CHAPTER 2

Traditional and ethnic foods of Sri Lanka—safety aspects

Chathudina J. Liyanage
Department of Food Science and Technology, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka

Contents

2.1 Introduction

It has been estimated that 600 million people fall ill after eating contaminated food and 420,000 die every year (World Health Organization, 2017). Food safety has therefore gained the status of a key global concern related to public health.

Today, there is a growing interest in traditional and ethnic food throughout the world. In Sri Lanka as well, foods that are produced according to the gastronomic traditions hold a prominent place in the local cuisine and diet. The ethnic diversity of Sri Lanka has contributed significantly to the wide variety of traditional and ethnic foods consumed in the country. The nutritional and microbiological profiles of many traditional and ethnic food types in Sri Lanka are relatively well described, but the safety aspects of these foods are not to be undermined as they are yet to be well researched and documented.

Even though many of the traditional and ethnic food items are rich in functional (bioactive) ingredients that lead to improved nutrition and health status, some key food safety challenges have been identified in studies conducted elsewhere in the world regarding microbiological and chemical risk factors (Cagri-Mehmetoglu, 2017; Lücke and Zangerl, 2014; Tajkarimi et al., 2013). Addressing the specific food safety challenges associated with traditional and ethnic food therefore is a key demand from

Nutritional and Health Aspects of Food in South Asian Countries
DOI: https://doi.org/10.1016/B978-0-12-820011-7.00019-8

the perspective of consumers as well as food producers. As the local food culture places an important emphasis on traditional and ethnic food dishes, providing wholesome and safe food is a key challenge associated with domestic- and commercial-level food preparations with traditional ingredients and/or traditional types of food processing and production methods. Chemical and microbiological aspects are the top priorities when the safety of raw materials and production processes of these foods are addressed with respect to the food safety standards and regulations (Prakash, 2016).

This chapter presents an overview of the key food safety issues and concerns associated with the traditional and ethnic foods in Sri Lanka emphasizing on the chemical (toxicological) and microbiological safety aspects of the raw materials and processing/preparation methods. The local regulations pertaining to food safety are also briefly described with a discussion on the specific strategies to address the key food safety issues and how they can be integrated into and addressed under the existing regulatory frameworks.

2.2 Historical overview, culture, and traditions associated with traditional and ethnic food in Sri Lanka

Traditional and ethnic foods constitute an important part in the heritage and culture of Sri Lankan people. Being a tropical country of immense indigenous floral and faunal diversity, the Sri Lankan diet remained largely plant-based for centuries. As documented by writers such as Robert Knox (1681) and Emerson Tennet (1860), plenty of naturally growing food commodities were available for consumption by the locals and a wide variety of gastronomic delights were prepared from them, thereby ensuring food security. According to the ancient legends and chronicles, the traditional Sri Lankan diet used to be mainly plant-based, rich in indigenous cereals and grains, roots, tubers and indigenous yams, legumes, vegetables, oil seeds, and fruits, with little or no animal products, meticulously selected for their specific nutritional as well as therapeutic properties (Perera, 2008; Weerasekara et al., 2018).

Contemporary culinary traditions of Sri Lanka are largely influenced by the different ethnicities of the country, namely Sinahala, Tamil, Sri Lankan Moor, Burgher, and Malay. In addition, colonization periods have also contributed significantly to shape the present culinary traditions of Sri Lanka. In particular, the shift from rice flour-based food items to wheat flour-based items was largely influenced by the colonization of the Dutch, Portuguese, and the English. A large number of ethnic and traditional Sri Lankan dishes are influenced by the Malay, Arabic, and South Indian culinary flavors and characteristics.

2.3 Major traditional and ethnic food categories consumed in Sri Lanka

Sri Lankans predominantly consume rice and curry-based diets for the main meals of lunch and dinner. A typical meal comprises a large portion of steamed/cooked rice

served with two or three vegetable dishes in the form of curries (mostly coconut milk–based and seasoned with local spices and condiments) and leafy vegetables (green leaves). Fish, meat, or dried fish (anchovy is the most widely consumed type) may also be included. Tubers, local yams, and local pulses are also a popular choice. Local fruits are eaten as dessert along with traditional sweets. A variety of traditional and ethnic food items exist in Sri Lanka to supplement the main meals, and in some cases they are chosen as a main item in breakfast or dinner (e.g., *pittu*, hoppers, string hoopers, *roti*). Traditional sweets are usually served with tea, and they are the typical choice for any special occasion and celebration such as the Sri Lankan New Year celebration. All forms of new beginnings and auspicious occasions in Sri Lanka are marked with the consumption of milk rice along with traditional sweets. A summary of the most important traditional and ethnic food categories in Sri Lanka is presented in Table 2.1.

2.4 Safety of traditional and ethnic food in Sri Lanka

2.4.1 Safety of raw materials

Quality and safety of raw materials are of paramount importance when it comes to food preparation and processing. As many traditional food preparations rely on locally or regionally sourced unique raw materials, their safety aspects should be assessed systematically, in terms of potential hazards.

