Underutilized and Underexploited Horticultural Crops

VOLUME : 3

Other Volumes of the Series

Underutilized and Underexploited Horticultural Crops

edited by K.V. Peter

..... deals with root and tuber crops, ornamentals, fruits, vegetables, herbs and spices and energy crops having considerable economic value, but not fully exploited. **— Dr. M.L. Chadha**

Underutilized and underexploited horticultural crops form an integral part of healthfood, greenparks, neutraceutical industry, home decorations, renewable sources of green energy and above all food reserves during calamities.

Vol. 1

Main Contents : Section I. General, II. Underutilized Tuber Crops, III. Underutilized Ornamentals, IV. Underutilized Herbs and Spices, V. Underutilized Vegetables, VI. Underutilized Fruits, VII. Underutilized Energy Plants.

2007 ISBN: 81-89422-60-X 392 Pages (29 Col. Plts.)

Vol. 2

Main Contents : Section I. General, II. Underutilized Fruits, III. Underutilized Vegetables, IV. Underutilized Root and Tuber Crops, V. Underutilized Flowers, VI. Underutilized Trees, VII. Underutilized Spices.

2007 ISBN: 81-89422-69-3 369 Pages (35 Col. Plts.)

Vol. 4

Main Contents : Section I. General, II. Underutilized Fruits, III. Underutilized Vegetables, IV. Underutilized Plantation Crops, Index.

2008 ISBN: 81-89422-90-1 429 Pages (35 Col. Plts.)

Reviewed in HortScience : February 2008, Volume 43: Issue # 1

(An Official Journal of The American Society for Horticultural Science)

Underutilized and Underexploited Horticultural Crops. Vol. 2. *K.V. Peter* (ed.) 2007. New India Publishing Agency, Pitam Pura, New Delhi, India 110 088, 355 p., 35 color plates. Hardcover ISBN 81-89422-69-3.

This book is the second volume on underutilized horticultural crops of the Indian subcontinent. Local authorities have prepared 20 chapters beginning with a general introduction on *In situ* Conservation of Horticultural Crops. The introduction is followed by chapters on specific underutilized crops, including six fruits, five vegetables, one root and tuber crop, two flowers, three trees, and two spices. Thus, there is something for horticulturists of every persuasion.

One chapter is dedicated to the underutilized fruits of the Andaman and Nicobar Islands, which are situated off the eastern coast of India. Many species that offer possibility of increased production are identified and discussed.

Individual chapters on fruits focus on giant granadilla (*Passiflora quadrangularis* L.), apricot (*Prunus armeniaca* L.), low-chill peach (*Prunus persica* (L.) Batch.), aonla (*Emblica officinalis* Gaertn), ber or Chinese date (*Ziziphus xylopyrus* Willd. or *Ziziphus jujuba* Mill.).

The vegetable section features two chapters on a multitude of cucurbit crops. Another chapter details vegetables suitable for production in arid areas of India. A short chapter is devoted to obscure plants in the genus *Alternanthera* Forsk. of the Amaranthaceae family and used as greens. The final vegetable chapter features the *Hibiscus* L. (roselle) and *Abelmoschus* Medic.(okra) genera of the Malvaceae family.

A multitude of underutilized root and tuber crops are included in one chapter. These crops are not grown widely but have potential for limited commercial culture. Many are illustrated with excellent images of above and below ground structures.

Underutilized flowering plants are featured in two chapters. One is on numerous types of lilies, and the other is on various native species. The sections on flowers (*Clerodendrum* spp. L. and others) are well illustrated with colored images.

Mahwa (*Bassia latifolia* Roxb.), chironji or charoli (*Buchanania lanzan* Spreng.) and moringa (*Moringa oleifera Lam.*), also known as drumstick or

horseradish tree, are the focus of three chapters. Mahwa flowers are used for distilled liquor and potable spirits, and fruits are used in various ways. Chironji fruit are enjoyed raw or roasted. Drumstick is a multipurpose tree having varied uses such as a windbreaks and medicinal preparations of many sorts.

Finally, the spices turmeric (*Curcuma longa L.*) and long coriander (*Eryngium foetidum* L.) are included in the last section of the book. Turmeric rhizomes are used as a coloring agent, flavoring spice, and for medicinal purposes. Long coriander leaves are used as a substitute seasoning for coriander especially in Asia and Central America.

The chapters vary considerably in length (3 to 63 pages) and in detail. Citations to local and international literature generally vary with chapter length. The book is not indexed so searching for a particular topic or crop is difficult.

Horticulturists in North America and elsewhere are familiar with the series that is edited by Jules Janick and others and that result from periodic New Crops (and New Uses) Conferences beginning in 1990. Several of these volumes have been reviewed in *HortScience*. The sixth volume in this series, titled *Issues in New Crops and New Uses*, resulting from a conference held in San Diego in 2006 will soon be published by ASHS Press.

Underutilized and Underexploited Horticultural Crops provides much useful information. However, horticulturists in many parts of the world may find the series edited by Janick to be also relevant to their needs.

Donald N. Maynard
University of Florida
Wimauma

Underutilized and Underexploited Horticultural Crops

VOLUME : 3

Editor

Prof. K.V. Peter

Professor of Horticulture and
Former Vice-Chancellor
Kerala Agricultural University, Thrissur - 680 656
Kerala (India)

2020

New India Publishing Agency
Pitam Pura, New Delhi- 110 088

Published by
Sumit Pal Jain *for*
New India Publishing Agency
101, Vikas Surya Plaza, CU Block, L.S.C. Mkt.,
Pitam Pura, New Delhi- 110 088, (India)
Phone: 011-27341717, Fax: 011-27341616
E-mail: newindiapublishingagency@gmail.com
Web: www.bookfactoryindia.com

ISBN 10 : 81-89422-85-5
ISBN 13 : 978-81-89422-85-1 eISBN : 978-93-89571-67-7

Typeset at: Laxmi Art Creations, Delhi and Printed at: Jai Bharat Printing Press, Delhi

Distributed by NIPA GENX Electronic Resources and Solutions Pvt. Ltd. New Delhi

DEDICATION

This volume is dedicated to the memory of Late (Dr) Rt. Rev. Mar Gregorious, Archbishop of Trivandrum and to His Excellency Rt. Rev. (Dr) Maxwell Norona, Bishop of Calicut who were my spiritual guides and leaders. They showered on me bountifull of blessings and peace during period of turbulence and pain.

FOREWORD

The Indian floristic diversity illustrates 17,500 Angiosperm species belonging to 4,000 genera of 315 families which include over 5000 endemic taxa. India is one of the twelve centres of diversity of crop plants of the world. It has domesticated about 152 species including vegetables, fruits, ornamentals, plantation crops, spices, medicinal plants, aromatic plants and industrial crops. By 2012, India alone requires 200 million tonnes of vegetables and 180 million tonnes of fruits to meet the nutrient requirements of an estimated 1250 million people. Production of traditional fruits and vegetables alone will not meet the nutrient demand. Growing of vegetables, fruits, ornamental plants and commercial crops as well as underutilized and underexploited crops like Atuna, Azafran de Bolta, Capers and Caper plants and Kair have become relevant to enlarge the biosphere flora. Demand for natural dyes is increasing with the awareness of negative effects of synthetic dyes and pigments. Under- exploited fruits like bael, carambola, Citrus species, fig, hog-plum and tropical plum need scientific attention for improvement. These fruits have traditional uses in ethnic medicines, food and preserves. Leaf vegetables provide much needed minerals, vitamins and fibre. Oriental pickling melon, snapmelon, spinegourd, tinda, pointed gourd and ivygourd are cucurbits with potential nutrient value. Agathi, chekkurmanis, edible begonias, Kang Kong and Colocasia leaf are leaf vegetables not fully utilized. Tree tomato is a delicate fruit vegetable. There are palms like palmyrah with potential to grow exclusively under arid and rainfed conditions. The volume 3 of Underexploited and Underutilized Horticultural Crops consists of 24 chapters, each chapter contributed by working scientists in the concerned crop(s). Forty eight eminent Botanists from 7 countries have contributed very informative chapters. The contributors include Prof.Ghillean T.Prance FRS, a world authority on Atuna. I congratulate Dr.K.V.Peter, Professor of Horticulture and former Vice Chancellor, Kerala Agricultural University, for editing this volume. I also compliment M/s New India Publishing Agency, New Delhi for undertaking the publication.

(Prof. M. Mahadevappa)

ACKNOWLEDGEMENT

The Editor is grateful to Dr Mahadevappa Madappa, Former Chairman, Agricultural Service Recruitment Board (ASRB), New Delhi and Vice-Chancellor, UAS, Dharwad for Foreword to the third volume. The editor places on record his appreciation to Dr. R. Keshavachandran, Coordinator, Bioinformatics Centre, Kerala Agricultural University, Thrissur and Miss Alishya Joy, JRF for the assistance provided.

