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Underutilized crops as a resource to combat the food, nutrient, and economic security in Sri Lanka

Niluka Nakandalage [1*] and H.I.G.K Anuruddi [1]

[1]Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

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Abstract

Food insecurity in Sri Lanka has risen dramatically owing to various factors, including the COVID-19 pandemic and the recent economic crisis. Movement and activity restrictions imposed to control the spread of the pandemic, combined with acute shortages of essential food items, have had a severe impact on people's livelihoods, resulting in food insecurity and increased vulnerability to malnutrition. Provision of quality food for the community at a minimum cost is prioritized by the government due to consecutive seasons of poor harvests, foreign exchange shortages, higher food inflation, and reduced household purchasing power. Currently, the focus has shifted to find sustainable food sources to meet both the nutritional and economic needs of communities. Meanwhile, consumption patterns based on a few dominant species of major food crops are recognized as one of the biggest threats to global nutrition and food security and this is also true for Sri Lanka. As a result, there is a growing need to discover new food crops targeting healthy and diversified dietary patterns.

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*Corresponding author
Postal address: Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka
Email: niluka@crop.ruh.ac.lk

Effective use of underutilized crops (UCs) in this context appears to be one of the imperative means to minimize the pressure mounted on major crops as they could produce different kinds of foods rich with macro- (Protein and carbohydrates) and micronutrients (Vitamins and minerals- Potassium, Calcium, Magnesium, Zinc, Iron). Fruits, vegetables, cereals tubers/yams and medicinal plants are examples for different groups of underutilized crops that are nutrient-dense, health-promoting, and climate-resilient. UCs are well adapted to a wide range of soil and climatic conditions as well as low-input farming systems. Their systematic cultivation is advantageous in rural areas where people have poor income generation and lack of market accessibility. Therefore, this rich genetic diversity could be used to enhance food and economic security in numerous ways, most importantly through, direct access to a diversity of nutritionally-rich foods, increased purchasing power from savings on food bills and year-round income from selling the value-added products. It is essential that people know how best to make use of these invaluable natural resources to ensure their wellbeing. This review discusses on the positive aspects of promoting UCs on addressing food, nutrient and economic security in Sri Lanka.

Keywords: Economic security; Food security; Nutrient security, Sri Lanka; Underutilized crops

Introduction

Sri Lanka is a biodiversity hotspot with a diverse range of plant species that provide numerous benefits. Only a small percentage of available plants are used for human consumption and other purposes, while many others are abandoned (Peduruhewa *et al*., 2023). According to Grote *et al.* (2021), the same pattern is observed in the global food supply where 87% of the world's plant species are still underutilized. Globalization and the economic context of emerging markets have inspired farmers to grow a few identified cash crops aimed at urban, regional, and international markets (Ebert, 2014). It has kept farmers away from cultivating UCs with high potential for addressing food and nutritional security in rural households while increasing their income. Food supply in Sri Lanka is heavily reliant on a few cereal crops, primarily rice, pulses, vegetables, and fruits (Bandula *et al.,* 2016) which is probably unstable in the long run (Ebert, 2014). Less diverse diets and a few dominant crops have been linked to

health risks, uncertainty, climate vulnerability and socioeconomic issues. However, a large number of unrecognized crops have ability to contribute largely to daily meals and as an income source of people in Sri Lanka.

Meanwhile the stability of food supply chains in Sri Lanka was undergoing one of the most forceful pressures owing to COVID- 19 outbreak in the recent past. The pandemic has evolved from a health concern to an economic threat to the island's food security. Meanwhile, a drastic macroeconomic crisis in Sri Lanka has resulted in intense shortages and price increases for essential products including food items and agricultural inputs. As a result, the nutritional well-being of people particularly children and pregnant women in Sri Lanka is jeopardized. One of the major causes of the economic crisis in terms of food and nutrition is the lack of proper management of the country's valuable economic and nutritional resources. Therefore, it is important to study the most effective approaches for utilizing available resources including underutilized species for relieving the economy and the nutritional needs of people in the island.

UCs are crops whose potential has not been fully realized. However, these species have been identified by the native inhabitants for generations due to their food, nutrition, health, medicinal, cosmetic, and economic values (Bandula *et al*., 2016). Vegetables, fruits, grains, yams as well as economically important trees and herbs, are examples of underutilized crop/plant groups that contribute to Sri Lanka's rich biodiversity (Peduruhewa *et al*., 2023). Though these crops have rich genetic diversity, less attention has so far been paid to commercial cultivation and domestication due to several reasons. Therefore, some of the underutilized crop species are partially or fully domesticated while some are totally unevaluated.

According to Sahoo *et al*. (2021), underutilized plants thrive in most agro-ecosystems and are usually encountered in home gardens and rural farm lands. According to Peduruhewa *et al.* (2023), many of these plants have been removed from the wild due to the ignorance of people despite of their economic and nutritional values. Underutilized crops are shown to display a low requirement of water and nutrients thus the production cost is low. Unfortunately, appropriate agro-technological packages for many of the underutilized crops have not yet been developed. Moreover, available information in relation to processing and value-addition methods is lacking.

Over-exploitation, habitat destruction, and heavy negligence are threatening the sustainability of these species due to severe genetic erosion. Therefore, it is essential to take immediate action to conserve these valuable genetic resources, while ensuring their sustainable utilization. Underutilized plants are not only imperative due to their high nutritional values but also, they are well-acclimated to a wide range of low-input farming systems. Their ability to thrive under harsh climatic conditions has made them valuable in fighting against the negative impacts of climate change on agricultural food production (Bala *et al*., 2006).