Rice, the staple food of the Sri Lankan traditional diet, can be easily contaminated from agrochemicals, insects, molds, mycotoxins, and bacteria. As traditional Sri Lankan cuisine has evolved around rice and due to the high level of consumption of rice flour-based traditional foods in Sri Lanka, there may be a possible overexposure to some toxic elements such as lead, chromium, and arsenic that may accumulate in rice. The metalloid arsenic (As) has gained much attention recently due to its chronic health effects. As soil in rice paddy fields can contain naturally occurring arsenic and also can be polluted by irrigation water that is contaminated with arsenic from anthropogenic sources such as agrochemicals, rice and rice flour-based foods can be potential dietary sources of arsenic. The Codex Alimentarius Commission has established a maximum allowable limit of 200 μg/kg for inorganic arsenic (iAs) in rice (Codex Alimentarius Commission, 2014; Carbonell-Barrachina et al., 2015, Jallad, 2015). The presence of arsenic in rice cultivated in Sri Lanka has been investigated in recent studies. Jayasumana et al. reported As levels in the range of 20.6–540.4 μg/kg in polished rice obtained from agrochemical dependent newly improved varieties of rice cultivated in seven different locations in Sri Lanka (Jayasumana et al., 2015). As reported in studies conducted elsewhere, there also exists a high potential for the occurrence of other toxic elements such as Cd, Cr, Hg, and Pb (Shraim, 2017). As rice is produced in Sri Lanka under environmental conditions favorable for the growth of fungi such as

Table 2.1 Main categories of traditional Sri Lankan food.

Food category	Examples
Cereal and grain-based food	Fermented: *hoppers* (crispy rice flour pancakes: plain flour and egg are the most common forms, and treacle is added sometimes to produce a sweet version), *dosa/thosé* (a type of pancake made from black gram flour with many local variations), *idli* (a type of savory rice flour cake) Nonfermented: boiled or steamed rice (a fragrant variation is known as Sri Lankan yellow rice), *kiribath* (milk rice: sometimes mixed with green gram, jaggery, raisins, cashew nut, etc. and also prepared with sweetened coconut stuffing—*imbul kiribath*), *string hoppers* (rice flour, finger millet flour, wheat flour), pittu (rice flour, odiyal flour-ground palmyrah root, finger millet, foxtail millet flour, or sorghum flour mixed with grated coconut and steamed), *upma* (dry roasted semolina or coarse rice flour porridge), *rotti* (a type of round flatbread, made from wheat flour, rice flour, finger millet flour, or a mix of them and usually mixed with grated coconut and sometimes with grated vegetables), *paratha/godamba roti* (a type of wheat flour flatbread), *kurrakkan thalapa* (a thick ball of dough made of finger millet flour), *habala pethi* (rice flakes—a traditional breakfast cereal)
Flour (from rice, wheat and other cereals, grains, and pulses) and sugar syrup/ treacle-based confectionery and other confectionery, snacks, and desserts	Traditional sweets: *aggala* (sweet roasted rice balls), *aluwa*, *welithalapa (sau dodol)*, *kevum* (deep-fried oil cakes-lots of regional varieties exist such as *konda kevum*, *pethi kevum*, *athirasa*, *naran kevum*, *mung kevum*—a mixture of green gram and rice flour is used), *aasmi*, *unduwel/päni*—walalu (deep-fried coils of black gram flour and rice flour mixture), *kokis* (crispy cookies), *hälapa* (finger millet steamed cake), *wandu appa* (a sweet steamed hopper), *lävariya* (sweet dumpling string hoppers), *rulang aluwa* (semolina toffees), *thala guli/ thala bola* (sesame rolls/balls), *kalu dodol* (a sticky, gel-like candy), *bibikkan* (Sri Lankan coconut cake), *pol dosi* (coconut toffees), *päni-kaju* (sweet toffee slices from ground nut or cashew nut), *ala dosi* (potato fudge), *inguru dosi* (sweet and spicy ginger toffee) Traditional snacks/appetizers: *wadai* (lentil fritters), *murukku* (spicy batter or sugar-coated diamond cuts), fried cassava chips and sweet potato chips, fried ash plantain chips, *papadam* (crispy black gram flour appetizer), odiyal (from palmyrah palm tubers/palmyrah sprouts) Traditional desserts: *watallapan* (cardamom-spiced coconut custard pudding), fishtail palm flour pudding, sago pudding

(*Continued*)

Table 2.1 (Continued)

Food category	Examples
Vegetable-based	Fermented: *Lunu dehi* Sinhala *achcharu* (traditional Sri Lankan pickle), *wambatu moju* (eggplant/brinjal pickle) Nonfermented: vegetable curries (with coconut milk), *Seeni sambol* (sweet onion relish or spicy caramelized onion relish), *kochchi sambol* (chili pepper)
Root crops and tuber-based	Boiled cassava tubers, boiled sweet potato tubers, cassava curry, sweet potato curry
Fruit-based	Fermented: *Polos achcahru* (pickle with baby jackfruit pickle) Nonfermented: *puhul dosi* (ash pumpkin preserves), pineapple curry, baby jackfruit curry, raw mango curry, amabrella curry, boiled jack bulbs, mango chutney, ambarella chutney, *atu kos* (jackfruit bulbs dehydrated on the hearth)
Milk-based	*Mee kiri* (buffalo curd)
Fish-based	Fish curry (with coconut milk), *Ambul Thiyal* (sour fish), *Jaadi* (cured fish), Maldive fish (boiled, smoked, and dried tuna fish)
Herbal plant-based	*Kola kända* (a creamy herbal porridge/gruel—prepared with the extracts of a variety of local fresh herbs and/or green leaves, mixed with raw rice and coconut milk)
Other traditional dishes	*Aanama*, *hath maluwa* (a mixed vegetable curry with seven ingredients), *niyabalawa*. *kos äta kalu pol maluwa* (Sri Lanka jackfruit seed curry), *lunu miris* (onions ground with dried red chili powder and lime), *coconut sambol* (grated coconut, onions, red chili powder, lemon, salt, and Maldive fish), *mallung* (shredded leafy vegetables, grated coconut, and various spices), coconut milk gravy