INTRODUCTION

The Global Facilitation Unit for Underutilized species (GFU), under Consultative Group on International Agricultural Research (CGIAR) defines Underutilized plants as 'species with underexploited potential for food, security and nutrition by combating "hidden hunger" caused by micronutrient deficiencies; they often have medicinal properties and other multiple uses; they provide options for improved income to the poor and for environmental services to the Global Community. These species collectively receive little attention from research, extension services, farmers, policy and decision makers, donors, technology providers and consumers.'

Dr. Ghillean.T. Prance, FRS, University of Reading, UK showed that *Atuna racemosa* subspecies *racemosa* has many uses in the medicinal area. The kernel of the fruit forms a wonderful cement, used to mend canoes, arrow shafts *etc*., Dr. Eugenia Luge, Cervantes from Mexico describes Azafran de Bolita (*Ditaxis heteratha*), a good pigment producing plant. It is valuable not only for its high protein and oil content but also as a potential alternative source of natural colourant for food industry. The plant has great potential of a cash crop. It needs little attention since it adapts to marginal areas with poor soil and low rain fall. Dr. Rivera and colleagues deal with Capers and Caper plants, their history, taxonomy and uses. Caper berries are used to produce "Caper paste "or pickled to be eaten as a condiment or added to culinary dishes. Antiallergic, anti-inflammatory, anticarcinogenic, anti-hepatotoxic, anti-microbial, anti-diabetic, antioxidant and hypolipemic properties are attributed to the caper plant parts. Dr. Pareek and Dr. Paliwal deal in detail Kair (*Capparis decidua*), an underexploited, drought hardy, multipurpose, perennial, woody shrub or small tree found in hot arid regions of the world. The green immature fruits are rich in protein, carbohydrate, fat and minerals. Ripe fruits are sweet and enjoyed by children. Kair is native to India. Prof. Cyrus MacFoy deals with natural dye plants. Natural colourants are used to impart colour to food products while dye stuff is used to colour textiles and other nonfood products like leathers, baskets and even human bodies. Indigo,

Madder and Woad are three dye plants, more important in the history of dyeing. These plant sources may serve as valuable pools of useful genes. The interesting case is transfer of a gene from a blue flower to the cotton plant aimed at the jeans market. Dr. Senjobi and others explain effect of oil sludge on growth and performance of *Celosia argentea*. Oil pollution has adverse effect on growth and performance of *Celosia argentea* despite the fertilizer application. Land users should not embark on cultivating land that has an oil sledge pollution level beyond 0.25% of oil. Dr. Yunus Dogan and others explain in detail plants used as dye sources. International awareness on ill effects of synthetic dyes pushed up demand for plant based natural dyes. Leaves of 118 taxa, barks of 70 taxa, above ground parts of 32 taxa, stems of 20 taxa, whole plant of 19 taxa, woods of 16 taxa and seeds of 11 taxa are used as dyeing materials. In all, 12 different colours are obtained. The leaves dominate among plant parts in dyeing. Colours attained from plant species are yellow in180 taxa, brown in 71 taxa, green in 66 taxa, red in 59 taxa, blue in 34 taxa, black in 28, grey, purple and orange in 13 taxa each, pink in 12 taxa, beige in 5 species and violet in 1 taxon. Dr. S.P. Mathew and others deal with the history of pomiculture with special reference to underutilized wild edible fruits of Kerala. The Indian floristic diversity illustrates 17,500 Angiosperm species belonging to 4000 genera of 315 families which include over 5000 endemic taxa. In Kerala, there are several edible fruit plant species whose functional value in crop improvement programme still remains relatively lesser known. *Garcinia gummi gutta,G. xanthochymus, G.indica, Grewia tiliifolia, Elaeocarpus munronii, Eserratus, Aegle marmelos, Clausena anisata, Glycosmis pentaphylla* etc are a few of them. Dr. D. Pandey elaborates the bael fruit for its nutritive values. Bael is one of the oldest and useful trees of India. Two of the important homeopathic medicines namely Aeglemarmelos and Aeglefolia are made from the fruit pulp and bael leaves respectively. The tender fruits are sliced, sun dried and sold in local markets. Bael oil is a purgative. The leaf juice mixed with honey is adminstered to allay catarrah and fever and if mixed with black pepper relieves jaundice and constipation accompanied by edema. Dr. Sarah T George elaborated the underutilized trees Carambola, Fig and Hog-Plum for their products and uses. Carambola is a rich source of reducing sugar, ascorbic acid, and minerals like K, Ca, Mg and P. It is mostly consumed as dessert in Australia. Pulp of unripe fruit is used to remove iron rust from linen and to impart shine to glass vessels. Flowers can also be made into a preserve. They are salads in Indonesia. The common fig is a fruit of warm temperate zone. It is a nutritious fruit with high sugar and low acid content. The fresh fruit is rich in Calcium, Iron and Vitamins A and C. Food value/ 100g of edible portion is protein(4.3g), fat (0.14-0.3g) and Carbohydrates(17.1-20.3g).The nutritional index of fig is as high as 11 compared to 9 of apple,8 of

raisin and 6 of date and pear. The figs are astringent and carminative, dried figs are given in doses of 150g with honey in menorrhagia, hepatitis and dysentery. It is useful in diabetis. Dr. E.T.S. de Arquitectura a Geodesia from Spain describes the cultivated citrus -origin, history and traditional uses known in Mediterranean region. The citron, the sour orange, the lemon and lime, the pomelo, the sweet orange, mandarin and grape fruit and related cultivars are described. Dr. Dinesh Babu and colleagues deal with guava and its close relatives. Because of its high nutritive value and availability at cheaper prices, it is eulogized as poor man's apple. The related ones are Cattle guava, Chinese guava, Mountain guava, Round shaped guava and Pear shaped guava. Hog-plum also called wild mango is described by Dr. Sarah T George. The fruit is astringent and antiscorbutic. The fruit is eaten as vegetable when green and as a fruit when ripe. It is used as a condiment and can be made into chutney, stews, pickles and jams. Leaves are used for flavouring. The flowers are sour and eaten as such or made into a curry or used as a flavouring agent. Stargooseberry is another important underexploited fruit. The fruit flesh is sliced from the stones and covered with sugar. If left longer, the flesh shrivels and the juice can be strained off as a clean, pale yellow syrup. The other uses are as a liver tonic to enrich the blood and as a stomachic. The fruit is used as a laxative. Tropical plum is another fruit tree which is an unconventional source of Vitamins A and C. Dr. Jana elaborates underutilized leafy vegetables of sub Himalayan terai region. Cucurbits like bottle gourd, pumpkin, ashgourd, chow chow, sweet gourd and pointed gourd, legumes like cowpea, garden pea, pigeon pea and khesari (*Lathyrus*). Sweet potato and potato; tender leaves of drumstick, mustard, radish, beet and cauliflower are dealt in the context of nutritional security. Underutilized leafy vegetables like leafy onion, baro mankachu, marsh amaranth, chauli, lal sag, data sag, smooth pig weed, spiny amaranth, leaf amaranth, kharkol, kulekhana, shulfa, brahmidag, poi, etc are described. Dr. Sankaran and others describe the underutilized vegetable crops in Tripura, one of the seven states in North East India. Greater galangal, Pisala alu, bamboo, Titbai begun, Malabar spinach, Parwal, Kakrol, Kundru, Ashgourd, Yardlong bean, Hiencha, Tree bean, Lajalu, Sem, Tannia, Winged bean, Sword bean, Amaranth and Laipata are a few of the under utilized vegetables in Tripura. Dr.Krishna Kumary explains two perennial leaf vegetables agathi and chakkurmanis. Leaf and flower of agathi are edible. Chekkurmanis is grown as a fence and is nicknamed 'multivitamine multinutritional' crop. Dr.My Lian T. Nguyen elaborates the introduction of *Colocasia gigantea* from Vietnam to USA by the war migrants. The vegetable becomes a memorable bond between two civilizations. Dr. Francisco Bas unto Pena and others from Mexico nerrates edible begonias as a leaf vegetable. Several species of begonias have medicinal uses. KangKong

is an aquatic viny leaf vegetable. There are two types- Red Kang Kong and white flowering KangKong. Dr. Krishna Kumari explains origin, distribution, cultivars, uses, soil and climate requirements and cultural practices of KangKong. Dr. Sadhan Kumar and Dr. Nirmala Devi bring into focus tree tomato, a perennial tree vegetable. It is grown for its edible fruit, having a sweet sour flavour on maturity. Dr. Arulraj and Dr. Augustine Jerard nerrate underutilized palms-palmyrah palm, *Phoenix sylvestris, Caryota urens, Nypa fruticans*, Rattans and other palms with economic values.

The volume III of underutilized and underexploited horticultural crops has 4 sections and 24 chapters authored by well known 47 eminent botanists from 7 countries-Nigeria, Turkey, Spain, UK, USA, Mexico and India. In India, Botanists from states like Kerala, UP, Meghalaya, West Bengal and Tripura have contributed chapters to the present volume.