Climate change will still be a specific driver and decisive factor in nutritional outcomes in the regions where chronic malnutrition is prevailed (Baldos *et al.,* 2014). Therefore, there should be long term, economically viable, socially acceptable and environmentally friendly strategies to boost the food production under changing climates. Since foods of animal origin are not easily affordable for low-income households in particular in urban and peri-urban areas, alternative nutrient sources should be introduced using potential local resources. In this context, unutilized or UCs could be mainstreamed to the local food systems expecting to alleviate malnutrition especially prevailing within the local communities. Use of unexploited and underexploited genetic materials, particularly the plant materials is one of the foremost strategies to enhance the food security, get rid of malnutrition and poverty while enhancing the income generation power of people. Therefore, this review article aims to gather facts on the status of the underutilized crops in Sri Lanka while emphasizing their importance and impact on food and nutrient security as well as economic security in Sri Lanka.

Methodology

This review was developed by conducting a literature search in Google Scholar online database during first half of 2023. Accessible publications in English language were collected including scientific articles, reviews, conference papers and book chapters covering publications over 20 years from 2003 to 2023. Relevant papers were identified by using specific search strings. Finally, 39 studies following the research criteria were selected to review.

Importance of underutilized crops

Underutilized crops are massive unused commodities which have a potential in contributing food security, health, income and environmental services (Hoeschle *et al.,* 2009). Potential of these species have not been fully realized or exploited. However, these crops still play an important role in the lives of rural people by providing them with a better livelihood while ensuring environmental sustainability (Malkanthi, 2017). They reduce the risk of inputs in agricultural practices such as nitrogen fertilizers and improve the dietary diversity by widening the food basket (Mayes *et al.,* 2011)**.** Also, the reduction of arable land area due to climate change has offered opportunities for underutilized crops to expand their production with the maximum utilization of marginal lands under low input conditions (Mabhaudhi *et al.,* 2019a). Since these crops possess a rich genetic diversity, they have a potential to be used in future crop improvement programs (Mabhaudhi *et al.,* 2019b). Traditionally, underutilized crops have been used as food, fiber, medicines, fodder and in oil production. These crops are considered as a part of the culture and tradition and associated with customs and beliefs of some communities in the world **(**Taylor *et al*., 2009). In Sri Lanka, neglected and underutilized fruit species are largely important in food and nutrient security and as traditional medicines (Rathnayaka *et al.* 2019). Underutilized crops enhance the nutritional quality of foods providing basic nutritional elements such as proteins, vitamins and minerals as well as ensure food safety while ensuring high income.

Status of underutilized crops in Sri Lanka

Sri Lanka is an island with highly vulnerable climatic change which impact on species distribution. In Sri Lanka, demand for commercialized crop varieties has been increased while most of the traditional varieties remained without much use as UCs. There are nearly 60 varieties of underutilized fruit crops grown particularly in marginal environments in the country (Dahanayake, 2015). Though many underutilized crop species have been identified in Sri Lanka (Table 1), only few species were found cultivated at commercial scale (Malkanthi *et al.,* 2014). These plants can be found in all climatic zones across the country, demonstrating a great diversity. Local food processors have been trained regarding processing of underutilized crops such as Jack fruit

(*Artocarpus heterophyllus*), Beli (*Aegle marmelos*) and Anoda (*Annona muricata*) (Malkanthi *et al*., 2014).

As stated by them, a range of usages of underutilized crops for the farmers has been identified. Among them, contribution towards the daily food requirement, as a source of extra income, and as home-based medicines for simple health disorders *etc*., are widely accepted. As mentioned by Ratnayake *et al.* (2019), *Limonia acidissima*, *Aegle marmelos*, *Annona muricata* and *Tamarindus indica* are some underutilized fruit species which have great potential as medicinal and as a source of food. Additionally, *Drypetes sepiaria*, *Manilkara hexandra* and *Schleichera oleosa* have been identified as important underutilized fruit species by Perera *et al.* (2022). They also investigated the active compounds in two species of wild berries, *Salacia chinensis* and *Dovyalis hebecarpa*. The National Red List in 2012 recognized five species of the genus Salacia in Sri Lanka. These species have numerous health benefits, and many multinational firms use them in pharmaceutical production (Amarathunge *et al*., 2021).

Sri Lanka is abundant in underutilized vegetable spices such as *Solanum macrocarpon*, *Solanum torvum*, and *Canavalia gladiate* (Hettiarachchi and Gunathilake, 2020). In Sri Lanka, underutilized crops grown in wild are harvested by collectors and are directed to village collecting centers or retail shops. Considerable number of underutilized crops could be found in road side stalls, weekly fairs and traditional village fairs. Also, urban consumers pay more attention on underutilized crops and their weekly shopping baskets are composed of some items of underutilized fruits and vegetables (Bandula *et al*., 2016). According to Ratnayake *et al.* (2020), there are twenty-six statement criteria used to prioritize neglected and underutilized fruit species in Sri Lanka. These criteria have been given under several categories such as research and policy framework, germplasm and agro-ecology, acceptability, uses, production and practices, post-harvest, market and value chain (Ratnayake *et al.,* 2020).

