has been traditionally used for asthma, deafness, leprosy, worms, liver and gall bladder trouble. Clinical experiments in recent times proved that garlic juice has most beneficial effect on the entire body system. In Ayurveda, a decoction of garlic boiled in milk is considered a wonderful drug for tuberculosis. It is used in the treatment of asthma, digestive disorders, high blood pressure, cancer, whooping cough, skin disorders, wounds and ulcers. It is also used both as food and seasoning agent in the preparation of soups, sauces and pickles.

*Piper nigrum*: Pepper is one of the oldest and most important of all spices. It is known as the King of Spices Pepper was mentioned by Theophrastis in 372 - 287 B.C. Pepper is a native of the Western Ghats of India. It is a stimulant, aromatic and digestive tonic. Pepper has a stimulating effect on the digestive organs and produces and increased flow of saliva and gastic juices. Pepper is beneficial in the treatment of cold, fever, amnesia, coughs, impotency, muscular pains and pyorrhoea.

## 16. HERBS THAT HEAL - NATURAL REMEDIES FOR GOOD HEALTH

*SRIDEVI, T.* and SARADHA, T.

Dept. in Zoology, Sri Parasakthi College, Courtallam.

The practice of herbal medicine dates back to the very earliest periods of known human history. There is evidence of herbs having been used in the treatment of diseases and for revitalising body systems in all ancient civilizations. Plants were the mainstay of medicine and credited with mystical and supernatural powers of healing. In India, records indicate that herbs have been in use for treating diseases since ancient times.

*Gingiber officinale:* Ginger is a perennial herb and used as medicine in India from Vedic period. Ancient physicans used it as a carminative or anti flatulent. Ginger is widely used in local medicines in India and Far East. Ginger is available in two forms, fresh and dried. Both forms are effective. Ginger is extremely useful in the treatment of syspepsia, vomiting, pain in stomach, cough, cold, impotency and Respiratory disorders. In western countries, it is widely used in biscuits, cakes, puddings, soups and pickles. The essential oil from the rhizomes is used in the manufacture of essence and in perfumes.

*Myristica fragrans:* Nutmeg is the dried kernel of the seeds of an evergreen tree. It has a strong aroma with a slightly bitter taste. The tree grows in Indonesia, Malaysia, Sri Lanka and West Indies. Nutmeg contains as essential oil and saponin. It was used in the preparations of various medicines in ancient times. It is used in the treatment of digestive disorders, insomnia, dehydration, Skin disorders, Rheumation. Nutmeg should be taken in very small doses. The ripe seeds of the fruit contains a volatile oil.

## 17. STUDIES ON THE WILD EDIBLE TUBERS OF KANYAKUMARI DISTRICT, TAMILNADU

*SHANTHAKUMARI, S.*[1], MOHAN, V.R.[2] and JOHN DE BRITTO, A.[3]

[1]Department of Botany, Sarah Tucker College, Tirunelveli - 627 007. [2]PG Department of Botany, V.O.C. College, Tuticorin - 628 008. [3]Research Department of Botany, St. Xavier's College (Autonomous), Tirunelveli - 627 002.

Tuber crops, a cheap source of food are rich in nutrients, vitamins and minerals. They play a major role in sustaining people during famine. The Kanikkars inhabiting the forests of Kanyakumari use wild tubers for food and medicine. The wild edible plants can be used as food, raw material for extraction of starch, medicine, animal feed and manure. The Lesser known rhizomatous plants and tuberous root crops such as *Maranta arundinacea, Dioscorea alata, D. bulbifera, D. oppositifolia, D. pentaphylla* etc. substitute their diet as well as treat their ailments.

About 12 wild edible tubers belonging to 4 families along with their mode of treating various ailments are listed.

## 18. எலுமிச்சையின் மருத்துவப் பலன்கள்

*பணி. அந்தோணி*

பெஸ்கி இல்லம். திண்டுக்கல்.