List of Contributors

A. A. AKINPELU
Department of Soil Science and Farm Mechanisation, Olabisi Onabanjo University
P.M.B.2002, Ago-Iwoye, Ogun State

A. O. OGUNKUNLE
Department of Agronomy, University of Ibadan, Ibadan

ALCARAZ, F.
Department of Plant Biology, University of Murcia-30100 Espinardo, Murcia, Spain

AMIT NATH, L.C.DE
ICAR Research Complex for NEH Region, Umiam, Barapani, Meghalaya - 793 103, India

B. A. SENJOBI
Department of Soil Science and Farm Mechanisation, Olabisi Onabanjo University
P.M.B.2002, Ago-Iwoye, Ogun State

B. AUGUSTINE JERARD
Scientist (Horticulture), Central Plantation Crops Research Institute, Kasaragod
Kerala 671 124, India

B.C. DEKA
ICAR Research Complex for NEH Region, Umiam, Barapani, Meghalaya - 793 103, India

C. P. KOSHY
Tropical Botanic Garden and Research Institute, Palode
Thiruvananthapuram, Kerala, India

C. T. SENJOBI
Department of Plant Science and Applied Zoology, Olabisi Onabanjo University
P.M.B.2002, Ago-Iwoye, Ogun State

CYRUS MACFOY
Montgomery College, University of Maryland, University Collage Maryland, USA

D. PANDEY
Central Institute for Subtropical Horticulture, Rehmankhera, PO Kakori
Lucknow, Uttar Pradesh, India

DELIA CASTRO LARA
Jardín Botánico, Instituto De Biología, Universidad Nacional Autónoma De México
Apartado Postal 70-614, Coyoacan 04510, México, D. F., México

EUGENIA LUGO-CERVANTES
Centro De Investigaciony, Asistencia en tecnología y Diseño del Estado de Jalisco Av. Normalistas 800 Colinas de la Normal 44270 Guadalajara Jalisco México

FRANCISCO BASURTO PEÑA
Jardín Botánico, Instituto De Biología, Universidad Nacional Autónoma De México
Apartado Postal 70-614, Coyoacan 04510, México, D. F., México

G. E. AKINBOLA
Department of Agronomy, University of Ibadan, Ibadan

G. PANDEY
Central Institute for Subtropical Horticulture, Rehmankhera, PO Kakori
Lucknow, Uttar Pradesh, India

GHILLEAN T. PRANCE
School of Biological Sciences, University of Reading, Whiteknights
Reading, RG6 6AS, UK

HH MERT
Dokuz Eulul Universit, Education Faculty, Biology Department, Bucalzmir, Turkey

INOCENCIO, C.
Department of Applied Biology, EPSO, University Miguel, Hernández-03312
Orihuela, Alicante, Spain

JAI PRAKASH
ICAR Research Complex for NEH Region, Tripura Centre
Lembucherra-792 210, Tripura, India

K. DHINESH BABU
ICAR Research Complex for NEH Region, Umiam, Barapani, Meghalaya - 793 103, India

K.M. BUJARBARUAH
ICAR Research Complex for NEH Region, Umiam, Barapani, Meghalaya - 793 103, India

KOSHY ABRAHAM
Kerala Agricultural University, P O KAU Thrissur-680 656, Kerala, India

KRISHNAKUMARI K.
Department of Olericulture, Kerala Agricultural University, P O KAU
Thrissur-680 656, Kerala, India

L RAMON-LACAE. T.S.DE
Arquitectura y Geodesia (Universidad de Alcala de Henares)
c/Santa Ursula, 8, 28801 Madrid, Spain

M. OZTURK
Ege University, Science Faculty, Botany Dept., Bornovalzmir, Turkey

M. SANKARAN
ICAR Research Complex for NEH Region, Tripura Centre
Lembucherra-792 210, Tripura, India

MIGUEL ANGEL MARTÍNEZ ALFARO
Jardín Botánico, Instituto De Biología, Universidad Nacional Autónoma De México
Apartado Postal 70-614, Coyoacan 04510, México, D. F., México

MY LEIN T. NGUYEN
Department of Biological Sciences, Wellesley College, Wellesley MA 02481

N. P. SINGH
ICAR Research Complex for NEH Region, Tripura Centre
Lembucherra-792 210, Tripura, India

NIRMALA DEVI, S.
Kerala Agricultural University, P. O. KAU Thrissur-680 656, Kerala, India

OBÓN, C.
Department of Applied Biology, EPSO, University Miguel
Hernández-03312 Orihuela, Alicante, Spain

R. PALIWAL
Department of Horticulture, SKN College of Agriculture (RAU), Jobner, Rajasthan, India

REJINA. K.
Kerala Agricultural University, P O KAU Thrissur-680 656, Kerala, India

RIVERA, D.
Department of Plant Biology, University of Murcia-30100 Espinardo, Murcia, Spain

S. A. AYANLAJA
Department of Agronomy, University of Ibadan, Ibadan

S. ARULRAJ
Project Coordinator (Palms), All India Coordinated Research Project on Palms
Central Plantation Crops Research Institute, Kasaragod, Kerala 671 124, India

S. BASLAR
Dokuz Eulul Universit, Education Faculty, Biology Department, Bucalzmir, Turkey

S. GANESHAN
Tropical Botanic Garden and Research Institute, Palode
Thiruvananthapuram, Kerala, India

S. K. SHUKLA
Central Institute for Subtropical Horticulture, Rehmankhera, PO Kakori
Lucknow, Uttar Pradesh, India

S. M. SHAREEF
Tropical Botanic Garden and Research Institute, Palode
Thiruvananthapuram, Kerala, India

S. P. MATHEW
Tropical Botanic Garden and Research Institute, Palode
Thiruvananthapuram, Kerala, India

S. PAREEK
Krishi Vigyan Kendra (MPUAT, Udaipur), Sirohi-307 001, Rajasthan, India

SADHAN KUMAR, P. G.
Kerala Agricultural University, P. O. KAU Thrissur-680 656, Kerala, India

SARAH T GEORGE
Kerala Agricultural University, P O KAU Thrissur-680 656, Kerala, India

Y. DOGAN
Dokuz Eulul Universit, Education Faculty, Biology Department, Bucalzmir, Turkey

CONTENTS

UNDERUTILIZED

FRUITS

VEGETABLES

PLANTATION CROPS

Colour plate can be found on pages

Underutilized and Underexploited Horticultural Crops, Vol. 3, pp. 1-5

New India Publishing Agency, New Delhi (India)

1 *Atuna racemosa* Rafin. (Chrysobalanaceae)

Ghillean T. Prance
School of Biological Sciences, University of Reading
Whiteknights, Reading, RG6 6AS, UK

Atuna racemosa subspecies *racemosa* is shown to be a species with many uses throughout its range from Malaysia to Melanesia. The principle uses described are the seed oil used as anti-inflamatory massage oil and for hair dressing, the seed pulp that is used for caulking and varnishing boats, the wood for house construction, and many parts of the plant as ingredients of local medicines. The medicinal uses of this species deserve further study since it has been shown to have both anti-bacterial and anti-inflamatory action. It is also uncertain whether its distribution over the Pacific is natural or human caused.

Atuna racemosa Rafin. is a widely distributed tree species that ranges from the Malay Peninsula through Malesia, Australasia and to the Pacific islands as far as Fiji, Tonga and Samoa. As with many useful plants, its natural distribution is uncertain because it has been transported around from island to island during the various migrations of the Pacific islanders.

Taxonomy

Atuna is a genus of the Chrysobalanaceae that ranges naturally from Southern India to Fiji. It consists of eight species. *A. racemosa* is subdivided into two subspecies (Prance, 1989), subsp. *racemosa* and subsp. *excelsa* (Jack) Prance. Full botanical descriptions of the species of *Atuna* are given in Prance (1989) and Prance and Sothers (2003). The literature about uses of this species is rather confused as *A. racemosa* subsp. *racemosa* is often referred to under

the synonyms *Parinari glaberrima* Hassk, *Cyclandropora glaberrima* (Hassk.) Kostermans, and in the Pacific as *Parinarium laurinum* A. Gray. There are numerous other synonyms in the genus *Parinari* for this species. The fruits are large and roundish to ellipsoid and up to 8 cm in diameter. The exterior is crustaceous verrucose and within the cavity is filled by the large ruminate cotyledons.

Uses

Almost throughout its range *Atuna racemosa* is used for extraction of oil from the large oily cotyledons. In the Pacific the pulp from the cotyledons is much used as a material for caulking boats. These uses in Samoa were documented in Prance (2005). Numerous minor medicinal uses for *Atuna* have also been recorded.