Table 1: Different groups of underutilized crop species in Sri Lanka

Vernacular name (Sinhala)	Scientific name	Family
	Fruits	
Ahu	*Morinda angustifolia*	Rubiaceace
Bilin	*Averrhoa bilimbi*	Oxalidaceae
Damba	*Cleistocalyx nervosum*	Myrtaceace
Damuna	*Grewia tiliifoila*	Tiliaceae
Gaduguda	*Baccauria motieyana*	Phyllanthaceae
Gal siyabala	*Dialium ovoideum*	Fabaceae
Himbutu	*Salacia chinensis*	Hippocrateaceae
Jam pera	*Psidium cattleianum*	Myrtaceae
Karamba	*Carissa spinarum*	Apocynaceae
Karawala kaballa	*Antidesma bunius*	Phyllanthaceae
Kirala	*Snnaeratia alba*	Sonneratiaceae
Kon	*Schleichera oleosa*	Sapindaceae
Kowakka	*Coccinia grandis*	Cucurbitaceae
Lavalu	*Pouteria campechiana*	Sapotaceae
Lemon	*Citrus limon*	Rutaceae
Local delum	*Punica granatum*	Punicaceae
Lolu	*Cordia dichotoma*	Boraginaceae
Lovi	*Flacourtiai inermis*	Salicaceae
Madan	*Syzigium cumini*	Myrtaceae
Mandarin	*Citrus reticulata*	Rutaceae
Mee amba	*Mangifera indica*	Anacardiaceae
Mora	*Dimocarpus longan*	Sapindaceae
Namnan	*Cynometra cauliflora*	Fabaceae
Nasnaran	*Citrus japonica*	Rutaceae
Nelli	*Emblica officinalis*	Phyllanthaceae
Palu	*Menilkara hexandra*	Sapotaceae
Sapodilla	*Menikkara zapota*	Sapotaceae
Siyambala	*Tamarindus indica*	Fabaceae
Uguressa	*Flacourtia indica*	Salicaceae
Veralu	*Elaeocarpus serratus*	Elaeocarpaceae
Weera	*Drypetes sepiaria*	Putranjivaceae

Table 1: Different groups of underutilized crop species in Sri Lanka (Continued)

Vernacular name (Sinhala)	Scientific name	Family
	Vegetables	
Ahas batu	*Solanum macrocarpon*	Solanaceae
Batu karavila	*Momordica denudata*	Cucurbitaceae
Diya Labu	*Lagenaria siceraria*	Cucurbitaceae
Kahata gedi	*Careya arborea*	Lecythidaceae
Kekiri	*Cucumis sativus*	Cucurbitaceae
Thibbatu	*Solanum torvum*	Solanaceae
	Leafy vegetables	
Gas Nivithi	*Talinum triangulare*	Talinaceae
Gata thumba	*Leucas aspera*	Lamiaceae
Girapala	*Commelina diffusa*	Commelinaceae
Kirihenda	*Celosia argentea*	Amaranthaceae
Koppa kola	*Polyscias scutellaria*	Araliaceae
Kurapala	*Amaranthus viridis*	Amaranthaceae
Monarakudumbiya	*Vernonia cinerea*	Asteraceae
Nivithi	*Basella alba*	Basellaceae
Thebu	*Costus speciosus*	Costaceae
	Cereals	
Heen meneri	*Panicum sumatrense*	Poaceae
Kurakkan	*Eleusine coracana*	Poaceae
Meneri	*Panicum miliaceum*	Poaceae
Thana hal	*Setaria italica*	Poaceae
	Roots/ tubers	
Angili ala	*Dioscorea alata*	Dioscoraceae
Dandina	*Dioscorea alata*	Dioscoraceae
Gahala	*Colocasia esculenta*	Araceae
Gonala	*Dioscorea spicata*	Dioscoraceae
Hingurala	*Dioscorea alata*	Dioscoraceae
Hulankeeriya	*Maranta arundinacea*	Marantaceae
Kukulala	*Dioscorea esculenta*	Dioscoraceae
Nattala	*Dioscorea alata*	Dioscoraceae
Rajaala	*Dioscorea alata*	Dioscoraceae

Table 1: Different groups of underutilized crop species in Sri Lanka (Continued)

Vernacular name (Sinhala)	Scientific name	Family
	Oil crops	
Aba	*Brassica juncea*	Brassicaceae
	Legumes	
Kollu	*Macrotyloma uniflorum*	Fabaceae
Awara	*Cnavalia gladiate*	Fabaceae
	Medicinal herbs	
Adhathoda	*Adhathoda vasica*	Acanthaceae
Hathawariya	*Asparagus racemosus*	Asparagaceae
Kalukammeriya	*Solanum americanum*	Solanaceae
Kiri Anguna	*Wattakaka volubilis*	Asclepiadaceae
Kowakka	*Coccinia grandis*	Cucurbitaceae
Masbadda	*Gymnema sylvestre*	Asclepiadaceae
Nika	*Vitex negundo*	Lamiaceae
Pita sudu sarana	*Boerhavia diffusa*	Nyctaginaceae
Thippili	*Piper longum*	Piperaceae
Udupiyaliya	*Desmodium gangeticum*	Fabaceae
Wadakaha	*Acorus calamus*	Acoraceae