# CHEMICAL ANALYSIS OF THE RHIZOME OF *MARANTA ARUNDINACEA* (L.)

**SHANTHAKUMARI. S[1], V.R. MOHAN[2] AND A.JOHN DE BRITTO[3]**
[1]*Department of Botany, Sarah Tucker College, Tirunelveli, 627007.*
[2]*P.G. Department of Botany, V.O.C. College, Thoothukudi, 628008.*
[3]*Research Department of Botany, St.Xavier's College (Autonomous), Palayamkottai, 627002..*

## ABSTRACT

The tribal Kanikkars in Kanyakumari district consume the rhizome of *Maranta arundinacea* (L.). The information on the chemical analysis, nutritional attributes and the anti-nutritional properties of the rhizome of *Maranta arundinacea* (L.) are not readily available. The proximate composition, total protein, starch, sugars, *in vitro* starch digestibility, *in vitro* protein digestibility and certain anti-nutritional properties of the rhizome of *Maranta arundinacea* (L.) were analysed.

The crude protein content was 13.13%, crude lipid 1.12%, crude fibre 6.48% and ash 2.10%. The rhizome was found to be a rich source of total starch. The *in vitro* protein digestibility and *in vitro* starch digestibility of the rhizome were 4.38 units and 6.12 units respectively. The anti-nutritional principles like total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity were also analysed.

## INTRODUCTION

Tuber crops, a cheap source of food play a major role in sustaining people during famine. They accumulate starch in the enlarged underground part. One among such tuber crop accumulating starch in the underground rhizome is *Maranta arundinacea* commonly called Arrow root, belonging to the family Marantaceae. This plant is an erect, perennial herb, indigenous to tropical America. It has been widely distributed throughout the tropical countries like India, Srilanka and West Indies.

The rhizome contains maximum amount of starch but the rhizome are more fibrous and the starch is difficult to extract. Arrow root starch is a fine, white powder, tasteless and odourless when dry and is valued as a food for infants, invalids and convalescents. Very little information is available on the chemical composition of wild tubers and rhizomes (Karnick, 1971; Shenoy *et al.*, 1990, Rajyalakshmi and Geervani, 1994 and Nassar, 1999).

In this context, in the present investigation, an attempt has been made to understand the chemical composition and anti-nutritional factors of the rhizome, *Maranta arundinacea* (L.) with a view to assess the chemical and nutritional quality.

## MATERIALS AND METHODS

The rhizome of *Maranta arundinacea* (L.) were collected from Thalaikkumalay, Kanyakumari District, Tamil Nadu. Soon after collection, the rhizome were sun dried and stored.

Moisture content was determined by the method of Rajaram and Janardhanan (1990). The rhizome were powdered in Willeymill 60 mesh size and stored in screwcap bottles at room temperature for further analysis. Nitrogen content was estimated by the microkjeldahl method (Humphries, 1956) and crude protein was calculated (Nx6.25) . The contents of crude lipid, crude fibre and ash were estimated by AOAC (1975) methods Nitrogen free extract (NFE) were obtained by difference (Muller and Tobin, 1980). The energy value of the rhizome was estimated (KJ) 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).

The total soluble protein content of the extract was estimated by the method of Lowry *et al.*, (1951). The total starch and total sugar content were determined by the titrimetric method of Moorthy and Padmaja (2002). The *in vitro* protein digestibility and *in vitro* starch digestibility were determined by the method of Padmaja (2001).

The antinutritional compounds, total free phenolics (Bray & Thorne, 1945), tannins (Burns, 1971), oxalate (AOAC, 1984) and hydrogen cyanide (Jackson, 1967), amylase inhibitor activity (Rekha and Padmaja, 2002) and trypsin inhibitor activity (Sasikiran and Padmaja, 2003) were quantified.

## RESULTS AND DISCUSSION

Table 1 shows the proximate composition of the rhizome of *Maranta arundinacea*. The results obtained in this study broadly agree with the data from elsewhere (Coursey 1967, Vimala 1995). The moisture content although considerably high the rhizome can be used effectively after drying and purifying. The crude protein content is somewhat similar to that of other tubers, *Dioscorea* species (St.Vincent 1887, Rajyalakshmi and Geervani 1994 and Coursey, 1967). The calorific value indicates that people of all age can consume it as their food.

