Lasia spinosa (L.) Thw., A high potential underutilized aroid in Asia: A step toward utilizing neglected crop genetic resources for food and nutritional security

Ranil Rajapaksha
University of Peradeniya

D. Siril. A. Wijesundara
National Institute of Fundamental Studies - Sri Lanka

CHAPTER 08

Lasia spinosa (L.) Thw., A High Potential Underutilized Aroid in Asia: A Step Towards Utilizing Neglected Crop Genetic Resources for Food and Nutritional Security

R.H.G. Ranil[1*], D.K.N.G. Pushpakumara[1], P.C.G. Bandaranayake[2], W.M.T.P. Ariyaratne[1], D.S.A. Wijesundara[3], R.M.S.R. Chamara[1]and J.P. Eeswara[1]

[1]*Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka*
[2]*Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka*
[3]*National Institute of Fundamental Science, Kandy, Sri Lanka*

Abstract

Lasias pinosa (L.) Thw. is considered as a high potential underutilized aroid in Asia. Even though *L. spinosa* consists of substantial level of medicinal as well as food properties, it is not widely cultivated and not popular among the famers compared to other vegetables. In spite of its wide range of morphological and genetic variation, *L. spinosa* has not yet been properly documented and studied adequately. This paper compiles and discusses available evidences of *L. spinosa* in Asia on its taxonomy, phytogeography, ecology, habitat requirements, morphological and genetic variation, cytology, medicinal and food properties, phytochemical values and cultivation aspects, while emphasizing future perspectives. Some of our findings are also included to fill the gaps in the available literature.

Keywords: Genetic resources, *Lasia spinosa*, medicinal and food properties, morphological variation.

*rhgranil@gmail.com

Introduction

Indigenous vegetables are important sources of food in many parts of the developing world since they play a significant role in food and nutritional security for the underprivileged people in both urban and rural areas (Weinberger and John, 2004). Many communities use them a sa primary food or as secondary condiments in dishes prepared from domestic varieties. Therefore, indigenous vegetables were considered as valuable source of energy and micronutrients contributing to the diets of the rural people in the past and still they continue to be an important component of dietary requirements. In this scenario, understanding of nutritional value and cultivation potential of these indigenous vegetables are important.

Lasia spinosa is one of the indigenous vegetable which is considered as a highly nutritious, but underutilized in various regions in Asia such as Bangladesh, China, India, Nepal and Sri Lanka (Fig. 1). The tender leaves and rhizome of *L. spinosa* are commonly used in curries. Apart from imparting its food value, *L. spinosa* plays a substantial role in traditional medicine system in various indigenous communities in South and South East Asia. Its leaves and rhizomes are reported to be used for treating tuberculosis, swollen lymph nodes, stomach aches, snake and insect bites, injuries, and rheumatism (Jayaweera, 1981; Goshwami *et al.,* 2013a; Rahmatullah, 2010; Yusuf *et al.,* 2009; Goshwami *et al.,* 2013b; Mritunjay Kumar *et al.,* 2013; Yusuf *et al.,* 1994; Uede *et al.,*2002; Nguyen *et al.,* 2004). Even though, pharmacognostical and phytochemical properties such as antioxidant capacity, antimicrobial property and cytotoxic activities, etc. of *Lasia* was well studied (Goshwami *et al.,* 2012a, 2013a; Das *et al.,* 2014; Dubey *et al.,* 2014), application of such findings in pharmaceutical industries is far from adequate.

Lasia spinosa is found on swamps, riverbanks, ditches, moist places in tropical and subtropical forests, sometimes cultivated along fish ponds and rice fields in Asia (Bangladesh, Bhutan, Cambodia, China, NE and SE India, Indonesia, Laos, Malaysia, Myanmar, Nepal, New Guinea, Sri Lanka Thailand, Taiwan and Vietnam) (www.eflora.cn/foc/pdf/Araceae.pdf). *Lasia spinosa* shows a wide range of morphological variations in Asia (Ara, 2001; Hossan and Sharif, 1984;

Sultana *et al.,* 2006; Alam *et al.,* 2012; Hore and Tanti, 2014; Nicolson, 1987). The genetic diversity of the species has not been properly studied, but existing information suggest that considerable diversity exists within the species. Taxonomic status of *L. spinosa* is not fully resolved yet. It is more complicated due to high level of polymorphism. Therefore, screening and study of morphological and genetic diversity is a prime need to resolve taxonomic ambiguities and such information will provide important platform for conservation and utilization of this high potential aroid in Asia.