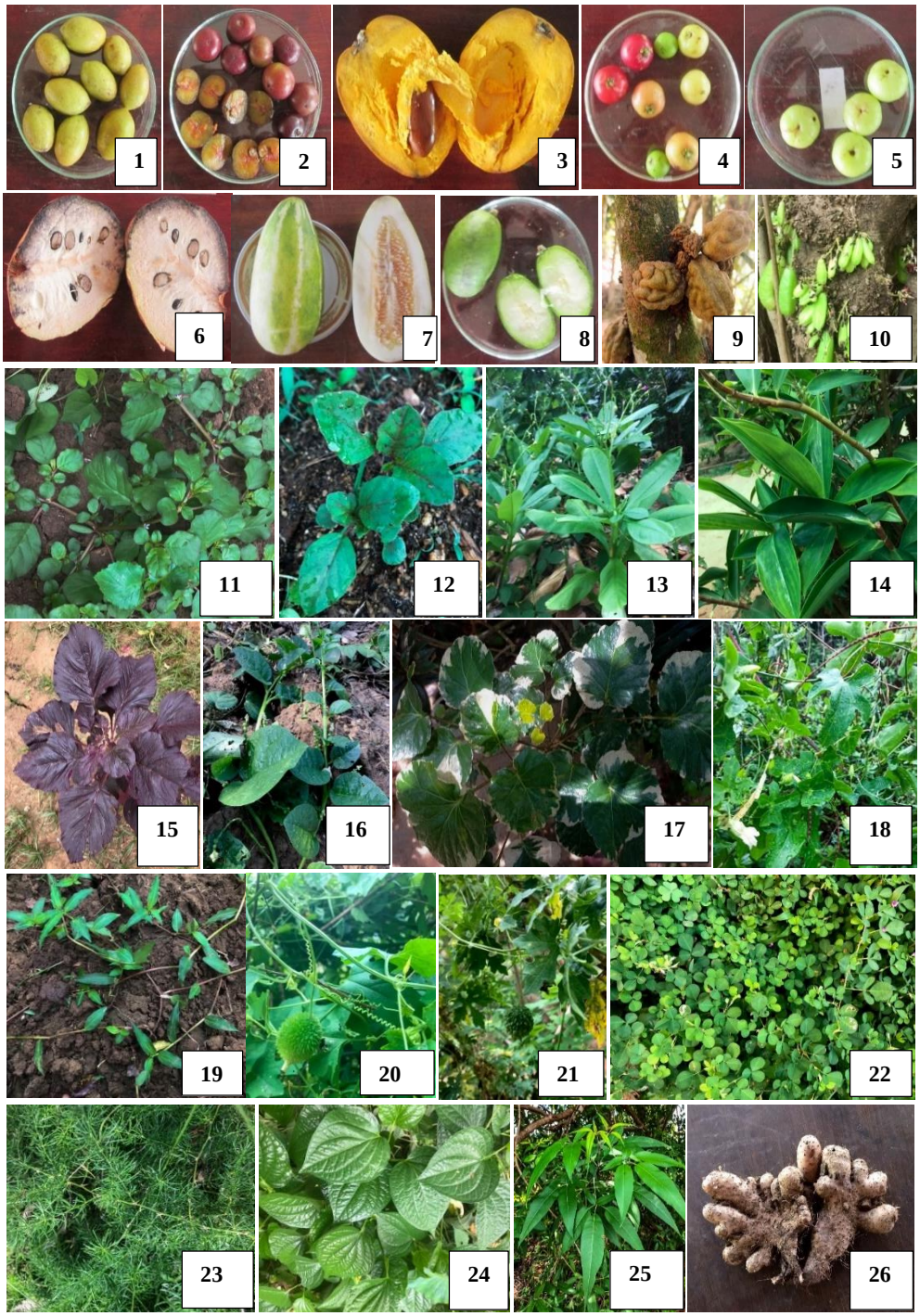
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Fig.1: 1: *Elaeocarpus serratus* (Veralu), **2**: *Flacourtia indica* (Uguressa), **3**: *Pouteria campec hiana* (Lavalu), **4**: *Flacourtiai inermis* (Lovi), **5**: *Emblica officinalis* (Nelli),**6**:*Annona reticulata* (Weli anoda), **7**: *Cucumis sativus (Seeni Kekiri),* **8**: *Menikkara zapota* (Sapodilla)*,* **9***: Cynometra cauliflora* (Nam-nam), **10**: *Averrhoa bilimbi* (Bilin), **11**: *Trianthema portulacastrum* (Sarana), **12**: *Boerhavia diffusa* (Pita sudu sarana), **13**: *Talinum triangulare* (Gas nivithi), **14**:*Costus speciosus* (Thebu), **15**: *Amaranthus viridis* (Rathu thampala), **16**: *Talinum triangulare* (Nivithi), **17**: *Polyscias scutellaria* (Koppa kola), **18**: *Coccinia grandis* (Kowakka), **19**: *Commelina diffusa* (Girapala), **20**: *Momordica dioica*.(Thumba Karawila), **21**: *Momordica charantia* (Batu karawila), **22**: *Desmodium triflorum* (Heen Undupiyaliya), **23**: *Asparagus falcatus* (Hathawariya), **24**: *Piper longum* (Thippili),**25**: *Vitex negundo* (Nika),**26**: *Dioscorea alata (Hingurala).*

Underutilized crops: food and nutrient security in Sri Lanka

Though it has not yet been substantially exploited, underutilized crops play a major role in the process of enhancing food security. These crops have great potential to alleviate hunger directly through increasing food production in challenging environments (Mayes *et al.,* 2011). Furthermore, they add nutrients to the plate of poor and provide convenient food for low-income urban people. Unique physico-chemical properties and nutraceutical characteristics possessed in many underutilized crops attribute to better diet for rural communities through fighting against micronutrient deficiencies, especially among the rural people.

