



USE OF BRINJAL
(*Solanum melongena* L.)
IN ALTERNATIVE SYSTEMS OF MEDICINE IN INDIA

C KAMESWARA RAO

Issued in Public Interest



FOUNDATION FOR BIOTECHNOLOGY AWARENESS AND
EDUCATION

BANGALORE 560004

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TO
DR SHANTHU SHANTHARAM
IN APPRECIATION OF
CONSISTENT AND AFFECTIONATE
PERSONAL AND PROFESSIONAL RELATIONSHIP
SINCE JULY 1968

FOREWORD

Dr C Kameswara Rao is passionate about the potential of GM technology to improve productivity in agriculture, which is almost stagnating in India. The development of *Bt* brinjal has been the harbinger in India for improvement in marketable yields of food crops, by offering protection against the relevant insect pests. Unfortunately, *Bt* brinjal introduction is under embargo for reasons that are not science-based, but based on ill-informed activism. One such objection is based on the myth that *Bt* brinjal would tend to replace brinjal as a component of Ayurvedic medicine and alter alkaloid and other contents in the preparations, causing deleterious effects. While, there is massive global data available on the environmental and health safety of *Bt* gene, *Bt* cotton and *Bt* corn, it does become necessary for scientists to examine every objection however frivolous it may be. In a recent meeting of experts, it was offered that if the varieties of brinjal used in Ayurveda are made known, introduction of *Bt* gene into these varieties could be banned, as a measure of abundant precaution. Interestingly, despite the propaganda, no one has been able to clearly identify the medicine or medicines in which authentic brinjal is a component. While, safety issue is paramount, wild conjectures should not be allowed to derail the use of GM technology.

Dr Kameswara Rao, true to his scientific culture, has made a thorough examination of the literature on major alternate and complementary systems of medicine practised in India, namely Ayurveda, Siddha, Unani and Homeopathy for possible use of brinjal. He has also analysed the inputs that were made available to the MOEF on this aspect. Dr Rao clearly points out the basis for the confusion. One is the pitfall in identifying the actual plant species used based on terms mentioned in Samskrith, Tamil, Urdu, Arabic, Persian etc. The same difficulty arises in identifying the *Solanum* species used in these medicines, in which some formulations may contain as many as 70 different plant species! For example, Dr Rao has carefully analysed literature on Dasamoola and other preparations and shows that there is evidence for the use of *Solanum indicum*, *Solanum xanthocarpum*/ *Solanum surattense*, *Solanum nigrum*, but not *solanum melongena* (brinjal). The major problem is the lack of appreciation that any species of *Solanum* (including potato, *Solanum tuberosum*) is not a brinjal variety! His extensive study and analysis indicate that there is no evidence for the use of *Solanum melongena* (brinjal) in any of the systems of medicine examined, except for stray references to minor uses of some unnamed varieties of brinjal. At times, Dr Kameswara Rao uses strong language to drive home his point and that arises from his conviction and frustration that despite the best effort of scientists, introduction of GM crops is being scuttled with repeated wild scientific untruths. I only hope that the present exercise of Dr Rao would atleast settle the controversy of *Bt* brinjal in Ayurvedic medicines once and for all. This is a non-issue.

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July 19, 2011

PREFACE

I have been writing about *Bt* brinjal since September 2006, starting with a submission in support of its commercialization to the Genetic Engineering Approval Committee's (GEAC) First Expert Committee on *Bt* brinjal, but was not aware of the contention that *Bt* brinjal would jeopardize the use of brinjal in Alternative and Complementary Systems of Medicine (ACSM), till the public consultation exercise of the then Minister for Environment and Forests (MoEF), Government of India (GoI), was in place in October 2009. The Primer issued at the 'National Consultations' meetings stated that '*In Ayurveda around 14 varieties of the brinjal are being used for medicinal preparations*', without naming even a single variety (Anonymous 2009a, p 17). This highly exaggerated view, unsubstantiated by reference to Ayurvedic sources, propagates a dangerous myth. The issue was sensationalized by the activists to disproportionate emotional levels and immediately taken up by the MoEF, as a potential arrow in his quiver, to shoot down *Bt* brinjal.

At the 'National Consultations' meeting at Bangalore on February 6, 2010, a participant asserted that over 2,500 (medicinally) important chemical compounds were isolated from brinjal, a claim unacceptable to those familiar with phytochemistry and pharmacology. Another participant claimed that brinjal is a very important ingredient in several Ayurvedic medicines, but did not substantiate it with sources. I did not get a chance to speak at this meeting to counter these claims. There may have been participants who have raised the same issue in meetings at the other centres, but there is no indication of this in the report on 'National Consultations' (Anonymous, 2010).

The report on 'National Consultations' on *Bt* brinjal stated that '*No assessment has been made on the potential impacts (toxicity or ineffectiveness) of Bt brinjal on Indian systems of medicine, given that brinjal and related plants are used in Ayurveda, Siddha, and so on*' (Anonymous, 2010, item 329, p. 41). However, the report had noted on an earlier page that '*The issue of the Bt gene having effect on the medicinal properties of other Solanum species is erroneous and unscientific*' (Anonymous, 2010, item 251, p. 36). The argument that *Bt* brinjal would single handedly seriously affect the use of *Solanum melongena* (brinjal) and other species of *Solanum* in all the Indian systems of medicine is a factoid. Nevertheless, the issue needs to be addressed to allay public concern ruffled by the activists.

There is vast and widely dispersed literature on the medicinal plants, attributing an extensive range of therapeutic benefits to plants. Most of this information, which is repetitive and often contradictory, cannot be traced to any of the classical source texts of indigenous medicine. In order to understand that the use of brinjal in any of the ACSM in India is not supported in literature, it is necessary to be aware of diverse and complex cognate issues that affect decisions on the main question. For this reason issues such as a) Alternative and Complementary Systems of Medicine, b) Problems in establishing the identity of Indian medicinal plants, c) Patterns of distribution of therapeutically active chemical compounds in plants, d) Establishing identity of medicinal plant species cited in classical literature, e) Reliability of sources of information on medicinal plants, f) Botanical and vernacular nomenclature of brinjal and relevant species of *Solanum*, were also discussed along with a) Dr G Sivaraman's letter to the MoEF, b) his reference to the CSIR publication Wealth of India, and Nair and Vasudevan's book, c) Use of species of *Solanum* in *Ayurveda, Siddha, Unani* and Homoeopathy, and d) the other issues raised by Dr Sivaraman (synergy, use of raw brinjal in medicine and safety of cooked *Bt* brinjal).

In spite of knowing that brinjal is of no consequence to indigenous Indian medicine, I worked with an open mind and ultimately the three-month effort turned out to be a search for an elusive needle in a haystack.

As expressed by Dr G Padmanabhan in his Foreword, I hope that the present exercise would set at rest the spurious claim that brinjal is an important ingredient in indigenous Indian medicine and that *Bt* brinjal would jeopardize that use.

In my experience no cereal, gram or vegetable species/variety in cultivation is a significant ingredient in the Indian medical systems. Yet, we should now be prepared with credible information on the medicinal uses of the other genetically engineered crops in development, so that a similar drama of 'Much Ado About Nothing' is not reenacted with a different '*dramatis personae*'.

An often haunting question is, 'how many of those who are fighting to protect traditional Indian medicine through banning *Bt* brinjal actually go for traditional medicine for themselves and for their families?' Of course, we know that they are fighting for their poor cousins who cannot afford modern medicine.

Acknowledgement

I am grateful to a) Professor G Padmanabhan, NASI-Platinum Jubilee Chair/ Honorary Professor, Department of Biochemistry, Indian Institute of Science, Bangalore, for kindly writing the Foreword; b) Dr G Sivaraman, Member, National Siddha Pharmacopeia Committee, Chennai, for kindly providing me with material from *Siddha* source texts and other publications, which is additional to MoEF's *Bt* brinjal moratorium documentation; c) Dr Gurumurthi Natarajan, Agricultural Scientist and Consultant, Chennai, for translating *Siddha* source material from Tamil and for providing additional inputs; and d) Dr Shanthu Shantharam, President, FBAE, who has been in the thick and thin of FBAE's efforts in supporting genetically engineered crops in India, for over a decade. In the early part of July 2011, a version of this booklet was sent to over 250 scientists and others in and out of India, as an e-mail attachment. I thank all those who have responded with encouragement and suggestions for improvement of this article, more particularly a) Professor Ron Herring, Cornell University, USA, b) Professor Klaus Ammann, Public Research and Regulation Initiative, Switzerland, and c) Professor Richard Goodman, University of Nebraska, Lincoln, USA. Dr M Sanjappa, Dr P Daniel and Dr GVS Murthy, of the Botanical Survey of India, have kindly provided the data on the species of *Solanum* occurring in India (Appendix I). The scientific support from Dr Santanu Dasgupta, Director, Scientific Affairs, Monsanto, Mumbai, provided the incentive to publish this printed version.

C Kameswara Rao

August 1, 2011

USE OF BRINJAL (*SOLANUM MELONGENA L.*) IN ALTERNATIVE SYSTEMS OF MEDICINE IN INDIA

EXECUTIVE SUMMARY

The activists opposing the commercialization of *Bt* brinjal have asserted that *Bt* brinjal would seriously affect the use of brinjal in the Alternative and Complementary Systems of Medicine (ACSM) in India, through 'loss of synergy'. The then Minister for Environment and Forests (MoEF), Government of India (GoI), repeatedly echoed this view. While there was no appropriate and substantial documentation to justify this highly sensationalized claim in the MoEF's *Bt* brinjal moratorium document (MD) of February 9, 2010 or elsewhere, the much repeated high decibel noise has clouded public mind and it became necessary to clarify on the issue in detail.

This article analyzes the issues raised and provides a detailed survey of authentic literature on the use of brinjal (*Solanum melongena*) and other species of *Solanum* in the ACSM in India, in particular *Ayurveda*, *Siddha*, *Unani* and Homoeopathy. The issues addressed are a) Alternative and Complementary Systems of Medicine, b) Problems in establishing the identity of Indian medicinal plants, c) Patterns of distribution of therapeutically active chemical compounds in plants, d) Establishing identity of medicinal plant species cited in classical literature, e) Reliability of sources of information on medicinal plants, f) Botanical and vernacular nomenclature of brinjal and relevant species of *Solanum*, g) Dr G Sivaraman's letter to the MoEF, and his reference to the CSIR publication Wealth of India, and Nair and Vasudevan's book, h) Use of species of *Solanum* in *Ayurveda*, *Siddha*, *Unani* and Homoeopathy, i) Other issues raised by Dr Sivaraman (synergy, use of raw brinjal in medicine and safety of cooked *Bt* brinjal), j) a concluding statement, k) 36 references, and j) an Appendix containing the list of species of *Solanum* occurring in India. Among a host of literature sources consulted, the more important ones are a) the Ayurvedic formulary of India, b) the Ayurvedic Pharmacopoeia of India, c) *Siddha Materia Medica*, d) Formulary of *Siddha* Medicines and e) an extensive compilation, the Database of Medicinal plants.

