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Indigenous and traditional foods of Sri Lanka



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Abstract

Indigenous and traditional foods of Sri Lanka inherit a long history and unique traditions continued from several thousands of years. Sri Lankan food tradition is strongly inter-wound with the nutritional, health-related, and therapeutic reasoning of the food ingredients and the methods of preparation. The diverse culinary traditions and preparations reflect multipurpose objectives combining in-depth knowledge of flora and fauna in relation to human well-being and therapeutic health benefits. Trans-generational knowledge dissemination related to indigenous and traditional food is now limited due to changing lifestyles, dwindling number of knowledge holders, and shrinking floral and faunal resources. Awareness on the relationship between non-communicable diseases and the diet has garnered the focus on traditional ingredients and foods by the consumers and major food producers in Sri Lanka. This review presents concise details on the indigenous and traditional foods of Sri Lanka, with scientific analysis when possible.

Keywords: Ethnic foods, Traditional ingredients, Food preservation, Food preparation, Health benefits, Sri Lanka

Introduction

Indigenous and traditional foods of Sri Lanka present a perfect blend of cultural diversity with human wisdom that has been evolved through generations in establishing a cultural heritage and an identity. In the Sri Lankan culture, food is treated with the highest gratitude, respect, and generosity, expressed by sharing and offering to fellow humans, animals as well as the divine powers. Sri Lankans love to share foods with neighbors, family, and friends; house visits are always accompanied with bundles of food items. Some foods and the preparation know-how are specialties of the locality. Trans-generational knowledge transmission of food and food ingredients is inter-woven with regular maintenance of

healthy life, cultural legacy, and religious concepts of the ethnicities of the land and have been the key to sustain a traditional food culture in Sri Lanka; evidence are found in written literal work and archeological sources as well as folklore.

Archeological findings, ancient travelers' records, and early world maps are living evidence for the significance of this island in geo-politics and sea trade since ancient times. Elements of Afro-Arabic, Central Asian, European, South-east Asian, and Oriental food cultures that followed with the trade activities, royal marriages, and invasions have been customized to align with the habits, the culture, and the palate of island inhabitants while keeping the indigenous and traditional food culture in a nutshell. A significant geographic differentiation can be seen in traditional foods aligning with the eco- and biodiversity of the island. Indigenous and Ayurveda medicine holds a strong base and provides recommendations with clear and defined identity on the ingredients, preparation methods, and consumption in order to maintain a healthy life while preventing and treating major diseases and minor ailments. Traditionally, the primary knowledge holders are the community elders (both male

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Common names of foods and ingredients provided in parenthesis and in italics are Sinhala language names unless otherwise the Latin name of the organism/plant.

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and female) and indigenous medical practitioners who are well versed about the local flora and fauna, their medicinal values, and the ingredients and preparations.

The present review describes the essentials of indigenous and traditional foods of Sri Lanka, for the first time, providing a perspective analysis in science, technology, and nutrition of food and preparations when possible. Ancient texts and books written on Sri Lanka by various authors and other published media and discussions with different individuals holding traditional knowledge were consulted in generating this condensed review.

Geographical and climatic perspective

Geo-positioning and climate of the country are highly relevant to the available food sources and existence of various food traditions. Sri Lanka is a tropical island positioned between 5° 55' and 9° 51' North latitudes and 79° 42' and 81° 53' East longitudes in the south of the Indian peninsula. The island and area of 65,610 km² bears distinguishable elevation (Fig. 1a; central highlands, plains, and the coastal belt), rainfall (Fig. 1b; wet, intermediate, and dry zones), and vegetation (Fig. 1c; closed rainforest, more open intermediate tropical forest, and open grassland) zones [1]. The terrain of the island is mostly low, flat to rolling plains with mountains in the South-central area. The island coastline is 1,340 km long and inland water bodies cover 2,905 km². Several offshore islands account for 342 km² area. The island receives monsoonal, convectional, and depressional rains annually, with < 900 mm in the driest areas (North-western and South-eastern regions) to > 5000 mm in the wettest areas (Western slopes and Central highlands). Mean annual temperature (MAT) varies between 26.5 °C and 28.5 °C, with the altitudes > 1800 m marking MAT of 15.9 °C, and the coldest temperatures in January and the warmest temperatures in April and August [2]. Of the total land area, ~ 19% is arable, and agriculture accounts for ~ 44% of the workforce and 12% of the GDP [3].

Crucial positioning in the middle of the Indian Ocean and to the extreme south of the Indian Peninsula together with the protective natural harbors and, floral and faunal richness have been the key elements that attracted many global travelers, explorers, and trading nations to this island. Ancient maps and manuscripts account the importance of harbor towns and cities of the island. The map by Claudius Ptolemy (second century CE) was the first to provide absolute co-ordinates of specific locations of the island. Many names referred by various nations identify this island: Taprobane (Greek), Serendib (Persian, Arabic), Simhaladvipah (Sanskrit), Ceilão (Portuguese), Ceylon (English), Thambapanni

(Mahavamsa) and since 1972 the country declared Sri Lanka (Sinhala) or Ilankei (Tamil).

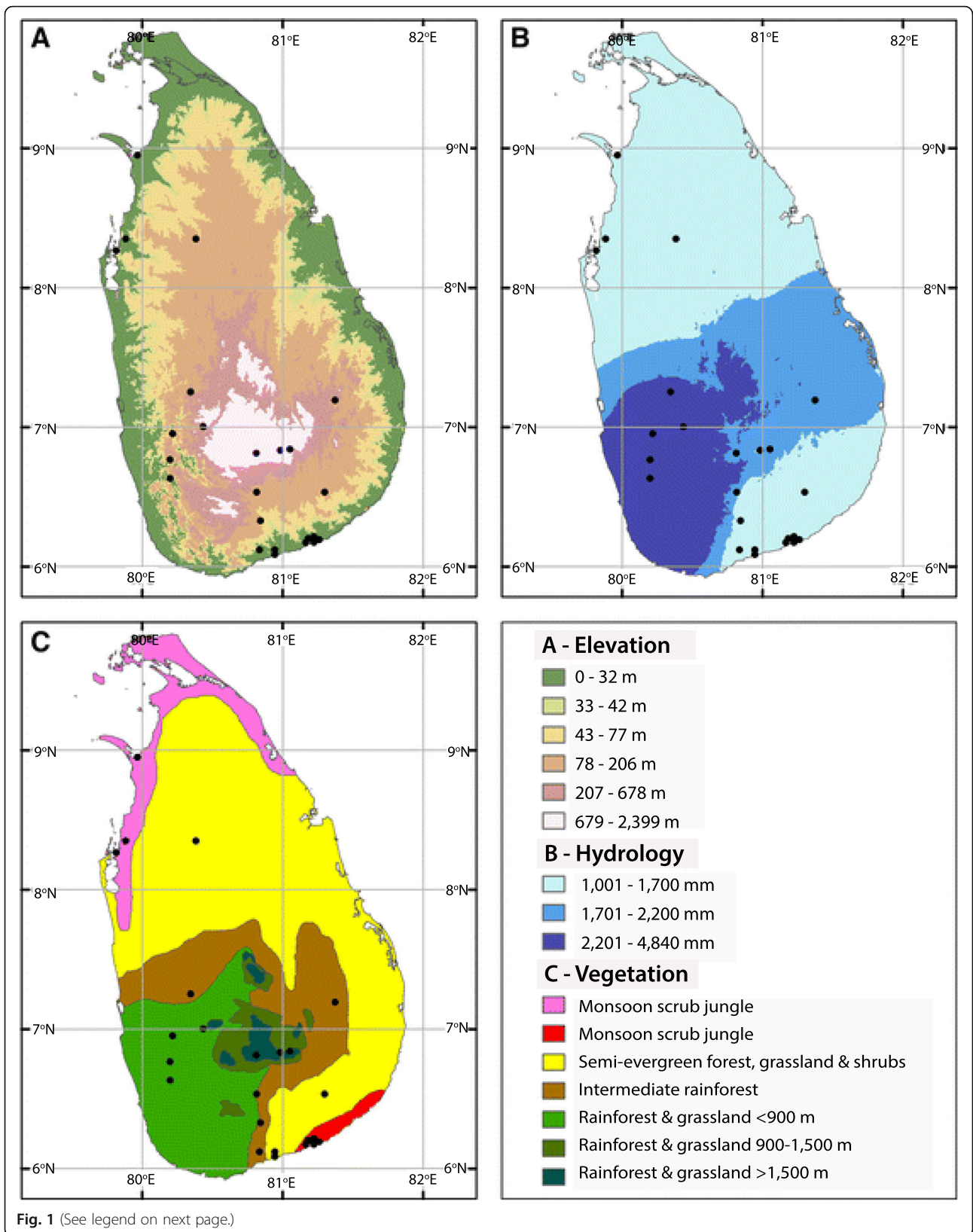
Food consumption patterns of pre- and proto-historic humans of Sri Lanka

The pre-historic man of Sri Lanka is known as the *Balangoda Man* (*Homo sapiens balangodensis*) belonging to the Pleistocene/Holocene epoch boundary in the geo-chronological scale [4], in which the Mesolithic period of archeological timescale coincides. The oldest human fossil evidence in South Asia (~ 45,000 to 38,000 calibrated years before present) were found in the rock shelters and caves scattered in all ecoregions of the island (Fig. 1a, b, and c) [1, 5–8]. The archeo-zoological and archeo-botanical evidence along with the microlithic and osseous tools and other artifacts found in these rock shelters indicate that the nutritional needs of these early human inhabitants have been supported by a number of sources [1, 5–7]. These include a variety of small and large animals and plant sources found above and below ground, and in the aquatic environments. Material evidence dating back to 2700 BCE support the involvement of pre-historic inhabitants in plant material processing, plant domestication, and pottery manufacturing, and the transition from forager, hunter-gatherer to agricultural, a more sedentary lifestyle [1, 5, 8, 9].

Foods of indigenous people

The *Veddā* (a.k.a. *Aadi Vaasin*, *Wanniyala-eththo*) is a group of people with indigenous ancestry, ~ 10,000 in number now, and confined to inland isolated pockets extending from the Eastern and North-eastern slopes of the hill country and the Eastern and North-central parts of the country [10]. They inherit an ancient culture that values the interdependency of social, economic, environmental, and spiritual systems. The Great Genealogy/Dynasty or *Mahāvamsa*, an ancient non-canonical text written in the fifth century CE on the Kings of Sri Lanka (the first version covers from 543 BCE to 304 CE) records *Veddā*'s origin dating back to the fifth to the sixth century BCE. Recent studies show that *Veddā* is genetically distinct from other populations in Sri Lanka [11–13] and most likely descends from early *Homo sapiens* who roamed the island. Hunting has been the mainstay of this group and skills still remain, using bow and arrows to hunt forest animals [14] and aquatic fish species that satisfy the animal protein supply. The hunter-gatherer lifestyle that *Veddā* subsisted on has now partly been replaced; they engage in crop cultivation to supplement grains and vegetables for food.

Traditionally, the *Veddā* group prepares meat and fish by direct roasting over wood fire, covering with hot ashes or smoking, and drying on a wooden rack [15, 16]. Excess hunt is sun-dried or smoked to preserve for rainy



(See figure on previous page.)

Fig. 1 Maps of Sri Lanka showing **a** Elevation map based on Digital Elevation Model, **b** Precipitation map showing Wet Zone, Intermediate Zone, and Dry Zone, and **c** Vegetation map ([1], with permission). Black circles in the maps indicate archeological and paleo-environmental sites of the island covered in the studies of reference [1]. Sri Lanka, formerly known as Ceylon is an island in the Indian Ocean, South-east of Indian subcontinent. Island terrain is primarily low, flat to rolling plain with mountains in the South-central interior. Island's climate is tropical monsoon. The mountains and the South-western part of the country (wet zone) receive annual average rainfall of 2500 mm and the South-east, East and Northern parts of the country (dry zone) receive between 1200 and 1900 mm of rain annually. The arid North-west and South-east coasts receive the least amount of rain, 600 to 1200 mm per year. There is strong evidence of prehistoric settlements in Sri Lanka that goes back to ~ 125,000 BP

seasons. Harvesting honey of various forest insects is a regular task and a group activity. Honey is for direct consumption and for meat preservation [17]. A sausage-like product, “*Perume*,” is an energy- and nutrient-dense preserved form of meat. Alternative layers of meat and fat consist this product with variations depending on the animal type (deer, venison) and parts (monitor lizard tail stuffed with fat from the sides of the animal, or clotted blood). Boneless game meat, roasted rice (*Oryza sativa*) flour, green chili (*Capsicum annuum*), cumin (*Cuminum cyminum*), coriander (*Coriandrum sativum*), and leaves of *Asamodagam* (*Trachyspermum roxburghianum*) are formed into balls, batter coated with rice flour and deep fried in *Bassia longifolia* seed oil to make “*Mas guli*” or “*Kurakkal*.” Present-day *Veddā*'s food reflects the use of condiments, spices, herbs, salt, and lime juice similar to making curries. Changing laws in the country that ensures conservation and sustainability of wildlife has limited the hunting lifestyle and the food sources of *Veddā* group.