In this review, we compile and discuss available literature on *L. spinosa* including taxonomy, phytogeography, ecology, cytological and phytochemical significance, food value and medicinal properties, while highlighting future research priorities. Furthermore, this account is enriched by the findings of ongoing project on "Potentials of spineless Kohila (*Lasia spinosa* (L.) Thw.) to be used as a promising crop in Sri Lankan agriculture". We believe that such information will be useful for taxonomists, plant breeders and conservation biologists who work on edible aroids and their conservation.

Origin and Geographical Distribution

The native range of *L. spinosa* is extending from Indian subcontinent to Malesia across East Asia. It is naturally distributed in Eastern Asia (China, Taiwan), Indian subcontinent (Bangladesh, Bhutan, India, Nepal, Sri Lanka), Indo-China (Cambodia, Laos, Myanmar, Thailand, Vietnam) and Malesia (Indonesia, Malaysia, Papua New Guinea) (Alam *et al*., 2012; Sultana *et al.,* 2006; www.eflora.org; www.iucnredlist.org). Figure 1 shows the native range of *L. spinosa*. Although, the available phytogeograhical information is not adequate to conclude its origin, Indo-Malaysian region can be considered as the putative center of origin for *L. spinosa*.

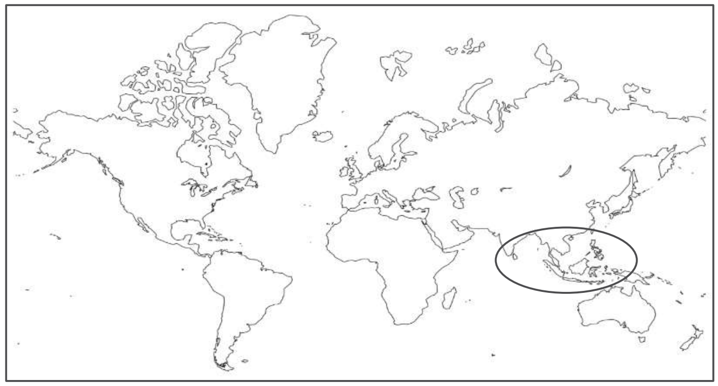

Figure 1: Geographical distribution of *Lasia spinosa*.

(Source: Alam *et al*., 2012; Sultana *et al.,* 2006; www.eflora.org; www.iucnredlist.org)

Ecology and Habitat Requirements

Although *L. spinosa* is generally found in semi-aquatic habitats, occasionally it behaves as an aquatic plant that completely immersed in water (Plate 1). Because of its amphibian nature, *L. spinosa* is getting comparative advantage to survive under limited water availability, showing a wide range of environmental adaptability. Based on our observations, we feel that it is a semi-aquatic plant and does not prefer to grow in habitats exposed to direct sunlight. Further, it naturally prefers to thrive in standing water.

Taxonomy

The genus *Lasia,* represented by two species, *Lasia spinosa* (L.) Thwaites and *Lasia consinna* Alderw belongs to the family Araceae has an Indo-Malaysian origin and considered to be native to tropical and sub-tropical Asia and New Guinea (Ara, 2001; www.eflora.cn/foc/pdf/Araceae.pdf). *Lasia consinna* shows a restricted distribution and confined to Indonesia (Hambali and Sizemore, 1997; Hay, 1988). *Lasia spinosa* has been described under different names by various authors after its first collection by Paul Hermann from Sri Lanka in 1698. Nicolson, (1987) has listed 18 synonyms for *L. spinosa* in his enumeration of Araceae in Sri Lanka whereas others listed 15 synonyms (www.theplantlist.org). There are several arguments on species delimitation, due to polymorphism in the species. As far back as in 1864 Thwaites reported it as “very variable species” and 123 years later, Nicolson (1987) confirmed this using the specimens collected from Sri Lanka. Apart from Sri Lanka, it is represented by two and four morphological forms based on leaf morphology in India and Bangladesh, respectively (Ara, 2001; Hore and Tanti, 2014). Furthermore, in Bangladesh two morphological forms based on flower colour was identified (Alam *et al.,* 2012). However, some taxonomists (www.the plantlist.org) believe that all these are variable forms of *L. spinosa*. Therefore, the correct taxonomic status is still needs to be verified.