There is a lot of confusion in the botanical identity and nomenclature of several species of *Solanum* occurring in India. Several names of brinjal in *Sanskrit*, *Tamil*, *Arabic*, *Persian* and *Urdu* are also applied to other species of *Solanum* in the classical literature on *Ayurveda*, *Siddha*, and *Unani*, which is the main reason for erroneously considering some other species of *Solanum* as equivalent to brinjal (*Solanum melongena*) and attributing the medicinal uses of the former to the latter. While there can be honest errors of judgment, this state of confusion is being used deliberately, to oppose commercialization of *Bt* brinjal.

The bottom line is that while such wild species as *Solanum indicum*, *Solanum nigrum*, *Solanum surattense* and *Solanum xanthocarpum* are used in different ACSM both as single drugs and in formulations, *Solanum melongena* is not a significant drug and is not an ingredient in any formulation, in any of the ACSM. While every system indicated certain negative effects of brinjal including its allergenic potential, the *Siddha* system actually prohibits its consumption in certain disease conditions. The claim that brinjal is an important medicine in treating respiratory diseases has no basis in literature. The other claim that brinjal reduces cholesterol was clinically disproved in Brazil. The assertion that the transgenic *Bt* gene affects synergy in medicine using brinjal is inaccurate and irrelevant when brinjal is not used in medicine. The stray mention of some insignificant uses

of brinjal as medicine was probably based on the properties of brinjal available centuries ago when the texts of classical medicine were compiled. These minor uses are no longer relevant as the present day cultivated brinjal (there is no wild brinjal) has undergone extensive genetic modification in conventional breeding during domestication through selection of more palatable and safer varieties, which means minimal active principles. In effect, *Bt* brinjal does not pose any threat to the use of non-*Bt* brinjal in medicine, as the scope for gene flow from *Bt* brinjal to non-*Bt* brinjal is almost non-existent.

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USE OF BRINJAL (*SOLANUM MELONGENA L.*) IN ALTERNATIVE SYSTEMS OF MEDICINE IN INDIA

I. INTRODUCTION

At the time declaring a moratorium of an unspecified duration on *Bt* brinjal on February 9, 2010, the then Minister of Environment and Forests (MoEF), Government of India (GoI), issued a 19 page text and 535 pages of four Annexures (MoEF, 2010, referred as MD here), wherein he raised the issue of *Bt* brinjal jeopardizing the use of brinjal in Alternative and Complementary systems of Medicine (ACSM) in India (MD, text para 20, p. 13). The MoEF's massive documentation was reviewed point by point (Kameswara Rao, 2010), including the issue of use of brinjal in ACSM (paras 105-109, pp. 31-32).

Dr G Sivaraman, Member, National Siddha Pharmacopeia Committee, Chennai, has made a very lengthy submission to the MoEF (MD, Annexure IIIA, pp. 209-224) and opposed *Bt* brinjal on the grounds that it affects the use of brinjal in Indian systems of medicine. Dr Sivaraman has appended pages from Wealth of India (WoI), a publication of the Council of Scientific and Industrial Research (CSIR), GoI, officially described as a 'dictionary of Indian raw materials and industrial products' (Chadha, 1972; vol. ix, pp. 383-390), and from a book by Nair and Vasudevan (a concise dictionary of medicinal plants, date of publication untraceable), in support of his arguments, but neither of the publications is an authentic source for any indigenous system of medicine.

The MoEF was very much concerned with the issue as he had observed in MD (text para 20, p. 13) that *"I have also been informed that Indian systems of medicine, including ayurveda, siddha, homeopathy and unani, use brinjal as a medicinal ingredient both in raw and cooked form for treatment of respiratory diseases and that the entire brinjal plant is used in such preparations. There is fear that Bt brinjal will destroy these medicinal properties due to loss of synergy, differences in the alkaloids and changes in other active principles"* (emphasis in bold is mine). The MoEF re-emphasized this concern in an interview later (Indian Express, February 24, 2010).

The MoEF referred to a submission (Annexure IIIA, pp. 225-231) from 'Doctors for Food Safety' qualifying it as *"a network of Around 100 doctors across the country"* (MD 20, p. 13). I could not trace this 'network', but six doctors, including Dr G Sivaraman, signed this submission which opposed *Bt* brinjal on the usual anti-tech grounds, and echoed Dr Sivaraman's concern that *'the investigators and inventors of Bt brinjal assumed as if nobody uses raw brinjal'*, and cited *Dasamoola asava* in *Ayurveda* and *Dasamoola choornam* in *Siddha* as using brinjal as an ingredient.

It boils down to that only Dr Sivaraman submitted a written statement with some pages from two publications in support of medicinal uses of brinjal, while all the others who raised this issue have not substantiated their claim with literature from any source. Nevertheless, there is a need to convince the public and the new Committee of the GEAC, which is currently concerned about the question, that the edible and cultivated brinjal (there is no wild brinjal) is not an ingredient in any system of medicine in India, and that *Bt* brinjal would not affect the use of brinjal in medicine, which is the objective of this article.

II. ALTERNATIVE AND COMPLEMENTARY SYSTEMS OF MEDICINE

There are over 125 Alternative and Complementary Systems of Medicine (ACSM), but only less than a dozen are plant based (see Kameswara Rao, 2000, 2002, for a detailed discussion).

Alternative systems are those with a potential to treat the whole range of diseases, and so are projected as alternatives to Allopathy, the modern medicine. In India, only *Ayurveda*, *Siddha*, *Unani* and Homoeopathy, which are formal and organized systems, are the important alternative systems while the Chinese and Tibetan systems are in limited practice.

Complementary systems are support systems that help to maintain health and prevent disease but not for treating all diseases. Naturopathy, Nutrition therapies, Bach's flower remedies (an arm of Homoeopathy), and Aromatherapy (sensory therapy) are Complementary systems in India.

Among the Indian ACSM, *Ayurveda* is the most important and most widely practiced in India, with strong religious and cultural bonds. The core literature of *Ayurveda* (source texts and commentaries) is in *Samskrith*, but translations of these are available in English (for example, Ray and Gupta, 1980; Ray et. al., 1980) and regional languages (see Kameswara Rao, 2000, 2002, for details).

The *Siddha* system of medicine is claimed to be more ancient than even *Ayurveda*. Conceived by 18 *Siddhars*, it is intricately connected with the Dravidian culture and tradition (Kameswara Rao, 2000, 2002). The core *Siddha* literature is in Tamil and the system is popular among the Tamil populations in India and abroad. The support given by the Government of Tamil Nadu to the development of the *Siddha* system is laudable.

Siddha and *Ayurveda* have many commonalities both in principles and practices. A number of formulations have similar composition and names in both the systems, as for example *Dasamoola churnam* and it is often difficult to say whether a particular formulation is from *Ayurveda* or *Siddha*. The significant difference between the two systems is the prominent use of minerals and metals such as gold, silver, mercury and arsenic, many of which are very poisonous (iatrochemical formulations), and some vegetable toxins, in the *Siddha* system.

The *Unani Tibb* system is traced to Greek medicine and is often referred as the 'Greco-Arab' system. The *Unani* system, popular among the Muslim populations around the world, owes its development primarily to the Arab and Iranian physicians and to a very considerable extent to the Indian *Hakeems*. *Unani* has absorbed what was best in the contemporary medicine in Egypt, Syria, Iraq, Persia, India and China, as well as the Middle and Far Eastern countries (Kameswara Rao, 2000, 2002). *Unani* has substituted Indian plant species for those Middle Eastern species not available in India. The bulk of *Unani* literature is in Persian, Arabic or Urdu.

There has been a close interaction and integration over centuries between and among *Ayurveda*, *Siddha* and *Unani* systems in India, resulting in the use of identical species in treating similar diseases. Only the native species or those introduced species naturalized millennia ago come into use in these systems but not the recently introduced one.

Homoeopathy originated in 1796 in Germany and owes its origin to Doctor Christian Samuel Freidrich Hahnemann. One of the cardinal principles of Homoeopathy is '*Similia similibus curentur*' meaning that a particular substance which produces a specific symptom in a healthy individual, cures the same symptom in a sick individual. Homoeopathy is also based on the concept of '*minimal dose*' that considers progressively smaller doses as increasingly powerful. Single dose remedies predominate in Homoeopathy while formulations are extremely rare and are of recent origin. All these three principles are in contrast to the principles of *Ayurveda*, *Siddha* and *Unani*. Homoeopathy is in use in many countries except China, Taiwan and Maldives and is actually banned in Israel and Muslim countries, as the mother tinctures are extractions in ethyl alcohol, whose consumption is a taboo. In India both the urban and rural populations patronize Homoeopathy (See Kameswara Rao, 2000, 2002, for a comprehensive discussion on Homoeopathy).

III. PROBLEMS IN ESTABLISHING THE IDENTITY OF INDIAN MEDICINAL PLANTS

One of the major problems in the study of Indian medicinal plants is establishing their correct scientific identity basing on plant descriptions in classical texts and other sources. The descriptions of plants and their uses given in the source texts are either in *Samskrith (Ayurveda)*, Tamil (*Siddha*) or Persian/Arabic/Urdu (*Unani*). The meaning and import of the language used for the names and descriptions of medicinal plants centuries ago, have to be interpreted and understood correctly, handicapped by our current understanding of and proficiency in the respective languages. The current form of these languages is vastly different from that of the classical. Similar difficulties are also faced in finding the modern equivalents for the names of symptoms and diseases in the classical texts. Any errors in these efforts will seriously affect the efficacy of the medicine and the credibility of the medical system, jeopardizing research on and utilization of medicinal plants.

For purposes of research and international scientific communication, the correct botanical identity and nomenclature of the plants used in medicine are essential. This is the job for a professional taxonomist (specialists in the area of identification, naming and classification) and not even for a general botanist.