Tubers and yams of forest origin mainly *Dioscorea* species (*D. spicata*, *D. pentaphylla*, and *D. oppositifolia*) and less often Aracea plants (e.g., *Arisaema leschenaultii*) roasted over direct fire is a carbohydrate source of the *Veddā*'s diet. Cultivated cereals such as rice, finger millet (*Eleusine coracana*), and maize (*Zea mays*) made into flour is for unleavened flatbread (*Roti*) or thick boiled flour paste (*Thalapa*) that accompany cooked smoked meat with gravy (*Ānama*) [18, 19]. When available, cereal flours are supplemented with cycad (*Cycas circinalis*) seed flour (sliced, dried, and ground) or *Bassia longifolia* flowers (dried and ground) for *Roti* and *Thalapa*. Various herbs, leafy vegetables, and unripe fruits of gourds and melons having medicinal and therapeutic properties are part of the regular diet. Among these, leaves of *Cassia tora*, *Ipomoea cymosa*, and *Memecyclon umbellatum*; ripe wild tree fruits and berries such as *Mangifera zeylanica*, *Nephelium longana*, *Hemicyclia sepiaria*, *Manikkara hexandra*, *Terminalia belerica*, and *Dialium ovoideum*; and wild mushrooms are integral. Transgenerational knowledge transfer on traditional systems for sourcing and sustainable harvesting practices of food, converting into safer ingredients (e.g., ways to reduce toxins and undesirable compounds while improving palatability, digestion, and safety), and effective

preservation technologies has enabled harmonic balance between human-forest environment while sustaining nutrition and health status of the *Veddā* group.

History-related influences

Sri Lanka has a continuous written history. Stone scripts as early as ~ 250 BCE, ancient texts together with remaining palm (*Ōla*) leaf texts evidence the knowledge on sophisticated agricultural practices and food preparations that appreciate intricacies of health and nutrition basis of foods. Archeological and documentary evidence found in Sri Lanka support continuous inward migration and convergence of various foreign nations ensuring trade, governing power, and diplomatic relations resulting in multiethnic nature of the foods and food traditions of the island.

The first recorded food-related hospitality is described in *Mahāvamsa* (Chapter VII), about a special incidence happened in fifth century BCE, between the noblewoman *Kuweni* and Indian prince *Vijaya* and crew. This Aryan language-speaking group of 700 from Northern India landed in the north-west coast of the island (coinciding with the passing away of lord *Gautama Buddha*) was served with special rice preparations, sweets made from rice, rice flour, *jaggery* (a traditional sweetener [20]), honey, and a variety of local fruits [21–23]. Reintroduction of Buddhism in third century BCE (250 to 207 BCE) and subsequent invasions, occupancies, royal marriages between foreign nations had a profound impact and significant contribution to the island food culture. Several nations including, Arabic, Roman, Oriental, Central Asian, and Indian in the early centuries for internal and foreign trade, and the domination of three European nations (Portuguese, Dutch, and English) in the island governance since 1505 AD had profound influence on Sri Lankan culinary tradition and style. Buddhism and Hinduism that existed since ancient times with the later introduction of Islam and Christianity influenced the religious aspects of food culture, traditions, and taboos. Low consumption of meat, particularly beef, even today may have a religious influence. Similar to the cultural practices and languages, all these foreign influences enriched Sri Lankan food culture than taking

presidency over in converting to a microcosm of another culture or a nation.

Food and traditional medical systems

Ingredients and preparation processes of traditional Sri Lankan foods have a strong relationship with maintenance of general health and prevention of non-communicable diseases (NCDs) of the consumer in addition to providing required nutrition. Today, the deeply rooted indigenous medical system (*Hela Wedakam* since the time of multi-talented local ruler *Rāvana*, time unknown) co-exists with the Ayurvedic since pre-Aryan civilization (*Siddha* and *Unani*) and the Western medical system introduced during the colonial era. Although taste and appeal are the key, the indigenous medical system emphasizes the use of ingredients and preparations that suit general wellbeing, physiological condition, involved activities, and disease conditions of the consumer, and the environment and climate of the consuming location as primary considerations. Indigenous medicine-based healing system focuses on mental and physical fitness simultaneously, bearing some similarities with Ayurveda but diverges in practice and constituents. Maintaining harmony between the human being and nature and integration of foods that nature provides in keeping the balance of bodily systems are the fundamentals of the indigenous medical system. Avoidance of extremes and selective use of opposites of “hot/heaty” and “cold/cooling” foods is embedded in indigenous and Ayurveda systems [24].

Foods and food preparation

Being a predominantly agrarian society, food culture and traditions in Sri Lanka have evolved with the cultivated crops, daily activities, beliefs and the seasonal nature of food sources. A typical traditional meal comprises a carbohydrate source/s (grains or grain products, tubers, or starchy fruit) and accompaniments providing protein, lipids, fiber, and micronutrients. Protein sources are animal or plant (e.g., cashew nut, *Anacardium occidentale*) based and lipids are mainly from plants, especially from coconut (*Cocos nucifera*) or sesame (*Sesamum indicum*). A variety of fruits, pods, seeds, leaves, tubers, stems, and flowers of native plants are included in the meal as various preparations. Ripe local fruits, buffalo milk curd with a sweetener, and simple sweetmeats are the common dessert options. A “Chew of Betel” comprised of betel leaves (*Piper betle*) and arica nuts (*Areca catechu*) with tropical aromatic spices such as cardamom (*Elettaria cardamomum*) finishes the traditional meal. The diverse nature of sources and preparations makes the plate of a Sri Lankan meal comprised of a range of colors, tastes, and flavors. When eating food, usually fingers are used, particularly the right hand. Each bite of food is a mix of

all food items in the plate that is squeezed well and mixed with fingers to combine all flavors and tastes.

Grains and grain products

Rice and rice-based products

Rice is the staple and the main carbohydrate source of Sri Lankan diet since ancient days. Cultivation of paddy and production of rice has been central to societal, cultural, religious, and economic activities of the island [17, 25]. The Cascade Tank-Village System of Sri Lanka is a recognized Globally Important Agricultural Heritage System that provides water needs for water-intensive rice cultivation securing food supply and creating a resilient ecosystem while preserving biodiversity and associated traditional knowledge [18, 26].

The *indica* varieties of rice are the primarily cultivated types in Sri Lanka. Among the traditional rice varieties, eating quality traits and grain milling characteristics, e.g., small round grains, thin long grains, pigmented (red-brown), fragrant, etc. are equally important considerations as agronomic performances. The low-protein levels (average value of 7.7% compared with 12.4% in traditional rice varieties) and high glycemic index (GI) [27] of modern rice varieties is a concern because of the considerable daily intake. In 2016, the per capita consumption of rice including rice-based products was ~ 114 kg per year providing 45% total caloric and 40% total protein requirement of a Sri Lankan [28]. Increasing science-based evidence and awareness of health benefits of the major and minor nutrients of traditional rice varieties have boosted production of indigenous varieties making them available for the average consumer [27, 29].

Traditional rice preparations Processing of paddy into edible rice grains, once a household task, is now an industrial operation. Unpolished rice and red-pigmented rice are considered superior in health benefits since ancient times. Parboiling has been in practice since time unknown and can be done for *indica* varieties. Boiling in water allowing grains to absorb all or rarely draining excess water out makes rice ready for consumption. Simple additives besides salt, vegetable oil, and ghee, turmeric (*Curcuma longa*), curry leaves (*Murraya koenigii*), *rampe* leaves (*Pandanus amaryllifolius*), cardamom, and/or nutmeg (*Myristica fragrans*) are cooked with rice depending on the choice of the consumer. These additives bring color, aroma, and flavor to rice while impregnating with water-soluble components having antioxidant and antimicrobial activities. Complex rice preparations include incorporation of different fat types, dairy products, coconut milk, honey, vegetables, and fruits. These practices essentially enhance nutrient density, flavor, and taste of cooked rice; such are central in festivities, religious, and spiritual offerings. A meal portion of warm

cooked rice with the accompanying curries, salads, and chutneys when wrapped in mildly withered (on direct heat to be pliable) banana (*Musa* spp.) leaves infuses leafy aroma to the content. This traditional meal presentation is common for packing meals and adorned by all regardless of age or social status.

Milk rice is a specialty in Sri Lankan food culture (Table 1, Fig. 2a). This preparation of non-parboiled rice cooked with coconut milk (rarely with dairy) can be a regular meal item adored by consumers of all ages and social levels. Milk rice of various forms takes a central place in the traditional ceremonies, devotions, and festivities. Elaborative milk rice preparations include the addition of mung bean or green gram (*Vigna radiata*) (Fig. 2b; cereal-pulse blends complement in improving essential amino acid profile and recommended by the FAO), sugarcane (*Saccharum officinarum*) jaggery, or grated coconut infused with concentrated sap of palm inflorescence (treacle) [22, 30].

Certain rice preparations are household remedies for various ailments. Leftover cooked rice of the previous night (no refrigeration) without reheating is a highly favored breakfast item that delays hunger. *Diyabath* made with leftover cooked rice (Table 1, Fig. 2c) can lower gastric acidity [31]. Mixing fresh cow's milk or curdled water buffalo milk with cooked rice enhances medicinal value and consumed by the locals where such milk products are abundant. A porridge-style or gruel preparation of roasted, non-parboiled rice is an easily digestible, energy-dense food for individuals recovering from any sickness (Fig. 3a). Although *indica* rice varieties have high amylose content (23–31%) in starch that resists digestion and pose low GI, longer cooking time, and excess water in porridge preparation can result in a high degree of starch gelatinization that increases digestibility [32]. Rice porridge can be enriched with protein and fat of coconut milk, sweetened with palm jaggery or treacle, or spiced with onion (*Allium cepa*), ginger (*Zingiber officinale* Roscoe), and garlic (*Allium sativum*), with or without various pulverized/juiced green leaves having medicinal value (Fig. 3b). Even today, the green leaves popular for porridges are *Aerva lantana*, *Asparagus racemosus*, *Cardiospermum halicacabum*, *Centella asiatica*, and *Vernonia cineria* which are known for their medicinal and therapeutic value in providing blood sugar controlling, anti-inflammatory, and/or blood-purifying effects according to indigenous and Ayurveda medical systems.

The recipes and notes maintained by chef clans for royal families of pre-colonial era show the use of various vegetable oils and animal fats in rice preparations. The sacred food offering to the Temple of Tooth Relic in Sri Lanka includes a wide range of traditional food items about 32 in number at a time, which is an honorable

task these chef clans performed and still maintained [33]. Present-day rice preparations in Sri Lanka reflect the influence of several ethnic cultures. Mixing cooked rice with tempered vegetables, especially carrots, leeks, and green peas, and garnishes such as cashew, raisins, meat, and egg in making fried rice could be a convergence of British and Oriental food preferences. *Biriyani*-style rice of Northern or Central Asian culinary tradition remains with a selection of spices and oil (vegetable oil replaces ghee) that are preferable to the local palate. The *Lamprais* is rice cooked with flavored oil and lumped together with shellfish-based fried chutney, curried plantains, and meat (poultry, beef, or mutton) and has Dutch influence.

Rice flour-based preparations

Traditionally, rice flour is prepared either by pounding grains (dehusked grains soaked and drained) in a wooden or stone mortar with a wooden pestle or grinding between two flat stone slabs which is now replaced by commercial-scale flour mills or home-scale electric grinders. Flour particle size is controlled by sieving with different mesh sizes.

Gruels (*Thalapa*, *Kanji*; Fig. 2d), unleavened flatbreads (*Roti*; Fig. 2e), string hoppes (*Indiappa*; Fig. 2f), hoppes (*Āppa*; Fig. 2h), and *Pittu* (Fig. 2i) that are made primarily from rice flour comprise the main meal item in the traditional diet and consumed with suitable accompaniments (Table 1). Flours of other grains and plant materials are combined depending on the product. Some of these food products are found in the South Indian food traditions. Mild fermentation, heat denaturation, and/or gelatinization of starch and protein of grain flours [34, 35] during steaming (moist-heat treatment) of the wet pastes or roasting of flour slurries create the unique structures, textures, and tastes of these products.