Morphological and Genetic Variation

Lasia spinosa shows a wide range of morphological variations in Asia (Alam *et al.,* 2012; Ara, 2001; Hore and Tanti, 2014; Hossan and Sharif, 1984; Nicolson, 1987; Sultana *et al.,* 2006). Hossain and Sharif, (1984) have first distinguished different forms and postulated them as an ecophenic variation. Later, Ara (2001) has reported four different morphological forms based on leaf morphology in Bangladesh, sagitate form; lamina dissected form; entire lamina margin form; and a mixed form of sagittate and lamina dissected. A karyotype analysis in three morphological forms (sagittate, lamina dissected and mixed from) in Bangladesh revealed that 27 bivalent number of chromosome from sagittate from and 26 from both lamina dissected and mixed forms. Furthermore, they postulate that the mixed form might be a natural hybrid between the sagittate and the lamina dissected form (Sultana *et al.,* 2006). Recently, Hore and Tanti (2014) also reported two leaf morphological forms, namely (i) lamina dissected leaves and (ii) a mix form with both sagittate and lamina dissected leaves from Assam, India. However, akaryo-morphological analysis of these two forms revealed 24 and 26 bivalent numbers of chromosomes in somatic cells from lamina dissected leaf form and mixed form, respectively. Further, they have not recorded any satellite micromosome in any morphological forms, whereas Sultana *et al.* (2006)

reported five and two satellite micromosome from mixed and lamina dissected form, respectively. Hore and Tanti (2014) postulated the difference of chromosome number and micromosome may be due to ecological adaptation. Table 1 summarizes the results of karyotype analysis of different morphological forms.

Apart from the leaf morphological forms, Alam *et al*. (2012) reported two forms based on spathe colour; namely common red flower form and rare green form. Cytological investigation of these two forms revealed 2n=26 and 2n=28 in the common red flower form and rare green flower form, respectively. Furthermore, molecular investigation using RAPD markers revealed that these two forms are distinguishable with RAPD markers. Based on these investigations, Alam *et al.* (2012) concluded that the green flower form and the red flower forms are entirely different morphological forms.

The information available on taxonomy and morphological variation of Sri Lankan population of *L. spinosa* is vague. The wide range of morphological variation of *L. spinosa* has been recorded by several botanists even within the same geographical area. Trimen (1900) was of the view that there was only one species with variable leaf forms. Bauren, (1917) claimed that there were two distinct varieties of *L. spinosa* in Sri Lanka. One has entire hastate or sagittate leaves (*ath-kohila* or *Sinhala-kohila*) while the other has a dissected lamina (*relou-kohila* or *angili-kohila*). Ibrahim *et al.* (1983) noted that there are two *Lasia* varieties in Sri Lanka, the one has only hastate leaves (*Sinhala-kohila*) and the other has heterophyllus leaves, hastate and dissected leaves, arising on the same rhizome, although they have not given adequate evidence to justify their varietal concept. Thus, identification of correct taxonomic status and variation of existing Sri Lankan population is fundamental to select superior germplasm for the crop improvement and to develop cultivation guidelines.

We did a germplasm collection recently covering major cultivation regions and the accessions were characterized using standard metrological traits (Kumari *et al*., 2017). Based on the result of this ongoing study, authors are in the view that the Sri Lankan population also consists of three distinct leaf morphological forms, namely (i) sagittae, (ii) lamina dissect; and (iii) mixed form (Fig. 2). During this study minor variation of each form was observed and discovered a novel spineless type (Plate 2C). People use dark colour morphological form in indigenous medicine and locally named as *Kalu kohila* (Black Lasia) (Plate 3). It is an introduced species (*Cyrtosperma johnstonii* N.E.Br.) to Sri Lanka but originated in Solomon Islands. Moreover, this species is mostly misidentified as a local variety by the indigenous community (Kumari *et al*., 2017). However, morphological data and other existing information are not adequate to determine place these variable forms in an acceptable taxonomic positions. Further, this variation might be purely due to macro and micro environmental effect. To eliminate such effects, all collected materials are now grown in the same location with replicated trails. Planed studies on molecular characterization of collected materials with DNA barcoding and SSR analysis will resolve the phylogeny of *Lasia* in Sri Lanka.