IV. PATTERNS OF DISTRIBUTION OF THERAPEUTICALLY ACTIVE CHEMICAL COMPOUNDS IN PLANTS

Medicine functions in terms of chemical compounds and their interaction with the body. The distribution of chemical compounds in plants has several unpredictable and diverse patterns. While there are several compounds in a particular species, one or a few compounds come to be considered important, depending upon their therapeutic potential. Some compounds like carotenoids or saponins or the flavonoids kaempferol, rutin, quercetin, etc., occur in a large number of diverse plant groups. Some others may occur exclusively in one species, or species of a single genus, or different genera of a family or in very diverse and botanically unrelated plant groups. Beneficial or hazardous, chemical compounds in plants may not all be present in all parts of the plant. Many of them accumulate in specific organs, such as the roots, bark, leaves, fruits or seeds, which form the ingredients in food or medicine. Representative examples to illustrate these diverse patterns of distribution chemical compounds are given below:

- a) Cannabinoids occur only in *Cannabis sativa* (*ganja, hashish, marijuana*; Cannabidaceae) and in no other species.
- b) The opium alkaloids occur only in the opium poppy plant (*Papaver somniferum*) among over 100 species of the genus *Papaver* (Papaveraceae).
- c) The alkaloids of *Rauwolfia serpentina* (Apocynaceae), are also present in varying quantities, in related Indian species such as *Rauwolfia tetraphylla*. *Rauwolfia vomitoria* in West Africa, has far higher quantities of reserpine (used against high blood pressure) than the Indian favourite *Rauwolfia serpentina* (Ayensu, 1986). Reserpine also occurs, though in small quantities, in *Alstonia scholaris*, an Indian species of the same family.
- d) The vinca alkaloids, vincristine (leucocristine) and vinblastine (vincaleucoblastine), occur in *Catharanthus roseus* (= *Vinca rosea*, Apocynaceae), from Madagascar, now naturalized or cultivated in India. But another Madagascaran endemic species *Catharanthus coriaceus* seems to contain much more of vincristine, popularly used against leukemia, than *Catharanthus roseus* (Ayensu, 1986).
- e) The sweet saponin liquorice (glycyrrhizin, 60 times more sweeter than cane sugar), occurs in the roots of *Glycyrrhiza glabra* (Fabaceae), the classical source of the compound, and in *Glycyrrhiza wralensis*, both of which are exotics cultivated in northern India, for use in many indigenous medicines. The leaves of the common Indian species, *Abrus precatorius* (crab's eye, Fabaceae), also contain liquorice, in far greater quantities than in the roots of species of *Glycyrrhiza* (Oliver-Bever, 1986; Kameswara Rao and Sangetaa, 1993).
- f) The original source of the anticancer alkaloid camptothecin is the Chinese plant *Camptotheca acuminata* (Nyssaceae) and has been discovered in and exploited from an unrelated Indian species *Nothopodytes nimmoniana* (= *Nothopodytes foetida*, Icacinaceae).
- g) The alkaloid ephedrine, widely used in bronchial problems, originally discovered in the species of the gymnosperm (seeds without fruits) *Ephedra*, also occurs in the distant angiosperm (seeds within fruits) species of the genus *Sida* (Malvaceae, the family of *bhindi*). This discovery was based on similar use of the species in *Ayurveda*.

- h) The stimulant chemical compounds are concentrated in the seeds of the coffee plant and in the leaves of the tea plant, the reason for using coffee seeds and tea leaves. The stem tubers of potato and the fruits of tomato and brinjal are safe for human consumption but not the green vegetative parts of these plants, which contain very high concentrations of toxic alkaloids. Anti-diabetic principles are present only in the seeds of fenugreek but not in other parts. Opiates are present only in the wall of the poppy fruit and nowhere else, not even in the seeds, the reason for poppy seeds being freely available in the market while opiates are severely restricted. Yet people use poppy seeds in different foods and feel drowsy on consumption of such food; faith is more powerful than fact.

These patterns of distribution would have been missed without correct chemical and botanical identities, which are essential not only to establish the original source, but also to make subsequent collections of the plant material and to identify suitable substitutes, when necessary.

The patterns of distribution of chemical compounds also mean that if a species in a genus is medically useful it does not mean that all the species in that genus are. Only in very rare instances all the parts of a plant of a species are useful as food or medicine.

V. ESTABLISHING IDENTITY OF PLANT SPECIES CITED IN INDIGENOUS MEDICAL LITERATURE

There are two ways of establishing the identity of medicinal plants from the classical sources:

- a) One is basing on the names and descriptions given in the source texts. The correct identification of the water weed and fern, *Salvinia natans*, was established on a reinterpretation of the descriptions in *Charaka Samhitha*. An error in interpretation resulted in the use of a wrong species earlier (Professor B A Hegde, Kolhapur, personal communication). The risk of misunderstanding the descriptions is of a major concern in this method.
- b) The second method is to obtain a sample of the plant material from reliable and authentic users and establish its botanical identity. The basis is continued traditional identification and use. An age old misinterpretation or a substitute being used in the original name for a long time due to the paucity of the original material, deliberately or out of ignorance, are the risks in this approach, besides the problem of determining who or what is an authentic source. Many competent people are very secretive and unhelpful.

Repeated verification and reconfirmation are the safer means of establishing plant identities. Botanical identities should be established based on studying complete specimens (containing all parts from roots to seeds) and whole plants (in the case of herbs and small shrubs) and just not the part which is the source of the drug such as the roots, leaves, bark, fruits or seeds. By and large the identities have been verified for a large number of medicinal plants (Vaidya, 1982; Sivarajan and Balachandran, 1994), yet several problems persist, a few of which are given here:

- a) The identity of *brahmi* is a long standing controversy. The confusion is between *Centella asiatica* (Apiaceae) and *Bacopa monnieri* (Scrophulariaceae), which are botanically unrelated. Both the species prefer water logged soils and in both, the active principles are saponins, though qualitatively different. They are used for various purposes, more importantly as memory enhancers. Another name *Hydrocotyl asiatica* also appears in literature, which is considered as a synonym of *Centella asiatica*. It is now generally agreed that *Centella asiatica* is *brahmi* as used in south India and *Bacopa monnieri* is *mandukabrahmi*, more popular in the north India. Nevertheless, doubts are raised now and then.
- b) Another infamous example of a deep rooted mistaken identity is the *ashoka* tree, whose bark is an important ingredient in Ayurvedic formulations such as the *Ashokaarishta*, widely used to treat menstrual problems. The correct identification is *Saraca asoca* (= *Saraca indica*, Caesalpiniaceae) but a very large number of people and manufacturers of Ayurvedic drugs erroneously consider the unrelated *Polyalthia longifolia* (Annonaceae), as the ashoka tree. One variety of *Polyalthia longifolia* (var. *pendula*) with a pyramidal architecture is a common avenue tree. In consequence, the wrong plant is used either out of ignorance or even deliberately, as a far cheaper but inappropriate substitute. The therapeutic consequences of such substitutions are any body's guess.

- c) The *samskrith* names *tavakshira* and *tvaksira* are orthographic variants of the same name applied to two different species. One is a bamboo, *Bambusa arundinacea* (Poaceae) and the other is *Curcuma angustifolia* (Zingiberaceae), a relative of the turmeric plant but unrelated to bamboo. The rhizomes of the two species which are used in medicine look alike when dry. Arguments persist in this case, though the bamboo rhizomes do not contain any essential oils, while those of the other species do, which should be of help.
- d) The *samskrith* name *svarna kshira* (golden milk) refers to the golden yellow milky latex, basing on which two unrelated species are indicated for use: *Euphorbia thomsoniana* (Euphorbiaceae) and *Argemone mexicana* (Papaveraceae). *Euphorbia thomsoniana* is an Indian species, while *Argemone mexicana*, a common weed, was introduced from South America less than two hundred years ago, and so could not have been incorporated into the Ayurvedic practice. This is an easier issue, yet many do not agree, probably because the exotic species is abundant, easy to collect and costs nothing.

There are several such problems with Indian medicinal plants. Recognizing the brinjal plant or the fruit is not the problem, but the vernacular names used in classical texts of different systems for species of *Solanum*, and establishing their botanical identities are. Added, is the difficulty caused by the complexity and confusion in the botanical names of species of *Solanum*.

VI. RELIABILITY OF SOURCES OF INFORMATION ON MEDICINAL PLANTS

The major classical authentic texts on *Ayurveda*, *Siddha* and *Unani* in the respective languages of their origin are not too many while commentaries are aplenty (see Kameswara Rao, 2000, 2002). Reliable translations of these in English and regional languages are also available since a long time. Additions to the species of medicinal plants in the literature come from research, in phytochemistry and pharmacology, published in standard journals. Basing on such research one may put together some species of plants to constitute an effective medicine, which is being done by many companies misleadingly calling it Ayurvedic medicine. This is herbal medicine which cannot be labelled as *Ayurveda*, *Siddha* or *Unani*, as this medicine is not based on the specific and rather rigid principles and practices of the respective classical systems.

During the past quarter century, there has been a spurt in amateur activity resulting in a very large number of repetitive lists of medicinal plants, in English and various regional languages, as articles and books. These publications mostly serve the personal interests of the authors, as they only contain information that has been merely copied from earlier compilations (such as by Kirtikar and Basu, 1918 and Nadkarni, reprint of third edition 1954), without any verification, substantiation or authentication. Such publications do not strengthen literature support to the subject. One needs to be very careful in using this kind of free-lance literature. Another problem is that the several very informative, important and popular publications of early 20th century such as by Kirtikar and Basu (1918) and Nadkarni (reprint 1954) were reprinted several times and unscrupulous publishers cite only the date of the reprinting but not the original date of publication, misleading the reader into believing that they are recent.

As far as *Ayurveda*, *Siddha* and *Unani* are concerned it is essential and safe to go to the original texts and also to focus more on formulations rather than use of plants as single drugs.

VII. NOMENCLATURE OF BRINJAL

1. Botanical Classification and nomenclature of species of *Solanum* occurring in India:

In a given geographical region, at a given time, species fall into two main categories: the *native* and *exotic*. Native species are those that originated in that region, but may be native to other regions, meaning that they originated more than once in time and/or space. Native species with very narrow and restricted ranges of distribution are the *endemic* species, as for example the sandalwood tree (*Santalum album*) and Jackfruit tree (*Artocarpus heterophyllus*) in South India and Sri Lanka, which do not occur in nature outside this region. Species that were introduced from other regions are the exotic species. Some exotic species were introduced accidentally (like through grain shipments), and may become acclimatized to the new environment, compete with the local species and establish rapidly as natural populations in the wild without human care (many road side weeds, such as *Parthenium*). These are the *naturalized* (exotic) species. The economically important exotic species, introduced intentionally for their various uses, cannot survive outside cultivation without human care (maize, potato, tomato). These are the *cultivated* (exotic) species. Exotic species that have been in cultivation for centuries are often erroneously considered as native species. The native species may have genetically related wild species in the region but the exotics, either naturalized or cultivated, usually do not have any.

The taxonomic treatment and nomenclature of the genus *Solanum* are very cursory in most Indian publications. Choudhary and Gaur (2009) listed 15 species (p. 5) and Anonymous (2009d) listed 22 species (pp. 6 and 7), both providing rather innocently simple and incomplete nomenclature, without synonyms that facilitate crosschecking. The species of *Solanum* that occur in India are listed in Appendix I, which also gives so far as available, information on whether a particular species is naturalized or cultivated in India, its country of origin and the other countries in which it occurs. As per the records of the Botanical Survey of India (BSI), there are 48 species of *Solanum* in India (Appendix I). All these species do not contribute to the genetic diversity of brinjal, as incorrectly considered by Choudhary and Gaur (2009), unless there is evidence for natural or experimental intercrossing among them resulting in fertile offspring. It is important to note that taxonomic relationships, mostly based on the balance of external resemblances and differences which lead to classification of species in a particular taxonomic group such as the genus *Solanum* or the family Solanaceae, do not necessarily mean genetic relationship, which is confirmed only when there is intercrossing resulting in fertile offspring from such crosses. The data in Appendix I provided by the BSI (personal communication) include two species, *Solanum vagum* B. Heyne ex Nees and *Solanum wightii* Nees, considered as endemic to Tamil Nadu and Kerala in South India. As the genus *Solanum* itself has originated in South America and its species introduced into different geographical regions of the world, identifying species of *Solanum* in India as native and/or endemic is open to question, though it is possible that some native species may have originated by differentiation from the exotic species, but this has to be scientifically confirmed. The species of *Solanum* in India are exotics, either naturalized or cultivated, until credible botanical, phytogeographic and genetic evidence becomes available to the contrary.