Aspergillus spp, there is a high potential for the contamination of rice form mycotoxins such as aflatoxin B_1, especially after harvest (Elzupir et al., 2015). Besides rice, the occurrence of As and Cd was detected in cereals and legumes such as finger millet, sesame, cowpea/black-eyed pea, urad dal/split bean, foxtail millet, long bean, and green gram that are commonly used as raw materials for traditional food preparations (Edirisinghe and Jinadasa, 2019).

From a safety point of view, the spices used in traditional food preparations should be free of undeclared contaminants and adulterants, such as toxic botanicals, pathogenic microorganisms, and excessive levels of microbial toxins, pesticide residues, or residues of fumigation agents (Salgueiro et al., 2010). The prevailing climatic conditions in Sri Lanka are highly favorable for mold infestations in spices leading to subsequent contamination with mycotoxins. Chilli and black pepper are perhaps the two

most widely used spices in traditional Sri Lankan cuisine. A recent study reports the occurrence of multiple mycotoxins such as aflatoxins, ochratoxin A, toxic sterigmatocystin, citrinin, and fumonisin B1 in Sri Lankan black peppers regardless of their low water activity and strong antimicrobial property (Yogendrarajah et al., 2014a). Similarly, aflatoxin B1 was found to be the predominant mycotoxin contaminating Sri Lankan dry chilli followed by ochratoxin A, sterigmatocystin, fumonisin, and citrinin (Yogendrarajah et al., 2014b).

As rice is accompanied by an assortment of vegetable curries in the typical Sri Lankan diet, vegetables are abundantly consumed in Sri Lanka. Vegetable farming is one of the most intensive cultivated farming systems in Sri Lanka that consumes a high volume of pesticides and fertilizers, leading to the accumulation of pesticide residues. Recent studies report the presence of diazinon, chlorpyrifos, phenthoate, prothiofos, oxyfluorfen, and tebuconazole in tomato, capsicum, and cabbage cultivated in major agricultural regions in Sri Lanka (Rajapakse et al., 2018; Lakshani et al., 2017). Residues of chlorpyrifos, captan, profenofos, diazinon, permethrin, and oxyfluorfen were detected in *Mukunuwenna* (*Alternanthera sessilis*), the most widely produced and consumed leafy vegetable in Sri Lanka (De Alwis et al., 2006). Green leafy vegetables can also be a source of foodborne pathogens. A study reports the presence of pathogenic bacteria such as *Salmonella* spp., *Listeria monocytogenes* in *Mukunuwenna*, *Gotukola* (*Centella asiatica*), and lettuce in local markets (De Silva et al., 2014). Cytotoxicity of the widely consumed green leafy vegetables in the Sri Lankan diet and the ones commonly used for preparing traditional types of herbal porridge (*kola kända*) were also reported (Balasuriya and Dharmaratne, 2007).

Marine foods are a common source of food poisoning worldwide. Although traditional dishes like *ambul thiyal* prepared from local fish such as tuna are highly popular in Sri Lankan cuisine, they are also linked to the prevalence of scromboid fish poisoning. Histamine is produced in high levels during the storage of Sri Lankan yellow fin tuna, and this may lead to acute toxicity in some sensitive individuals when consumed (Jinadasa et al., 2015). Traditional fish dishes can also be a major route of exposure for toxic heavy metals such as Hg, Cd, and Pb (Jinadasa et al., 2014; Jinadasa et al., 2018). Some local fish species could also be vectors of ciguatera toxin that leads to ciguatera fish poisoning—one of the most common foodborne illnesses related to seafood consumption (Deepananda et al., 2016). Crustacean shellfish and molluscan shellfish consumed in the form of traditional dishes can also be sources of seafood allergy and paralytic shellfish poisoning, although cases are not well reported (Taylor, 2008). Predominant presence of pathogenic species such as *Aeromonas hydrophila*, *Vibrio parahaemolyticus*, *Vibrio carchariae*, *Vibrio harveyi*, and *Plesiomonas shigelloides* in marine shrimp harvested in Sri Lanka was also reported (Jayasinghe et al., 2010).