The long period of isolation from mainland India combined with climatic and geographic characteristics may be the main reason to have such pronounced morphological and genetic variation in Sri Lankan population of *Lasia*. The ongoing study on morphological and genetic variation will provide valuable information source to determine the correct taxonomic status of different morphotypes or ecotypes of *L. spinosa*. Other than Bangladesh, India and Sri Lanka, the information on morphological and genetic variation within natural or cultivated populations are not available. However, it is a prime need to screen the populations in other Asian countries to understand the genetic composition and structure of this species for the selection of superior germplasm for future crop improvement programs.

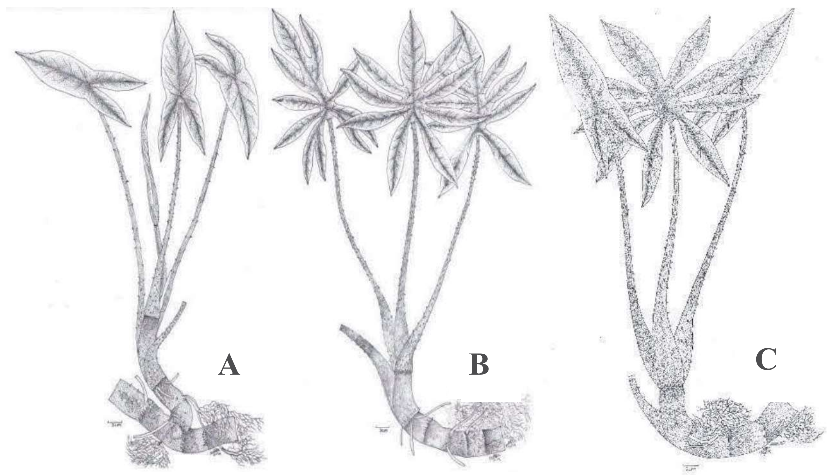

Fig 2: Three morphological forms of *Lasia spinosa* reported in Sri Lanka. A: Sagittate form; B: Lamina dissected form and C: Mixed form. (Kumari *et al*., 2017).

Genetic background of the plant is the major determinant of the chemical composition of a particular plant. Interestingly, only two reported studies on cytological work to identify different morphotypes (Hore and Tanti, 2014; Alam *et al*., 2012) and one study on genetic characterization of those types using Random Amplified Polymorphic DNA (RAPD) (Alam *et al.*, 2012). Identification of superior genotypes is the essential first step in any breeding and agronomic programs. Therefore, it is encouraged to conduct such studies with local germplasm of any country or region considering agronomic and medicinal properties.

Table 1: Summary of karyotype analysis of different morphological forms of *Lasia spinosa*.

Morphological form	2n		Centromeric formula		Total length of 2n chromosome (µm)	
	A	B	A	B	A	B
Sagittate	27	*na*	19m +7sm+ 1st	*na*	102	*na*
Lamina dissected	26	24	9m+15sm+2st	4m+14m+3sm+1st+ 2t	57.78	1.09-4.42
Mixed form	26	26	14m+11sm+1t	7m+14m+5sm	74.46	2.31-4.08

Note: A and B denoted by the findings of Sultana *et al.,* (2006) and Hore and Tanti (2014), respectively. *na*: not assessed.

Plate 1: Different morphological types of *L. spinosa* and their habitats. A: plants thrive well in aquatic habitat. B: in shaded homegarden. C: lamina dissected type population. D: deeply lobed lamina dissected type leaf. E: sagitate type population. F: mixed form

Plate 2: Morphological characters of *L. spinosa*. A: rhizome with highly dense spines. B: rhizome with moderately dense spines. C: rhizome without spines. D: inflorescence covered by the spathe. E: a microscopic view of inflorescence. F: a mature fruit.

Plate 3: Black *Lasia*: A: Dark green colored mature leaves; B: Immature leaves with pink colored prominent veins; C: Collection of hairy leaf stalk.