The botanical classification and nomenclature of the species of *Solanum* have undergone substantial changes over time, as is the case with several other plant groups and ignorance of recent literature makes ample room for confusion. *Solanum melongena* var. *incanum* (L.) Kuntze and *Solanum melongena* var. *insamum* (L.) Prain are confused as varieties of brinjal by many, but *Solanum*

incanum L., and *Solanum melongena* L., are distinct and well established species. The name *Solanum insamum* is now a synonym of *Solanum melongena* and so is not a different species or a variety of the latter. *Solanum khasianum* var. *chattarjeeanum* Sen Gupta, which has been projected as the most important source of the alkaloid solasonine (solasodine is the aglycone) used in the commercial production of steroidal compounds, is now *Solanum viarum* Dunal (Babu and Hepper, 1979). In spite of international efforts, the taxonomic status and nomenclature of *Solanum indicum* L., are still a vexing question. One subspecies of *Solanum indicum* is now treated as the subspecies *multiflorum* of *Solanum violaceum* Ortega (Appendix I). Both *Solanum surattense* Burm.f., and *Solanum xanthocarpum* Schrad., & Wendl., are regarded as synonyms of *Solanum virginianum* L., (Appendix I). The multilingual multiscript plant name database of the University of Melbourne (Anonymous, 2009b) may be consulted for the current status of specific and vernacular names of species of *Solanum*. As there are still some contradictions between the Melbourne list and that in Appendix I as provided by the BSI, both should be used with the precaution that the final word on the taxonomy and nomenclature of many species of *Solanum* is yet to come.

If I use the currently valid botanical names in this article meant for a wide range of non-botanist readers, it would affect clarity in referring to classical literature on ACSM, adding to the existing confusion, and hence I reluctantly use the familiar old names, fully conscious that it is not a scientifically sound practice.

2. Vernacular names of species of *Solanum* occurring in India:

Correct vernacular names are critical in issues of plant utilization. Folklore taxonomy and vernacular names are important as they lead to scientific taxonomy, the latter being essential for uniformity, international communication and in establishing Intellectual Property Rights, if any. For example, it is the vernacular name apple first and then came its scientific name *Malus domestica* Borkh., (= *Pyrus malus* L.). Widely distributed and commonly used species of plants acquire several names, both in science and vernacular, or the same name applied to different species. The cultivated African *Solanum aethiopicum* L., is also known as the aubergine or egg plant. Several commonly occurring species may have acquired many scientific names (though only one of them is valid for use). For example, brinjal had 13 different botanical names, before *Solanum melongena* L., was accepted as the valid name for it. Botanists have established procedures to resolve such situations through checking with the original literature and comparing with the herbarium specimens (pressed and dried plant specimens mounted on cardboard sheets with a record of relevant original information) used, while first naming a species. Such an approach is global in perspective, in the sense that if one is concerned even with a single species, such as *Solanum indicum* or *Solanum virginianum*, all the literature and specimens of the species, available around the world should be studied, so that the decisions are internationally applicable and acceptable.

Vernacular names of many plant groups are a veritable monkey puzzle. Different names given to the same species in the same language or the same vernacular name applied to different species, caused confusion. Both the situations occur for the species of *Solanum*. For example, the Samskrith name *brihatbi* (or its orthographic variants), was applied to different species, *Solanum indicum*, *Solanum torvum*, *Solanum violaceum* and *Solanum virginianum*, which may result in misidentification and/or substitution. Similar is the problem with the Tamil name *karimulli* for *Solanum indicum* and *Solanum violaceum*. The application of the Tamil name *kandakathri* for *Solanum surattense*, *Solanum virginianum* and *Solanum xanthocarpum*, interestingly coincides with the current

botanical opinion which considers both the names *Solanum surattense* and *Solanum xanthocarpum* as synonyms of the valid species *Solanum virginianum* (Appendix I). But this is a rare coincidence and not a decision based on application of botanical knowledge and/or any rules of nomenclature. The Tamil name for brinjal (*kathri* and its orthographic variants) is also the suffix of the Tamil name *Kandakathri* which leads to problems in species identification in the *Siddha* system. The *samskrith* name '*rajakooshmanda*' (King's egg, alluding the fruits of the pure white variety to a large egg, similar to the English name 'egg plant' for brinjal) also was applied to brinjal (Jagga Rao *et al.*, 1933), but when the ash gourd (*Benincasa hispida*, Cucurbitaceae) is known by the *Samskrith* name '*kooshmanda*', an uncritical approach would lead to mix up of identity and medicinal uses. While scientific taxonomy and nomenclature are international, to which the application of vernacular nomenclature should be connected, the decisions on vernacular names themselves have only a local import.

The *Samskrith* (S), Tamil (T) and Arabic (A) / Persian (P) / Urdu (U) names of species of *Solanum* of present concern, taken from diverse medicinal plant literature sources, as given below, reflect the complexity of the situation outlined above. These languages are chosen because the discussion here is related to the use of brinjal in *Ayurveda*, *Siddha* and *Unani* medicine.

- i) *Solanum ferox* L.: S: garbhanda, svetakantakaari; T: aanaichundai, molakkai
- ii) *Solanum indicum* L.: S: bhantaki, brahat, cundaa, sauhika, simhi, vrihati; T: chiru vazhuthalai, karimulli, mullamkatti, papparamulli; U: katali
- iii) *Solanum melongena* L.: A: badanjaan, amb, qahqab; P: badangan, badinjan, kahlat, kahkan; S: bartaku, bhantaki, hingoli, jukutam, nattimngan, vartakka, peetaphalam, rajakooshmanda, vartahu, vartakam, vatinga, vatingnah; T: kathri, kathrikai, kattri, kattrikai, veluthalai; U: baingan
- iv) *Solanum nigrum* L.: A: enab edh dhib, enab eth thalab, ribriq, unnab us sau'lab; P: rubhatareek; S: kaakamaachika, kakamischluka, kaakini; T: mantakkali, milaguthakkali; U: makoi, makoya
- v) *Solanum surattense* Burm. f., (now a synonym of *Solanum virginianum* L.): S: dhivane, dusparsa, kantakaarika, kaudri, nidigdhika, vyaghre; T: kandangatri, kandanghathiri, kandankatri
- vi) *Solanum torvum* Sw.: S: brihati; T: sundaikkai
- vii) *Solanum trilobatum* L.: S: achunda, agnidamani, alaarka, kaarika, swethabrihati, valliharta; T: nittidam, sandunayattam, surai, thuthuvalaikkeerai, tunduvalai
- viii) *Solanum violaceum* Ortega: S: brihati, kantakin, simhi; T: karimulli, cheruvalutanai
- ix) *Solanum virginianum* L.: S: bhantaki, brahati, kantakaari; T: kantankathiri, kandakathri
- x) *Solanum xanthocarpum* Schrad. et Wendl., (considered as a synonym of *Solanum virginianum* L.): S: dhavani, dusparsa, kankapatrika, kantakaari, kantakaarika, nidigandha, nidigandhika, ksudra, vaartakee, vyaghri; T: kandakathri; U: kandiari

VIII. DR G SIVARAMAN'S CONTENTION

1. Letter to the MoEF:

In the four page letter he submitted to the MoEF (MD, Annexure IIIA, pp. 209-224), Dr Sivaraman noted that **“there are two major varieties, i.e., *Solanum melongena* and *Solanum indicum* are in the pharmaceutical applications in traditional medicine”** (emphasis in bold is mine). This is not correct as *Solanum indicum* is a well established species notwithstanding the nomenclatural problems, both in *Ayurveda* and botany, distinct from brinjal (*Solanum melongena*) and not a variety of the latter, even according to WoI (Chadha, 1972, IX, p. 381). But there is another hitch in WoI's recording, that mentions four main 'botanical varieties' of *Solanum melongena* (*incanum*, *melongena*, *depressum* and *serpentinum*) (Chadha, 1972, IX, p. 385). This does not constitute sound taxonomy, since *incanum* is a distinct species and *depressum* is an obsolete name, leaving *melongena* and *serpentinum* (the name for the group of very long cylindrical brinjal) as subgroups under brinjal.

Dr Sivaraman wrote that **‘In southern part of India, especially *Solanum melongena* (Brinjal—*Katthirikkai*) has been used as a substitute for *Solanum indicum*’** (emphasis in bold is Dr Sivaraman's). Systems of medicines are plagued with problems created by the use of substitutes, either deliberately or out of ignorance. Some examples were already mentioned. While some substitutes may be functional, many a time a substitute would result in nonfunctional or even dangerous medicine. Substituted use of brinjal cannot be the basis for a major decision affecting a crop cultivated nationwide.

2. Wealth of India:

Dr Sivaraman submitted to the MoEF photocopied material on *Solanum melongena* (see Annexure IIIA, pp. 213 to 220) from WoI (Chadha, 1972; vol. IX, pp. 383-390), which cannot be taken as an authentic source for *Ayurveda* or *Siddha*. Dr Sivaraman had kindly sent me pages 381-382 from Chadha (1972), that contain information on *Solanum ferox*, *Solanum giganteum*, *Solanum hispidum*, *Solanum indicum*, *Solanum khasianum*, which is not a part of MoEF's documentation. WoI contains some references to the use of these species in indigenous medicine. There are no references to authentic texts of any of the ACSM but only to Kirthikar and Basu (1918) and other such publications, which again cannot be taken as sources for ACSM. As will be shown in the present article, brinjal is not used in the indigenous systems in any significant way and certainly not in any formulation. Most of the information cited by the activists comes, not even from Kirthikar and Basu (1918) or WoI (1972) or folklore literature, but from subsequent repetitive publications. WoI gives botanical, phytochemical and pharmacological information, but since WoI was published in 1972, such information is now rather dated. For example, it was stated that **‘Brinjal, leaf and fruit, fresh or dry, produce a marked drop in cholesterol level’, the ‘action is attributed to the presence of magnesium and potassium salts in the plant tissues.’** However, it was admitted that **‘experimental results have not been confirmed by clinical trials.’** If the small quantities of magnesium and potassium salts as can be obtained from vegetables like brinjal can control cholesterol levels, no one would suffer from high levels of cholesterol, at least for two reasons: a) we consume large amounts of chlorophyll from green parts of vegetables and magnesium is at the heart of chlorophyll, and b) a variety of foods, including wheat and rice, contain more than two per cent of potassium salts.