The soluble protein, starch, total sugar content,, *in vitro* protein digestibility and *in vitro* starch digestibility of the rhizome of *Maranta arundinacea* are given in table 2. Arrow root cannot contribute sufficiently to the recommended daily protein requirement of 23 to 56 g (National Research Council, 1974), but it supplies almost pure starch. The total starch content is found to be higher than that of the tubers like *Dioscorea oppositifolia*, *D. bulbifera*, *D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994); *Amorphophallus campanulatus* (Parkinson, 1984) and *Ipomoea batatus* (Truong *et al.*, 1986).

The total sugar content of the investigated rhizome was relatively lower than other tubers like *Ipomoea batatus* (AVRDC, *1983); Colocasia esculenta* (Yamashite and Yoshikawa, 1973) and *Manihot esculentum* (Ketiku and Oyenuga, 1970). The *in vitro* starch digestibility is found to be lower than the other tubers like *Dioscorea oppositifolia*, *D. bulbifera, D. pentaphylla* and *D. hispida* (Rajyalakshmi and Geervani, 1994).

The protein quality is affected by factors that interact with the intestinal tract such as protease inhibitors, phytate, lectins, tannins and saponins that reduce protein digestibility and amino acid absorption. These substances unless destroyed by heat or by some other suitable treatment can exert adverse physiological effects when ingested by man and animals (Liener, 1994).

On the contrary, it has been suggested that consumption of low levels of certain anti-nutrients may produce health benefits while avoiding some of the adverse effects associated with their large intake (Thompson, 1988). In view of this, in the present investigation an attempt has been made to detect the presence of certain anti-nutritional factors such as total free phenolics, tannins, total oxalate, hydrogen cyanide, trypsin inhibitor activity and amylase inhibitor activity (Table 3).

The content of total free phenolics of *Maranta arundinacea* appears to be lower than the earlier reports in the tubers of *Ipomoea batatas* (Adelusi and Ogundana, 1987); *Dioscorea esculenta, D. alata, D. rotundata* (Babu *et. al.*, 1990); Sundaresan *et al.*, 1990) and *Manihot esculenta* (Babu *et al.*, 1990). The investigated rhizome contain less tannin when compared with other earlier reports in the tubers of *Dioscorea alata, D. cayenensis, D. rotundata* and *D. esculenta* (Udoessien and Ifon, 1992). The hydrogen cyanide level is found to be lower when compared with the earliest results obtained in the tubers of *Manihot utilisima* and *M.palmata* (Oke, 1975), *M.esculenta* (Nambisan and Sundaresan, 1990) and in the tubers of *Dioscorea alata*, *D. cayenensis*, *D. rotundata* and *D. esculenta* (Udoessien and Ifon, 1992).

The level of total oxalate in the rhizome of *Maranta arundinacea* is very low when compared with the level in the Yam species like *Dioscorea alata, D. cayenensis, D. rotundata* and *D.esculenta* (Esuabana, 1982). $\alpha$-amylase occur widely in plant and animal kingdom. Inhibitors of these enzymes are implicated to have a major role in the regulation of plant metabolism, animal digestion of carbohydrate and insect resistance mechanism of plants. The $\alpha$-amylase inhibitor content is lower in the analysed rhizome than the other *Dioscorea* species like *D. oppositifolia*, *D. bulbifera, D. pentaphylla and D. hispida (Rajyalakshmi and Geervani,* 1994*)*.

Trypsin inhibitor activity was low when compared with other species like *Dioscorea alata*, *D. rotundata* and *D. esculenta* (Sasikiran *et al.*, 1999).

A trypsin inhibitor with low molecular weight capable of inhibiting trypsin, $\alpha$-chymotrypsin and enterokinase has been reported from arrowroot by Rao *et al.* (1983).