Pharmacognostical and Phytochemical Properties

Herbal products have been used in traditional systems in various civilizations since ancient times and the attention has even increased over last few decades. *L. spinosa* is one of such widely used plant species in many Asian countries for wide range of tonics and ailments. Other than the primary metabolites and trace elements, it consists of various secondary metabolites such as alkaloids, flavonoids, tannins, terpenoids, saponin and steroids (Bramha, 2014). Because of increased attention and demand, a considerable amount of scientific investigations are done on its pharmacological phytochemical and nutritional properties.

L. spinosa consists of 17.6 kcal/100g protein, 83 kcal/100g moisture, 1.16 kcal/100g fats, 34 kcal/100g ash, 17 kcal/100g total solids, 35.7 kcal/100g carbohydrate. Micronutrients such as Zinc, Magnesium, Molybdnum, Copper, Iron and Manganese are also present in 7.44 ppm, 6.22 ppm, 1.18 ppm, 0.31 ppm, 17.06 ppm, 1.33 ppm respectively (Brahma *et al*., 2014). According to stems compared to deep frying in respect of in-vitro bioaccessibility, the mature stem is a good source of pro-vitamin A and carotenoids. Preparation of a curry with coconut milk is a better method of cooking the stems compared to deep frying in respect of in-vitro bioaccessibility (Priyadarshani and Jansz, 2006). Rhizome is also a rich source of dietary fiber with 40%-75% of total dietary fiber on dry weight basis (Shefana and Ekanayake, 2009).

Antioxidants have received significant attention over last few decades due to their potential applications in human health. *L. spinosa* rhizome consists of total antioxidant activity of 145-957 µmol/g TEAC on a wet weight basis, making it a good source of antioxidants (Shefana and Ekanayake, 2009). Similar studies have conducted by other research groups and confirmed its potent antioxidant activity (Goshwami *et al*., 2012a; Maisuthisakul *et al*., 2008). Dubey and colleagues particularly studied the bioactive ethyl acetate fraction, from the methanol-water (80:20) extract of *L. spinosa* rhizome for gastroprotective and antioxidant activity and showed its anti-ulcerogenic and antioxidant activities (Dubey *et al*., 2014).

Goshwami and his group investigated the antinociceptive activities of partitionates of methanolic extract of leaves of *L. spinosa* and revealed that most of partitionates consist of significant antinociceptive effects (Goshwami *et al*., 2012b). The young tender leaves of *L. spinosa* are used to treat intestinal worms' infections in folk medicine of Naga tribes of India (Temjenmongla *et al.,* 2005). To study the science behind that, experiments were conducted to evaluate anthelmintic activity of methanolic extract of leaves of *L. spinosa* against helminthes (Goshwami *et al.,* 2013b). The results of present study indicated that methanolic extract significantly exhibited paralysis and also caused death of worms especially at highest concentration of 100 mg/ml, and concluded that the leaves of *L. spinosa* possess potent anthelmintic activity. Tubers of *L. spinosa* are a significant component of kohiladi decoction recommended by Sri Lankan traditional and Ayurvedic physicians to stop bleeding and clotting of blood. Weerasekara *et al*. (2005) did research on kohiladi decoction and found out that it has anticlotting action in vitro and proclotting activity *in vivo*.

Hasan (2014) determined the anti- hyperglycemic effects of methanolic and ethanolic extracts of leaf of *L. spinosa* plant in oral glucose tolerance tests compared with standard (glibenclamide) in Swiss albino mice (Hasan *et al*., 2014). In their experimental system, different extracts (methanolic and ethanolic) and dosses (200 and 400mg/kg body weight) for each extracts were orally administered and the serum blood glucose level was measured by glucometer after 2 h. Significant hypoglycemic activity was observed regarding both of the extracts and dosses compared to control. Both extracts revealed a significant hypoglycemic activity and the methanolic extract showed the higher inhibitory activity than ethanolic extract. Their results indicate that both stem and leaf extract of *L. spinosa* shows potent anti-diabetic activity in mice model and its potential applications.