The oil is extracted from ruminate cotyledons by pressing or leaving shavings in the sun for oil to ooze out. The method of extraction in Samoa is described in Prance (2005). The main uses for the oil are as a hair dressing and as a massage oil. In the Pacific, a mixed coconut/Atuna oil is used for medical massage for body pain, and minor injuries especially of the back, neck and stomach. The people interviewed insisted that massage oil with Atuna in it is much more effective than other oils without Atuna. There is a good reason for this since it has been shown that Atuna oil contains the flavanol 3-derivative anti-inflammatory compounds 4'-Me)-(-)-gallocatechin and (+)-gallocatechin Noreen *et al.*, 1999, Prance, 2005). These authors showed that both these compounds are strong COX-1 inhibitors and that the first compound exhibits a weaker activity towards COX-2 enzyme. This means that Atuna oil is indeed effective against minor bruises and inflammation.

Atuna also contains several fatty acids. A summary of fatty acid and glyceride content of *A. racemosa* was given by Andersson-Dunstan *et al* (1997) mainly based on work of Riley (1950) who used the synonym *Parinarium laurinum*. *Atuna racemosa* contains α-parinaric acid and α-oleostearic acid and the glycerides triparinarin and elaestearoparinarin.

Numerous uses for *Atuna racemosa* oil are recorded in Pacific Islands in Micronesia and Melanesia. The oil is often mixed with other plants to make a perfume. In Samoa, ylang ylang (*Cananga odorata*) is used and in Yap, it is mixed with turmeric (*Curcuma longa*) roots. The oil is used to keep off insects in some places and fishermen in Samoa use it to combat the cold.

One of the most frequently recorded uses for Atuna is the employment of the pulp from the cotyledons as a material for caulking boats. This is the

preferred material in many places because of its durability. Canoes are also frequently painted with Atuna oil and when mixed with soil it forms a dark red varnish-like coating. In the Philippines the oil is used by natives of the Ayusan Valley for waterproofing bamboo and rattan baskets.

The wood of Atuna has many local uses as a hard resistant wood for house construction due to presence of silica in the wood. In Pohnpei, the wood is the most popular to make boating poles.

In Fiji, many traditional village houses have the walls thatched with the leaves of Atuna. In those islands, the leaves are particularly large and make an effective thatch for walls.

Apart from the uses as a massage oil, *A. racemosa* is also used widely in local medicines. In Samoa, the inner living bark is immersed in water and a tea is prepared to treat severe abdominal pains of the lower intestinal area. The leaves are used for swellings and inflammation. If a leg is swollen, the leaves of Atuna are soaked in the oil and wrapped around the swelling. The roots are used to treat foot infections, especially of children. A recent paper (Buenz, 2007) has shown antibacterial activity from an extract of the kernel of the fruit. It is interesting that the lead was from the ancient publication of Rumphius (1741) that described medicinal uses that seemed possibly to be antibiotic in nature. The bacterial toxicity occurs in a mitochondrial dependent fashion.

Biogeography

Atuna racemosa is an extremely widespread species and is common in the forests of Indonesia and New Guinea. The interesting question is whether the Pacific distribution is natural or human dispersed. The fruit is large and buoyant and so the possibility of marine dispersal exists. The trees are often found in upland areas in many of the islands. They are often found to be clustered in pure stands indicating former plantations. It seems unlikely that this large dispersal was all by ocean currents and the fruit is too large and heavy to have been distributed so far by birds or wind. I think that this is a species that has had its range increased by humans for its many uses and has then naturalized in regenerating forests.

Conclusions for the future

This paper has shown that *Atuna racemosa* subspecies *racemosa* has many uses and still has potential for more investigations particularly in the medicinal area. Also a study of the genetic variation of the DNA would be interesting to

trace its dispersal around the Pacific and perhaps show whether the distribution is natural or human caused. I end with a quote from a collector in Bougainville Island: "*The kernel of the fruit forms a wonderful cement, it being ground up, heated, then applied. It is universally used to mend canoes, arrow shafts etc.*" (From herbarium specimen *S. F. Kajewski 2211*)

References

Andersson Dunstan, C., Noreen, Y., Serrano, G., Cox, P. A., Perera, P and Bohlin, L.

1997. Evaluation of some Samoan and Peruvian medicinal plants by prostaglandin biosynthesis and rat ear oedema assays. *J. Ethnopharmacology* 57: 35-56.

Buenz, E. J. 2007. Mitochondrial involvement in *Atuna racemosa* induced toxicity. *J. Ethnopharmacology* 109: 304-311.

Noreen, Y., Serrano, G., Perera, P. and Bohlin, L. 1999. Flavan-3-ols isolated from some medicinal plants inhibiting COX-1 and COX-2 catalysed prostaglandin biosínthesis. *Planta Medica* 64: 520-524.

Prance, G. T. 1989. Chrysobalanaceae. *Fl. Malesiana*, Ser. 1. 10: 635-678.

Prance, G. T. 2005. The uses of *Atuna racemosa* Raf. (Chrysobalanaceae) in Samoa. *Economic Botany* 58: 470-475.

Prance, G. T. and Sothers, C. A. 2003. Chrysobalanaceae. *Species Plantarum* 12 (2): 1- Riley, J. P. 1950. The seed fat of *Parinarium laurinum* Part I: Component acids of the seed fat. *J. Chem, Soc*. 1950: 12-18.

Riley, J. P. 1951. The seed fat of *Parinarium laurinum* Part II: Component glycerides of the seed fat. *J. Chem. Soc*. 1951: 291-293.

Rumphius, G. E. 1741. Herbarium amboinense. Amsterdam.

colour plates contd...

Samoa 1. Flowers of *Atuna racemosa*

Samoa 2. Fruits of *Atuna racemosa.*

Samoa 3. Canoe caulking using paste from *Atuna racemosa* fruit.

Underutilized and Underexploited Horticultural Crops, Vol. 3, pp. 7-17

New India Publishing Agency, New Delhi (India)

2 Azafran De Bolita (*Ditaxis heterantha* Zucc) : New Crop For Semi-arid Land—A Food Pigment Producing Plant

Eugenia Lugo-Cervantes

Centro De Investigaciony
Asistencia en tecnología y Diseño del Estado de Jalisco Av. Normalistas 800 Colinas de la Normal 44270 Guadalajara Jalisco México

Euphorbiaceae is a large family that includes 310-320 genera and 7500 species (Walters and Keil, 1996). Two centers of distribution for this family are tropical America and tropical Africa. The family has an extremely variable life span and habits are found as annual and perennial herbs, vines, succulents, shrubs and tall trees. Members of the Euphorbiaceæ are found in many habitats, from deserts to rain forests. Euphorbiaceae family has genera used as unconventional foods

In Mexico, 826 species under Euphorbiaceae family are found with 50 genera including those introduced from elsewhere and cultivated. A subfamily with a larger number of genera is Acalyphoieae (16), while Euphorbioideae has more species (306), and Crotonoideae has more specific endemism (Martinez-Gordillo *et al,* 2002). Some of these plants are used in traditional medicine, in oil industry, as ornamental plants, and as food additive. A few examples of its uses include edible wax from *Euphorbia antisyphilitica* (candelilla) that coats fruits and vegetables to retard water evaporation. *Jatropha dioica* is a small shrub that is used in traditional medicine and *Euphorbia pulcherrima* (Poisenetta) an ornamental plant.

Ditaxis (A. Juss.) Croiz genus is an American genus with 40 - 60 species. It is distributed in dry areas between 40° latitude North (South USA) and 40° latitude South, (Argentina) (Ingram, 1980, Webster, 1975, 1994). This genus originated from South-America and propagated to North to Central America to Mexico and to United States of America (Ingram, 1980). In Mexico, two species under *Ditaxis* genus are known that are used by man. *Ditaxis tinctoria* (Mill sp.) Pax, ("tinta roja") that grows in South East of the country having dyer properties and *Ditaxis heterantha* Zucc., also called "azafrán", "azafrancillo" o "azafrán de bolita", grown wild in semiarid areas of Mexico and was used as coloring and flavor agent in food (Martinez, 1937). This plant was recently cultivated locally but not extensively. It has an economic potential and could be a new crop.

Names of species and taxonomy

Ditaxis heterantha belongs to subtribe Ditaxinae, tribe Crozophoreae, subfamily Acalyphidea, family Euphorbiaceae, order Euphorbiales, subclass Rosidae, class Magnoliopsidae, division Magnoliophyta (Webster, 1994).

Ditaxinae, a sub-tribe including the genus *Ditaxis*, is native to New World; it grows from sea level to an altitude of about 2450 m, and essentially between latitudes 40° N and 40° S. The genus *Ditaxis* is closely related to the genus *Argythamnia*. A few authors have therefore divided the genus *Argythamnia* into three sub-genera: *Argythamnia, Ditaxis* and *Chriropetalum* (Ingram, 1980). According to Webster (1994), there is evidence including pollen morphology, indicating that there are three different genera. In fact, Radclife-Smith (2001) separates the genus *Ditaxis* from *Argythamnia*, even though he mentions that these genera are closely related, they can be differentiated by androecium with 8-10 stamens placed in two whorls and their pollen is bilaterally symmetrical.