Other cereals and pulses

Various grains requiring far less water than rice to grow are common in low-rainfall seasons and non-irrigating areas and replace rice in the meals.

Cereals

Grains of finger- (*Eleusine coracana*), proso- (*Panicum miliaceum*), foxtail- (*Setaria italica*), and kodo- (*Paspalum scrobiculatum*) millets and maize are primarily converted into flour for various products (Figs. 2b, d, e, j, k and 3c, Table 1). Boiled maize cob is a popular snacking item and now a street food. Incorporation of wheat flour to the Sri Lankan food culture may be since the Portuguese invasion, now a sought-after ingredient for many flour-based foods [19]. Depending on the availability, flours of cycad seeds or *Bassia longifolia* dry flower supplement the grain flour. Hypocholesterolemic and

Table 1 Popular cereal and cereal flour-based meal items identified with their name, ingredients and method of preparation

Name of the food	Main ingredients	Method of preparation	Accompaniments	Remarks
<i>Kiribath</i> / milk rice (Fig. 2a)	Rice, coconut milk.	<ul style="list-style-type: none"> - Rice is cooked, mix with coconut milk and cook till grains hold together. - Form into shapes or cut into pieces after forming a soft cake. 	<ul style="list-style-type: none"> - <i>Lunumiris</i>; a coarse ground mixture of onions, dry chili, salt and lemon. - Curried vegetables, fish or meat. - Molded with sweetened coconut makes <i>Imbul kiribath</i>. 	<ul style="list-style-type: none"> - Rice can be supplemented with green gram (<i>Mung kiribath</i>, Fig 2b) - Dairy milk can replace coconut milk. - Cooked rice grains are held together by the soft gel network created from gelatinization of released starch and denatured coconut milk protein.
<i>Diyabath</i> (Fig. 2c)	Cooked rice, water, condiments, with/without coconut milk.	<ul style="list-style-type: none"> - Soak cooked rice overnight in water at room temperature. - Garnish with shallots, salt and green chili. 	<ul style="list-style-type: none"> - Consume as a whole food. 	<ul style="list-style-type: none"> - Mild fermentation may have occurred. - Consider as a suitable remedy for gastric acidity and to reduce blood glucose levels.
<i>Thalapa</i> (Fig. 2d)	Flour of rice, finger millet, or cymas, water, salt.	<ul style="list-style-type: none"> - Boil flour-water slurry until a thick paste is formed. - Make balls with fingers. 	<ul style="list-style-type: none"> - <i>Ánama</i>; a thick gravy formulated with pulses (mung bean, horse gram) or meat. 	<ul style="list-style-type: none"> - A thick gravy is needed to consume sticky gelatinized flour balls without chewing.
<i>Roti</i> /flat breads (Fig. 2e)	Flour of rice, finger millet or cymas, fresh scraped coconut, salt, water.	<ul style="list-style-type: none"> - Portions of wet dough form into a flat circle and bake directly on a heated solid surface made of clay, metal or stone. - Use banana (<i>Musa</i> spp.) or <i>Macaranga peltata</i> (<i>Kenda</i>) leaves to cover <i>roti</i> surface that controls scorching and provides roasted green leafy aroma and taste. 	<ul style="list-style-type: none"> - <i>Lunumiris</i> - Curried vegetables, fish or meat. 	<ul style="list-style-type: none"> - Variations; mixing other additives such as finely chopped green leaves, green chilies, shallots or sugar to give savory or sweet notes. - <i>Kee Roti</i> is a fermented product. Prepared in a special vessel that provide, roasting and steaming capability, coconut milk is added during cooking. Then soak in sugar syrup soon after cooking. - <i>Koththu Roti</i> is a modern day popular street food, made with a wheat flour-based oil impregnated <i>roti</i>, cut into pieces, mixed and cooked in a heated metal platform with curry gravy, vegetables such as carrots, leeks and tomato, eggs and/or meat. The <i>roti</i> is thin and roasted separately before mixing, and believed to be of Malay origin.
<i>Indiappa</i> / string hoppers (Fig. 2f)	Flour of rice, finger millet, or wheat (fine particles), salt, water.	<ul style="list-style-type: none"> - A paste of steamed or roasted flour is prepared with near boiling water. - Extrude the paste to make fine continuous strands into a circular mound. Use a special press and a raised circular mat made of bamboo strips (now plastic). - Steam till flour paste strands becomes semi-vitreous, cooked, and the product holds together. 	<ul style="list-style-type: none"> - <i>Kiri hodi</i>; a thin to medium thick mildly spiced gravy of coconut milk. - <i>Sambōla</i>; a spiced grated fresh coconut. - Curried vegetables, fish or meat. 	<ul style="list-style-type: none"> - Direct heating of wet flour batter (25–30% moisture) with moist heat (steaming) cause complete or partial denaturation of starch and protein. - Modification of starch properties such as stabilizing granule swelling, controlling the release of soluble starch, and pasting properties leading to control gelatinization may occur at the stages of flour, paste and final product preparation. - <i>Laveriaya</i> (Fig 2g) is the sweet form made with grated coconut and palm treacle filling using rolled string hopper as the cover.
<i>Áppa</i> / hoppers (Fig. 2h)	Rice flour, coconut milk, salt, sugar.	<ul style="list-style-type: none"> - Thick flour batter is naturally fermented and then made thin with coconut milk for cooking. - Batter is spooned into a small heated wok and rotate to coat the pan. - Final product is a form of pancake with a crispy, lacey outer fringe and a spongy middle. 	<ul style="list-style-type: none"> - <i>Lunumiris</i>, - Curried vegetables, fish or meat. 	<ul style="list-style-type: none"> - The crispy outer fringe is a thin layer of roasted, and browned starch and protein of rice and coconut milk together with its oil. The spongy structure in the middle is created by trapped air in the heat denatured/ gelatinized starch and protein of fermented flour and coconut milk. - Addition of treacle, milk or eggs to the center during cooking or sugar to the batter enhances the taste and nutritional value.

Table 1 Popular cereal and cereal flour-based meal items identified with their name, ingredients and method of preparation (Continued)

Name of the food	Main ingredients	Method of preparation	Accompaniments	Remarks
Pittu/steamed rice cake (Fig. 2i)	Flour of rice, finger millet or other, fresh grated coconut, water, salt.	- Flour particles coat small coconut pieces and make small beads. - Flour-coconut beads are steamed. - Steaming as a mound or in a long (15-25 cm) cylindrical mold (bamboo or metal).	- Lunumiris - Heated coconut milk. - Curried vegetables, fish or meat.	- Starch and protein of the flour coating are gelatinized during moist heat treatment and holds the bead structure without disintegrating. - Addition of finely chopped green leaves enhances fiber and micronutrient level.

hypoglycemic effects of cycad seed flour have been reported [36]. Water lily (*Nymphaea pubescens*) seeds harvested from large water bodies where they grow naturally are prepared similar to rice and prescribed for diabetic patients [37].

Pulses and legumes

Mung bean and black gram (*Vigna mungo*) are common in rain-fed Chena cultivation (slash-and-burn cultivation method) and contribute to traditional diet and food products. Cowpea or black-eyed peas (*Vigna unguiculata* L. Walp), white or red skin, was popularized during the Green Revolution for intercropping. Horse gram (*Macrotyloma*

uniflorum) has well-recognized medicinal properties [38] and included in meals in various ways. Pigeon pea (*Cajanus cajan*) whole or split (dhal) is for curries and fried/roasted snacks. Chick pea (*Cicer arietinum*, both Kabuli and Desi) and lentil (*Lens culinaris*, red and green, Mysoor dhal) have been introduced after 1977 through the trade relationships with India [39]. Boiled whole grain pulses garnished with salt, coconut pieces, red chilies, and/or onion makes a simple meal (Fig. 2j, k). Curried red lentil has become a necessity in present-day Sri Lankan meals without limits of consumer income, type of occasion, or the social class. In 2011, lentil comprised > 70% of the average monthly per capita consumption of pulses amounting to 671 g/person/month [40].

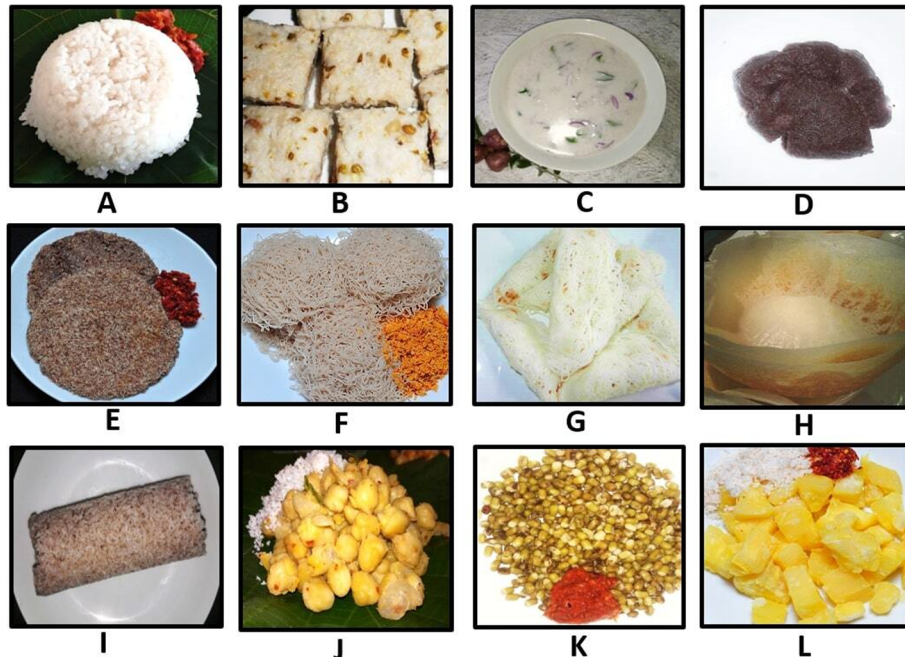


Fig. 2 Starchy staples of traditional Sri Lankan food items and meals are based on cereals, pulses and/or tubers. Some of the preparations do not show locality dependence but alternative cereals to rice is used according to abundance of the growing areas. A meal is comprised of a main food item and accompaniments which are usually paired with the food product. Accompaniments could be hot-savory and/or sweet. Fresh coconut kernel is used in a variety of ways mixed with cereal flour or in preparation of the accompaniments. **a** Milk rice with accompanying Lunumiris, **b** Milk rice with mung bean accompanied with Lunumiris, **c** Diyabath preparation, **d** Thalapa made of finger millet flour, **e** Roti made of rice and finger millet flour with Lunumiris, **f** String hoppers or Indiappa with Sambola, **g** Laveriya- sweetened string hoppers, **h** Plain Hoppers or Appa, **i** Pittu made of red rice flour, **j** Boiled chickpea with fresh scraped coconut, **k** Boiled mung bean with Lunumiris, **l** Boiled cassava roots with fresh scraped coconut and Lunumiris

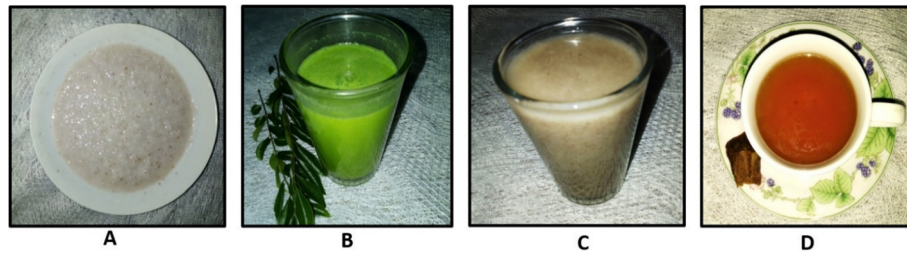


Fig. 3 Beverages based on leaves, flowers, stems, bark or root of plants and trees that are known for various health benefits are part of traditional foods of Sri Lanka. A creamy, smooth porridge-style beverage is prepared with cooked cereals or cereal flours and with fresh coconut milk and pulverized plant materials or their water extract. Herbal teas are prepared as water infusion or by boiling with water. Usually, herbal beverages are accompanied with palm *jaggery*. Herbal beverages prepared with cereals could be a breakfast meal due to their caloric-richness. Water infusions and extracts are consumed as herbal teas in any time of the day. **a** Plain rice porridge, **b** Rice porridge made with extract of plant leaves or *Kola Kenda*, **c** Porridge made with finger millet flour, **d** Herbal tea made with flowers of bael fruit

Accompaniments

Various preparations of animal and plant sources accompany the carbohydrate staple of the traditional meal. These accompaniments are prepared as a thin gravy (*Hodda*), sour curry (*Ambula*), thick gravy (*Niyambalāwa*), mildly cooked salad (*Malluma*), deep fried (*Thel Beduma*), or dry roasted (*Kabale Beduma*). Coconut milk, grated coconut, coconut (or sesame) oil, and a variety of herbs and spices are essential ingredients in these preparations [17]. Some of these accompaniments are paired with main meal items. For example, milk rice goes well with *Lunumiris*, and *Sambōla* with boiled tubers or jack fruit. Similarly, some of the food items have preferred meal of the day, and physiology or health condition of the consumer depending on the health attributes of the source material, e.g., mung bean usually does not accompany the nighttime meal or a person suffering from the common cold.