Based on the above findings, rhizome of arrowroot are reported as a good source of starch, protein, sugar and fibre and they are capable of making valuable contributions to human diet in their areas of production. As all the anti-nutritional compounds are found only in a low level in this rhizome it can be recommended to both rural and urban people for its wide utilization.

**ACKNOWLEDGEMENT**

The author wishes to express her sincere thanks to Dr.S.Edison, Director, CTCRI, Sreekariyam, Thiruvananthapuram, and Dr.G.Padmaja, Head, Division of Crop Utilization, CTCRI for offering training in their institute.

**Table 1**: Proximate composition of the rhizome of *Maranta arundinacea*[a]

| Components | g/100 g. |
|---|---|
| Moisture | 78.08 |
| Crude protein (Kjeldhal Nx6.25) | 13.13 |
| Crude lipid | 1.12 |
| Crude fibre | 6.48 |
| Ash | 2.10 |
| NFE (Nitrogen free extract) | 77.17 |
| Calorific value ($KJ100^{-1}$ DM) | 1550.23 |

[a]Mean of triplicate determinations expressed on dry weight basis.

**Table 2**: Soluble protein, starch, total sugars, *invitro* protein digestibility and *in vitro* starch digestibility of the rhizome of *Maranta arundinacea*[a]

| Components | g/100 g. |
|---|---|
| Soluble protein | 1.242 |
| Starch | 64.29 |
| Total sugars | 3.27 |
| *Invitro* protein digestibility units* | 4.38 |
| *Invitro* starch digestibility units** | 6.11 |

[a]-Mean of triplicate determinations expressed on dry weight basis.

* 1 Unit = g aminoacid released per 100g tuber (DM basis)

** 1 Unit = mg reducing groups /hr /g sample

**Table 3**: Antinutritional factors of the rhizome of *Maranta arundinacea*[a]

| Components | g/100 g. |
|---|---|
| Total free phenolics | 0.09 |
| Tannins | 0.76 |
| Oxalate | 0.43 |
| Cyanogens (mg/100 g) | 0.05 |
| Amylase inhibitor activity AIU/g soluble protein | 1.69 |
| Trypsin inhibitor activity TIU/g soluble protein | 4.40 |

[a] – Mean of triplicate determinations expressed on dry weight basis.

## REFERENCES


1. ADELUSI, A.A. & S.K. OGUNDANA, S.K. 1987. Phenolics and ascorbic acid accumulation in some infected root crops. *J. Root Crops*: 270-273.
2. AOAC, *Methods of Analysis* (12edn). Association of Official Analytical Chemists, Washington D.C. 1975. Binghams. 1978. Nutrition: A Consumer's Guide to Good Eating: 123-127.
3. AOAC, *Methods of Analysis* (14edn). Association of Official Analytical Chemists, Washington D.C. 1984. Bradbury, J.H. and Holloway, W.D. 1988. Chemistry of tropical root crops: Significance for nutrition and agriculture in the Pacific Australian Centre for International Research, Canberra: 46.
4. AVRDC, 1983. *Annual Report of Asian Vegetable Research and Development Centre*, Taiwan, Ibid., 308.
5. BABU, L., B. NAMBISAN, S. SUNDARESAN, S. 1990. Comparative evaluation of biochemical constituents of selected tuber crops. *J. Root Crops*: 270-273.
6. BRAY, H.G. & W.V. THORNE, 1945. Analysis of phenolic compounds. *Meth Biochem. Anal* **1**: 27-52.
7. BURNS, R.R. 1971. Methods for estimation of tannin in grain. *Sorghum. Agron J.* **63**: 511-512.
8. COURSEY, D.G. 1967. Yams, *Dioscorea* species. In: *Evolution of crop plants*, Ed. Simmords, N.W., Longman Inc., New York, 339.
9. ESUABANA, N.J. 1982. The Phenolic and Toxic compiound in four types of yarms *Dioscorea* species. HND project, Polytechnic Calabar.
10. HUMPHRIES, E.C. 1956. Mineral Components and ash analysis. In: *Modem methods of plant analysis*. Vol. 1 (Eds.) Paech, K. and Tracey, M.V. Springer-Verlag. Berlin: 468-502.
11. JACKSON, V.L. 1967. Soil chemical analysis; Madras, India: Asia Publishing House.
12. KARNICK, C.R. 1971. *Quart.* Phytochemical Investigation of some *Dioscorea* species and varieties found in India. *J. Crude Drug Res.*, II (3): 1761-1773.
13. KETIKU, A.O. & V.O.OYENUGA. 1970. Preliminary report of carbohydrate content of cassava root and yam tubers. *Nig. J. Sci.* **4**: 25-30.
14. LIENER, I.E. 1994. Implications of antinutritional components in soybean foods. CRC. *Crit. Rev. Food Sci. Nutri.* **34**: 31-67.
15. LOWRY, O.H., N.J. ROSEBROUGH, Farr., A.L., Randall, R.J. 1951. Protein measurement with Folin Phenol reagent. *J. Biol. Chem.* **193**: 265-275.
16. MOORTHY, S.N. & G. PADMAJA, 1990. Comparative study on digestibility of raw and cooked starch of different tuber crops. *J. Root Crops* (Special Issue) **17**: 255-258.