Mahmood and colleagues studied the antihyperlipidemic activity of methanolic leaves extract of *L. spinosa* and for its role in the prevention of hyperlipidemia induced pancreatitis in rats (Mahmood *et al*., 2015). Experiments done with mice model systems revealed that the hydroalcoholic extract of *L. spinosa* roots possesses significant anti-nociceptive, anti-inflammatory, and anti-diarrheal potential (Deb *et al.,* 2010). Goshwami colleges investigated the scientific basis for the traditional uses of the crude methanolic extract of the leaves of the plant while evaluating its antinociceptive activity in mice, anti-inflammatory and antipyretic activities in wistar rats. Their results showed that the crude methanolic extracts of *L. spinosa* showed analgesic, anti-inflammatory and antipyretic effects Goshwami *et al*.,2013a). Further, leaf extract of *L. spinosa* is effective against all the three life cycle stages of encysted muscle larvae of parasite, *Trichinella spiralis* (Yadav, 2012).

Although, several studies are conducted on potential therapeutic applications of *L. spinosa*, work on biochemical analysis is limited. Majority of work is on qualitative analysis and no major compound present is identified so far. It is well understood that the secondary metabolism of the plants depends on environmental factors and therefore biochemical and medicinal properties vary depending on where they were grown. However, no such studies are conducted to date. Such studies will be useful for selecting better sites for large-scale cultivation of *L. spinosa*. Further, chemical composition and medicinal properties changes with the age of the plant tissues and identification of correct harvesting stage to achieve maximum medicinal benefits is important. Comprehensive studies on above topics will lead to identification of markers to be applied in the field level.

Food Value and Uses in Traditional Medicine

In Sri Lanka, the tender leaves, petiole and rhizomes of *L. spinosa* are used as a supplementary disc with staple food rice. The tender leaves and petiole are cooked and served as a vegetable. The peeled rhizomes are also cooked and used for the same purpose. The peeled rhizomes in raw forms are used to prepare*sambal*. Porridge is also prepared using the rhizomes (Jayaweera, 1981; Shefana and Ekanayake, 2009). Its food value as a vegetable in Bangladesh and China, has also reported by Alam *et al*.,2012 and www.eflora.org, respectively. In Thailand, it is given orally to male animals for increasing the libido (Suthikrai *et al*., 2007). A comprehensive ethnobotanical survey will help for future crop improvement program and pharmaceutical industries.

The rhizomes of *L. spinose* are used medicinally for treating tuberculosis of lymph nodes, swollen lymph nodes, stomach aches, cough, snake and insect bites, injuries, and rheumatism (Wu *et al*., 2010). It is also used against stomach ache, colics, rheumatism, and to treat sore throat (Duke, 1998). It has played a role in traditional medicine system in various indigenous communities in South and South East Asia (Goshwami *et al*., 2013; Jayaweera, 1981; Kumar *et al*., 2013; Nguyen *et al.,*2004; Rahmatullah, 2010; Uede *et al*.,2002; Yusuf, 2009; Yusuf *et al*., 1994).The summarized information of medicinal uses of *L. spinose* in some countries is given in Table 2.

Currently, the indigenous vegetables have become important and the attention of the scientists is being diverted to conserve and use them. A major reason for this is the danger of extinction, via narrowing the genetic base. Further, the food and nutrient security of the rural population could also be addressed by paying greater attention to the indigenous vegetables which they are familiar with. Considering the problems of over and unbalanced nutrition and related issues such as obesity, hypertension diabetes and cancer prevalent in the urban populations, these crops will play a major role in the future food supply chain. Presence of *L. spinosa* and some other valuable indigenous vegetable and fruits in luxury supermarkets agree with above notion. *L. spinosa* is such a high potential indigenous vegetable which is having high food and medicinal properties.

Table 2: The summarized information of medicinal uses of *L. spinosa* in selected Asian countries.

Country	Medicinal uses	Reference
Bangladesh	The plant is recommended for colic, rheumatism intestinal diseases. Corm is used as a remedy for throat affections. Leaves and corms are given as a cure for piles. The tuber of plant is used for treatment of rheumatoid arthritis, constipation and to purify blood.	Rahmatullah, 2010; Yusuf *et al.*, 2009; Goshwami *et al.,* 2013b; Kumar *et al.,* 2013; Yusuf *et al.,*1994
India	The young tender leaves and stalk are used to treat intestinal worms' infections and demonstrate profound anticeptodal efficacy. Furthermore, leaves are used for stomach ache and other pains. The rhizome is used for treatment of lung inflammation, bleeding cough and the whole plant in uterine.	Temjenmongala 2005; Anonymous, 1948; Jayaweera, 1981
Sri Lanka	The juice of the rootstock is given as a remedy for piles, haemorrhoids. Black Lasia is used as a treatment for chemical poisoning, Haemorrhoids and pistula.	(Jayaweera, 1981; Anonymous, 1948; Shefana and Ekanayake, 2009).
Vietnam	The plant is used as an anti-rheumatic and anti-inflammatory remedy.	(Uede*et al.,* 2002; Nguyen *et al.,* 2004)
China	The rhizomes are used medicinally for treating tuberculosis of lymph node, swollen lymph node, stomach, snake and insect bites, injuries, and rheumatism.	www.eflora. org