Milk-based traditional foods such as curd are widely consumed in Sri Lanka. Contamination of cow's and buffalo milk used for the production of such traditional

food by residues of veterinary drugs could be a significant food safety issue since bearing a risk to human health, as they can cause allergic reactions in hypersensitive individuals (Vishnuraj et al., 2016). In addition, the incidence of aflatoxin M1, a common contaminant in cow's milk, was reported in locally produced raw milk (Pathirana et al., 2010). The potential IgE-mediated food allergenicity of cow's milk has also been widely recognized, although specific cases are not well documented regarding Sri Lanka (Arakali et al., 2017).

Coconut oil, traditionally extracted from dried coconut kernels, is the most widely used vegetable oil in Sri Lankan cuisine. It has been a key source of fat in the local diet for ages. A recent study reports aflatoxin contamination in locally produced coconut oil in the ranges of 2.25−72.70 μg/kg for total aflatoxins and 1.76−60.92 μg/kg for aflatoxin B1 (Karunarathna et al., 2019).

Nuts such as peanuts and cashew nuts used commonly for traditional food preparations can also pose food safety concerns with the presence of allergenic substances and mycotoxins. Moderate contamination (12.5 ppb) of local peanut with aflatoxins was reported in studies (Dissanayake and Manage, 2010).

Adulterants have been detected in many market food commodities resulting in the production of inferior quality raw materials for traditional food, rendering it a significant food safety concern. Routine inspections by public health inspectors have found adulteration by unapproved flavors, preservatives, and coloring and addition of unpermitted organic substitutes. As revealed by such inspections, spices have been adulterated with wheat or rice flour, paddy husk, poonac, sawdust, salt, and a variety of synthetic colors/fabric dyes. Coconut oil is adulterated with cheaper oils such as palm oil. Coconut vinegar is adulterated with acetic acid (The Sunday Times, 2017).

Central to any food processing is the availability of potable water. Lack of municipal water in many rural areas compels the use of water from dug wells and other sources such as streams for traditional food preparations that may pose food safety hazards through the presence of microbial pathogens such as *Escherichia coli*.

2.4.2 Safety during processing, handling/serving, and storage

Many traditional and ethnic foods in Sri Lanka are characterized by the use of unsophisticated, informal, and low-cost food processing techniques.

Heat treatment, being one of the most ancient technologies used for traditional food processing, significantly improves the raw material quality features such as digestibility, taste, mouth feel, and consistency. From a food safety perspective, heat treatment can effectively eliminate many pathogenic microorganisms. Boiling is perhaps the most common heat treatment in Sri Lankan traditional food that gives rise to microbiological safety. However, widely used heat treatment options for traditional food at the household level such as boiling (rice, caasava, most vegetable curries),

steaming (*pittu*, *wandu appa*, *string hoppers*), simmering in hot water and coconut milk (vegetable curries), deep and shallow frying (traditional sweets and snacks) that lacks precise control of the temperature and holding time, and total inactivation of pathogenic microorganisms may not be achieved therefore. The growth of Gram-positive food poisoning bacteria such as *Bacillus cereus* that can also cause spoilage of cooked rice was reported from studies (Waduwawara and Manage, 2009). Intensive thermal processing of traditional food especially the starch-based food items also generates carcinogenic process contaminants such as acrylamide (Arvanitoyannis and Dionisopoulou, 2014). Recycling of frying oils or repeatedly heating oil is a regular practice at domestic-level traditional food preparations that can lead to the generation of carcinogenic free radicals. In addition, repeated heating of oils at high temperatures (160°C−190°C) over a long period of time causes the conversion of fatty acid from *cis* to *trans* isomers, which can pose a significant health hazard (Perumalla Venkata and Subramanyam, 2016). Burning of locally sourced wood for food preparations is still common in many rural areas in Sri Lanka. Besides the environmental impact, it can also contribute to the deposition of ash and other toxic emanates to deposit on food. A common practice after frying food at a domestic level is to drain the oil through leaflets of newspapers. This can lead to the transfer of toxic metals such as Pb, which are normally used in printing ink. The same happens when food items are wrapped in such leaflets.

Sun drying and other traditional dehydration methods used in Sri Lanka, such as placing in the surroundings of the hearth in the kitchen (used for dehydrating jackfruit bulbs and seeds), are economical means of reducing the water content in food matrices that lead to the retardation of microbial growth. Such dried food may nevertheless subject to spoilage by fungi (particularly yeasts and molds) if they are processed and stored under unhygienic conditions. Sun-dried local raw materials are also prone to the accumulation of dust and other environmental contaminants and pest attacks.

Fermentation is a highly useful food processing technique applied to traditional food such as fermented fish and curd. The incorporation of spices for their antimicrobial effect (garcinia, black pepper, ginger, and cinnamon leaves) and natural preservatives such as salt help in preventing major food safety issues due to the growth of pathogenic bacteria (Ekanayake, 2016). Fermentation in buffalo curd is controlled mainly by the growth of microorganisms belonging to the genera of *Lactobacillus and Streptococcus*. The fermentation process comes with the additional benefit of the preservative effect from lactic acid synthesized during the process. Beneficial *Lactobacillus* strains (some of them are regarded as probiotics) in curd can effectively retard the growth of harmful bacteria and common foodborne pathogens, such as *E. coli* and *Salmonella* spp., through a competitive inhibition mechanism (Lievin-Le Moal and Servin, 2014). However, inadequate fermentation conditions and/or contamination during processing may lead to the occurrence foodborne pathogens in all fermented

products. To produce safer traditional foods with consistent quality, the fermentation process must therefore be controlled and carefully selected raw materials should be used so that contamination by pathogenic microorganisms can be eliminated.