Herbs and spices

Various herbs and spices add flavor while prolonging product shelf life. Almost all the herbs and spices used in traditional Sri Lankan cooking have reported antifungal, antimicrobial, bacteriostatic, fungicidal and/or fungistatic properties, or pH-lowering ability and medicinal value such as anti-inflammatory and anti-diabetic [41, 42].

Turmeric, the rhizome of *Curcuma longa* L. is an essential ingredient that gives unique yellow color and subtle flavor to Sri Lankan curries and rice preparations. Heat-blanching turmeric rhizome is dried and used as a powder or a paste. The main active ingredient, curcuminoids possess cardioprotective, hypo-lipidemic, antibacterial, anti-HIV, anti-tumor, anti-carcinogenic, and anti-arthritic activities [43].

The hot pungent taste and flavor of traditional dishes are primarily from ginger and black pepper (*Piper nigrum* L.) besides several hot chili pepper varieties. Oriental/brown (*Brassica juncea*) and black mustard (*B. nigra*), fenugreek (*Trigonella foenum-graecum*),

cardamom, nutmeg, cloves (*Syzygium aromaticum* (L.) Merr. & L.M. Perry) provide a range of flavors and aroma in the traditional dishes. The dried husk of *Garcinia gummi-gutta* (L.) Roxb. (Gambooge, formerly *G. cambogia*), and the flesh of ripe tamarind (*Tamarindus indica* (L.) pods give a tart note and increase the viscosity of the medium. The lemons (*Citrus limon*), limes (*Citrus aurantiifolia*), and fruits of *Averrhoa bilimbi* (Oxalidaceae; *Bilin*) are used for sour, tangy taste notes. The bark of cinnamon (*Cinnamomum zeylanicum*), Moringa (*Moringa oleifera*), and *Terminalia arjuna* are used in various preparations. Dry spices are used as whole, pieces, powder, or a wet paste. The traditional spice base (*Thuna-Paha*) is quite distinct in flavor and comprises either three (*Thuna*) seeds (coriander, fennel, and cumin) or five (*Paha*) aromatic spices (cinnamon, cardamom, turmeric, cumin, and curry leaves) together. Combinations and pre-treatments such as dry roasting create variations in the appearance and taste in the final spice preparation.

Preparation types

The variations of curries could be with a thin or thick gravy, moist without a gravy, white/yellow, red, black, sour, sweet, bitter, or hot-pungent. White curries are made pungent with immature green chili, garlic, ginger, or ground black pepper. Red curries contain a considerable amount of red chili paste/powder with a few other spices. Black curries are prepared with dark roasted spices, especially coriander, fennel, and cumin [44]. Dry gambooge gives dark, brown-black color to the final preparation. Coconut milk, buffalo milk, or water is the base for gravy while roasted rice flour (bland, roasted), soaked and ground mustard (pungent), and ripe tamarind pulp (sour) are the primary thickeners. A thin spiced gravy made with ground coriander, cumin, black pepper, red chili, curry leaves, and garlic is *Kāyan hodda* or *Thambum hodi*; an appetizer and a remedy for various ailments including stomach disorders, reducing blood

cholesterol, and for post-confinement mothers. Seven different plant items curried together (*Hath Māluwa*, Fig. 4a) is a must in the traditional New Year (based on the movement of sun and constellations, and the arrival of spring in April) menu that accompanies milk rice and also for specific spiritual devotions. It is a macro- and micro-nutrient-dense plant-based dish made of fruits (e.g., squash), flowers (e.g., pumpkin *Cucurbita maxima*), green leaves, nuts (cashew, immature coconut), pods (e.g., long bean *Vigna unguiculata* or winged bean *Psophocarpus tetragonolobus*), seeds (e.g. pulses, jackfruit seeds), and tubers that can accompany any meal. Ingredient choices depend on local availability. Dried fish is optional [21].

Oilseeds, nuts, and other seeds

Plant oils are preferred over animal fats in regular food preparations. The use of clarified butter (*ghee*) is limited to infuse flavor and in devotion preparations. Coconut, the most sought-after oil-rich seed, is integral to the island's food culture since time unknown. Virtually, almost all parts of the mature coconut tree are utilized in a range of products for sustaining human life providing food, medicine, construction materials, decoration pieces, animal feed, and fuel. Coconut kernel fresh or dried, the water of the fruit, and inflorescence sap are all

direct foods or food ingredients. The liquid inside the immature coconut drupe is rich in electrolytes and sugars and considered the most natural drink after water. Fresh coconut kernel, finely grated, is an accompaniment to starchy staples. A spicy salad (*Sambōla*, Fig. 4b) is made with fresh scraped coconut, onion, chili, lemon, and salt. Such spicy coconut salad with thinly cut green leaves, starchy items such as pulses, tubers, breadfruit (*Artocarpus altilis*; *Del*) or jackfruit (*Artocarpus heterophyllus*; *Kos*) cooked together makes *Malluma*, a macro- and micronutrient-rich food. The water extract of mature coconut kernel or “coconut milk” is rich in protein and oil, an essential ingredient in Sri Lankan curries and gravies. Mildly cooked (near boiling) coconut milk with salt, turmeric, green chili, shallots, curry leaves, pandanus leaves, and lime juice makes *Kiri Hodi* (Fig. 4c) a versatile accompaniment for any meal. Mechanical pressing of dry mature coconut kernel produces oil for cooking or for lighting fuel. The pleasant nutty aroma and almost bland flavor of coconut oil make it a sought-after oil for deep frying. Oil extracted from fibrous residue is a filler in certain sweets or for animal feed.

Sesame oil obtained from mechanical pressing is valued for its medicinal properties and a popular food oil among the Tamil ethnic group. Whole seed is adorned

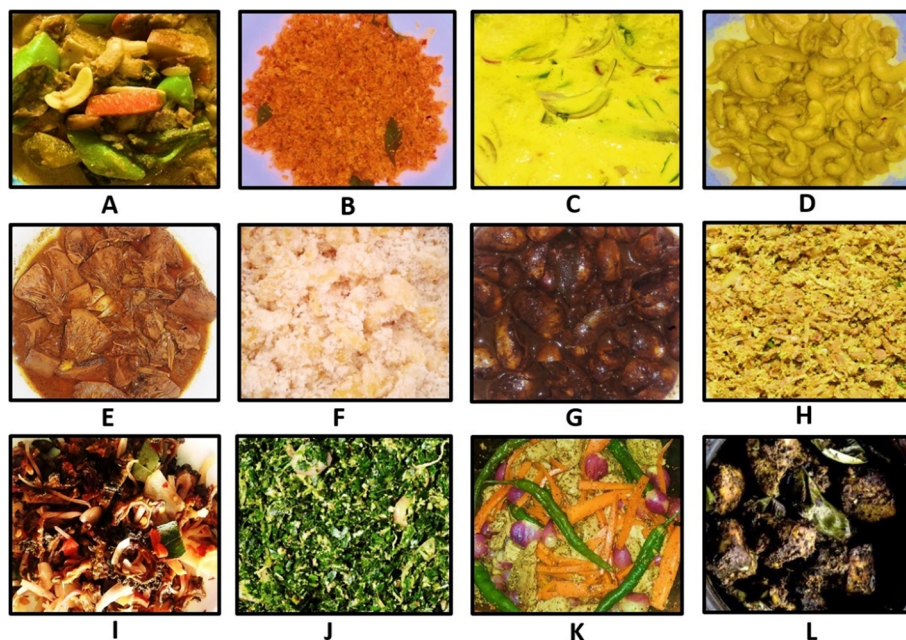


Fig. 4 Accompaniments are essential in the typical Sri Lankan meal plate. They are prepared with animal or plant sources and complete the main meal with starchy staple such as rice and rice flour-based food products. Accompaniments are prepared in various ways and consistencies. These accompaniments add protein, fats, dietary fiber and micronutrients and complete the nutrient package that the meal provide. Condiments and spices that are added and the way of preparation give a range of colors, flavors and taste while improving the eating satisfaction of the food. **a** *Hath Maluwa* made with seven ingredients, **b** *Sambōla*, **c** *Kiri Hodi*, **d** Curried cashew, **e** Curried immature jackfruit, **f** Boiled mature jackfruit perianth with scraped coconut, **g** Curried jackfruit seeds, **h** Bread fruit *Malluma*, **i** Fried bitter melon salad, **j** Green leaf *Malluma*, **k** Traditional Sri Lankan pickle, **l** Dry sour fish curry (*Ambulthiyal*)

in traditional sweetmeats and vegetable preparations [33]. Groundnut/peanut (*Arachis hypogaea*) oil is not traditional in Sri Lankan food but the whole seed is a cheaper alternative to cashew in sweetmeats. Roasted or oil tempered mature groundnut and boiled immature groundnut are popular snacks. Cashew takes a special place in Sri Lankan food culture. Mature cashew is a popular snack and tender or mature nut is used in various preparations. Curried mature/tender cashew (Fig. 4d) is an energy-dense (48.3% lipids, 20.5% protein, ~4% dietary fiber and free sugars) vegan dish [45, 46] and essential ingredient for the *Hath Māluwa*.

Tubers, roots, and their products

Various tubers and roots (yams) satisfy carbohydrates in the Sri Lankan diet. The edible species of *Dioscorea* and *Colocasia* are the most popular. Tubers of *Amorphophallus paeoniifolius* (elephant-foot yam), *Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea sativa*, and *Typhonium trilobatum* (Bengal arum) are consumed since historical times [30]. Arrowroot (*Maranta arundinacea*), cassava/tapioca (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas*), and red-colored *Canna discolor* may be introductions by the Portuguese [47]. Potato (*Solanum tuberosum*), a popular root vegetable, has been introduced by the British ~ 1850 [48].

Yams boiled in water with or without salt accompanied by grated fresh coconut and *Lunumiris* or *Sambōla* makes a meal (Fig. 2l). Whole yams are stored in dry conditions such as sand pits for off-seasons. Thinly sliced yams are sundried and make into flours for supplementing *roti* and gruels.

Fruits and vegetables and their preparations

The traditional meals comprise a wide range of plant materials of different species prepared in a variety of ways. Pre-treatments such as steaming, sun drying, and soaking in salt or acidified water are practiced for some plant items as they contain potentially harmful compounds and/or enzymes that can release toxic compounds; e.g., alkaloids, cyanogenic glycosides that release hydrocyanic acid [17].

Two *Moraceae* trees, jackfruit, and breadfruit found ubiquitously in the island provide many edible components. Jackfruit, a multiple fruit that grows in the tree trunk, is the largest fruit known; the achenes with fleshy perianth covering the seed comprise a fruit. Both perianth and seed are edible and record significant nutritional, phytochemical, and medicinal value [49–51]. All developing stages and components of the multiple fruit are edible, e.g., inflorescence, young fruit, mature starch-rich fleshy perianth, starch-rich seed, and perianth of the ripe fruit. The young fruit (*Polos*) is considerably high in phenolic compounds and dietary fiber

and processed as a vegetable that provides several health benefits (Fig. 4e). These various jackfruit components and preparations are enjoyed regardless of age, social status, or physiological condition of the consumer. The starchy perianth (~ 25% carbohydrates) of one jackfruit provides a meal for several individuals. The simplest preparation is the small cut pieces of mature perianth boiled in water with salt until soft. Popular accompaniments are curried meat, fish or dry fish, and grated coconut kernel or *Sambōla* (Fig. 4f). Low GI (< 55%), and high levels of dietary fiber and slowly available glucose (30%) have been reported for such meals [51]. Starch-rich jackfruit seed is a good source of fiber, protein and vitamins [52], makes an appetizing food when boiled, roasted, or curried (Fig. 4g). When ripe, the starchy perianth becomes a fragrant, sweet-tasting dessert fruit either with soft, melting pulp (*Wela*) or firm, fleshy pulp (*Waraka*).