Some underutilized food species provide more nutrients and vitamins when compared to staple food crops. Particularly, underutilized fruits, vegetables and nuts are rich sources of proteins, carbohydrates, fats, energy and vitamins including A, B_1, B_2, B_3, B_6, B_9, B_{12}, C, and minerals such as Ca, P, Fe and dietary fiber. Thus, they have the nutritional capacity to avoid diseases like marasmus, night blindness, diabetes, cancer, hypertension (Nandal *et al.,* 2014). Many underutilized vegetables have more vitamin C and pro vitamin A than commonly cultivated commercial varieties and cultivars (Jena *et al,.* 2018). Horse gram pulse is a rich source of protein, minerals, vitamins and different non-nutritive bioactive substances which reduce the risk of various diseases (Prasad *et al.,* 2015). The public awareness regarding the value of underutilized vegetable species is increasing as they provide dietary fiber, vitamins and minerals.

There are many scientific evidences for the nutritional aspects of underutilized crops in Sri Lanka. Perera *et al.* (2022), studied nutritional composition and

antioxidant activity of some selected underutilized fruit species; Màdan (*Syzygium cumini*), Maha Karamba (*Carissa carandas*), Himbutu (*Salacia chinensis*), Ugurassa (*Flacourtia indica*), Barbados cherry (*Malpighia emarginata*), and Ceylon gooseberry (*Dovyalis hebecarpa*). According to them, these species contain dietary fiber, phenolic compounds, vanillin, gallic acid, and minerals such as potassium, phosphorous and calcium, magnesium, sodium and iron. *Phyllanthus emblica* (Nelli) is one of the important underutilized fruits available in Sri Lanka with higher biochemical and nutritional parameters in terms of ascorbic acid content, total vitamin C, phenolic compounds, antioxidants and flavonoids (Abeysuriya *et al.,* 2020). According to Piyathunga et al. (2016), *Manilkara hexandra* (Palu) exhibits a higher antioxidant capacity. Mallawaarachchi *et al.* (2015) studied antioxidant potential of *Dialium guineense* (Gal siyambala), *Solanum nigrum* (Kalukammeriya) and *Carissa carandas* (Maha karamba) grown in Sri Lanka and report that *S. nigrum* possesses the highest antioxidant potential among them. They conclude the underutilized species with good antioxidant contents can be exploited as raw materials for the production of antioxidant supplements. Padmini et al. (2015) report that the ethanolic extract of Sri Lankan *Anona muratica* L. fruit pulp possess a moderate antioxidant capacity.

Apart from fruit species, underutilized roots and tuber crops provide major nutrients to the people in Sri Lanka through their regular diets. Chiranthika *et al.* (2022) studied physicochemical characters of flours and starches of some underutilized roots and tuber crops in Sri Lanka; *Dioscorea alata* (Kahata ala and Hingurala), *Dioscorea esculenta* (Java ala), *Lasia spinosa* (kohila) and *Nelumbo nucifera* (Nelum). According to them, these species comprised with considerable amounts of dietary fiber and favorable starch facilitating the formulation of value-added products. Leafy vegetables are another neglected group of UCs in Sri Lanka. Nadeeshani *et al.* (2018) investigated ten species of commonly grown leafy vegetables in Sri Lanka including some underutilized species such as *Amaranthus viridis* (rathu thampala and kola thampala), *Dregea volubilis* (Aguna), *Coccinia grandis* (Kowakka), *Costus speciosus* (Thebu) and *Trianthema portulacastrum* (Sarana). After studying the proximate and mineral composition of each species, they concluded that *A. viridis* was the richest with essential minerals. Peduruhewa *et al.* (2021), explored microelements and phytochemicals of *Commelina diffusa* (Girapala) which is an edible

underutilized leafy vegetable in Sri Lanka. According to them, it was a abundant with minerals such as Ca, Fe, Cu and Zn compared to other prominent leafy vegetables consumed by people. And also, it was rich with bioactive compounds such as flavonoids, alkaloids, saponins, phenols, steroids and tannins.

Value addition of underutilized crops for food and nutrient security

Sri Lanka's varied weather conditions provide an ideal environment for growing a wide range of crop species. Majority of underutilized crops are seasonal and abundantly available at various times of the year. Specifically perishable fruits are affordable as seasonal surpluses in different parts of the country during different time periods and are wasted in large amounts due to lack of facilities and knowledge for proper handling, distribution, marketing, and storage. This has limited their potential for expansion, despite the fact that they are nutritious. However, due to their acidic nature and astringent taste, some of these fruits are not marketable in fresh form. As a result, there is a pressing need to focus on the diversifying and commercialization of such underutilized crops. This can be accomplished by developing appropriate processing and marketing strategies for underutilized crops. Sarananda *et al.* (2017) developed low cost healthy ready to serve fruit drinks using several underutilized fruit species; *Flacourtia inermis* Roxb. (Lovi), *Elaeocarpus serratus* L. (Weralu), *Tamarindus indica* L. (Siyambala), *Limonia acidissima* L. (Diwul), and *Annona muricata* L. (Katu anoda). Some other value-added products are presented in Table 2.