Botanical description

Genus description

Ditaxis Vahl ex A.Jussieu, Euphorb. Gen 27.1824. *Ditaxis fasciculata* Vahl ex A. juss. *Aphora* Nutt., Trans.Amer.Philos. Soc. II 5: 174. 1837. *Serophyton* Bemth., Bot. Voy. Sulphur 52.1844. *Stenonia* Didr., Vidensk. Meddel. Dansk. Naturhist. Foren. Kjobenhavn 1857f : 146.1857 *Paxia* Herter, Fl.Urug.Pl. vasc.80.1931.*Paxiuscula* Herter, Revista Sudamer. Bot. 6: 92.1939. *Argythamnia* subg *Ditaxis* (Vahl ex A. Juss) Croizat, J.Arnold Arbor. 48: 364.1967

Ditaxis heterantha Zucc. was first gathered at Tolimán, Querétaro by Karwinski von Karwin in 1827 (McVaugh, 2000), and clasified by Joseph

Zuccarini, a botanist, who published its name -*Ditaxis heterantha*– and its description in the Abhandlungen der Matematisch – Physikalischen Classe der Königlichen Bayerishen Akademie der Wissenschaften (1:290) in Munich. Nevertheless Müller described and classified the plant in 1866, calling it *Argythamnia heterantha* Müll. Arg (Müller, 1866). Currently, it is found under both names in herbaria.

Ditaxis heterantha is endemic to Mexico. It is found in semiarid regions in coarse sandy soils. Its distribution is limited and it is not widely used. It is a bush with heights ranging from 2.5 to 3 m (Vázquez, 2000). Its stems are ligneous; leaves are alternate, petiolate, laceolate, acuminated, from 4 to 8 cm long (Fig.1).The abaxial surface is puberulent and whitish, mainly on the young leaves. The inflorescences are extensively pedicelated, with small pale yellow unisexual flowers. The fruit is a green glabrous trilocular capsule and the seeds are black or dark brown (Fig. 2). It is known as "azafrán", azafrancillo" or "azafrán de bolita" (Standley, 1924; Martínez, 1937; Martínez 1959; Nowicke, *et al.* 1999).

Origin and centre of diversity

It is believed that Ditax originated from South America and it was propagated to North through to Central America to Mexico and United States of America (Ingram, 1980) It is distributed in central and western Mexico, in the states of Sinaloa, Queretaro, Hidalgo, San Luis Potosi, Guanajuato, Jalisco, Michoacan and Guerrero (Standley, 1924; Martinez, 1959; Herbario Nacional de México (MEXU), Herbarium of the Instituto Ecológico del Bajío (IEB), Herbarium of the Escuela Nacional de Ciencias Biologicas of the IPN (ENCB), Herbarium of the Instituto de Botanica of the Universidad de Guadalajara (IBUG)). In Mexico, it grows at an altitude ranging from 1,600 to 2,200 m above sea level and between 16^{o} and 23^{o} North latitude and 99^{o} and 136 ^{o} West longitudes, usually in semiarid regions (Fig. 3)

In a first study, it was found that only Jalisco and Zacatecas states had started to cultivate it. In the Northern part of the Jalisco state, the plant is normally found in back yards, where it grows without being groomed. However, wherever the plant grows, the nearby villagers gathered it for their own consumption. The presence of plants was verified in the States of Hidalgo and Queretaro, however, fruits could not be collected since it was not harvest season. It is consumed by the Otomi Indians in the states of Hidalgo and Queretaro. In several villages of the states of Michoacán, this plant is only known by the elderly, significantly decreasing its consumption. No fruit samples could be gathered in this state.

Uses

Seed of *Ditaxis* is consumed locally in the regions where it grows. Inhabitants gather them yearly and keep the seed using it as yellow colouring for their food, such as rice, chicken or fish dishes as *Crocus sativus* (saffron). Each plant produces from 2 to 3 kg of seeds / year. Its price reaches up to US$35/kg. Currently, it is used in villages of semiarid regions of the states of Jalisco, Hidalgo and Queretaro, and it is only traded at local markets. However in other states, such as Michoacan, its use is forgotten and only the elderly population remembers it.

Chemical Composition

The "azafrán de bolita" seed has a hard dark husk covering the yellow endosperm. Chemical composition of the seed indicates that the protein content varied from 15.3 to 23.7 %, and the oil content from 36.9 to 42.3 %, depending on the source of the samples. The variations are probably due to environmental factors, such as soil type, climatic and cultivation conditions (irrigation, if any). The average oil content is similar to that of cottonseed (35 %). In comparison to other edible seeds of the same Euphorbiaceae family, the oil content of *Ditaxis heterantha* is higher than *Colliguaya integerrima* (35%), native of South America but similar to *Pluketia volubilis* (35-60%) which grows in South America and Africa and *Caryodendron orinocense* (34-41%) a native of South America (Jimenez L.C. and Bernal, 1992). Nevertheless *Ditaxis* surpasses the oil (%) reported for species commercially cultivated for producing edible vegetable oils, such as corn and soybean.

Ditaxis heterantha contains fatty acids as palmitic, estearic, oleic, linoleic and linolenic acids and it was compared for composition with other edible Euphorbiaceae as *Plukentia volúbilis, Colliguaya integérrima, Caryodendron orinocense.* In these Euphorbiaceae, linolenic acid is in high percentage (Mendez 2004).

Ditaxis contains tocopherols and phytoesterols responsible for antioxidant activity, This shows that Ditaxis heterantha is a seed with nutraceutical properties (Robles 2006).

The protein content of *Ditaxis* seed is low compared to soybean, but similar to sunflower seeds (23 %) (Abraham and Hron, 1992). The high content of protein in the "azafrán" seed also offers another possibility, once the pigment and oil have been extracted, the pulp residue may be used as animal feed, such as is done with soybean. The "azafrán de bolita" offers a storage advantage since its low moisture content prevents microbiological attacks.

Chemical composition of *D. heterantha* from different places of Mexico.

(%)	**D. heterantha (Totatiche, Jalisco State)**	***D. heterantha* (Cuquío, Jalisco State)**	***D. heterantha* (Moyahua, Zacatecas State)**	***D. heterantha* (Market)**
Oil	42.3	36.9	35.1	39.0
Protei n	15.3	21.4	20.22	19.7
Crude fiber	21.0	22.7	26.80	21.2
Moisture	3.6	4.0	4.35	3.5
Ash	2.6	2.5	2.32	2.4

Oil content of different Euphorbiaceae and *Ditaxis heterantha* from seeds for human comsumption.

Species	**Oil composition (%)**	**Reference**
Ditaxis heterantha	41.3	Mendez (2004)
Plukentia volúbilis	35-60	Mensier, 1957
Colliguaya integérrima	35	Ravetta and Soriano (1990)
Caryodendron orinocense	34–41	Jimenez and Bernal (1992)

Oil composition in different Euphorbiaceae plants

Species	**Palmitic acid**	**Estearic acid**	**Oleic acid**	**Linoleic acid**	**Linolenic acid**	**Reference**
Ditaxis heterantha	1.39 +0.09	15.41	21.31	10.40	49.83	Mendez-Robles (2004)
Plukentia volúbilis	5.61	2.23	9.60	36.99	43.75	Hamaker *et al* (1992)
Colliguaya integérrima	10.60	1.90	18.70	38.50	23.6	Malec *et al* (1986)
Sapium sebiferum	9.0	5.0	10	30	54	William W. Christie (1969)

Identification of the pigment

In order to determine the chemical group to which the pigment of *Ditaxis heterantha* seed belongs, as well as the number of its compounds, the extract obtained by hexane was fractioned by HPLC identifying 7 compounds. The result showed that the pigments are carotenoids. Two predominant compounds were observed at 9 and 15 minute retention times (Fig. 4). These compounds constitute 80 % of the total pigment. The UV-Visible spectrum of each fraction was determined and all fractions showed three maxima absorbance in their spectra. Britton (1991) reported that pigment is characteristic of carotenoids to have three maxima spectra.

Mendez *et al.* (2006) purified the two principal fractions in open column and identifiable as ditaxin and heteranthin by RMN and MS spectrometry. These molecules possessed antioxidant and DNA oxidative damage protection activities.

Toxicology

Ditaxis heterantha is a plant with characteristics of Euphorbiaceae family which includes various species with toxic and poisonous characteristics. The principal compounds reported are lectins and phorbol. Their milky latex has strong skin irritant activity, and chronic exposure results in carcinogenic effect. The toxic constituents of Euphorbiaceae species are specific diterpenes, called common as phorboids. These compounds possess extreme pro-inflammatory and tumor promoting effects due to the activation of protein kinase C enzyme. Lectins are proteins that agglutinate blood cells such as erythrocytes

Ditaxis seeds contain le lectins and phorbol at low concentrations.The lectins are removed by heat and phorbol is non toxic in similar manner as *Jatropha curcas*, variety not toxic that grows in Mexico. It is also assumed that this seed is safe to consume as consumption has been reported for years. However further studies on this aspect is recommended. (Arana, 2005).