The mature breadfruit is rich in starch and considered a “heaty food.” The food preparations are more or less similar to jackfruit and the curried or *Mallun* preparations accompany rice (Fig. 4h). The reduction in glucose absorption upon breadfruit consumption is linked to its fiber components [53].

Various types of gourds (snake, ridge, bitter, bottle), squashes, melons, beans (long, French, winged, broad) are popular traditional vegetables. Health benefits and medicinal properties of the edible plant parts are serious considerations when incorporating in a meal than their taste. For example, although tastes bitter, the bitter melon/gourd (*Momordica charantia*, Fig. 4i) is a very popular vegetable for curries and salads. The ability of *M. charantia* to control blood glucose levels in type 1 and type 2 human diabetes is supported by traditional medicine and scientific research [54, 55].

Green leaves of various local plants having positive health attributes enrich the meal with fiber and micro-nutrients. The most common preparation is *Malluma* (Fig. 4j), thinly sliced tender leaves mixed with grated coconut and spiced to provide pungency and acidity making a salad-style preparation that is consumed fresh or with mild heating. Few examples are *Gotu kola* or Indian pennywort (*Centella asiatica*) which has many health benefits including neuroprotective, brainpower and eyesight improving, bitter-tasting leaves of green milkweed (*Wattakaka volubilis*/*Dregea volubilis*) and crepe gingers (*Costus speciosus*) are considered to lower blood glucose levels, Indian coral tree (*Erythrina indica*) leaves are natural de-worming food for young children and the leaves, flowers of vegetable hummingbird tree (*Sesbania grandiflora*) is a good source of antioxidants and calcium, and *Alternanthera sessilis* (sessile joyweed/drawf copper leaf) from aquatic environment relieves simple digestive problems [56]. Greens mixed with

cooked pulses, yams, unripe jackfruit, or breadfruit also make popular accompaniments.

Vegetable as pickles or relishes makes a taste-enhancing side dish for the traditional meal. The young fruits of papaya (*Carica papaya*), jackfruit, mango, Ceylon olive (*Elaeocarpus serratus*), *Spondias dulcis*, or the stems of *Lacia spinosa* with shallots and green chilies combined with coconut vinegar as the acidulant with the flavor supplemented by the pungent isothiocyanates released from wet pastes of mustard and chopped pieces of Moringa root bark makes the traditional Sri Lankan vegetable pickle (Fig. 4k). Immature fruits of mango (*Mangifera indica*), forest mango or hog-plum (*Spondias pinnata*), Indian gooseberry (*Phyllanthus emblica*), and boiled fruits of Ceylon olive garnished with hot chili and salt are popular snacks and available from present-day roadside vendors.

A wide range of ripe fruit such as mango, papaya (*Carica papaya*), pineapple (*Ananas comosus*), passion fruit (*Passiflora edulis*), anona (*Anona reticulata*), durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), mangosteen (*Garcinia mangostana*), guava (*Psidium guajava*), banana, and jackfruit are common dessert fruits accompanying the main meal. Usually, wood apple (*Limonia acidissima*), bael (*Aegle marmelos*) fruit, and avocado (*Persea americana*) are further prepared by mixing with a sweetener, salt, and/or lemon/lime juice.

Sweetmeats, snacks, and desserts

Sweetmeats are snacking foods that occupy a special place in regular life, festivities and offerings, and adorned in folklore poems, stories, and historical texts. The fourth century CE *Thonigala* rock inscription indicates the quantity of a meal provided with the food items such as curd, bee honey, sweets, sesame, butter, salt, green herbs, and turmeric in between the morning and noon for the refectory of the monastery [57]. Family and friendly visits accompany bundles of sweetmeats and the content varies with the locality, availability of the expertise, and affordability. Obvious regional variations depending on the ingredients found in the ecoregions reflect the product diversity. Visitors during non-meal times are served with sweets available in the house with hot or cold beverages. Sweets are usually accompanied by ripe banana of different types. Home-made sweets are essential food items of the traditional New Year celebrations for the family, visitors, and friendly food exchanges. Traditional sweeteners are bee honey, treacle and *jaggery*, which now replaced mostly by cane or corn sugar. *Jaggery* and treacle making involves collection of sugar-rich inflorescence sap of *Caryota urens* or *Cocos nucifera* palms into clay pots containing fresh lime, pieces of *Vateria copallifera* and/or *Careya arborea* tree bark, and leaves of *Azadirachta indica* (avoids

fermentation), then boiled to become a thick brown syrup for treacle or further concentrated to a solid soft enough to bite as *jaggery* (65–85% total sugar) [20, 58].

The starch base for sweetmeats is mainly rice flour. Supplementation with mung bean, finger millet, or black gram flour brings variations. Depending on the product, particle size, moisture content, and pre-gelatinization are significant considerations in preparing the flour base. Coconut milk, fresh scraped coconut, dry aromatic spices (e.g., ginger, black pepper, cardamom, nutmeg and cloves), cashew, and sesame seeds enrich these preparations. Coconut oil is the preferred medium for deep frying. The non-deep-fried products are usually flattened and cut into pieces or formed into shapes (Table 2). The simplest and the most ancient sweetmeat is *Aggalā* (Table 2, Fig. 5a) which is made with rice flour and sweetener syrup. Popped rice (*Vilanda*) with bee honey is another ancient sweetmeat even mentioned in Buddhist literature.

Among the deep-fried sweetmeats, few variations of oil cakes (*Kevum*) are central in the traditional food culture. For oil cakes, a mixture of rice flour-liquid sweetener prepared in various ways is deep fried to obtain a soft-spongy cake about 2-bite sizes. Variations of the product (Table 2, Fig. 5b–e) are created by heat and moisture treatments during the batter preparation, sweetener type (treacle vs cane sugar), mixing of roasted mung bean flour, and addition of coconut milk, etc. The “*Undu Walalu*” (Table 2, Fig. 5f) which is a famous sweetmeat of the central hilly areas of the country is an example of eco-region specialty. The *Aasmi* or *Del Kevum* is a unique Sri Lankan fried sweetmeat of semi-circular shape that has filigreed white honeycomb look and soft-crispy texture (Table 2, Fig. 5g). Although not sweet, *Kokis* (Fig. 5h) is a fried, molded (different shapes) batter of rice flour and coconut milk colored with turmeric, with a crunchy, crispy texture and nutty taste, and may be of Dutch origin [16, 19].

Among the other non-deep-fried sweetmeats, *Aluvā* (Fig. 5i) and softer, semi-moist *Dodol* have few variations. The dark brown/black *Kalu Dodol* (Fig. 5j) made from coconut milk and treacle is a special delicacy of the island south while the not so dark product *Kiri Dodol* is made with dairy milk and a specialty in the mid-country. Granules of *Pittu* sweetened with sugar syrup and cut into pieces makes *Welithalapa/Sow Dodol* (Fig. 5k). Moreover, roasted nuts, seeds, and pickled fruits are simple snacking foods. Sesame seeds mixed with honey, *jaggery*, with or without coconut and made into balls (*Thala Guli*) is a timeless popular product.

Helapa (Table 2, Fig. 5l) is a unique sweetmeat prepared by steaming the mixture of rice flour, finger millet flour, grated coconut, and a sweetener [16]. Deep-fried fritters (*Wade*) is made from soaked split pulses (e.g.,

Table 2 Popular traditional sweetmeats; ingredients, method of preparation and the variations

Name of the food	Main ingredients	Method of preparation	Remarks
<i>Aggala</i> (Fig. 5a)	Roasted rice coarsely ground into flour, coconut or <i>Kithul</i> treacle, roasted and cracked mung bean, grated coconut, cashew, sesame, ground black pepper.	<ul style="list-style-type: none"> - Mixture of rice flour and ingredients is thickened with heat. - Form small balls of the paste and dusted with roasted flour. 	<ul style="list-style-type: none"> - Ground cinnamon, black pepper and cashew pieces enhance taste. - Sesame seeds can be used for the coating. - Variations come from the flour source: left-over cooked rice dried, roasted and ground, roasted jack fruit seeds, or roasted maize seeds.
<i>Kewum</i> /oil cakes (Fig. 5b)	Unroasted rice flour, coconut or <i>Kithul</i> treacle, salt, cumin (optional).	<ul style="list-style-type: none"> - Mixture of rice flour-liquid sweetener is portioned into boiling oil. - Deep fry till a brown skin is formed. - Mixture of flour and sweetener without any preheating makes a soft-spongy cake in the middle. - Cooking of flour and liquid sweetener makes a denser middle structure and creates a product variation. 	<ul style="list-style-type: none"> - Variations are as <i>konda kewum</i> (Fig 5b), <i>hendi kewum</i> and <i>athirasa</i>. - Non-heat-treated rice flour mixed with liquid sweetener creates a soft, spongy texture with air holes in the middle of <i>hendi</i> and <i>konda kewum</i>. The skilled cook can raise the middle of the cake like a hair knot during cooking and makes <i>konda kewum</i>. - Portions of heated mixture of flour and sweetener is made into flat circles and deep fried until brown skin is formed makes <i>athirasa</i>.
<i>Mung kewum</i> (Fig. 5c)	Unroasted rice flour, flour of roasted mung bean, coconut or <i>Kithul</i> treacle, turmeric.	<ul style="list-style-type: none"> - Rice and mung bean flour mixed with liquid sweetener to a thick but pliable paste. - Flattened paste is cut into shapes or made into balls, batter coated (made of rice flour and turmeric) and deep fried. 	<ul style="list-style-type: none"> - Horse gram flour can replace mung bean. - Variations: <i>Nāran kewum</i> (Fig. 5d) - Coarse pieces of roasted mung bean, cashew, with sweetened scraped coconut mixture made into balls, batter coated and deep fried. - <i>Pittu</i> cooked in liquid sweetener until hold together to form balls and batter coated and deep fried.
<i>Undu walalu</i> (Fig. 5f)	Black gram (skin removed) flour, unroasted rice flour, coconut milk, sugar syrup or <i>Kithul</i> treacle, salt.	<ul style="list-style-type: none"> - Mixture of black gram and rice flour poured as a single strand through a small opening into boiling oil making a circular/coil shape structure. - When cooked soak in a sugar syrup. 	<ul style="list-style-type: none"> - Polysaccharides of black gram creates thick viscous consistency of the mixture. - Wheat flour can replace some amount of rice flour but creates a denser texture.
<i>Āsmi</i> (Fig. 5g)	Unroasted rice flour with fine particles, water and coconut milk extract of <i>Neolitsea involucrate</i> (<i>Dawul kurundu</i> leaves), salt.	<ul style="list-style-type: none"> - Mixture of rice flour and the slimy leaf extract is directly poured into a wok of boiling oil using a strainer (a coconut shell with tiny holes drilled in the bottom) to make a circular shape structure and fold-in-half during cooking. - A second deep frying of the product after 1–2 day of storage. - Decorate the top of the product with condensed sugar syrup (can add food coloring) before consumption. 	<ul style="list-style-type: none"> - Mucilage-rich leaf extract provides continuous flour mixture strands during pouring and keeps structure pliability to fold into a semi-circular shaped product while frying. - A second frying gives the pure white color, delicately soft but crunchy texture. - Colored sugar syrup enhances taste and appearance.
<i>Kokis</i> (Fig. 5h)	Unroasted rice flour coconut milk, salt, turmeric, eggs (optional).	<ul style="list-style-type: none"> - A special heated mold is dipped into the slightly thick flour batter. - The mold with batter coating is deep fried until the batter turns golden brown. - Use a skewer to release the crispy product from the mold. 	<ul style="list-style-type: none"> - Brass mold (<i>kokis achchuwa</i>) comes in different shapes e.g., flowers, butterflies, stars, etc. and has a long handle. - Complex interactions of starch, protein and oil of the batter makes crispy yellow-brown product.
<i>Aluvā</i> (Fig. 5i)	Roasted rice flour, coconut or <i>Kithul</i> treacle, salt.	<ul style="list-style-type: none"> - Cook rice flour-sweetener syrup mixture till a thick paste is formed. - Flattened the paste, cut into pieces and dust with roasted flour to prevent sticking. 	<ul style="list-style-type: none"> - Cashew, sesame seeds, roasted shredded coconut, ground black pepper and ground dry ginger enhance, taste and flavor of the product.
<i>Kalu dodol</i> /glutinous rice cake (Fig. 5j)	Unroasted rice flour, coconut milk, coconut or <i>Kithul</i> treacle or jaggery, cashew, cardamom, salt.	<ul style="list-style-type: none"> - Rice flour, coconut milk and sweeteners together are cooked and simmer till oil separate out. - Cooked flour mixture becomes a thick soft jelly that holds together. - Oil is spooned out and the soft gel is either transferred to a tray or folded in a cleaned wide base part of the arica nut 	<ul style="list-style-type: none"> - Spices and cashews enhance taste. - Sago beads can be used. - Through oil removal extends product shelf life. - Complex changes occur with the protein, starch and lipids of the ingredients; Maillard reaction, lipid-protein interaction and polymerization, browning, etc.