Two reports from Brazil (Ribeiro Jorge *et al.*, 1998; Guimarães P.R., *et al.*, 2000) claimed that egg plant extracts and orange juice had a beneficial effect on cholesterol levels, lipid peroxidation and endothelial function, but a later study based on human clinical trials dismissed the whole concept (Praca *et al.*, 2004).

There are references in WoI and elsewhere to the adverse effect of brinjal alkaloids basing on the changes in the ratio of body and liver weights in mice. The activists have blown this up ignoring the fact that the mice were fed with purified alkaloids at much higher doses than the possible dietary intake through brinjal. Friedman *et al.*, (1996) reported that the increase in relative body and liver weight induced by solanidine and solasodine in potato, tomato and egg plant (brinjal) is a reversible adaptive response, dropping to control levels on discontinued alkaloid intake. Considering the low levels of these alkaloids in currently cultivated brinjal and the quantity and frequency of brinjal intake, make this hardly be an issue. Somehow the presence of nicotine in brinjal was totally missed.

3. Nair and Vasudevan's book:

The second publication from which Dr Sivaraman provided photocopied material to the MoEF (see MD, Annexure IIIA, pp. 209-224) is Nair and Vasudevan (date of publication unavailable in spite of Dr Sivaraman's efforts to find it, at my request), called a 'concise dictionary of common medicinal plants'. The authors gave only the names of supposedly medicinal species, without mentioning any of their medicinal properties or references to sources. The book lists *Solanum nigrum*, *Solanum ferox*, *Solanum violaceum*, *Solanum virginianum*, *Solanum capsicoides* (= *Solanum aculeatissimum*) *Solanum tuberosum* (potato) and *Solanum melongena* (Nair and Vasudevan, pages 108-109). The names of some species given here are no longer scientifically valid. *Solanum aculeatissimum* Jacq., is a valid species, not to be synonymized with *Solanum capsicoides* All., which is another valid species. The book cites *Solanum melongena* var. *insamum* and *Solanum melongena* var. *incanum*. As already mentioned, *Solanum incanum* is a recognized species while *Solanum insamum* is a synonym of *Solanum melongena* (Appendix I). Treating them as varieties of *Solanum melongena* leads to the belief that these are varieties of brinjal and that brinjal is medicinal, as *Solanum incanum* may have some medicinal uses, basing on phytochemistry and pharmacology, though not in ACSM. Potato (*Solanum tuberosum*), a cultivated exotic species, is also listed as a medicinal plant in this book, but there is no evidence for this even in Peru, the country of origin of potato, though the vegetative parts of potato may be used to extract solanum alkaloids. Basically Nair and Vasudevan's book is a vague, uncritical and unreliable listing of supposedly medicinal species.

IX. USE OF SPECIES OF SOLANUM IN ACSM

1. In Ayurveda:

Jagga Rao *et al.*, (1933), taking from Ayurvedic sources, stated that brinjal has a cooling effect on the eyes, neutralizes acidity and removes calcium. The side effects of brinjal are, it increases phlegm, darkens the skin and causes skin irritation. Other recorded negative effects of brinjal are headache, increased body heat, increased intestinal parasites, pain in the rib cage, nausea, and obstruction of liver and spleen (Jagga Rao *et al.*, 1933). Can a medicine that increases phlegm cure respiratory diseases as claimed by the activists and the MoEF? Why do people continue to suffer from respiratory diseases even after consuming brinjal routinely?

i) Ayurvedic Formulary of India:

The Ayurvedic Formulary of India (AFI, Anonymous, 1978a), was compiled by the Ayurvedic Pharmacopoeia Committee consisting of 22 experts, constituted by the Government of India. This compilation, strictly confined to Ayurvedic source texts, listed 444 formulations (as against 341 drugs in *Charaka Sambhitha* and 395 in *Sushrutha Sambhitha*), that use 351 plant species, among which *Solanum indicum*, *Solanum nigrum* and *Solanum xanthocarpum* were mentioned in different formulations but not *Solanum melongena* (brinjal).

ii) The Ayurvedic Pharmacopoeia of India:

The Ayurvedic Pharmacopoeia of India (API) is an official two part publication of the Government of India, compiled by a large Committee with several sub-Committees, under the Central Council for Research in Ayurveda and Siddha, of the Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry of Health and Family Welfare (Anonymous, 1978b, 2007). Four volumes of Part I contain information on 324 plant species used as drugs and two volumes of Part II contain details of Ayurvedic formulations. The API included monographs only on *Solanum surattense* (Part I, volume I, p. 59) and *Solanum indicum* (Part I, volume II, pp. 27-28) and no other species of *Solanum*, which means that brinjal is not of any concern in *Ayurveda*. There are three problems here: a) the uncertainties related to *Solanum indicum* were not recognized, b) the name *Solanum xanthocarpum* was treated as a synonym of *Solanum surattense* (Anonymous, 2007, Part I, vol. I, pp. 59), when both the names are synonyms of *Solanum virginianum* (see Appendix I and Anonymous, 2009b), and c) the API (Anonymous, 2007) did not stick to the name *Solanum surattense* in all formulations that contained it, but used the name *Solanum xanthocarpum* (which compilers themselves considered as a synonym of *Solanum surattense*), in some formulations such as *Chyavanaprasa* (Part II, vol. I, p. 13), *Dasamoola palaka ghritha* (Part II, vol. I, p. 68) and *Dhanvantara ghritha* (Part II, vol. I, p. 80), under the *Sanskrit* name *kantakaari*.

iii) Ayurvedic Formulations:

Dr Sivaraman specifically mentioned about '*Dasamoola*' (roots of 10 species), and formulations based on it, as containing brinjal. '*Dasamoola*' contains 70 plant species, including both *bribati* (*Solanum indicum*) and *kantakaari* (*Solanum xanthocarpum*)

but brinjal is not one of them (Anonymous, 1978a). So is the case with *Dasamoola* based formulations such as *Dasamoolaharitaki* (*Ashtangabridaya*), *Dasamoolarishtha* (*Sarangadhara sambhitha*), *Dasamoola katubriya kvatha churna* (*Sahasrayoga*), *Dasamoola panchakoladi kvatha churna* (*Sahasrayoga*), *Dasamoola ghritha* (*Ashtangabridaya*) and *Dasamoola satpalaka ghritha* (*Chakradatta*), based on the Ayurvedic source texts given in parenthesis above (Anonymous 1978a, pp. 10, 33, 46, 71, 72, 74).

In API (Part II, vol. I, Anonymous, 2007) the following formulations contain *Solanum indicum* and/or *Solanum surattense* (the latter as *Solanum xanthocarpum* in some): *Chitraka haritaki* (p. 10), *Chyanavaprasa* (p. 13), *Vyaghri harithaki* (p. 35), *Dasamoola ghritha* (p. 65), *Dasamoola palaka ghritha* (p. 68), *Kalyanaka ghritha* (p. 75) and *Dhanvantara taila* (p. 117). *Solanum melongena* is not an ingredient in any of these formulations.

Dr Sivaraman also mentioned *Dhanwantara kashayam* and *Dhanwantara tailam* as containing brinjal. *Dhanwantara ghritha* (from *Ashtangabridaya*, containing *brahati*, *Solanum indicum* and *kantakaari*, *Solanum xanthocarpum*), *Dhanwantara gutika* (from *Sahasrayoga*, containing only *brahati*) and *Dhanwantara taila* (from *Vaidyayogaratnavali*, containing both *brahati* and *kantakaari*), were listed in Anonymous (1978a; pp 71, 73, 108, 148) but brinjal is not an ingredient in any one of them.

I have looked into other publications, as for example *Vaidya Yoga Ratnavali* (Ramalingayya, 1968) and did not find even a single mention of brinjal, while the use of the other species of *Solanum* (*Solanum nigrum*, *Solanum indicum*, *Solanum surattense* and *Solanum trilobatum*) was indicated. I have also consulted well qualified and practicing Ayurvedists who could not recall even a single drug use or formulation, in which brinjal is an ingredient.

2. In Siddha:

- i) Dr Sivaraman stated that '*CSIR, in its Wealth of India publications clearly mentioned that 'vazbuthunangkai' is a synonym (Malayalam) for Solanum melongena*' (MD, Annexure IIIA, p. 209). I have looked into WoI (Chadha, 1972, IX, p. 383), Nair and Vasudevan (publication date not known, p. 109) and the *Siddha Materia Medica* (Murugesu Mudaliar, 1988, p. 218), all of which cite only *vazbuthana* as the Malayalam name for brinjal and not *vazbuthunangkai*. Besides, there is no reason to take a Malayalam name as a lead in preference to *Sanskrit* and Tamil names which are the authentic source languages for Ayurvedic and *Siddha* medicines, respectively.
- ii) Dr Sivaraman sent me pages 218-221, relevant to brinjal from *Gunapadam* (*Siddha Materia Medica*, in Tamil by Murugesu Mudaliar, 1988), which are not a part of MoEF's MD. Dr Gurumurti Natarajan, an agricultural scientist and native Tamilian helped in translating this material. Finding that the Tamil used in *Gunapadam* to be archaic, he had to take the help of a Tamil scholar.
 - a) *Gunapadam* praises brinjal as a medicinal vegetable which will solve health problems, causes no harm even on consuming three times a day, and can be

consumed without hesitation. Heated or dried and fried brinjal fruit cures stomach ache and de-worms cattle (contrary to Ayurvedic opinion that it promotes intestinal parasites in humans). Use of the same Ayurvedic medicine for both cattle and humans is no contradiction, as I know of some Ayurvedists who use Ayurvedic veterinary medicine on their patients in much reduced doses and obtain similar therapeutic effects. Burnt or charred, brinjal fruit helps digestion, reduces acidity and gas. Poked with a needle and fried in sesame oil, brinjal cures dental problems (a use not mentioned by any other source). Brinjal removes mucous (contrary to Ayurvedic opinion that it increases phlegm) and removes bile (contrary to Ayurvedic opinion that brinjal obstructs liver and spleen). The brinjal root-in-oil preparation (*thailam*) cures gastric problems. The seed induces sleep and removes phlegm (contrary to Ayurvedic opinion that brinjal increases phlegm). Brinjal in a mud pack, is also used in tempering (hardening) metals and alloys used in some *Siddha* formulations.