Table 2: Different underutilized crops and their value additions

Vernacular name (Sinhala)	Scientific name	Value addition
	Fruit Crops	
Madan	*Syzigium cumini*	Juice, squash, jelly, wine
Bilin	*Averrhoa bilimbi*	Sauce, jam, juice, pickle, jelly candy
Pera	*Pisidium guajava*	Jelly, jam, juice, leather, wine
Jam pera	*Psidium cattleianum*	Fresh juice, jams

Table 2: Different underutilized crops and their value additions

Vernacular name (Sinhala)	Scientific name	Value addition
Kon	*Schleichera oleosa*	Animal feed (cake), oil, pickle, bio diesel
Weli jambu	*Zyzygium jambos*	Jam
Ambarella	*Sondias dulcis*	Chutney, Nectar
Palu	*Menilkara hexandra*	Cooking oil
Namnan	*Cynometra cauliflora*	Wine
Lovi	*Flacourtiai inermis*	Juice
	Vegetables	
Ahas batu	*Solanum macrocarpon*	Pastry cream, flour
Murunga	*Moringa oleifera*	Leaf powder
Diya labu	*Lagenaria siceraria*	Pickles, chutney, sweets
	Cereals	
Kurakkan	*Eleusine coracana*	Porridge, puddings, pancakes, biscuits, roti, bread, noodles
Thana hal	*Setaria italic*	Flour, laddu
	Legumes	
Kollu	*Macrotyloma uniflorum*	Chapathi, bread
	Medicinal Herbs	
Pita sudu sarana	*Boerhavia diffusa*	Root powder, capsules
Masbadda	*Gymnema sylvestre*	Supplements
Nika	*Vitex negundo*	Leaf powder, capsules

Promote availability of underutilized crops through propagation, conservation and genetic improvements

Crop improvements and conservation of gene pools are pre-requisites in order to ensure continuous supply of products and raw materials to strengthen global food and nutritional security. Similar to the studies on staple crops, there should be a broad range of opinions on how to grow and use the underutilized crops at commercial scale. Lack of quality planting materials with sufficient quantities is one of the major drawbacks in the development of the sector (Daniel and Dudhade, 2007). At present, underutilized crops drew attention of the decision makers and the need to rescue and improve the use of them is frequently discussed. The selection of the species for commercialization needs to be done carefully based on its capacity to meet the social, economic and environmental perspectives. Conservation and sustainable use of underutilized crops has not been prioritized in Sri Lanka (Peduruhewa *et al.,* 2023).

Farmers are reluctant to use these crops since they are not competitive with other crop species, which might result in declining and eroding the genetic base of these crops. Lack of interest of farmers, on the other hand, would prevent the use of distinctive useful traits of these crops in adaptation and improvement (Padulosi *et al.,* 2006). Selection of crop species which have multiple benefits can be used for successful commercialization and thereby can protect the farmers from seasonality of the product and price fluctuation. Many underutilized crops which were widely grown in the past, are now given minor importance mainly because of lack of genetic improvements, agronomic and socio-economic drawbacks. Therefore, there should be proper genetic improvements and breeding technologies along with farmer awareness programs to address these issues.

Underutilized crops are rich sources of genes which are resistant to biotic and abiotic stresses, thus they can be utilized in genetic improvement processes of commodity crops (Kole, 2011). Accurate identification of species to be conserved is important to make the best use of limited resources in conservation and development process of underutilized crops. Improvement or conservation of underutilized crops is not only related with food security but also it is crucial to safeguard cultural, artistic and landscape values of these species. The genetic diversity of these species should be maintained through *in*

situ and *ex situ* approaches where active participation of farmers and breeders should be ensured. However, the evidence suggests that *ex-situ* conservation of many underutilized species is highly inadequate (Padulosi *et al.,* 2006). One of the best ways to conserve the underutilized crops is incorporating them with production systems.

Underutilized crops: economic security in Sri Lanka

Underutilized crops are essential to the livelihoods of millions of poor farmers throughout the world (Padulosi *et al.,* 2006). They have great potential for domestication, income generation and thereby facilitate better life. Commercial scale cultivation of underutilized crops helps to protect this valuable resource, while ensuring sustainable utilization. Due to wide climatic and soil adaptability of underutilized crops, infertile and marginal lands can also be used to boost the productivity and thereby increase income generation. Underutilized crops can be successfully introduced into the traditional and existing farming systems as well as home gardens. Farmers can grow them as crop rotations or intercrop with other crop species while promoting agro- biodiversity at field level. Then farmers can use their resources in an effective and efficient manner to enhance the productivity.

This will enable to earn higher income and create employment opportunities. For an example, Punarnava/ Pita sudu sarana (*Boerhavia diffusa*) is an underutilized medicinal herb widely distributed in Sri Lanka and India. This crop is capable of cultivating in Sri Lanka utilizing available lands. There are numerous pharmaceutical products developed using *punarnava* available in the market. Majority of these products and raw materials of *punarnava* is imported to Sri Lanka, from India. Promotion of its cultivation and value addition will provide opportunities to earn foreign exchange to the country. Moreover, women empowerment can be utilized for cultivation, management, harvesting, processing, value addition and marketing of underutilized crops. It also provides primary health care needs of people through cheap and easy accessibility and this will lead to produce healthy population. Yield surplus can be exported and it also helps to earn foreign exchange thereby alleviates the poverty and at the same time have substantial contribution to the national economy.