Table 2 Popular traditional sweetmeats; ingredients, method of preparation and the variations (*Continued*)

Name of the food	Main ingredients	Method of preparation	Remarks
<i>Welithalapa/Sowdodol</i> (Fig. 5)	Unroasted rice flour, scraped coconut, cardamom, coconut or <i>Kithul</i> treacle, salt.	tree. - Serve as cut pieces. - Granules of <i>pittu</i> is made first then cooked in sweetened sugar syrup with flavorings until granules hold together. - Cooked mixture is flattened and cut into pieces.	- Smaller and uniform <i>pittu</i> granules are preferred. - Variation: the mixture can be formed into small balls, batter coated and deep fried to make <i>Nāran kevum</i> .
<i>Helapa</i> (Fig. 5l)	Unroasted rice flour, finger millet flour, scraped coconut, coconut or <i>kithul</i> treacle, leaves of <i>Macaranga peltata</i> .	- Mixture of rice and finger millet flour with sweetened coconut (<i>peni pol</i>) is portioned and flattened between folded leaves of <i>Macaranga peltata</i> or banana. - Products are steamed until the flour mixture becomes a completely gelatinized mass.	- Moist heat gelatinizes starch and denatures protein and infuses unique leafy flavor notes to the product. - Supplementing the flour with ground dry flowers of <i>Madhuca langlifolia</i> , seeds of <i>Shorea megistophylla</i> or de-bittered seeds of <i>Vateria copallifera</i> depending on the availability improves health benefits of the product.

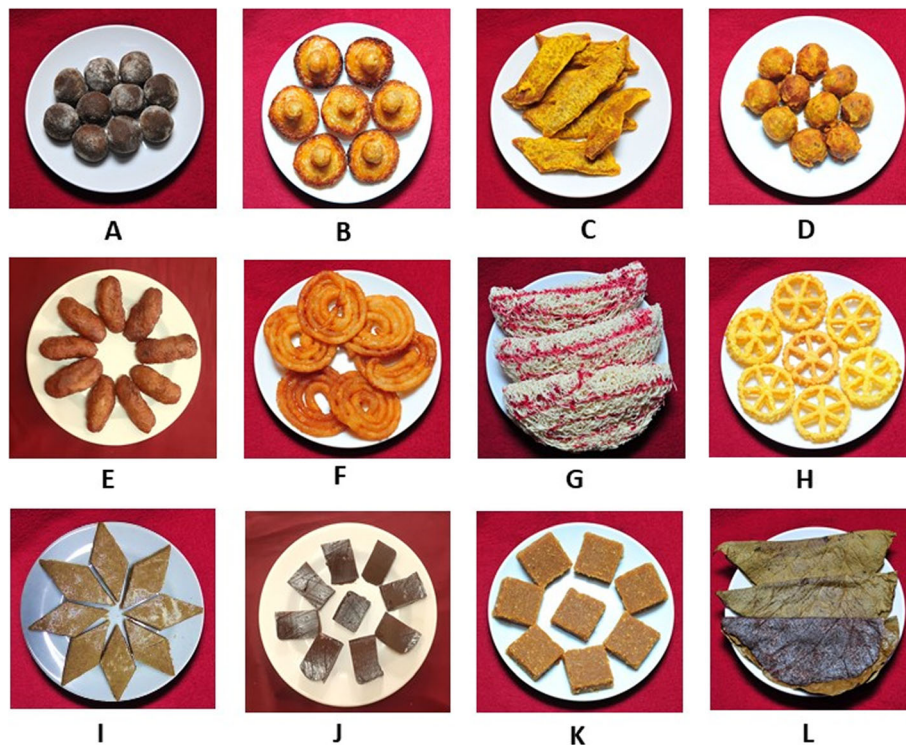


Fig. 5 Sweetmeats can be snack items or dessert food of the traditional main meal. Common ingredients for sweetmeats are cereal (rice, millet) or other grain flours, palm sap-based sweetener, fresh coconut kernel and vegetable oil. Preparation methods include steaming, deep frying, and roasting. Final products are of various shapes, texture and taste and some are local specialties based on the ingredients of the eco-region. **a** *Aggalā*; Balls formed from flour of roasted rice and a sweetener, **b** *Konda Kevum*; deep-fried knotted oil cakes made from a rice flour and a sweetener mixture, **c** *Mung Kevum*; deep-fried, batter-coated oil cakes of mung bean flour, **d** *Nāran Kevum*; batter-coated and deep-fried balls made from sweetened mixture of coconut, pieces of roasted mung bean and cashew nuts or balls of sweetened *Pittu*, **e** *Athirasa*; deep-fried oilcakes made from the flattened balls of rice flour and a sweetener dough, **f** *Undu Walalu*; sweetener infused deep-fried product of black gram flour and rice flour mixture, **g** *Aasmi*; deep-fried (2 times) product of a mixture of rice flour and viscous plant extract with sugar syrup decorations, **h** *Kokis*; deep-fried rice flour and coconut milk batter using a mold, **i** *Aluvā*; roasted rice flour and sweetener syrup mixture cooked, flattened and cut into pieces, **j** *Kalu Dodol*; dark brown/black soft, delicate sweet made of rice flour and coconut milk cooked together until a soft dark caramel color solid and then flattened and cut into pieces, **k** *Sow Dodol*; a cooked mixture of rice flour *Pittu* and a sweetener until a soft cake is formed and then cut into pieces, **l** *Helapa*; steamed dough of rice and finger millet flour with grated coconut and sweetener that is wrapped in *kenda* (*Macaranga peltata*) leaves. Preparation details of these products are in Table 2

lentil, chick pea, or mung bean) ground into a coarse paste and mixed with ingredients that contribute to a hot savory taste. Various pastry forms (e.g., *Cutlets*, Chinese rolls, *Pattis*) found today are introductions from foreign food cultures.

Puddings such as *Watalappan* and *Bibikkan* are desserts having international roots and use coconut milk or grated coconut, rice flour (for *Bibikkan*), eggs, and treacle or *jaggery* and involve heat setting by steaming or baking. Cooked Sago beads in water, sweetened and with or without dry fruits and nuts, generate a spoonable gel-like product and considered a cooling food.

Beverages, alcoholic and non-alcoholic

Natural springs provide regular drinking water; storing in unglazed clay vessels cools drinking water for the tropical household. The liquid of immature coconut drupe rich in sugars, vitamins, amino acids, and minerals is a highly valued natural beverage. King coconut, a native variety with an orange-yellow outer skin, provides a sweeter liquid than regular coconut, and a healthy drink with a cooling effect. Consumption of juices of local fruits is popular since ancient times, primarily for their therapeutic/medicinal properties. Different oranges and mandarin types; *Cirtus sinensis*, *Citrus aurantium*, *Citrus nobilis*, *Citrus reticulate*, and *Citrus madurensis* are common in households. Juice of sweet orange or pomegranate (*Punica granatum*) enhances recovery from minor ailments. Excessive consumption of citrus juices is considered affecting the chemical balance of the body towards more phlegmatic conditions. Sour orange juice mixed with honey and fresh ginger root juice is a household remedy for cough. Ripe fruits of *Aegle marmelos* and *Phyllanthus emblica* have medicinal value and usually made into nutrient-rich drinks. Watermelon that grows in the dry areas is a thirst quencher.

Traditional herbal teas (Fig. 3d) with associated health benefits were the common beverages before introduction of coffee and tea ~ 300 years ago. Dry flowers (e.g., *Cassia auriculata*, *Aegle marmelos*), leaves (e.g., *Justicia adhatoda*), roots (e.g., *Hemidesmus indicus*), barks (e.g., *Coscinium fenestratum*), stems (e.g., *Tinospora cordifolia*), young fruits (e.g., *Aegle marmelos*), mature fruits (e.g., *Coriandrum sativum*, *Phyllanthus emblica*), or whole plants (e.g., *Sida alnifolia*, *Aerva lanata*) having proven medicinal value is boiled in water and the extract is consumed with palm *jaggery*.

Coffee (*Coffea arabica* mainly) was introduced in part of the “production states” of the Dutch East-India trade scheme. Hot coffee is a beverage served for breakfast, late night, or cold rainy days. Coffee infused with cardamom, nutmeg, sugar, and milk is served chilled for warm afternoons. Tea (*Camelia sinensis*) and cocoa (*Theobroma cocoa*) were introduced around 1820 and

1834, respectively by the British for the commercial value in foreign markets [59]. Careful monitoring of soil, environmental conditions, and the production practices up to final dry tea preparation is crucial for the unique flavors and color of world-famous “Ceylon black tea.” Hot water infusion of black tea with or without milk and sugar is the beverage that starts the day and also common in social gatherings and festivities. Darker red infusion with strong tea taste sometimes with a slice of fresh ginger root is mostly preferred; the delicate fancy flavors or aroma-infused teas are only a modern consideration.

Fruit-based milk or smoothie-type traditional drinks are found in different eco-regions. Juice of mangrove *Sonneratia caseolaris* fruit mixed with coconut milk is a vitamin-rich, delicate refreshing drink with recognized medicinal value [60] and popular in the Southern coastal areas [17]. Wood/elephant apple fruit pulp blended with coconut or dairy milk is an authentic Sri Lankan beverage. Ripe banana and coconut milk sweetened with palm *jaggery* is popular in the North central region and resembles the banana-based non-dairy smoothie of today’s popular food trend.

Gruels or porridge (Fig. 3a–c) popular since ancient times could be cereal grain-based or from starch and polysaccharides rich flours such as the spongy pith of *Caryota urens* palm (contains 28.4% amylose and 71.3% amylopectin), [61] and Sago palm (*Metroxylon sagu*, 60% starch) [62]. Health effects of these are described as digestion tract health, blood sugar lowering, and body cooling.

Traditional fermented alcoholic drinks are from the inflorescence sap of *Cocos nucifera* (in the coastal area) or *Caryota urens* (in the inner parts of the island. Sucrose, glucose, and fructose of the sap [63] are allowed to ferment naturally by *Saccharomyces* species in clay pots till ethanol concentration reaches 5–6% (by volume) to procure sweet-tasting cloudy, white palm wine or *toddy* [64]. Fermentation if continued, growth of *Acetobacter* increases acidity and produces sour-tasting palm vinegar. Tapping the inflorescence, sap harvesting, and conversion to palm wine, sweetener, or vinegar all require a highly skilled “*Toddy Tappers*” who know the techniques and routines. Consumption, production, and sale of *toddy* has been documented since ancient times; however, introduction and consumption of other wines, distillates, and spirits were after the occupancy of European nations [65].

Animal products and their preparations

Meat

Being a pluri-religious and multi-ethnic society, religious and cultural biases and prejudices preclude the consumption of animal flesh among Sri Lankans. Meat supply of the traditional diet is primarily from a variety of

large and small game, ground mammals, and birds. Drying with or without smoking or marinating in honey are traditional preservation practices that ensured low water activity to prolong shelf life in the tropical, humid environment. Such products are similar to the Jerky-style, low-moisture, protein, and energy-dense meat products. Consumption of beef and cow meat is less common since these animals are valuable helpers in agricultural and draft activities and provide milk for the family. Animal rearing for meat in the household is very much limited to non-Buddhists. Goat meat is popular among Hindu and Islamic groups. Traditionally, meat is curried with spices with or without coconut milk making a suitable accompaniment for rice and other starchy staples. Cured meat products such as bacon, ham, and sausages introduced from foreign cultures have limited popularity. *Lingus*, a special form of sausage made by cooking small pieces of pork with spices (coriander, black pepper, cinnamon, nutmeg, cloves, vinegar, and salt) [66] stuffed into casings and smoked, is a specialty in Sri Lanka and a delicacy inherited from Portuguese.