17. MOORTHY, S.N. & G. PADMAJA, 2002. A rapid titrimetric method for determination of starch content of Cassava tubers. *J. Root Crops.* **28**(1): 31-38.

18. MULLER, H.G. & G. TOBIN, 1980. *Nutrition and food processing.* Croom Helm Ltd., London.

19. NAMBISAN, B. & S. SUNDARESAN, 1990. Distribution pattern of cyanoglucosides in cassava tubers and leaves at different growth stages. *J. Root Crops.* **17**: 261-264.

20. NASSAR, N.M.A. 1999. Wild cassava, Manihot spp. Biology and Potentialities for crop genetic improvement. *J. Root Crops.* **25**(1): 33-50.

21. National Research Council. 1974. Recommended daily dietary allowance. *Nutrition Reviews* **31**(12): 373-395.

22. PADMAJA, G. 2001. Personal Communication, CTCRI, Trivandrum.

23. OKE, O.L. 1975. The role of cassava in the nutrition of Nigerian Population. *J. Root Crops.* **1**: 1-15.

24. PARKINSON, S. 1984. The contribution of aroids in the nutrition of people in the South Pacific. In: *Edible Aroids* (Ed. S. Chandra) and Clarendon Press, Oxford, 215-224.

25. RAJARAM, N. & K. JANARDHANAN, 1990. Chemical analysis and nutritional evaluation of certain under exploited *Vigna* sp. *J Food Sci. Nut.* **42**: 213-221.

26. SASIKIRAN, and PADMAJA, G. 2003. Inactivation of trypsin inhibitors in sweet potato and taro tubers during processing. *Pl. Foods for Hum. Nutr.* **58**: 153-163.

27. SASIKIRAN, K; PADMAJA, G. Easwariamma, C.S. and SHEELA, M.N. 1999. Trypsin and chymotrypsin inhibitor activities of sweet potato and yam tubers. *J. Root. Crops.* **25**(2): 193-199.

28. REKHA, M.R. and PADMAJA, G. 2002. Alpha-amylase inhibitor changes during processing of sweet potato and tarotubers. *Plant Foods for Human Nutr.* **57**: 285-294.

29. RAO,M.N., RAO, H.N. and PATTABIRAMAN, T.N., 1983. Enzyme inhibitors from plants, isolation and characterization of a Protease inhibitor from arrowroot (*Maranta arundinacea*) tuber *J. Bio. Sci.* **5**: 21-34.

30. RAJYALAKSHMI, P. PAND GEERVANI. 1994. Nutritive value of the foods cultivated and consumed by the tribals of South India. *Plant Foods for Human Nutrition.* **46**: 53-61.

31. SADASIVAM, S & A. MANICKAM, (Eds.) 1996. New Age International (P) Limited, Publishers, New Delhi, India. Biochemical methods, pp.1-250.