Systematic cultivation of underutilized crops in particular, fruit crops and medicinal plants have immense potential to develop industries based on these raw materials. Uniform and quality materials are the foundation of successful industry. Continuous supply of raw materials through cultivation of underutilized crops allows manufacturers for continuous production and it assures regular income to the farmers. Underutilized crops can be used not only for food purposes but also for the production of essential oils, herbal extracts, herbal powders, food colorants and timber (Peduruhewa *et al.,* 2021). The unique strength of certain underutilized and neglected crops in their rich and favorable nutritional composition, nutraceutical value and product development offer uncommon opportunities for income generation to the farmers, particularly the farm women. They can be used to earn high income through selling of value-added products.

It is an effective way to attract consumers more easily than when they are selling as it is. There is a higher demand for underutilized crop-based products in the global market. Major value-added products prepared using underutilized crops are jam, jelly, candy, wine, chutney, sauce and pickles etc. Sri Lanka has a greater potential to develop such products with the available resources targeting export market and can earn a huge amount of foreign exchange. Urban farmers collect underutilized crops from wild and sell them to their target customer groups. In most of the cases, they target urban travelers who are with the ego of consuming village food. Seasonality of underutilized fruits attracts urban consumers to the market places (Bandula *et al.,* 2016). The developing interest from customers in developing and developed nations for range and novelty in foods is developing a new market especially for underutilized vegetables (Jena *et al.,* 2018). In order to accelerate all these positive benefits from underutilized crops, more importance should be given for crop improvement and gene pool preservation.

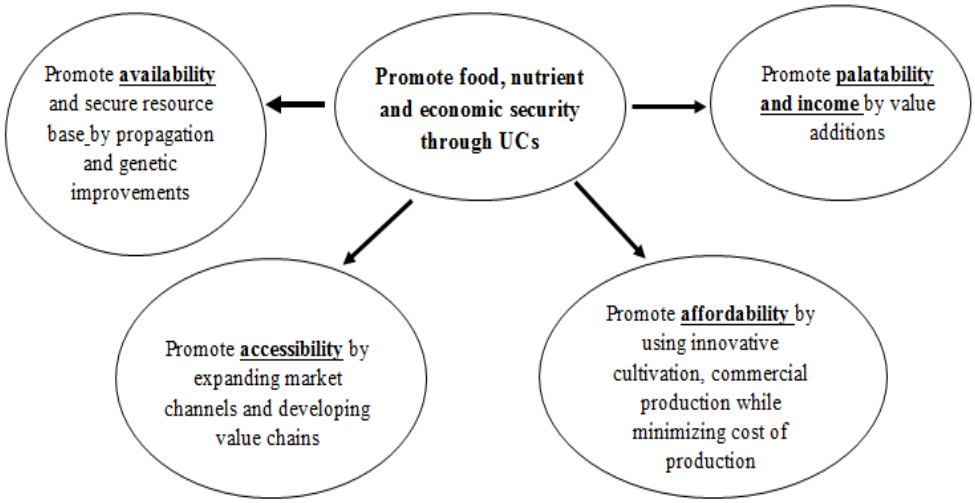

Fig. 2: Different aspects to consider when promoting underutilized crops for food, nutrient and economic security.

Challenges and strategies in promotion of underutilized crops in Sri Lanka

Globalization of the agriculture market has become a key issue in improving the use of underutilized crops. Low competitiveness, loss of traditional knowledge, lack of market accessibility /poor commercialization, and lack of propagation techniques, inadequate knowledge on production methods and value addition, challenges in seeking for credit such as high interest rates, lack of information on loans and government support, no proper extension services and poor knowledge in cultivation and processing are understood as major constraints in the promotion of underutilized species (Padulosi *et al.,* 2006) (Fig. 3). Further, difficulty in obtaining sufficient quality and number of seeds or other planting materials of underutilized crops is another major issue in promoting these crops. Also, the competition created from modern crops is a major challenge for promoting underutilized crops as major crops have shown short lifespan, higher productivity and increasing demand. Majority of projects/ researches heavily focus on improving the yield of some selected commercial crops resulting in these crops being over researched and over produced. On the other hand, underutilized nutritious food species are under researched and are insufficiently available (Kour *et al*., 2018; Mabhaudhi *et al.* 2019). Meanwhile

negative attitude of the consumers towards the underutilized crops is also a matter of great concern. Consumption of underutilized crops has become a sort of old-fashioned task to the new generation. Consumers have low awareness on the medicinal properties, nutritional value and other special characteristics of underutilized crops (Malkanthi *et al.,* 2014).

Increasing use of underutilized crops for food security imposes many obliges? in different steps from plant selection to consumption processes. Therefore, it is vital to develop and strengthen the sustainable linkages among organizations, farmers and consumers. Further studies that bring together sparse and often inaccessible literature are also needed (Padulosi *et al*.,2006). Improving the availability of information on underutilized crops is one of the most important areas that demand our immediate attention (Padulosi *et al.,* 2006). For example, commercial cultivation of jackfruit is still at a primitive stage in India, primarily because of the difficulty in procuring elite planting materials, long gestation, lack of knowledge about the yield and income, restricted use, sporadic demand and unorganized market (Narayan, 2007).