Fish

Generally, fish is acceptable among all religious and ethnic groups and always in great demand [17]. Oceanic fish is abundant for the coastal area population while fresh-water species are available for inland dwellers. About 70% of the country's animal protein supply is from fish and aquatic sources, in which marine sources provide 86% of the supply [67]. Small and large, near and offshore, pelagic and demersal fish, sharks, skates and rays, etc. comprise food fish supply. Popular food fish are; large species such as *Lethrinus lentjan*, *L. nebulosus*, *Pristipomoides* spp., *Epinephelus* spp., commercially important *Katsuwonus pelamis* (Skipjack tuna) and *Thunnus albacares* (tuna), *Scomberomorus commerson* (Seer fish), *Platypterus* spp., *Tetrapturus angustirostris*, *T. audax*, *Makaira nigricanus*, *M. indica*, *Xiphias gladius* and *Caryphaeus hippurus*, *Istiophorus platypterus* (Sail fish), *Euthynnus affinis*, and small- and medium-size fish like *Amblygaster sirm*, *Amblygaster clupeioides*, *Auxis thazard*, *Hirundichthys* spp. (Sore fish), *Lepturacanthus savala*, *Rastrelliger* spp., *Sardinella albella*, and *Stolephorus* spp., (Anchovy) [68].

A variety of freshwater fish including *Arius falcarius* (Whiskered fish), *Heteropneusts fossilis* (Stinging catfish), *Clarias brachysoma* (Walking catfish) and *Ophiocephalus striatus* (Murrel catfish) and the highly productive freshwater fish *Oreochromis mossambicus* (introduced in 1951) together contribute ~ 15% of food fish supply [69].

Oceanic fish sun dried in sea breeze preserves and generates unique savory and salty (up to 17% salt content) [70] taste of dry fish, an affordable protein source

with a long shelf life. The "Maldivian fish" is a special form of dried fish preparation having a long shelf life and processed by cooking, drying, and smoking, mostly the deboned flesh of *Scromboidiae* species. It is a favorite additive in curries and salads for meaty/umami taste. Autolyzing fish under controlled conditions by maintaining a high salt level and acidity (*Garcinia gummi-gutta* as the acidulant) makes fermented or wet-salted fish *Jādi* [71, 72], another preserved fish delicacy in the coastal regions.

The dry curry preparation of fish, sour fish curry or *Ambulthiyal* (Fig. 4) with a paste of peppercorns, *Garcinia gummi-gutta*, and salt is a traditional ready-to-eat, short-term (3–7 days at ambient temperature), and preserved form common in the coastal areas. The bioactives of pepper together with pH reduction by organic acids of *Garcinia* fruit pulp suppress microbial spoilage of fish tissues. This popular dish primarily uses tuna species. Curried fish with gravy in red-style or white-yellow (with coconut milk) is also common. In the coastal areas, a traditional meal consists of non-parboiled red rice, curried fish, and grated fresh coconut or *Sambola* (or *Maluma* with green leaves), providing the full complement of protein, carbohydrates, dietary fiber, essential fatty acids, and micronutrients. Freshwater fish from inland reservoirs are prepared similar to oceanic fish and the excess harvest is converted to dry fish with no or less salt.

Eggs

Since historic times, rearing free-range hens is common among rural households primarily for eggs; an animal protein source for the family [73]. Harvesting eggs of wild birds is less common under the current regulatory protection of wild bird species. Incorporation of eggs in meals could be mainly in cooked forms and raw uncooked uses of eggs are also found. Along the coastal area, curried fish roe is commonly consumed.

Dairy

Dairy and water buffalo milk is consumed in various ways. In a traditional village setting, milking cows and few calves are considered essential for the sustainable life that ensures good nutritional status of the family and perhaps neighbors who can afford to buy excess milk. Dairy milk gives five essences (*Pasgorasa*); milk, curd, ghee, cream/butter, and whey which are the traditional delicacies that are considered noble and extraordinary [74]. Ghee is exclusively obtained from the cream by removing water; the remaining non-fat solids and fat develop characteristic flavor and texture. Traditionally, water buffalo milk (~ 17% of the total milk production of the country) is converted to curd for consumption. The curdling of heated buffalo milk is by coagulation of

milk protein at low pH (4.8–5.8) due to lactic acid generated by the growth of *Lactobacillus delbrueckii subsp. lactis*, *L. plantarum*, *L. helveticus*, *Lactobacillus delbrueckii subsp. bulgaricus* and *L. casei subsp. casei*, *Streptococcus thermophilus* and *S. lactis*, *S. diacetylactis*, *S. cremoris* under controlled fermentation [75]. Buffalo milk has high total solids content (16.3 to 18.4%); protein (3.8 to 4.5%), fat (6.6 to 8.8%), lactose (4.5 to 5.2%), and casein (3.0 to 3.2%) compared with cow's milk [76] and produces a firmer curd that is a bio-therapeutic agent with a long history of use in traditional medicine. Curd accompanied with *treacle* completes the most favored traditional dessert that is integral for a Sri Lankan meal. The whey fraction or buttermilk (*Mōru*) makes a popular beverage.

Concluding remarks

Traditional foods of Sri Lanka depict a convolution of indigenous foods with adaptations from various non-native cultures. An in-depth understanding of the nutritional and therapeutic value of local flora and fauna, preparations, and conversion methods of these sources into safe, edible ingredients, and an almost similar to personalized nutrition-based consumption patterns guided by indigenous medicine have converged and evolved into traditional foods of this island. In traditional Sri Lankan food, health benefits and nutrition take precedence over sensory attributes, and both diet and lifestyle are serious considerations for a healthy body and mind. At present, traditional foods are celebrated more for culinary diversity. Various socio-economic factors that prevail in this middle-income developing country challenge the appreciation and understanding of traditional foods and consumption patterns while limiting the traditional knowledge transfer even at the non-urban household. Socio-economic factors that favor lifestyle changes, consumption patterns to accommodate limited time and resources, the dwindling supply of traditional ingredients, inward migration of multi-national fast and processed food chains together with the limited knowledge and interest in food, ingredient preparation and traditional practices have overshadowed the persistence on indigenous and traditional foods in Sri Lanka. Although the direct relationship is not made, the marked rise in NCDs in last two decades despite the general good health status of the country's population questions about the food sources, ingredients, consumption patterns, and lifestyle of the nation. About 25% of adults in Sri Lanka suffer from metabolic syndrome, and 1/5th of the adult population is either pre-diabetic or diabetic while 1/3rd of those are undiagnosed despite the low level of obesity (body mass index BMI > 30 is 3.7%) [77–80]. Consumers mindful of the diet and lifestyle have created a renewed demand for healthy, indigenous, and traditional food

ingredients and products. Building the evidence-based data with modern science tools and practices is necessary to protect traditional knowledge of Sri Lankan foods, which is happening at a slow phase than needed. Handful number of products are available through public and private sector partnerships that are convenient, ready to eat, and portion limited while utilizing traditional food concepts.

Rapidly expanding urban population and the changing lifestyles increase the demand for processed and semi-processed convenient foods, especially in urban markets. Urban and semi-urban consumer groups look for traditional staples and sweetmeats in the form of convenient foods without compromising their known health benefits and sensory attributes. This is a window of opportunity to upgrade traditional food making presently carried out at cottage level to small-scale food industries that satisfy the safety regulations and quality standards. In a wider scale, the indigenous and traditional foods are a cultural identity that play a vital role in improving the tourism industry in Sri Lanka; therefore, sources and preparations must meet the needs other than the regular local consumer.

Consumer awareness on the food and ingredients, in general, creates the market pull in the direction of healthy eating which needs co-operation of both agri-food and health sectors. The food processing industry needs quality parameters that are science-based and measurable in order to maintain raw material sourcing, ingredient processing, product manufacturing, and storage aligning with the nutritional and therapeutic value intended in the final product. In that context, a considerable gap exists in the science and technology development related to strengthening the position of indigenous and traditional foods in Sri Lanka.

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Authors' contributions

JKJ, CVLJ, and JPDW devised the main conceptual ideas and proof project outline and initiated, wrote and revised the paper with input from all authors. SM worked out the technical details and performed information collection, manuscript drafting, and incorporating revisions. The author(s) read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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References