Low-cost traditional techniques such as burial in dry sand (lime fruits, yams, tubers, jackfruit seeds), immersing in honey (meat), sun drying (fish, vegetables, and mushroom), and fermentation (fruit- and vegetable-based pickles, milk) used in traditional food preservation are intended to have a significant impact on food safety by controlling the growth of foodborne pathogens. Salting and addition of sugar syrup and/or treacle and bee honey aid in controlling the water activity in many traditional food preparations that impart a significant controlling effect on the growth of microorganisms.

There are also some equipment and raw material handling-related aspects that may contribute to food safety issues such as the absence of mechanized grinding and milling tools (milling and grinding in domestic food preparations are done manually using mortar and pestle) and issues regarding improper cleaning. Such practices may give rise to cross contamination and allow the harboring of foodborne pathogens and their subsequent growth.

Some food items such as the traditional sweets are specially prepared for some occasions and consumed within a short period before any food safety issue arises due to ambient storage. However, the potential for cross contamination is still high due to manual handling.

Some fermented fruit and vegetable products are also regarded as integral elements in traditional Sri Lankan cuisine. Lime pickle, perhaps the most popular traditional pickle, benefits largely by the incorporation of salt crystals during its production for its extended shelf life owing to the natural preservative effect of salt. In other types of pickles, vinegar is used as an additive, which imparts natural preservative effect.

Domestic-level traditional food preparations followed by the exposure to household flies, ants, rodents, and cockroaches in most cases lead to cross contamination and may shorten the expected shelf life. In some cases, when the traditional confectionery items are sold in mass food markets, they are usually stored in open containers, leading to possible contamination by microorganisms and environment pollutants.

The use of aluminum ware for cooking traditional food instead of food-grade stainless steel or traditional clay pots may lead to the leaching of aluminum into the food.

Food poisoning at a household level is not often reported in Sri Lanka. Hence, there is not much evidence to believe that there are hygiene concerns in homemade foods. Furthermore, incidences of food poisoning of people who regularly eat food prepared outside such as in hotels, food stalls, and restaurants are rare. Sri Lankan food habits mostly consist of well-cooked food items instead of raw food items, and this may be a possible reason for lesser number of food poisoning incidents. One reason

Table 2.2 Major food safety issues and concerns associated with Sri Lankan traditional food.

Food category	Safety issues and concerns
Fermented fish products	Histamine food poisoning Growth of food poisoning bacteria (e.g., Clostridium) Heavy metal poisoning (e.g., Pb, Hg) Unpermitted food additives used in the curing process Yeast and mold infestations Insects and mice infestations
Fermented dairy food products	Residues of antibiotics in other veterinary drugs in milk Yeast and mold infestations Use of unpermitted preservatives (e.g., formalin) Contaminated packaging (clay pots)
Vegetable and fruit-based food items	Pesticide residues in raw commodities Presence of microbial pathogens
Cereal and legume-based foods/baked and confectionery items	Adulterated raw materials (rice flour, treacle, jaggery) Pesticide residues and heavy metal residues Yeast and mold infestations Presence of mycotoxins Repeated use of frying oil Food allergies (e.g., nut allergies) Unsafe packaging materials (e.g., newspapers and printed material)

for low number of recorded incidences may be due to nonserious nature or personal treatments using easily accessible medicines and other traditional home remedies.

A summary of some general food safety issues and concerns associated with traditional food is given in Table 2.2.

2.4.3 Regulations governing food safety in Sri Lanka

Food Act No. 26 of 1980 (amendment No. 20 of 1991 and amendment No. 29 of 2011) is the apex national regulation governing food safety in Sri Lanka with the primary purpose of regulating and controlling the manufacture, importation, sale, and distribution of food within the country (Parliament of the Democratic Socialist Republic of Sri Lanka, Food Act, No. 26 of 1980). There are some other supportive acts, such as Food Supplies Ordinance Act 30 of 1957, The Consumer Affairs Authority Act, 2003, Food Production (Estates) Act No. 40 of 1954, that aid in the governance of overall food quality and safety. Although there are no special provisions for traditional and ethnic foods under the existing regulations, the generic principles pertaining to food preparation, storage, handling, serving, and distribution are applicable.

Some of the raw materials used in the production of the popular traditional food items are covered by Sri Lanka Standards (SLS), issued by the national authority responsible for issuing food standards (e.g., Wheat flour SLS 144, White Sugar SLS 191, Cashew nuts SLS 245, Sesame seeds (gingelly seeds) SLS 386, Rice flour SLS 913).

Industrial producers (large scale) frequently use certification schemes and standardizations such as good manufacturing practices (GMP) and hazard analysis and critical control point (HACCP), ISO22000. However, there are several small-scale entrepreneurs who produce traditional food products such as pickles, snacks, and confectioneries in the household and distribute it to the consumers in the same area. These products are not subjected to any test or certification procedures, and therefore food safety concerns may arise. The nonavailability or inadequacy of standards for assuring the quality and safety of local produced spices and condiments is perhaps one of the key issues when using such raw material for traditional food preparations.