32. SHENOY, K. T., K.B. LEENA, , V. ASH, R. SUMA, V. BALAKRISHNAN, & R.F. HELLER, 1990. Utilization pattern of cassava (*Manihot esculenta* crantz) by a tribal population in Southern Kerala, *J. Root Crops.* 17 (Special issue): 315-317.

33. SIDDHURAJ, P., K. VIJAYAKUMARI, & K. JANARDHANAN, 1996 b. Chemical composition and Nutritional evaluation of an under exploited legume, *Acacia nilotica* (L.). Del. *Food Chem.* **57**: 385-391.

34. ST.VINCENT, Arrowroot analysis. 1887. from *Britannica*.

35. SUNDARESAN, S., L. BABU, & B. NAMBISAN, 1990. Biochemical changes in Yam tubers during storage. *J. Root Crops*. **17**: 265-269.

36. THOMPSON, L.V. 1988. Anti-nutrients and blood glucose. *Food Technol.* **42**: 123-132.

37. TRUONG, C.J. VON DEN, BIERMAN & J.A. MARLEFT. 1986. Simple sugars, oligosaccharides and starch concentration in starch of cooked sweet potato. *J. Agric. Fd. Chem.* **34**: 421-425.

38. UDOESSIEN, E.I. & E.T.IFON, 1992. Chemical evaluation of some anti-nutritional constituents in four species of yam. *Trop. Sci.* **32**: 115-119.

39. VIMALA. B. 1995. Lesser known edible tuber crops in India. A review. *J. Root Crops* **21**(2): 51-64.

40. YAMASHITA, E. & N. YOSHIKOWA, 1973. Studies on the mucilage in Sakoima (*Colocasia antiquorum* Schott. var., *esculenta*. Eng.), *J. Jap. Soc. Food Nutr.*, **26**: 303-307.

## PC/P1

**POSTER PRESENTATIONS**

# Chemical composition and nutritive value of tannia (*Xanthosoma sagittifolium* (L.) Schott.)

S. Shanthakumari[1], V.R. Mohan[2] and J.D. Britto[3]
[1]Sarah Tucker College, Tirunelveli, Tamil Nadu
[2]V.O.C. College, Thoothukudi, Tamil Nadu
[3]St. Xavier's College, Palayamkottai, Tamil Nadu

The corms of tannia, *Xanthosoma sagittifolium* (L.) Schott. are rich in calories and nutrients and hence play a major role in sustaining people during famine and also as a vegetable in the daily dietary regime of many Indians. The corms and cormels of tannia have traditionally been eaten by the tribal Kanikkars in Kanyakumari District. The proximate components viz., total protein, starch, sugars, *in vitro* starch digestibility and *in vitro* protein digestibility and certain anti-nutritional components of the corm of *Xanthosoma sagittifolium* were analysed. The crude protein content was 8.75%, crude lipid 7.42%, crude fibre 7.48% and ash 4.53%. The corms were found to be a rich source of total starch. The *in vitro* protein digestibility (IVPD units) and *in vitro* starch digestibility (IVSD units) of the corm were 5.09 units and 118.94 units, respectively. The anti-nutritional principles like total free phenols, tannins, hydrogen cyanide, total oxalate, amylase inhibitor activity and trypsin inhibitor activity were also anlaysed.

## PC/P2

# Pharmacological properties of *Amorphophallus paeoniifolius*

Bala Nambisan, B. Wilson, V.S. Manju and S. Sundaresan
Central Tuber Crops Research Institute
Thiruvananthapuram, Kerala

*Amorphophallus paeoniifolius* is a tuber crop which is used in indigenous medicine for the treatment of inflammatory conditions, haemmorhoids and rheumatism. The pharmacological properties of tuber extracts from wild *Amorphophallus* were examined for anti-microbial, anti-inflammatory, analgesic and antioxidant activity. Antimicrobial activity was tested against six bacterial and two fungal strains. Acetone and ethanolic extracts inhibited all bacterial