1. Roberts P, Boivin N, Petraglia M. The Sri Lankan 'microlithic' tradition c. 38,000 to 3,000 years ago; tropical technologies and adaptations of *Homo sapiens* at the southern edge of Asia. *J World Prehist.* 2015;28:69–112.
2. Climate of Sri Lanka. Department of Meteorology Sri Lanka. http://www.meteo.gov.lk/index.php?option=com_content&view=article&id=94&Itemid=310&lang=en. Accessed 15 Jan 2019.
3. AQUASTAT Main Database Food and Agriculture Organization, FAO. 2016. <http://www.fao.org/nr/water/aquastat/data/query/index.html?sessionId=F67F49971951339DF5F174D603717BE0>. Accessed 6 Nov 2018.
4. Articles on Archaeology. <https://www.archaeology.lk/articles>. Accessed 1 Nov 2018.
5. Wedage O, Amano N, Langley MC, Douka K, Blinkhorn J, Crowther A, Deraniyagala SU, Kouampas N, Simpson I, Perera N, Picin A, Boivin N, Petraglia M, Roberts P, et al. Specialized rainforest hunting by *Homo sapiens* ~45,000 years ago. *Nat Commun.* 2019. <https://doi.org/10.1038/s41467-019-08623-1>.
6. Deraniyagala SU. The prehistory and protohistory of Sri Lanka. In: Prematilleke L, Bandaranayake S, Deraniyagala SU, Silva R, editors. *The art and archeology of Sri Lanka*. Colombo: Central Cultural Fund; 2007. p. 1–96.
7. Roberts P, Perera N, Wedage O, Deraniyagala S, Perera J, Eregama S, Gledhill A, Petraglia MD, Lee-Throp JA, et al. Direct evidence for human reliance on rainforest resources in late Pleistocene Sri Lanka. *Science.* 2015;347:1246–9.
8. Roberts P, Perera N, Wedage O, Deraniyagala S, Perera J, Eregama S, Petraglia MD, Lee-Throp JA, et al. Fruits of the forest: human stable isotope ecology and rainforest adaptations in late pleistocene and holocene (~36 to 3 ka) Sri Lanka. *J Hum Evol.* 2015;106:102–18.
9. Deraniyagala SU. *The Prehistory of Sri Lanka: an archeological perspective*. 2nd ed. Colombo: Department of Archeology; 1992.
10. De Silva P. Diminishing or struggle for survival; case of Veddhas' culture in Sri Lanka. In: Samarasinghe GLW, editor. *SARRC culture vol 2. Diminishing cultures in South Asia*. Colombo: SARRC Cultural Centre; 2011. p. 127–74.
11. Illeperuma RJ, Markalanda DA, Ratnasooriya WD, Fenandopulle ND, et al. Genetic variation at 11 autosomal STR loci in the aboriginal people, the Veddhas of Sri Lanka. *Forensic Sci Int Genet.* 2010;4:142.
12. Illeperuma RJ, Mohotti SN, De Silva TM, Fernandopulle ND, Ratnasooriya WD, et al. Genetic profile of 11 autosomal STR loci among the four major ethnic groups in Sri Lanka. *Forensic Sci Int Genet.* 2009;3:105–6.
13. Ranaweera L, Kaewsutthi S, Tun AW, Boonyarit H, Boonyarit H, Poolsuwan S, Lertrit P, et al. Mitochondrial DNA history of Sri Lankan ethnic people: their relations within island and with the Indian subcontinental populations. *J Hum Genet.* 2014;59:28–36.
14. Jayashantha P, Johnson NW. Oral health status of the Veddhas-Sri Lankan indigenous people. *J Health Care Poor Underserved.* 2016;27(1):139–47.
15. Knox R. *An historical relation of the Island Ceylon*. 3rd ed. Karunaratna D, Translator, Gunasena Publishers, Colombo; 2001. p. 59–111.
16. Hussein A. *Ilvily Pevilly: the gastronome's guide to the culinary history and heritage of Sri Lanka from the stone age to the modern era*, vol. 19-23. 1st ed. Battaramulla: Neptune Publications; 2012. p. 42–3.
17. Seligmann CG, Seligmann BZ. *The veddhas*. 1st ed. Ranasinghe, C, Translator, Fast Publishing, Colombo. 2009; 102-103.
18. Panabokke CR. Evolution of the indigenous village irrigation systems of Sri Lanka. *Econ Rev.* 2010;35(3):3–9.
19. Silva TP. *Sri Lankeya Jathinghe Iwum Pihum*. 1st ed. Rathmalana: Pubiliis Publishers; 2015. p. 13–4.
20. Rao PVK, Das M, Das SK. Jaggery- a traditional Indian sweetener. *Indian J Tradit Knowl.* 2007;6(1):95–102.
21. Silva TP. *Authentic Sri Lankan cuisine*. 1st ed. Sri Lanka: Sarasavi Publishers; 2011. p. 23–4.
22. Silva TP. *The great chronicle of culinary art*. 1st ed. Colombo: Seviko Printing and Packaging; 2017. p. 22–3.
23. Jayasinghe JMK. Influence of social changes to the food industry in Sri Lanka. In: *Proceedings of the 70th annual sessions*. Sri Lanka: Sri Lanka Association for the Advancement of Science; 2013. p. 27–42.
24. Wandel M, Gunawardena P, Oshaug A, Wandel N. Heaty and cooling foods in relation to food habits in a southern Sri Lanka community. *Ecol Food Nutr.* 1984;14:93–104.
25. Wickramanayake TW. The beginnings of rice cultivation in Sri Lanka. *J R Asiatic Soc Sri Lanka New Ser.* 2007;53:203–18.
26. Geekiyanage N, Pushpakumara DKN. Ecology of ancient tank cascade systems in island Sri Lanka. *J Mar Island Cult.* 2013;2:93–101.
27. Pathiraje PMH, Madhujith WMT, Chandrasekera A, Nissanka SP, et al. The effect of rice variety and parboiling on in vivo glycemic index. *Trop Agric Res.* 2010;22:26–33.
28. Senanayake SMP, Premaratne SP. An analysis of the paddy/rice value chains in Sri Lanka. In: *ASARC working paper 04*. 2016. Sri Lanka: University of Colombo. https://crawford.anu.edu.au/acde/asarc/pdf/papers/2016/WP2016_04.pdf. Accessed 15 Nov 2018.
29. Perera ANF, Perera ANK, Perera ERK. Traditional food and beverages of Sri Lanka. *Econ Rev.* 2010;35(3):59–62.
30. Jayasinghe C. *Indigenous foods of ancient Sri Lanka*. 1st ed. Makandura: Department of Food Science and Technology, Wayamba University of Sri Lanka; 2013. p. 16–9.
31. Jayawardena JAEC, Wansapala MAJ. Study on developing micronutrients enriched spread using fermented cooked rice. *Int J Innov Res Technol.* 2015;1:1603–5.
32. Kaur B, Ranawana V, Henry J. The glycemic index of rice and rice products: a review and table of GI values. *Crit Rev Food Sci Nutr.* 2016;56:215–36.
33. Piliimalavuvva AS. *Recipes from the cookery book of the last Kandyan dynasty*. Colombo: Vijitha Yapa Publishers; 2010. p. 27.
34. Cham S, Suwannaporn P. Effect of hydrothermal treatment of rice flour on various rice noodles quality. *J Cereal Sci.* 2010;51:284–91.
35. Pancha-aron S, Uttappa D. Rice starch vs rice flour: differences in their properties when modified by heat. *Carbohydr Polym.* 2013;91:85–91.
36. Senevirathna RMISK, Ekanayake S, Jansz ER. Traditional and novel foods from indigenous flours: nutritional quality, glycaemic response and potential use in food industry. *Starch Stärke.* 2016;68(9):999–1008.
37. Mukherjee PK, Mukherjee D, Maji AK, Rai S, Heinrich M, et al. The sacred lotus (*Nelumbo nucifera*)—phytochemical and therapeutic profile. *J Pharm Pharmacol.* 2009;61(4):407–22.
38. Prasad SK, Singh MK. Horse gram- an underutilized nutraceutical pulse crop: a review. *J Food Sci Technol.* 2015;52(5):2489–99.
39. Ariyawardena A, Govindasamy R, Lisle I. Capturing the consumer value; the case of red lentils. *Br Food J.* 2015;117:1032–42.
40. Department of Census and Statistics. *Household income and expenditure survey 2009/10 preliminary report*. Colombo: Department of Census and Statistics; 2011.
41. Weerakkody N, Caffin N, Turner MS, Dykes GA, et al. In vitro antimicrobial activity of less-utilized spice and herb extracts against selected food-borne bacteria. *Food Control.* 2010;21:1408–14.
42. Liu Q, Meng X, Li Y, Zhao CN, Tang GY, Li HB, et al. Antibacterial and antifungal activities of spices. *Int J Mol Sci.* 2017;18(6):1283.
43. Prathapan A, Lukshman M, Arumughan C, Sundaresan A, Raghu KG, et al. Effect of heat treatment on curcuminoid, colour value and total polyphenols of fresh turmeric rhizome. *Int J Food Sci Technol.* 2009;44:1438–44.
44. Adikari AMNT, Lakmal T. *A recipe book of traditional Sri Lankan food*. *Procedia Food Sci.* 2016;6:60–4.
45. Venkatachalam M, Sathe S. Chemical composition of selected edible nut seeds. *Journal of Agricultural Food Chemistry.* 2006;54(13):4705–14.
46. Rico R, Bullo M, Salas-Salvado J. Nutritional composition of raw fresh cashew (*Anacardium occidentale* L.) kernels from different origin. *Food Sci Nutr.* 2015;4(2):329–38.
47. Jayasuriya AHM. *Dioscorea koyamae* (Dioscoreaceae), a new edible yam from Sri Lanka. *Brittania.* 1990;42:142–6.
48. Sathiamoorthy K, Prange R, Mapplebeck L, Haliburton T, et al. Potato production in Sri Lanka. *Am Potato J.* 1985;62:555–67.
49. Jagtap UB, Bapat VA. *Artocarpus: a review of its traditional uses, phytochemistry and pharmacology*. *J Ethnopharmacol.* 2010;129:142–66.
50. Baliga MS, Shivashankara A, Haniadka R, Souza J, Bhat HP, et al. Phytochemistry, nutritional and pharmacological properties of *Artocarpus heterophyllus* Lam (jackfruit): a review. *Food Res Int.* 2011;44:1800–11.
51. Hettiarachchi UPK, Ekanayake E, Welihinda J. Nutritional assessment of a jackfruit (*Artocarpus heterophyllus*) meal. *Ceylon Med J.* 2011;56:54–8.
52. Swami SB, Thakor NJ, Haldankar PM, Kalse SB, et al. Jackfruit and its many functional components as related to human health: a review. *Compr Rev Food Sci Food Saf.* 2012;11(6):565–76.
53. Medagoda I. Bread fruit in the Asian region-focus on Sri Lanka. *Acta Hortic.* 2007;757:65–70.

54. Fuangchan A, Sonthisombat P, Seubnukarn T, Chanouan R, Chotchaisuwat P, Sirigulsatien V, Ingkaninan K, Plianbangchang P, Haines ST, et al. Hypoglycemic effect of bitter melon compared with metformin in newly diagnosed type 2 diabetes patients. *J Ethnopharmacol*. 2011;134(2):422–8.
55. Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pac J Trop Dis*. 2013;3(2):93–102.
56. Senadheera ASSP, Ekanayake S. Green leafy porridges: how good are they in controlling glycaemic response? *Int J Food Sci Nutr*. 2013;64(2):169–74.
57. Maya R. Pitisara Minissu. 2nd ed. Colombo: S&S Printers; 2004. p. 95–8.
58. Chandrasekhar K, Sreevan S, Seshapani P, Pramodhakumari J, et al. A review on palm wine. *Int J Res Biol Sci*. 2012;2:33–8.
59. History of Ceylon tea. Sri Lanka Tea Board. <http://www.pureceylontea.com/index.php/features/history-of-ceylon-tea>. Accessed 11 Apr 2018.
60. Jayatissa LP, Hettiachchi S, Dahdouh-Guebas. An attempt to recover economic losses from decadal changes in two lagoon systems of Sri Lanka through a newly patented mangrove products. *Environ Dev Sustain*. 2006;8:585–95.
61. Wijesinghe JAAC, Wickramasinghe J, Saranandha KH. Changes in characteristics of Kithul (*Caryota urens*) flour prepared by different modification techniques. *J Food Process*. 2016; Article ID 7820102. <https://doi.org/10.1155/2016/7820102>. Accessed 27 May 2018.
62. Karim AA, Pei-Lang Tie A, Manan DMA, Zaidul ISM, et al. Starch from the Sago (*Metroxylon sagu*) palm tree-properties, prospects, and challenges as a new industrial source for food and other uses. *Compr Rev Food Sci Food Saf*. 2008;7:215–28.
63. Kapilan R. Determination of efficient fermentation inhibitor of the tapped inflorescence sap of *Caryota urens* in Sri Lanka. *Int J Curr Microbiol Appl Sci*. 2015;4(10):487–96.
64. Lal JJ, Sreeranjit Kumar CJ, Indira M. Coconut palm. In: Trugo L, Finglas PM, editors. *Encyclopedia of food science and nutrition*. 2nd ed: Elsevier Science Ltd; 2003. p. 1464–75.
65. Dayaratne GD. State of the Sri Lankan alcohol industry and analysis of governing policies, Research studies working paper No.19. Colombo: Institute of Policy Studies of Sri Lanka; 2013.
66. William de Alwis. The Sausage. The Island Magazine online edition. <http://www.island.lk/2005/10/01/satmag4.html>. Accessed 9 Apr 2018.
67. Amarasinghe US. Fisheries resources in alleviation of hunger and malnutrition in Sri Lanka - accomplishment and challenges in Sri Lanka. *J Aquat Sci*. 2013;1:1–15.
68. Devadason C, Jayasinghe C, Sivakanesan R, Senarath S, Beppu F, Gotoh N, et al. Comparative analysis of lipid content and fatty acid composition of commercially important fish and shellfish from Sri Lanka and Japan. *J Oleo Sci*. 2016;65(7):543–56.
69. Fishery Country Profile, Food and Agriculture Organization of the United Nations, Fisheries Data, FID/CP/LKA. 2006. <http://www.fao.org/fi/oldsite/FCP/en/LKA/profile.html>. Accessed 10 Apr 2018.
70. Nuwanthi SGLI, Madage SSK, Hewjulige IGN, Wijesekere RGS, et al. Comparative study on organoleptic, microbiological and chemical qualities of dried fish, goldstripe sardinella (*Sardinella gibbosa*) with low salt levels and spices. *Procedia Food Sci*. 2013;6:356–61.
71. Lakshmi WGI, Prassanna PHP, Edirisinghe U. Production of Jaadi using Tilapia (*Oreochromis niloticus*) and determination of its physico-chemical and sensory properties. *Sabaragamuwu Univ J*. 2011;9:57–63.
72. Jayasinghe P, Fonseka TSG, Bamunuarchchi A. Some biochemical changes of the fermented fish (Jaadi) during bio-preservation. In: FAP Fisheries report 563. Asia-Pacific Fishery Commission Working Group report; 1996. p. 335–45.
73. Abeykoon MNDF, Weerahewa J, Silva GLLP. Determinants of market participation by indigenous poultry farmers: a case study in Anuradhapura district in Sri Lanka. *Trop Agric Res*. 2013;24:347–61.
74. Perera ANF. Sri Lankan traditional food cultures and food security. *Econ Rev*. 2008;33(6):40–3.
75. Dekumpitiya N, Dulani G, Sriyani IA, Dehiwala LJ. Identification of the microbial consortium in Sri Lankan buffalo milk curd and their growth in the presence of prebiotics. *J Food Sci Technol*. 2016;9:20–30.
76. Mohamed AE, El-Shibiny. A comprehensive review on the composition and properties of buffalo milk. *Dairy Sci Technol*. 2011;91(6):663–99.
77. Katulanda P, Constantine GR, Mahesh JG, Sheriff R, Seneviratne RD, Wijeratne S, Wijesuriya M, McCarthy MI, Adler AI, Matthews DR, et al. Prevalence and projections of diabetes and pre-diabetes in adults in Sri Lanka—Sri Lanka diabetes, cardiovascular study. *Diabet Med*. 2008; 25:1062–9.
78. Katulanda P, Jayawardena MA, Sheriff MH, Constantine GR, Matthews DR, et al. Prevalence of overweight and obesity in Sri Lankan adults. *Obes Rev*. 2010;11(11):751–6.
79. Jayawardena R, Ranasinghe P, Byrne NM, Soares MJ, Katulanda P, Hills AP, et al. Prevalence and trends of the diabetes epidemic in South Asia: a systemic review and meta analysis. *BMC Public Health*. 2012;12:380–91.
80. Jayawardene R, Byrne NM, Soares MJ, Katulanda P, Yadav B, Hills AP, et al. High dietary diversity is associated with obesity in Sri Lankan adults: and evaluation of three dietary scores. *BMC Public Health*. 2013;13:314–22.

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