Ecology

Ditaxis heterantha is well adapted to arid and semi-arid conditions. It grows on well-drained soils with good aeration and adapts well to marginal soils with low nutrient content. It grows from 10 to 230 mm annual precipitation and annual temperature of 18.0 to 24 °C. Soil pH from 5.3 to 6.2, however it tolerates extreme temperatures in December, strong frost and high temperatures –2- 45 °C. (Vazquez, 2000).

Physiology

Seeds germinate within 22 to 30 days (Vazquez, 2000) but germination can be accelerated by scarification, an overnight soak in water and subsequent treatment with 2.5% $NaNO_3$ solution for 3 min (Hernandez-Gonzales 2006). Germination is epigeous and phanerocotylar. Seeds can be sown either in seed beds or containers. Containers are recommended if seedlings remain in the nursery for longer than four months. Thereafter, deep tap root development will make eventual lifting out and transplanting more difficult. Germinated seedlings should be shaded until they reach a height of about 30 cm.

In the first 2 year after germination, the plant grows at high rates and no branches are observed. It grows to a height of 2 or 3 m and then it begins to produce branches. *Ditaxis heterantha* has long life cycle, it is possible to find plants that are 100 years old. The first pollination appears 2 years after germination which is realized by insects and bees. The first fructification is 2 between 2-3 years during August and December (Vazquez, 2000)

Cultivation

Cultivation of *Ditaxis heterantha* has begun in Zacatecas state, the maximum plant populations are 100 plants/2000 m^{2}. Commonly propagated from seed, requiring 1–3 weeks to germinate.

Potentials of the crop

Ditaxis heterantha, shows great potential for a cash crop It needs a little attention since it adapts to marginal areas with poor soil and low rainfall and produces 1-3 kg of seed depending of plant age. If each kilo in le market is 10 to 30 dollars, 100 plant can bring 3,000 to 9,000 dollars.

The seeds of *D. heterantha* are consumed for generations in the semi-arid regions of Mexico. *Ditaxis* is a valuable plant, not only for its high protein and oil content. Presence of carotenes in the seed presents a potential as an alternative source of natural colorants for food industry.

This type of plant may be introduced in the barren semiarid regions as an alternative crop where the yield of traditional crops, like corn and beans, is low. Its low production costs offers less further advantage for less expansion promotion for its cultivation.

Research needs

There are many areas that need further studies about *Ditaxis heterantha*. To utilize the seed and to develop industrial products for full application of knowledge generated. The chemical composition and their properties are necessary. Additionally the seeds present potential as cash crop for the semiarid region.

Acknowledgements

We would like to express gratitude to Azafran Productors from Colotlan and Totatiche Jalisco for their help. We are grateful to Martha Martinez of Sciences Institute of UNAM for help on genus of this plant and Dr. Hea-Ran Ashif for help in manuscript revision.

References

Abraham G and Hron 1992. Oils seeds in: Encyclopedia of food science and technology. Ed. Hui Y.H. John Wiley and Sons. 3: 1901-1910.

Arana-Sedano C. 2004. Determinación de factores antinutricionales y contenido de forbol en las semillas de Azafran de bolita (*Ditaxis heterantha*). Thesis University of Guadalajara. Mexico

Association of Official Analytical Chemists. 1997. Official Methods of Analysis of AOAC International. Vol. I and II, Sixteenth Edition, AOAC International, Gaithersburg, Marylland, USA.

Britton G. 1991. Carotenoids. In: Methods in plant biochemistry. Ed. P.M. Dey and J.B. Harborne. Editado by B.V. Charlwood and D.V. Banthorpe. Academic Press. 7:473-518.

Britton G. 1995. UV/Visible Spectroscopy. In: Carotenoids. Ed. G.Britton, S. Liaan-Jensen and H. Pfander. Birkäuser Verlag. 1B:13-62.

Christie W W. 1969. The glyceride structure of Sapium ... sebiferum seed oil. Biochem and Biphysic acta. Lipids and Lipids metabolism. 187: 1-5 Gross J. 1991. Pigments in vegetables. N.Y. pp 75-92

Hamaker C. Valles R. Gilman, R M. Hardmeier D. Clark H H. Garcia, A E. Gonzales I. Kohlstad M. Castro,R. Valdivia T. Rodriguez, and M. Lescano. 1992. Amino Acid & Fatty Acid Profiles of the Inca Peanut (*Plukenetia volubilis*) *Cereal Chem* 69:461-463

Hernandez-Gonzalez S. J. 2006. Morfologia reproductiva y germinación de *Ditaxis heterantha* Zucc, especie con potencial agroindustrial. Licenciatura Thesis. ENEP Zaragoza. Universidad Nacional Autonoma de Mexico. Mexico

Ingram J. 1980. The generic limits of Argythamnia (Euphorbiaceae) defined. *Gentes Herbarum* 11 (7): 427-436

Jiménez L C and Bernal H Y. 1992. El "inchi" *Caryodendron orinocense* karsten (Euphorbiaceae). Convenio de San Andrés Bello.CAB en Coedición con el ministerio de educación y Ciencia de España. Bogotá Colombia. 430 pag.

Malec L S. Vigo M S. Cattaneo P. 1986. *Colliguaya* spp. An. Asoc. *Quim. Argent* 74: 229-235.

Mc Vaugh R. 1980. Karwinski's itineraries in México 1827-1832 and 1941-1843. *Contribution of Michigan Herbarium* 14 pp. 141-152

Martínez, M. 1937. Catálogo de Nombres Vulgares y Científicos de Plantas Mexicanas. De. Botas, México. 71 pp.

Martínez, M. 1959. Plantas Utiles de Flora Mexicana, Ediciones Botas. México. 621 p.

Martínez-Gordillo M. Jiménez R J. Cruz D R. Juarez A E. Garcia R. Cervantes A. and Mejía H R. 2002. Los generos de la familia Euphorbiaceae en Mexico. Annales del Instituto de Biología. *Universidad Autonoma de Mexico*. 73: 155-281.

Mendez-Robles M D. 2004. Identificacion y caracterizacion del pigmento obtenido a partir de las semillas de azafran de bolita (Ditaxis heterantha). Ph.D. Thesis, Polytechnic Nacional Institute.

Mendez- Robles M D; Flores-Chavira C; Jaramillo-Flores M E; Orozco Avila I; and Lugo-Cervantes E. 2005. Chemical composition and current distribution of azafran de bolita (*Ditaxis heterantha* Zucc Euphorbiaceae) : A food pigment producing plant. *Econ. Bot*. 58:530-535.

Mendez-Robles M D; Permady H H; Jaramillo-Flores M E; Lugo-Cervantes E; Cardador-Martinez A; Canales-Aguirre A; Lopez-Dellamary F; Cerda-Garcýa-Rojas C M. and Tamariz J. 2006. C-26 and C-30 Apocarotenoids from seeds of *Ditaxis heterantha* with antioxidant activity and protection against DNA oxidative damage. *J. Nat. Prod.* 69:1140-1144.

Mensier P H. 1957. "Dictionaire des huiles vegetables" Edition Paul Lechevalier, Paris.

Müller J. 1866. Euphorbiaceae, in DeCandolle, Prodromus systematis naturalis regni vegetabilis 15 29: 189-1286.

Nowicke J W. Takahashi M. Webster G L 1999. Pollen morphology, exine structure and systematics of Acalyphoideae (Euphorbiaceae). Part 2. Tribes Agrostistachydeae (Agrostistachys), Pseudograstistachys, Cytrhanthus, Chondrostilis), Crozophoreae (Speranskia, Capperonia, Philyta, Ditaxis, Argythamnia, Chiropetalum). *Review Palaeobotany and Palynology*. 105: (1-2): 1 – 62.

Radcliffe-Smith A. 2001. Genera Euphorbiacearum. Royal Botanic Gardens, Kew. UK. pp. 41-43.

Ravetta, D and A. Soriano. 1990. *Colliguaya integerrima* (Euphorbiaceae): A possible new crop for temperate deserts. In: J. Janick and J.E. Simon (eds.), *Advances in new Crops*. Timber Press, Portland, pp.267.

Robles- Lopez R L 2006. Identificación y caracterización de la fracción lipidica de semillas del azafrán de bolita *(Ditaxis heterantha),* y evaluacion de su actividad antioxidante. Master Thesis. University of Guadalajara. Mexico.

Standley, P C. 1924. Trees and Shrubs of Mexico. Smithsonian Institution. United States National Museum. Contributions from the United States National Herbarium. Washington Government Printing Office. 620 – 621 pp.

Vázquez V. 2000. El azafrán de bolita (*Ditaxis heterantha*) en el Norte de Jalisco. Centro Regional Universitario de Occidente (Universidad Autónoma de Chapingo)-CIATEJ. Reporte técnico de un estudio de campo.