- b) *Gunapadam* also listed a host of side effects of brinjal which are enough to consider a ban on brinjal cultivation. Brinjal produces body heat (contraindicated in several health conditions), induces purging, causes skin itching, eruptions, pimples, eczema, and skin diseases akin to leprosy (as also indicated in *Unani*), and affects fertility.
 - c) There are many contradictions in *Gunapadam*. It was stated that *vazhuthalai* cures hard breathing, panting and mucous but also causes inflammation of the liver and gall bladder, and produces body heat, infertility and leprosy. The problem here is that the name *vazhuthalai* is the Tamil vernacular for *Solanum indicum* and not for *Solanum melongena*. There is a reference to *kandan (kantani) kattthri* suggested as a good medicine for liver problems, but *kandan kattthri* is the Tamil vernacular name for *Solanum virginianum* (= *Solanum jacquini*). The reference to the Tamil vernacular name *aakasha kattthri*, which is not mentioned in any other publication referring to brinjal or species of *Solanum*, is another botanically untenable issue, as this was equated with the totally unrelated species, *Hibiscus longifolius* (Malvaceae). Obviously, there is a lot of confusion between brinjal and brinjal-like plants and their names in the ancient *Siddha* medical literature.
- iii) The Formulary of *Siddha* medicines (Anonymous, 1989) does not mention any medicinal uses of brinjal. In addition to *Solanum indicum* and *Solanum xanthocarpum* used in *Ayurveda*, *Solanum trilobatum* is also used in *Siddha* medicine, and the number of Tamil names for this species indicates its wide distribution in Tamil Nadu. *Solanum trilobatum* is probably the only species of *Solanum* that is cultivated for use in medicine in Tamil Nadu.
 - iv) The *Siddha* system considers brinjal as allergenic. Several web postings on health caution the patients undergoing *Siddha* treatment not to consume brinjal and tomato, which aggravate skin ailments and rhinitis, as they are allergic reactions. Many respiratory diseases such as asthma are caused by allergens. The website of the Indian *Siddha* Medical Graduates Association, Chennai, that offers professional advice on diseases and their treatment in the *Siddha* system, cautioned in the context of allergic rhinitis, that *‘important thing during the course of Siddha medicine is food restriction. Certain*

foods must be avoided' and listed a dozen foods including '*brinjal and vegetables belonging to its family*' (Anonymous, 2011). Brinjal does not go into home remedies for it is allergenic, though allergy is an individualistic issue. Only some people are allergic to egg, fish, groundnut or any of the other allergenic foods. There is no single allergen that affects everyone and not everyone is affected by any/or all allergens nor all the time, but caution is the watch word till the offending agent is identified and individual's response ascertained.

3. In *Unani*:

Many Indian publications do not cite Arabic, Persian or Urdu names for medicinal plant species nor make references to their uses in the *Unani* system, which makes it difficult to connect. Added, there is paucity of literature on *Unani Materia Medica* in English.

Fathima (1994) compiled a glossary of plants used in *Unani* medicine, under the joint supervision of four experienced teachers and practicing physicians in *Ayurveda* and *Unani*.

Depending upon the availability of information, she has given *Unani* formulations in which the plant species are used and also their uses in *Ayurveda* separately and included information on action, therapeutic uses, harmful effects, etc. Only *Solanum melongena* (pp. 102-103) and *Solanum nigrum* (pp. 308-309) were treated in this compilation but no other species of *Solanum*. Uses of *Solanum nigrum* in *Ayurveda* were recorded but none for brinjal; obviously there are none. There is no information on the use of *Solanum melongena* and *Solanum nigrum* in any *Unani* formulations, as none were indicated in the vast *Unani* literature she looked into. There are suggestions in one *Unani* source that brinjal cures eczema, piles and splenic tumours (Fathima, 1994), contrary to the side effects cited in *Ayurveda* and *Siddha*. As in *Siddha*, *Unani* too considers that brinjal causes leprosy (Fathima, 1994).

4. In Homoeopathy:

Homoeopathic literature indicates the use of *Solanum nigrum* and *Solanum xanthocarpum* but not brinjal (Boericke, 1991, among several other publications). That brinjal is not used in homoeopathy was also confirmed by the Director General of the Central Council for Research in Homoeopathy (Indian Express, February 24, 2010).

5. Database of Medicinal Plants:

The Database of Medicinal plants contains long lists of species (including exotics) indicated for use against specific disease states, in the ACSM or based on modern phytochemistry and pharmacology (see Appendices, Kameswara Rao, 2000, 2002). These lists are intended to form the basis for scientific evaluation through modern research of the species indicated therein. Those states that involve species of *Solanum* are given below:

Analgesic: *Solanum stramonifolium* Jacq., *Solanum surattense* Burm.f., *Solanum torvum* Sw.

Anthelmintic, nematocidal and antifilarial: *Solanum indicum* L.

Antifungal: *Solanum nigrum* L.

Antiinflammatory and astringent: *Solanum melongena* L., *Solanum nigrum* L., *Solanum*

surattense Burm.f., *Solanum torvum* Sw.

Antiviral: *Solanum indicum* L., *Solanum xanthocarpum* Schrad. et Wendl.

Dental care: *Solanum indicum* L., *Solanum stramonifolium* Jacq., *Solanum surattense* Burm.f., *Solanum torvum* Sw.

Depressants of nervous system: *Solanum nigrum* L.

Emetic and purgatives: *Solanum indicum* L., *Solanum nigrum* L., *Solanum xanthocarpum* Schrad. et Wendl.

Gastro-intestinal disorders: *Solanum nigrum* L., *Solanum surattense* Burm.f., *Solanum violaceum* Ortega.

Geriatric care: *Solanum torvum* Sw.

Immunomodulatory: *Solanum torvum* Sw.

Solanum nigrum L., *Solanum torvum* Sw., *Solanum indicum* L., and *Solanum surattense* Burm.f., seem to be the most important species in ACSM. In all this, brinjal's single effect as an anti-inflammatory and astringent is marginal, for which there are dozens of other more effective species.

X. OTHER ISSUES RAISED BY DR SIVARAMAN

In addition to what has been discussed, Dr Sivaraman has raised the following issues:

1. Synergy:

Dr Shivaraman stated that the alkaloidal comparison shows significant differences between *Bt* and non-*Bt* brinjal, which *‘can affect the entire synergy of the plant’* (MD, Annexure IIIA, pp. 210). This view was highlighted by the MoEF (MD, text para 20, p. 13), and repeated on February 24, 2010. And in the absence of a clarification on what Dr Sivaraman and the MoEF mean by *‘synergy of the plant’*, I am at a loss to understand the objection which cannot be taken on its face value.

The Primer on ‘National Consultation’ inaccurately translated the Ayurvedic term *‘prabhava’* as *‘synergetic property’* (Anonymous, 2009a, p. 17). As per Ayurvedic sources, *‘prabhava’*, the effectiveness or potency of a substance, means *‘the characteristic and specific actions of substances which can’t be explained in terms of the pharmacological actions of their various individual constituent principles taken out separately’* (emphasis in bold is mine; Anonymous, 2009c). So the effect of a formulation is not the same as that of the components.

Synergy, a concept in science, means that *‘when several elements, such as A and B are combined, the result is greater than the expected arithmetic sum of A+B’*. The concept of synergy is applied in diverse situations such as biology, environment, pharmacology, chemistry, management, sports and others, and the elements involved can be chemical compounds, drugs, organisms in ecosystems, people, hardware, software, facilities, etc. Corning (1998) provides a detailed analysis of the concept of synergy.

One frequently quoted example of drug synergy is the use of codeine and ibuprofen together, whose combined effect in pain relieving is several times more than the individual effect of the two drugs put together. Synergy can also cause negative effects, such as when valium and alcohol are taken together, which can be fatal.

Consequently, the view of Dr Sivaraman and the MoEF and that of science, on what constitutes synergy are at variance.

It is understood for a long time that the whole of the food, drink or medicine we consume function holistically on all parts of the body system, on the balance of all synergetic and antagonistic interactions, not just among the constituents of the intake but also, more importantly, with the gastro-intestinal chemical environment and that of the target organ/tissue as well. Accordingly, there are a) liquid vehicles (*anupaana*, taken with, before or after drug intake) to promote drug delivery to the target site, b) foods that are complementary to the medicine (*pathya*), and c) foods that should be avoided as they are antagonistic to the medicine (*apathya*), recommended by physicians.

In the context of plant based medicine the situation is extremely complex as each species contains thousands of different chemical compounds, the majority being products of metabolism (secondary metabolites), that accumulate in different parts of plants. For example, coffee decoction contains

over 600 different chemicals. Most of these compounds are plant defense products, occurring at higher concentrations in times of stress (pathogens, temperature, drought, etc.), the reason for some vegetables being bitter in the dry summer months. A chemical compound may be nutritional, therapeutic or even toxic depending upon dosage and concentration in the body system, from which arose the adage food is medicine is toxin.

The formulation *Dasamoolaarishtha* contains 70 different plant species, plus other ingredients. The complexity of chemical constituents in this formulation is staggering and their interactions can only be imagined, even taking that some species such as *Solanum indicum* and *Solanum xanthocarpum* in the formulation may contain identical compounds,

It is well established for long, that there is natural qualitative and quantitative variation in the chemical constitution of plants within individual plants and populations and between populations and varieties, at different times of the day, season and the lifecycle and in different localities, often the result of interactions between the genotype and the environment. The protein profiles of the seeds from the same pea pod were immunologically demonstrated to be different from each other. A sample jackfruit seeds from Bangalore showed 2,500 times more of lectin activity than a sample from Chennai. Seeds of three of seven varieties of tomato (*Solanum lycopersicum*, =*Lycopersicon esculentum*) and eight of 20 varieties of rice (*Oryza sativa*) tested did not contain the respective lectins (Kameswara Rao, 2000, pp. 394-395, 390-391). Only some varieties of a species are therapeutically useful, as some of them do not contain the active principles. In addition, the method of preparation of the medicine may bring in some chemical changes. Too many parameters are involved here resulting in an extremely complex situation.

In drug synergy two or more chemically characterized compounds whose effect is identical, would produce the same but much enhanced effect, like codeine and ibuprofen the pain killers produce a vastly enhanced pain killing effect in combination. Allopathy uses chemical compounds whose structure and therapeutic effects are known. This situation does not occur in plant based indigenous medicine as no one knows all the individual chemical components, or their concentrations and so their effects, in any plant used, as the systems are not based on chemical analysis, characterization and the effects of each one, though the effect of the whole plant is known based on experience gained from its long use. The combinations and quantities of the ingredients in a formulation were determined basing on extensive experience through trial and error. The synergistic and antagonistic effects of the constituents in indigenous medicine could only be surmised, since there has been no experimental demonstration of synergy in any of the classical medical preparations.

When the edible and cultivated *Solanum melongena* (there is no wild brinjal) is not an ingredient of any medicine, the question of *Bt* brinjal affecting synergy does not arise. The other species of *Solanum* used in different ACSM do not come into the picture. Those who contend that *Bt* brinjal affects ACSM should first convincingly show that cultivated brinjal is an ingredient of indigenous medical formulations and demonstrate synergy in the formulations and that synergy was affected in formulations using *Bt* brinjal. In the context of indigenous medicine, the expression 'entire synergy of the plant' ((MD, Annexure IIIA, p. 210) is out of context and scientifically untenable.