2.4.4 Strategies to address the food safety issues of traditional and ethnic food

Given their significance in the local food culture, there is a dire need of robust prevention and control strategies to assess and mitigate the microbiological and chemical (toxicological) risks associated with Sri Lankan traditional and ethnic foods. In this context, it is imperative that basic food safety principles and practices are applied throughout the entire food supply chain to ensure the safety of the final product.

There are however some inherent techniques in the traditional food preparations that can evade some of the common chemical and microbiological food safety issues. Traditional Sri Lankan dishes contain a lot of spices that render a lot of additional benefits in addition to their effect on the taste profile. Antibacterial and antifungal activities of widely used spices in traditional food preparations against food spoilage bacteria such as *Bacillus subtilis* and *Pseudomonas fluorescens*, pathogens such as *Staphylococcus aureus* and *Vibrio parahaemolyticus*, and harmful fungi such as *Aspergillus flavus* have been reported (Liu et al., 2017). Spices and condiments such as cloves, nutmeg, cinnamon, black pepper, cucurmin, ginger, and garlic containing natural bacteriocins are frequently associated with traditional food preparations. Acidification using natural agents such as tamarind (tartaric acid) and garcinia (hydrocitric acid) also aids in controlling the growth of foodborne pathogens while curry leaves/pandan leaves can absorb some of toxic elements present. Cooking rice in excess water, pressure cooking, and the use of clay pots are identified as effective strategies to reduce the level of aflatoxin in rice grains (Reddy et al., 2008).

Different solutions for the reduction of arsenic and other toxic element intake are proposed at different levels: (1) during the plant-growing process through agronomic practices, (2) pretreatment of rice before its use in the food industry, (3) optimization

of the conditions of unit operations during processing, and (4) by cooking (Carbonell-Barrachina et al., 2015).

Reliable and unsophisticated indices/indicators are required to circumvent certain issues such as the repeated use of oil for frying that can be used for traditional food preparations at household level as well as commercial level. Postharvest conditions, especially the storage conditions, for raw materials should be strictly controlled and monitored, as they have a direct impact on the quality and safety of the final product. Environmental factors (light, humidity, oxygen, and temperature) and the presence of living organisms (bacteria, yeasts and molds, mites and nematode worms, insects/moths) should be taken into consideration when designing storage systems for raw materials such as spices (Salgueiro et al., 2010). Given that Sri Lankan ambient storage conditions are in the ranges of 30°C ± 2°C in terms of the temperature and relative humidity of 75% ± 5%, proper attention must be placed on using the correct storage techniques for raw materials used for traditional food processing procedures, especially cereals, grains, and spices that are highly susceptible for mycotoxigenic fungal contamination. Cultivation of such crops under Good Agricultural Practices would be one strategy to especially address the issue of pesticide residues resulting from the indiscriminate use of pesticides on plant material used for traditional food preparations. The Sri Lankan Good Agricultural Practices has been launched recently to achieve this objective.

Although there may be technological and financial constraints regarding the implementation of recommended food safety strategies such as HACCP, at least basic GMP Good Hygiene Practices can be adopted regarding traditional and ethnic food preparation even at the household level, storage, handling, serving, and distribution. Therefore adequate quality control measures should be applied along the food chain to circumvent the common food safety issues.

Sun drying in open air is the traditional method of drying spices in Sri Lanka. As this method potentially exposes them to the risk of contamination by a wide range of mycotoxigenic fungi, emerging techniques such as irradiation can be applied as a surface decontamination treatment for spices. Incorporation of an aflatoxin contamination monitoring system into the regulatory scope for dried coconut kernels (copra) would also be an important step toward ensuring consumer safety in that aspect.

Food service establishments such as restaurants and the household or private residences are identified as the most common venues for foodborne illnesses (Gormley et al., 2012). The small-scale food processing plants and food service establishments such as small eateries and groceries producing and serving the traditional and ethnic foods in Sri Lanka can possibly ignore basic sanitation and hygiene rules. Street food vending outlets could also contribute to a higher incidence of foodborne pathogens, probably due to the lack of safe food handling, improper packaging, and poor storage facilities. Therefore regular inspections should be carried out by the relevant authorities to avoid any risk for public health in traditional food prepared and served in such places.

2.5 Future outlook

Any future strategy to address the safety of traditional and ethnic food should be based on a risk analysis approach, and any national food regulatory standards for them should be aligned according to the Codex principles. It should also be emphasized that food safety is not the responsibility of a single stakeholder but is a shared responsibility between all involved in the value chain.

The existing national regulatory frameworks should be strengthened by integrating prevention and control strategies to address the microbiological and chemical risks associated with traditional and ethnic foods. Food safety regulations and standards for traditional and ethnic food should only be established based on a comprehensive risk assessment, and they should be based on a holistic approach that extends from farm-to-fork and involves all the relevant stakeholders in the agri-food chain.

As traditional and ethnic food preparation practices are informal and mostly transferred from generation to generation, basic food safety education should be an integral component of the public school curriculum to ensure that all citizens are equally well educated on food safety issues and concerns, particularly those associated with traditional and ethnic food.