Walters D R. Keil D J. 1996. Vascular plant taxonomy. Fourth edition. Kendall/Hunt Publishing Co. Iowa 245-247.pp.

Webster G L. 1975. Conspectus of a new classification of the Euphorbiaceae. *Taxon* 24(5/6) 593-601

Webster, G L. 1994. Synopsis of taxa of Euphorbiaceae. *Ann. Missouri Botanical Garden*. 81:33-144.

colour plates contd...

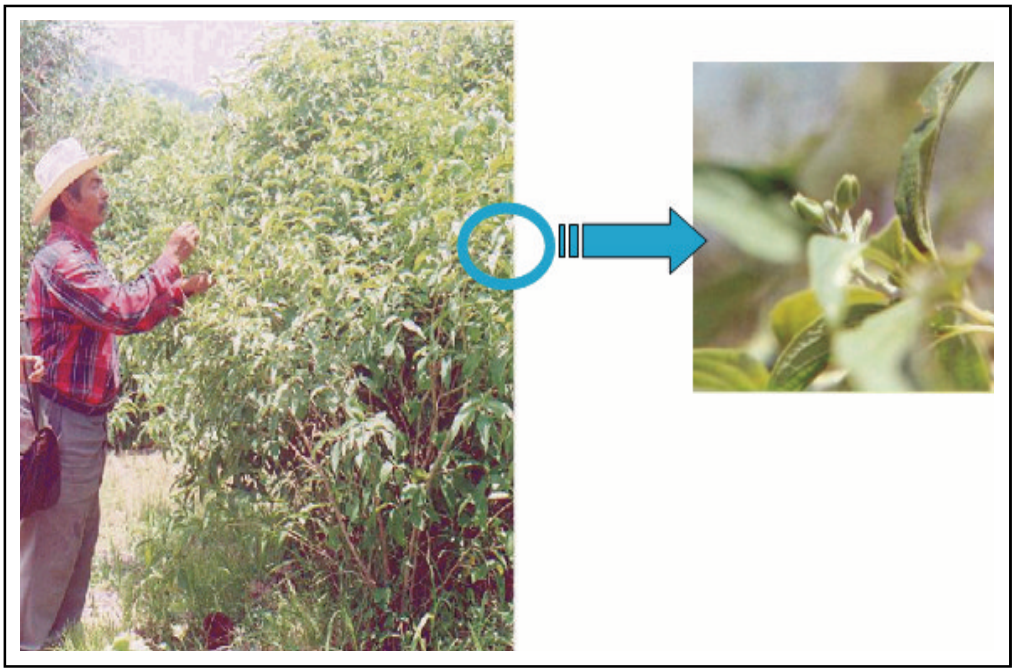

Fig. 1. *Ditaxis heterantha* shrub and flower

Fig. 2. *Ditaxis heterantha* brown seeds and seed without shell

Fig. 3. Distribution of *Ditaxis heterantha* in México

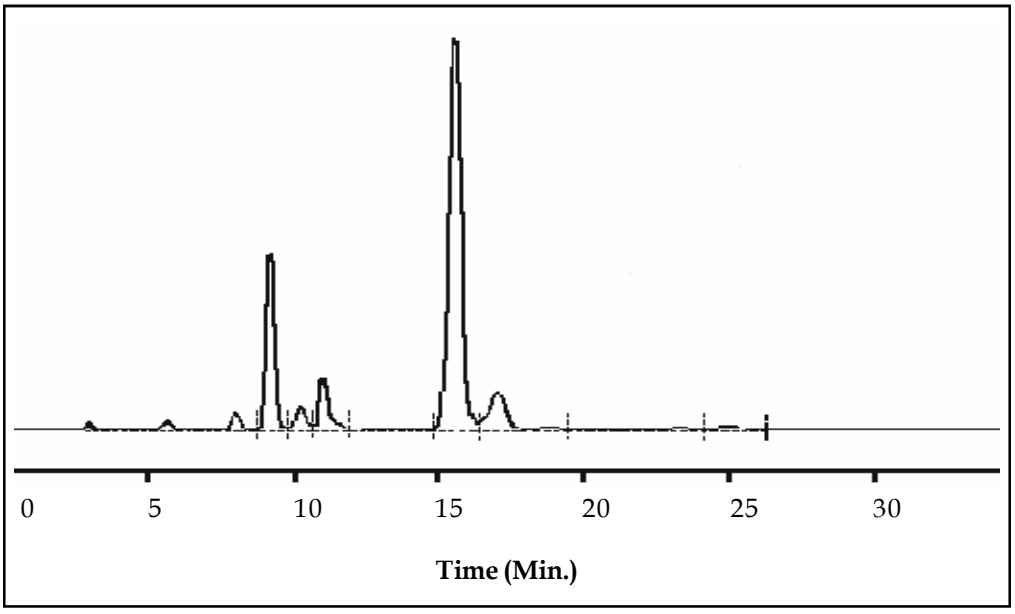

Fig. 4. HPLC and UV-Visible Absortion Spectra of pigment from *Ditaxis heterantha.*

Underutilized and Underexploited Horticultural Crops, Vol. 3, pp. 19-63

New India Publishing Agency, New Delhi (India)

3 Capers and Caper Plants History, Taxonomy and Uses

Rivera, D.*[1], Obón, C.[2], Alcaraz, F.[1], Inocencio, C.[2]

[1]Department of Plant Biology, University of Murcia, 30100 Espinardo, Murcia, Spain.
[2]Department of Applied Biology, EPSO, University Miguel Hernández, 03312 Orihuela, Alicante, Spain.

Commercial capers are the immature flower buds, which have been pickled in vinegar or preserved in granular salt; they are used raw or cooked as condiment in different recipes. Semi- mature fruits (caper berries) and young shoots with small leaves may also be use as a condiment in salads or as an appetizer before meal. Capers and caper plants, wild and/or cultivated, are used in almost all the area of *Capparis* subgenus *Capparis*, extending from West Africa to the Norfolk islands in the Pacific, and most of the species are of alimentary or medicinal interest (Rivera, Inocencio, Obón & Alcaraz, 2003).

Capparis is a term coined by Theophrastus (4th cent. BC) and validated by Dioscorides (1st cent. AD) (Êáððáñéò), although it seems not to have come into wide use until the spread of the Arab world.

Caper and its relatives in several European languages can be traced back to Classical Latin *Capparis* "caper". Latin *Capparis*, in turn, was loaned from Greek *kapparis* [êáððáñéò], whose origin (as that of the plant) is unknown but probably West or Central Asia. Another theory links *kapparis* to the name of the island Cyprus (Kypros [Êáðñïò]), where capers grow abundantly.

The prefix *al-* in Romanic names (Portuguese *alcaparra* "caper", Spanish *alcaparrón* "caper berry") indicates that these names are not simply inherited

* *Corresponding author*

from Latin, but have been reloaned from Arabic *al-kabara* [ÇáßÈÑ] "the caper", where the article al has been interpreted as part of the word and thus included into the loan word. In last consequence, Arabic *kabara* [ßÈÑ] of course, is related to Latin *capparis* (Katzer, 2002).

The genus comprises around 250 species, ranging from South America, to Mediterranean countries, Africa, Madagascar, Asia, Australia and the Pacific Islands (Inocencio *et al.* 2005).

Taxonomy of Caper plants

Taxonomy and systematics

The taxonomy of *Capparis* section *Capparis* has unfortunately been approached confusedly on occasion. This confusion is reflected in the high number of combinations and changes of rank, with frequent placement under *C. spinosa*. This name, *C. spinosa*, became a sort of large blanket term useful for covering the scarce level of definition of the taxa previously described (Greuter, Burdet and Long, 1984). This fact is most relevant as the *Capparis* flower buds are the crude material used for commercial capers and variability in this economic product is determined mostly by taxonomic differences (Inocencio, 2001, Inocencio *et al.* 2006).

Capparis belongs to the subfamily Capparoideae (Capparaceae), which also includes *Cadaba, Crataeva, Morisonia, Boscia*, and other New World and Old World genera (Hall *et al.* 2002).