2. Use of raw brinjal in medicine:

When brinjal is not used in any medicine, this question does not arise. However, since Dr Sivaraman was emphatic on the use of raw brinjal in *Siddha* (*Dasamoola choornam*) and *Ayurveda* (*Dasamoola asava*) (MD, Annexure IIIA, pp. 212), a response is needed. *Choornam* is fine powder and the 'fresh and raw' brinjal has to be thoroughly dried to pulverizing it, and *aasava* is a product of fermentation of decoction of powdered ingredients. The process of preparing the two formulations does not retain the 'fresh and raw' nature of the ingredients.

3. Safety of cooked *Bt* brinjal:

Dr Sivaraman raised another issue, that brinjal is cooked in India in different ways (such as adding tamarind) and that the biosafety of *Bt* brinjal in the cooked preparations is not demonstrated (MD, Annexure IIIA, pp. 211-12). Brinjal has centuries of history of safe human consumption, though excessive consumption may cause some adverse effects, recognized in all the indigenous systems of medicine as already mentioned. The antidotes are ghee, jaggery, mustard, ginger, tamarind and *gavam masala* (Jagga Rao *et al.*, 1933), and *jeera*, *ajwain*, curds and oil (Fathima, 1994). The recipes to cook brinjal contain one or more of these antidotes to make the preparation safer. Cooking recipes aim at visual appeal and palatability, and other considerations are not their concern.

The Cry 1Ac protein is denatured in the highly acidic mammalian stomach in less than 30 seconds and its fate is the same as that of any other protein without binding sites on mammalian gut lining. The ingredients in the recipe and the cooking process of brinjal also affect protein integrity. The biology of toxicity of Cry 1Ac and its safety in human consumption are well studied and several plant foods containing *Bt* proteins have been consumed in North America for nearly 15 years without any adverse effects on human health. Studying the effects of *Bt* brinjal cooked in a dozen different ways is a wild and wasteful exercise.

XI. IN CONCLUSION

As is my contention, the Head of the Foundation for Revitalization of Local Health Traditions, Bangalore, stated that “*the brinjal that we eat does not have any medicinal value*” (Indian Express, February 24, 2010).

There are two reasons for this:

- a) The earlier varieties of brinjal, cited in the millennia-old source texts, contained higher concentrations of anti-nutritional and/or toxic chemical constituents, which may have had therapeutic potential, but which imparted unpleasant taste and even affected health. This is also indicated by the unflattering early name of brinjal as ‘*mala insana*’ (bad egg, mad apple). Human selection during domestication was aimed at reducing the hazardous constituents to improve safety and palatability, which decreased its therapeutic potential; and
- b) The concept of Hormesis emphasizes that when we are exposed to small doses of toxic substances, the body system is prepared to tolerate them in higher concentrations and so they become relatively harmless. On habitual usage, certain drugs like aspirin necessitate increasingly higher and/or more frequent doses for the same effect and in the long run the drug may become ineffective. This is similar to acquired resistance of pests to pesticides, and of pathogens to antibiotics and drugs, with the difference that acquired resistance is heritable. Present day brinjal varieties do not have appreciable quantities of therapeutically active chemical compounds, and even if some varieties still have them, the body system is already adjusted to make them ineffective. Centuries of cultivation and use as food have made cultivated brinjal unfit for use as medicine, while the wild species of *Solanum* still contain adequate quantities of active principles and so can be used in medicine.

Orthodox Brahmins do not use brinjal in food on anniversary days of death of their family members, just as several other vegetables which are not native to the country are prohibited. Swamy (1978) narrated his grandfather’s irritation on not being able to use even chillies (green or red) on the anniversary of his father’s death, when only black pepper was permitted. Since the Ayurvedic profession was dominated by Brahmins till the turn of the last century, what was prohibited as food would not go into medicine.

Charaka stated that ‘*There is no substance in the world which cannot be used for medicinal purposes. An appropriate substance only needs to be used appropriately, to be effective*’ (*Charaka Sambhita, Suthra Sthana*, 26.10). Accordingly, any species is a potential medicinal plant, provided we find a use for it and a means to use it. It would be in our interest to connect traditional uses with phytochemistry and pharmacological action, to put plants to better medicinal uses, avoiding processes that affect such use. For example, the purple brinjal has anthocyanins in the skin which can be suggested as antioxidants, but charring brinjal skin while cooking would remove this benefit. One can invent a useful formulation putting several species with desired therapeutic benefits, but this makes it only a non-exclusive nutritional supplement and certainly not a medicine as per the indigenous systems.

Even if the current day medical concoctions use brinjal, it is not on the basis of authentic classical texts of ACSM, but on the whims of latter day specialists, a majority of who have developed an unfortunate habit of claiming to cure all diseases including AIDS, cancer and diabetes. How much of brinjal do they use in medicine and how frequently and which cultivars? If they want non-*Bt* brinjal, the farmers can easily grow the preferred cultivars in the small quantities they need. For this limited use, one need not force all the brinjal farmers and the consumers to continue to suffer with pest infested brinjal, the excessive use of pesticides affecting health and causing financial losses.

Dr Padmanabhan mentioned in the Foreword here, that *‘in a recent meeting of experts, it was offered that if the varieties of brinjal used in Ayurveda are made known, introduction of Bt gene into these varieties could be banned, as a measure of abundant precaution. Interestingly, despite the propaganda, no one has been able to clearly identify the medicine or medicines in which authentic brinjal is a component.’*

Those who oppose *Bt* brinjal are using the issue of brinjal’s nearly non-existent medicinal uses, exploiting the confusing the scientific and vernacular names of brinjal and other species of *Solanum* in classical literature, the consequent misinterpretations, and the general ignorance of the public about ACSM.

Bt brinjal does not pose any threat to the use of non-*Bt* brinjal in medicine if any, as the scope for gene flow from *Bt* brinjal to non-*Bt* brinjal is almost non-existent.

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APPENDIX I

SPECIES OF SOLANUM IN INDIA

The currently valid names of species are shown in bold; the rest are synonyms (rejected names), no longer valid for scientific use. The distribution of the species in different States of India indicated is based on data recorded on herbarium specimens available in different circles of the Botanical Survey of India (BSI). Since some of the specimens were collected decades ago, some of the species may not now be available in places indicated. The status of a species in India, naturalized or cultivated (usually in gardens), is from BSI records, but not available for all species. The country of origin and the countries from which a species is known are given so far as available from literature, but this information needs to be revalidated for many species.

Sl. No.	Species	Distribution (in States of India and other countries)
1	<i>Solanum aculeatissimum</i> Jacq. Solanum khasianum C.B. Clarke var. khasianum Solanum myriacanthum auct. non Dunal	Assam, Himachal Pradesh, Manipur, Meghalaya, Nagaland and Sikkim. Naturalized. Native to South America.
2	<i>Solanum aethiopicum</i> L. Solanum integrifolium Poir.	Arunachal Pradesh and Meghalaya. Cultivated. Native of South Africa. China and Sri Lanka.
3	<i>Solanum americanum</i> Mill. Solanum nigrum auct. non L.	Throughout India. Naturalized. Native to North America.
4	<i>Solanum arundo</i> Mattei Solanum diplacanthum Dammer	Goa and Gujarat. Cultivated. Native to East tropical Africa.
5	<i>Solanum aviculare</i> G. Forst.	Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal. Cultivated. Native to Australia.
6	<i>Solanum barbisetum</i> Nees Solanum eriophorum Dunal Solanum involucreatum sensu Kurz non Blume 1. var. barbisetum 2. var. griffithii Prain Solanum griffithii (Prain) C.Y. Wu et Huang	1. var. barbisetum: Assam, Jammu & Kashmir, Meghalaya, Nagaland, Sikkim, Tripura, Uttar Pradesh and West Bengal. Bangladesh, China, Laos, Myanmar and Thailand. 2. var. griffithii: Assam and Sikkim. Bhutan, China and Myanmar.
7	<i>Solanum capsicoides</i> All. Solanum ciliatum Lam. Solanum acerosum sensu R.R. Rao et S.K. Jain non Sendt. Solanum aculeatissimum auct. non Jacq.	Assam, Karnataka, Kerala, Tamil Nadu, Uttar Pradesh. Naturalized. Native to Brazil. Established in warmer regions of the world.

8	<i>Solanum chacoense</i> Bitter	Tamil Nadu. <i>Cultivated.</i>
9	<i>Solanum cordatum</i> Forssk. <i>Solanum gracilipes</i> Decne.	Gujarat and Punjab. Native to Arabia, North Africa and Pakistan.
10	<i>Solanum diphyllum</i> L.	Maharashtra and West Bengal. <i>Naturalized.</i> Native to Mexico and Central America.
11	<i>Solanum dubium</i> Fresen.	Gujarat and Maharashtra. <i>Naturalized.</i> Native to Sudan, Africa and Arabia.
12	<i>Solanum dulcamara</i> L. <i>Solanum lyratum</i> Thunb. <i>Solanum persicum</i> Willd. ex Roem. et Schult.	Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Nagaland, Punjab, Sikkim and Uttar Pradesh. China, Europe, Japan, Pakistan, Russia, Northern Africa, Western and Central Asia.
13	<i>Solanum elaeagnifolium</i> Cav. <i>Solanum esuriale</i> sensu Vartak non Lindl.	Gujarat, Karnataka, Jammu & Kashmir, Maharashtra, Rajasthan and Tamil Nadu. <i>Naturalized.</i> Native to temperate South America, Mexico and Central America. Naturalized in Southern Europe, Australia and Pakistan.
14	<i>Solanum erianthum</i> D. Don <i>Solanum verbascifolium</i> auct. non L. <i>Solanum pubescens</i> sensu Roxb. non Willd. <i>Solanum verbascifolium</i> L. var. <i>adulterinum</i> (Buch.-Ham.) G. Don var. <i>exstipulatum</i> Kuntze	Almost throughout India. <i>Naturalized.</i> Southeast Asia, Northern Australia, Sri Lanka, tropical Africa and Americas.
15	<i>Solanum forskalii</i> Dunal <i>Solanum albicaule</i> Kotschy ex Dunal <i>Solanum scindicum</i> Prain	Gujarat, Maharashtra and Rajasthan. <i>Cultivated.</i> Northeast Africa, Arabia and Pakistan.
16	<i>Solanum giganteum</i> Jacq. <i>Solanum niveum</i> Vahl <i>Solanum farinosum</i> Wall. <i>Solanum argenteum</i> sensu Prain non Dunal ex Poir.	Andhra Pradesh, Bihar, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu and Uttar Pradesh. <i>Naturalized.</i> Wide spread in tropical Africa and Sri Lanka.
17	<i>Solanum glaucophyllum</i> Desf. <i>Solanum glaucum</i> Dunal	Maharashtra, Tripura, Uttar Pradesh and West Bengal. <i>Naturalized.</i> Native to Argentina. Widely cultivated elsewhere
18	<i>Solanum hispidum</i> Pers.	Assam, Haryana, Himachal Pradesh, Tamil Nadu and Uttar Pradesh.