References

Arakali, S.R., Green, T.D., Dinakar, C., 2017. Prevalence of food allergies in South Asia. Ann. Allergy Asthma Immunol. 118 (1), 16–20. Available from: https://doi.org/10.1016/j.anai.2016.09.441.

Arvanitoyannis, I.S., Dionisopoulou, N., 2014. Acrylamide: formation, occurrence in food products, detection methods, and legislation. Crit. Rev. Food. Sci. Nutr. 54 (6), 708–733. Available from: https://doi.org/10.1080/10408398.2011.606378.

Balasuriya, B.M.G.K., Dharmaratne, H.R.W., 2007. Cytotoxicity and antioxidant activity studies of green leafy vegetables consumed in Sri Lanka. J. Nat. Sci. Found. Sri Lanka 35 (4), 255–258.

Cagri-Mehmetoglu, A., 2017. Food safety challenges associated with traditional foods of Turkey. Food Sci. Technol. (Campinas) 38 (1), 1–12. Available from: https://doi.org/10.1590/1678-457X.36916.

Carbonell-Barrachina, Á., Munera-Picazo, S., Cano-Lamadrid, M., Burló, F., Castaño-Iglesias, M.C., 2015. Arsenic in your food: potential health hazards from arsenic found in rice. Nutr. Diet. Suppl. 1. Available from: https://doi.org/10.2147/nds.s52027.

Codex Alimentarius Commission, 2014. Joint FAO/WHO Food Standards Programme. 37th Session. Distribution of the Report of the Eighth Session of the Codex Committee on Contaminants in Foods. <http://www.fao.org/input/download/report/906/REP14_CFe.pdf> (accessed 19.01.03.).

De Alwis, G.K.H., Wijesekera, R.D., Jayasekera, T.A.D.N.A.K., 2006. Use patterns and residue levels of pesticides on Mukunuwenna, a leafy vegetable grown in Sri Lanka. Bull. Environ. Contam. Toxicol. 76 (1), 119–125. Available from: https://doi.org/10.1007/s00128-005-0897-3.

Deepananda, K.H.M.A., Amarasinghe, U.S., Jayasinghe-Mudalige, U.K., 2016. *Herklotsichthys quadrimaculatus* Korumburuwa in the stilt fishery in Southern Sri Lanka: are they really poisonous? Sri Lanka J. Aquat. Sci. 21 (1), 73–75.

De Silva, A., Abayasekara, C., Dissanayake, D., 2014. Freshly eaten leafy vegetables: a source of food borne pathogens? Ceylon J. Sci. (Biol. Sci.) 42 (2), 95–99. Available from: https://doi.org/10.4038/cjsbs.v42i2.6613.

Dissanayake, D., Manage, P.M., 2010. Aflatoxin contamination in peanuts commercially available in Sri Lanka. Vidyodaya J. Sci. 14 (1), 151–159.

Edirisinghe, E.M.R.K.B., Jinadasa, B.K.K.K., 2019. Arsenic and cadmium concentrations in legumes and cereals grown in the North Central Province, Sri Lanka and assessment of their health risk. Int. J. Food Contam. 6 (1). Available from: https://doi.org/10.1186/s40550-019-0073-x.

Ekanayake, S., 2016. Ethnic fermented food and beverages of Sri Lanka. In: Tamang, J.P. (Ed.), Ethnic Fermented Foods and Alcoholic Beverages of Asia. Springer, New Delhi, pp. 139–150. Available from: https://doi.org/10.1007/978-81-322-2800-4.

Elzupir, A.O., Alamer, A.S., Dutton, M.F., 2015. The occurrence of aflatoxin in rice worldwide: a review. Toxin Rev. 34 (1), 37–42. Available from: https://doi.org/10.3109/15569543.2014.984229.

Gormley, F.J., Rawal, N., Little, C.L., 2012. Choose your menu wisely: cuisine-associated food-poisoning risks in restaurants in England and Wales. Epidemiol. Infect. 140, 997–1007. Available from: https://doi.org/10.1017/S0950268811001567.

Jallad, K.N., 2015. Heavy metal exposure from ingesting rice and its related potential hazardous health risks to humans. Environ. Sci. Pollut. Res. 15449–15458. Available from: https://doi.org/10.1007/s11356-015-4753-7.

Jayasinghe, C., Ahmed, S., Kariyawasam, M., 2010. The isolation and identification of Vibrio Species in Marine Shrimps of Sri Lanka. J. Food Agric. 1 (1), 36–44. Available from: https://doi.org/10.4038/jfa.v1i1.1838.

Jayasumana, C., Paranagama, P., Fonseka, S., Amarasinghe, M., Gunatilake, S., Siribaddana, S., 2015. Presence of arsenic in Sri Lankan rice. Int. J. Food Contam. 2 (1). Available from: https://doi.org/10.1186/s40550-015-0007-1.

Jinadasa, B.K.K.K., Edirisinghe, E.M.R.K.B., Wickramasinghe, I., 2014. Total mercury, cadmium and lead levels in main export fish of Sri Lanka. Food Addit. Contam. B 7 (4), 309–314. Available from: https://doi.org/10.1080/19393210.2014.938131.