Capparis Section Capparis and Capparis Section Galeatae

Capparis is mostly a Pantropical genus, but Section *Capparis* is almost strictly Holarctic with six exclusive species (*C. aegyptia, C. atlantica*, C. orientalis, *C. ovata, C.* x *spinosa, C. zoharyi*), one paleotropical species (*C. hereroensis*) and three in Holarctic and paleotropical areas (*C. mucronifolia, C. parviflora*, *C. sicula*). Here we name the floristic categories (kingdoms and regions) according to Takhtajan, 1986. *Capparis* section *Capparis* has its maximum diversity in the Saharo-Arabian Region (Holarctic) with seven species in North Africa and Arabian Peninsula (*C. aegyptia, C. ovata, C. zoharyi, C. mucronifolia, C. parviflora, C. sicula*). It is followed next by the Mediterranean Region (also Holarctic) with six species (*C. aegyptia, C. atlantica, C. orientalis, C. ovata, C.* x *spinosa, C. zoharyi, C. sicula*). The Irano-Turanian Region (Holarctic) is inhabited by four species extending along most of West and Central Asia (*C. aegyptia, C. mucronifolia, C. parviflora, C. sicula*). The Sudano-Zambezian Region (Paleotropical) is inhabited by three species in tropical

East Africa, littoral Arabia, western India and southern Pakistan (*C. mucronifolia, C. parviflora, C. sicula*). The African Karoo-Namib and Indian regions are inhabited by one single species each (*C. hereroensis* and *C. sicula* respectively). *Capparis sicula*, is the most widespread species, stretching from the Western Mediterranean to the Himalayan Mountains and the Rajasthan of India (Indian Region, Paleotropical) (Fig. 1). *Capparis hereroensis* Schinz, is the only species confined to the African Karoo-Namib Region (sensu Takhtajan, 1986) in western Namibia. Endemic taxa are infrequent in this section, although *Capparis atlantica* is endemic to the Atlas range in Morocco, *C. mucronifolia* ssp. *rosanoviana* is endemic to central Tajikistan, and *C. parviflora* ssp. *sphaerocarpa* is endemic to the western provinces (Nimruz, Farah, Herat) in Afghanistan (Inocencio *et al.,* 2006) (Figs 2, 3, 4, 5).

Section *Galeatae* is mostly Paleotropical with three exclusive species (*C. antanossarum, C. cordifolia*, *C. nummularia*), and two in Holarctic and paleotropical areas (*C. cartilaginea, C. napaulensis*).

Species of *Capparis* section *Capparis* and section *Galeatae* are widely used as food and medicine in the Old World. Capparis x *spinosa* is almost exclusively known in cultivation. The supposed wild individuals of *C.* x *spinosa* are often remnants of ancient caper fields or escaped from cultivation. Local caper cultivars and ethnovarieties are recognized throughout the Western and central Mediterranean region (Spain, France, Italy, continental and insular). These principally belong, to *C.* x *spinosa* but also to *C. orientalis*. (Rivera, *et al.*, 1999 and 2003 b). Flower buds, consumed as brined product, are a rich source of the antioxidant phenolic compound rutin (Inocencio, *et al.* 2000).

Capparis Section *Capparis*. Type Species : *Capparis spinosa* L.

A total of 10 species, 12 subspecies and one nothospecies of economic relevance are recognized and distributed in the tropical, subtropical and Mediterranean zones of both hemispheres. It is widely represented in Asia, and reaching Southern Europe, Eastern, Northern and Southwestern Africa.

Synopsis of *Capparis* diversity within Section *Capparis*.

Capparis taxa and synonyms	**Distribution and Habitat**
1. *Capparis aegyptia* Lam. Encycl. Method. Bot. I: 605. 1783. Capparis spinosa var. aegyptia (Lam.) Boiss., Fl. orient. 1: 420. 1867. *Capparis sinaica* Veill. in Duhamel, Traité Arbr. Arbust. Ed. 2, Vol. I: 144. 1801. *Capparis*	Saharo-Arabian, extending into the Irano-Turanian and Mediterranean Regions. North Africa, Middle East into India [Egypt, India, Israel, Jordan, Saudi Arabia];.

Contd...

deserti (Zohary) Täckh. & Boulos Publ. Cairo Univer. Herb., 5: 14. 1972 [1974]. *Capparis spinosa* L. var. deserti Zohary Bull. Res. Coun. Israel 8D: 56. 1960	
2. *Capparis atlantica* Inocencio, D. Rivera, Obón & Alcaraz. Annals of the Missouri Botanical Garden 93(1): 131. 2006	Mediterranean Region. North Africa [Morocco].
3. *Capparis hereroensis* Schinz, Bull. Herb. Boissier 1(3): 396. 1895.	Karoo-Namib Region. South Africa [Namibia].
4. a.*Capparis mucronifolia* Boiss. ssp. mucronifolia Diagn. Pl. Orient., Ser. I, Vol. I: 3. 1843. *Capparis spinosa* L. var. *mucronifolia* (Boiss.) Hedge & Lamond, Fl. Ir. Hoch. Umr. Geb.: 7. 1970. Boiss. *Capparis elliptica* Hausskn. & Bornm. ex Bornm. var. *maskatensis* Hausskn. & Bornm., Mitt. Thür. Bot. Ver. N.F. VI: 49. 1894.	Sudano-Zambezian and Saharo-Arabian, extending to the Irano-Turanian Regions. Middle East [Afghanistan, Iran, Oman, United Arab Emirates].
4. b.*Capparis mucronifolia* Boiss. ssp. rosanoviana (B. Fedtsch.) Inocencio, D. Rivera, Obón & Alcaraz. , Annals of the Missouri Botanical Garden 93(1): 135. 2006. As well in the Kafimigan, Pani and Amudarya river valleys, in southwestern Tajikistan.	Irano-Turanian Region. Middle East [Tajikistan]. At the eastern slope of the mountains Aryktau, above Goranty and on the left bank of the River Vakhsh, between Kurgan-Tyube and Lechman.
5. *Capparis orientalis* Veill. in Duhamel, Traité Arbr. Arbust. ed. 2, 1: 142. 1801. *Capparis spinosa* L. ssp. *orientalis* (Veill.) Jafri, Flora of Libya, Vol. XII: 3. 1977. *Capparis rupestris* Sm. Fl. Graec. Prodr. Vol. I: 355. 1809. *C. spinosa* L. ssp. *rupestris* (Sm.) Nyman, Consp. Fl. Eur.: 68. 1878. *C. spinosa* L. var. *rupestris* (Sm.) Hook. f. & Thoms. in Hook. f.	Mediterranean Region. Mediterranean Europe and North Africa [Albania, Algeria, Croatia, Greece, Italy, Libya, Malta, Spain, Turkey].
6. a.*Capparis ovata* Desf., Fl. Atlant., Vol. I: 404. 1798. *Capparis spinosa*	Saharo-Arabian and Mediterranean Regions. North Africa [Algeria, Libya,

Contd...

Contd...

L. var. *ovata* (Desf.) Batt. in Batt. & Trabut., Fl. Algérie: 82. 1888. 6 a. *Capparis ovata* Desf. ssp. *ovata*, *Capparis sicula* Veill. var. *kruegeriana* Pamp. L'Agricoltura Col. 22: 459. 1926. *Capparis spinosa* L. var. *rupestris forma kruegeriana* (Pamp.) Pamp. Prodr. Fl. Ciren.: 234. 1931. *Capparis spinosa* L. ssp. *orientalis* (Veill.) Jafri. var. *kruegeriana* (Pamp.) Jafri. Flora of Libya. Vol XII: 4. 1977.	Morocco, Tunisia].
6. b.*Capparis ovata* Desf. ssp. *myrtifolia* Inocencio, D. Rivera, Obón & Alcaraz. Annals of the Missouri Botanical Garden 93(1): 137-138. 2006.	Saharo-Arabian Region. North Africa [Algeria, Chad].
7. a.*Capparis parviflora* Boiss. Diagn. Pl. Orient., Ser. I, Vol. I: 4. 1843. ssp. *parviflora* = *Capparis spinosa* var. *parviflora* (Boiss.) Boiss., Fl. Orient. Vol. I: 420. 1867. *Capparis leucophylla* DC. var. *parviflora* (Boiss.) Zohary, Bull. Res. Coun. Israel 8 D: 59. 1960. *Capparis murrayana* Graham. Cat. Pl. Bombay: 9. 1839.	Irano-Turanian and Saharo-Arabian Regions, extending to the Sudano-Zambezian Region. Middle East and Central Asia [Afghanistan, Iran, Pakistan, Saudi Arabia, Turkmenistan].
7. b.*Capparis parviflora* Boiss. ssp. kurdica (Zohary) Inocencio, D. Rivera, Obón & Alcaraz. , Annals of the Missouri Botanical Garden 93(1): 139. 2006. Basionym: *Capparis ovata* Desf. var. kurdica Zohary Bull. Res. Coun. Israel. Vol. 8D, 56. 1960.	Irano Turanian Region. Middle East [Afghanistan, Iran, Iraq].
7. c.*Capparis parviflora* Boiss. ssp. sphaerocarpa Inocencio, D. Rivera, Obón & Alcaraz. Annals of the Missouri Botanical Garden 93(1): 139. 2006.	Irano-Turanian Region. Central Asia [Afghanistan, Turkmenistan].
8. a.*Capparis sicula* Veill., in Duhamel, Traité Arb. Arbust. Ed. 2, 1: 159. 1801. subs. *sicula*. = *Capparis ovata* var. *sicula* (Veill.) Zohary, Bull. Res. Counc.	Mediterranean and Irano-Turanian Regions; locally introduced in the Saharo-Arabian Region. Mediterranean Europe, North Africa, Middle East into

Contd...