as it has long been used in a variety of culinary preparations across many different Asian ethno-linguistic groups. Our understanding also that demand for *L. spinosa* among the urban community has increased suddenly. It is probably due to the general belief that the use of agrochemicals is minimum in the cultivation as it has inherent ability to resistance for pest and diseases. Further, application of inorganic fertilizer is also negligible in the cultivation of *L. spinosa.*

Future Perspectives

The indigenous varieties are threatened through extinction of their genetic resources. The erosion of genetic resources of indigenous vegetables is accelerated further due to the introduction of high yielding hybrid varieties in the recent past. The hybrids are replacing not only the indigenous varieties but even the improved selections which were grown by the farmers in many countries. Unless actions are taken, the genetic base of vegetables will be narrowed, which may lead to serious catastrophes in the future. In that sense, study on food and medicinal value of *L. spinosa* is a prime need. Furthermore, understanding of existing genetic diversity is also important for the conservation and utilization of such neglected, but high potential crops.

Without accurate taxonomic identification, research carried out in academic and applied branches of life science are worthless (Kholia and Fraser-Jenkins, 2011). A correct and updated species description is one of the most beneficial tools and key requirement for plant identification. Furthermore, the type description of a particular species may differ from the individuals of the same species due to changing environment (climatic and soil parameters), geographical or reproductive isolation, etc. The little taxonomic work revealed that morphological and genetic variability of Asian population of *L. spinosa* as well as problems associated with its species delimitation. Therefore, a comprehensive taxonomic study with morphological, cytological, phytochemical and molecular evidence is needed to resolve taxonomic complication. A continuous monitoring and documentation of species characters and updated descriptions are also vital in future studies.

Lasias pinosa have been subjected to various phytochemical analyses. However, detailed studies are needed considering environmental variation as well. Such studies will lead to identification of specific bioactive compounds and their therapeutic values. As we understood, available research findings are not adequate to attract the entrepreneurs. Therefore, developing a continuous dialog between researches and pharmaceutical and other companies is important to develop value added products. For an example, Pupulawaththa *et al*. (2014) has developed fiber rich soft dough biscuits fortified with *L. spinosa* flour with a significant amount (7g/100 g, on dry basis) of dietary fiber. Tharangani *et al*., (2012) has also developed a chicken burger by incorporating *L. spinosa* and oyster mushroom. Apart from its traditional food preparations, introduction of value added products bring more attention in commercial venture.

The information on cultivation status of *L. spinosa* is not readily available in any Asian country. There are no large-scale cultivations in Sri Lanka. The crop is restricted to small pockets in marshy lands, paddy fields and home gardens. The cultivation package developed by the Department of Agriculture is not popular among these small scale growers. Though its nutritional properties are well understood, it is very popular as a vegetable. The less palatability due to high fiber content can be postulated as one of the possible reasons for that. Furthermore, there is a belief among the public that it absorbs high amount of heavy metals from contaminated soil and water. Kananke *et al*. (2014) have found that level of Ni, Cd and Pb in *L. spinosa* exceed the permissible limits set by FAO/WHO for human consumption in their market survey.

The Collection and conservation of wild populations and cultivated forms are important for both *ex-situ* and *in-situ* conservation. The ongoing study aims to collect and evaluate its potent genetic and morphological variability in 46 of Agro-ecological regions in Sri

Lanka. Such germplasm will provide superior material for cultivation purposes and future crop improvement program. During our literature survey we realized that the knowledge on morphological and genetic diversity, taxonomy and reproductive biology of *L. spinosa* is incomplete. Therefore, we hope that information gathered and discussed here will set baseline, while showing new direction for plant breeders, taxonomists and conservation biologists who work on *L. spinosa* and its relatives.

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