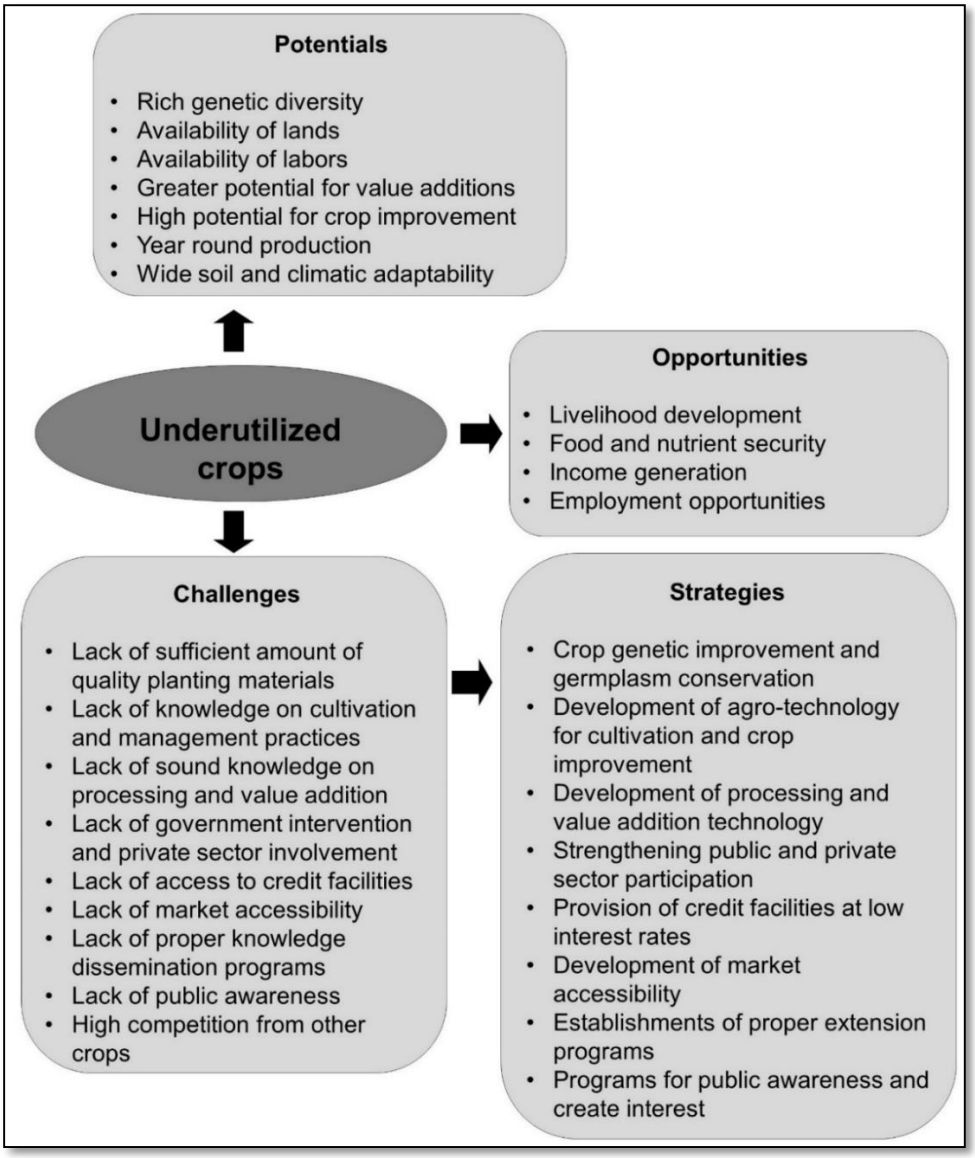

Fig. 3: Potentials, opportunities and strategies to overcome existing challenges of underutilized crops in Sri Lanka

Proper selection of suitable varieties for different eco systems, development of value-added products, proper harvesting, packing, storage, transport techniques and postharvest processing facilities have to be improved in order to minimize losses and achieve quality products either for local or export market. However, market demand for equipment and machinery for post-harvest processing of these underutilized fruits has not been fully understood (Gunasena *et al.,* 2004). Developing an agenda specific to the crops must be recognized as an important and continuing need (Padulosi *et al.,* 2006). Development of cost-effective new technologies (e.g: molecular genetics and GIS) will certainly play their part in the process of developing conservation and use strategies (Padulosi *et al.,* 2006). For example, during the last two to three decades, the demand for tamarind has increased significantly because of the use of modern technologies for processing the pulp into ready-to-use cubes and powder (Narayan, 2007). Thus, there is an earnest need to take up program on hereditary assets investigation, usage and improvement of underutilized crops to guarantee food and dietary security for the future (Jena *et al.,* 2018).

Conclusions

Cultivation and sustainable use of underutilized crops play an important role in food, nutrient and economic security of the country while improving peoples' livelihoods. UCs must be promoted among different communities for better establishment of a social, economic and environmentally friendly food and nutrient security system. It is a joint responsibility of different stakeholders in the sector including Department of Agriculture to establish and promote the concepts related to underutilized plant production. On the other hand, it is essential to promote the development of market channels so as to enhance the availability and affordability of value-added food products based on underutilized crops at low prices. Meanwhile the scientific research findings must be communicated to the general public especially regarding propagation, value addition and nutrient values of underutilized crops. It is essential to target commercial cultivation, in-situ conservation, development of new technologies, genetic improvements as well as awareness programs for farmers and consumers, in order to preserve and make good use of these rich valued natural resources.

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