19	<i>Solanum incanum</i> L. Solanum sanctum L. Solanum melongena L. var. incanum (L.) Kuntze var. insanum auct. non Prain Solanum melongena sensu C.B. Clarke non L. Solanum coagulans auct. non Forssk.	Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Pondicherry, Punjab, Rajasthan, Sikkim, Tamil Nadu and Uttar Pradesh.
20	<i>Solanum jacquemonti</i> Dunal Solanum hovei Dunal	Dadra & Nagar Haveli, Goa, Gujarat, Karnataka, Maharashtra and Rajasthan.
21	<i>Solanum jasminoides</i> Paxton	Himachal Pradesh, Kerala, Maharashtra, Meghalaya, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh and West Bengal. <i>Cultivated.</i> Native to England (?).
22	<i>Solanum kurzii</i> Brace ex Prain Solanum pubescens Willd. var. lobata C.B. Clarke Solanum sanitwangsei Craib	Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim, Tripura. Bhutan, China and Thailand.
23	<i>Solanum lasiocarpum</i> Dunal Solanum ferox-majus Wight Solanum stramineifolium Dunal Solanum hirsutum Roxb. Solanum ferox auct. non L.	Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Meghalaya, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal. South and South East Asia.
24	<i>Solanum macrocarpon</i> L.	Assam, Kerala and Tamil Nadu. Tropical Africa,
25	<i>Solanum mammosum</i> L.	Kerala and Uttar Pradesh. Native to tropical Americas.
26	<i>Solanum marginatum</i> L. f.	Tamil Nadu, Uttar Pradesh and West Bengal. <i>Cultivated.</i> Native to Africa.
27	<i>Solanum mauritianum</i> Scop. Solanum auriculatum Aiton	Kerala, Tamil Nadu, Uttar Pradesh and West Bengal. Native to Argentina. Occurs throughout the tropics.
28	<i>Solanum melongena</i> L. Solanum insanum L. Solanum zeilanicum Scop. Solanum trongum Lam. Solanum esculentum Dunal Solanum pressum Dunal Solanum heteracanthum Dunal Solanum longum Roxb. Solanum pseudo-undatum Blume Solanum melanocarpum Dunal Solanum sativum Dunal Solanum cumingii Dunal Solanum torvum Sw. var. inerme Dalzell et A. Gibson	Throughout India. <i>Only under cultivation.</i> Cultivated in many tropical countries.

29	<i>Solanum nigrum</i> L.	Throughout India. <i>Naturalized.</i>
30	<i>Solanum pseudocapsicum</i> L. 1. var. <i>pseudocapsicum</i> 2. var. <i>diflorum</i> (Vell.) Bitter <i>Solanum diflorum</i> Vell. <i>Solanum capsicastrum</i> Link ex Schauer	1. var. <i>pseudocapsicum</i> : Assam, Himachal Pradesh, Jammu & Kashmir, Kerala, Maharashtra, Meghalaya, Punjab, Sikkim, Tamil Nadu, Uttar Pradesh and West Bengal. Naturalized in Australia, Bourbon, Brazil, China, Madeira and South Africa. 2. var. <i>diflorum</i> : Tamil Nadu. Naturalized in Australia, Bourbon, Brazil, China, Madeira and South Africa.
31	<i>Solanum pubescens</i> Willd. <i>Solanum conanthum</i> Dunal <i>Solanum calycinum</i> sensu Nees non Dunal	Andhra Pradesh, Karnataka, Kerala, Maharashtra and Tamil Nadu. Sri Lanka.
32	<i>Solanum robustum</i> H. Wendl. <i>Solanum barbisetum</i> sensu Chithra non Nees	Tamil Nadu and Uttar Pradesh. <i>Naturalized.</i> Native to Brazil.
33	<i>Solanum rostratum</i> Dunal	Uttar Pradesh. <i>Cultivated.</i> Native to Northern Mexico and the greater plains of the U.S. Naturalized in Australia, Europe, South Africa and West Indies.
34	<i>Solanum seaforthianum</i> Andrews	Andhra Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. <i>Naturalized.</i> Native to Central America. Cultivated in the tropics.
35	<i>Solanum sisymbriifolium</i> Lam.	Assam, Kerala, Maharashtra, Meghalaya, Tamil Nadu, Uttar Pradesh and West Bengal. <i>Naturalized.</i> Native to Americas.
36	<i>Solanum spirale</i> Roxb.	Arunachal Pradesh, Assam, Manipur, Meghalaya and Nagaland. Bhutan, China, Myanmar, Thailand and Vietnam.
37	<i>Solanum torvum</i> Sw. <i>Solanum stramoniiifolium</i> Lam. <i>Solanum ferrugineum</i> Jacq. <i>Solanum pseudosaponaceum</i> Blume	Throughout India. <i>Naturalized.</i> Native to the West Indies. Tropical regions excepting the western arid region, to China and tropical America.
38	<i>Solanum trilobatum</i> L. <i>Solanum acetosaefolium</i> Lam.	Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Pondicherry, Rajasthan, Tamil Nadu and West Bengal. <i>Cultivated</i> Malay Peninsula from Aracan and Malacca, and Sri Lanka.

39	<i>Solanum triquetrum</i> Cav.	Rajasthan and Uttar Pradesh. <i>Naturalized.</i> Native to tropical America.
40	<i>Solanum tuberosum</i> L.	Throughout India. <i>Cultivated.</i> Native of South America. Cultivated throughout the world.
41	<i>Solanum vagum</i> B. Heyne ex Nees	Tamil Nadu. Stated to be endemic to the Tirunelveli hills in Western Ghats, but this is open to question.
42	<i>Solanum viarum</i> Dunal Solanum khasianum C.B. Clarke var. chatterjeeanum Sengupta Solanum myriacanthum auct. non Dunal Solanum khasianum auct. non C.B. Clarke	Arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Lakshadweep, Meghalaya, Orissa, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal. <i>Naturalized.</i> Native to Brazil.
43	<i>Solanum villosum</i> Mill. <i>1. var. villosum</i> Solanum luteum Mill. Solanum nigrum auct. non L. <i>2. var. punicerum</i> (Kirschl.) Edmonds Solanum nigrum L. subsp. punicerum Kirschl. Solanum rubrum Mill. Solanum purpureolineatum Sabnis et Bhatt Solanum roxburghii sensu Drury non Dunal Solanum nigrum auct. non L.	<i>1. var. villosum:</i> Throughout India. Native to Europe. <i>2. var. punicerum:</i> Throughout India. Native to Europe.
44	<i>Solanum violaceum</i> Ortega Solanum sodomeum L. Solanum ferox-minus Wight Solanum indicum auct. non L. <i>1. subsp. multiflorum</i> (Roth ex Roem. et Schult.) K.M. Matthew Solanum multiflorum Roth ex Roem. et Schult. Solanum indicum L. var. multiflora (Roth ex Roem. et Schult.) C.B. Clarke Solanum anguivi Lam. var. multiflorum (Roth ex Roem. et Schult.) Chithra <i>2. subsp. violaceum</i>	<i>1. subsp. multiflorum:</i> Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Uttar Pradesh. <i>2. subsp. violaceum:</i> Throughout India.

45	<i>Solanum virginianum</i> L. Solanum xanthocarpum Schrad. et J.C. Wendl. Solanum surattense Burm. f. Solanum jacquini Willd. Solanum armatum R. Br. Solanum diffusum Roxb. Solanum mccanni Santapau	Throughout India. Sri Lanka extending to Malaya and from SE. Asia to Northern Australia and Waziristan.
46	<i>Solanum wendlandii</i> Hook. f.	Andhra Pradesh, Bihar, Karnataka, Kerala, Maharashtra, Meghalaya, Tamil Nadu, Uttar Pradesh and West Bengal. <i>Cultivated</i> , sometimes an escape. Native to Costa Rica.
47	<i>Solanum wightii</i> Nees Solanum hohenackeri van Heurck et Müell.-Arg. Solanum grandiflorum auct. non Ruiz et Pav.	Kerala and Tamil Nadu. Stated to be endemic to Kerala and Tamil Nadu, but this is open to question.
48	<i>Solanum wrightii</i> Benth. Solanum grandiflorum auct. non Ruiz et Pav.	Bihar, Karnataka, Kerala, Maharashtra and West Bengal. <i>Cultivated</i> Native to Bolivia.

Data courtesy Botanical Survey of India (personal communication, June 15, 2010)

ABOUT THE AUTHOR

Professor C Kameswara Rao has over 50 years of professional experience in biological sciences. Educated at the Andhra University, Waltair, he served at the Bangalore University from 1967 to 1998 and was the Chairman of the Departments of Botany and Sericulture. He and his research students worked on Indian medicinal plants from 1987 to 2002, with financial support from the Department of Forests and Ecology, Government of Karnataka. A 458-page volume, 'Database of Medicinal Plants', constituting the work of his team on medicinal plant databases and experimental work on selected medicinal plants, was jointly published in 2000 by the Karnataka State Council for Science and Technology and the Department of Forests and Ecology, Government of Karnataka, and was distributed free of cost. The entire contents of this volume plus profiles and photographs of 90 species of Indian medicinal plants were placed in the public domain on the website 'Database of Medicinal Plants' accessible at www.medicinalplants-kr.org, in 2002. His services to the cause of indigenous medicine were recognized by the Open International University for Alternative Medicine, Colombo (established by the authority of the Sri Lankan Parliament), which awarded him a D.Sc. (h.c.) in 1997 and by the Lama Gangchen World Peace Foundation, Beijing (affiliated to the UN) which awarded a Certificate of Merit in 2001.

Professor Kameswara Rao taught plant systematics (taxonomy) at the Andhra and Bangalore Universities for over 37 years. He produced computer based plant identification packages at the British Museum (Natural History), London, and the Royal Botanic Gardens, Kew, UK, the international hubs of plant taxonomy, while on a Commonwealth Academic Staff Fellowship and a Royal Society and Nuffield Foundation Bursary. He was the President of the Indian Association for Angiosperm Taxonomy for 1999, and a member of the Programme Advisory Committee of Botanical Survey of India and Zoological Survey of India (2001-04), and a Member of the Multi-disciplinary Expert Committee, Botanical Garden of the Indian Republic (2005-06), both under the Ministry of Environment and Forests, Government of India. He is a member of the Indian Subcontinent Plant Specialist Group, under the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources (IUCN), Gland (Switzerland), and has compiled from IUCN publications, the 'Red List of Threatened Vascular Plant Species in India' published by the Botanical Survey of India, Ministry of Environment and Forests, Government of India (2003).

Since January 2001, Professor Kameswara Rao has been the Executive Secretary of the Foundation for Biotechnology Awareness and Education, Bangalore, and has written and spoken extensively on genetically engineered crops. His articles are regularly posted on www.fbae.org, www.plantbiotechnology.org.in, www.agbioworld.org and AgBioIndia Forum, besides several other websites. He has been a member of a large number of national and international committees on modern biotechnology, and has travelled far and wide in and outside the country, in this context. He is a member of the Expert Panel on Agricultural Biotechnology, Council for Biotechnology Information, Washington DC.

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