Jinadasa, B.K.K.K., Galhena, C.K., Liyanage, N.P.P., 2015. Histamine formation and the freshness of yellowfin tuna (*Thunnus albacares*) stored at different temperatures. Cogent Food Agric. 1 (1). Available from: https://doi.org/10.1080/23311932.2015.1028735.

Jinadasa, B.K.K.K., Chathurika, G.S., Jayaweera, C.D., Jayasinghe, G.D.T.M., 2018. Mercury and cadmium in swordfish and yellowfin tuna and health risk assessment for Sri Lankan consumers. Food Addit. Contam. B 1–6. Available from: https://doi.org/10.1080/19393210.2018.1551247.

Karunarathna, N.B., Fernando, C.J., Munasinghe, D.M.S., Fernando, R., 2019. Occurrence of aflatoxins in edible vegetable oils in Sri Lanka. Food Control 101, 97–103. Available from: https://doi.org/10.1016/j.foodcont.2019.02.017.

Lakshani, P.W.Y., Rajapakse, M.K.L.K., Sendthuran, K., 2017. Pesticide residues in selected vegetables in several growing areas by GC/MS using QuEChERS technique. Ann. Sri Lanka Dep. Agric. 19 (2), 188–208.

Lievin-Le Moal, V., Servin, A.L., 2014. Anti-infective activities of *Lactobacillus* strains in the human intestinal microbiota: from probiotics to gastrointestinal anti-infectious biotherapeutic agents. Clin. Microbiol. Rev. 27 (2), 167–199. Available from: https://doi.org/10.1128/cmr.00080-13.

Liu, Q., Meng, X., Li, Y., Zhao, C.-N., Tang, G.-Y., Li, H.-B., 2017. Antibacterial and antifungal activities of spices. Int. J. Mol. Sci. 18 (6), 1283. Available from: https://doi.org/10.3390/ijms18061283.

Lücke, F.K., Zangerl, P., 2014. Food safety challenges associated with traditional foods in German-speaking regions. Food Control 43, 217–230. Available from: https://doi.org/10.1016/j.foodcont.2014.03.014.

Parliament of the Democratic Socialist Republic of Sri Lanka, Food Act, No. 26 of 1980. <http://www.health.gov.lk/en/FOODWEB/files/regulations.html> (accessed 12.02.19.).

Pathirana, U.P.D., Wimalasiri, K.M.S., Silva, K.F.S.T., Gunarathne, S.P., 2010. Investigation of farm gate cow milk for Aflatoxin M1. Trop. Agric. Res. 21 (2), 119–125.

Perera, A.N.F., 2008. Sri Lankan traditional food cultures, and food security. Econ. Rev. 34 (7–8), 40–43.

Perumalla Venkata, R., Subramanyam, R., 2016. Evaluation of the deleterious health effects of consumption of repeatedly heated vegetable oil. Toxicol. Rep. 3, 636–643. Available from: https://doi.org/10.1016/j.toxrep.2016.08.003.

Prakash, V., 2016. Introduction: the importance of traditional and ethnic food in the context of food safety, harmonization, and regulations. In: Prakash, V., Martín-Belloso, O., Keener, L., Astley, S., Braun, S., McMahon, H., et al.,Regulating Safety of Traditional and Ethnic Foods. Academic Press Elsevier, Waltham, MA, pp. 1–6. Available from: https://doi.org/10.1016/B978-0-12-800605-4.00023-2.

Rajapakse, M.K.L.K., Weerakkody, N.S., Lakshani, P.W.Y., 2018. Quantification of pesticide residues in selected vegetables using the QuEChERS method. OUSL J. 13 (1), 29–42. Available from: https://doi.org/10.4038/ouslj.v13i1.7427.

Reddy, K.R.N., Reddy, C.S., Abbas, H.K., Abel, C.A., Muralidharan, K., 2008. Mycotoxigenic fungi, mycotoxins, and management of rice grains. Toxin Rev. 27 (3–4), 287–317. Available from: https://doi.org/10.1080/15569540802432308.

Salgueiro, L., Martins, A.P., Correia, H., 2010. Raw materials: the importance of quality and safety. A review. Flav. Frag. J. 25 (5), 253–271. Available from: https://doi.org/10.1002/ffj.1973.

Shraim, A.M., 2017. Rice is a potential dietary source of not only arsenic but also other toxic elements like lead and chromium. Arab. J. Chem. 10, S3434–S3443. Available from: https://doi.org/10.1016/j.arabjc.2014.02.004.

Tajkarimi, M., Ibrahim, S.A., Fraser, A.M., 2013. Food safety challenges associated with traditional foods in Arabic speaking countries of the Middle East. Trends Food Sci. Technol. 29, 116–123. Available from: https://doi.org/10.1016/j.tifs.2012.10.002.

Taylor, S.L., 2008. Molluscan shellfish allergy. In: Taylor, S. (Ed.), Adv. Food Nutr. Res.. Academic Press, New York, pp. 139–177. Available from: https://doi.org/10.1016/s1043-4526(07)00004-6.

The Sunday Times., 2017. Tainted food, fruit, veggies, and cooking oil galore. <http://www.sundaytimes.lk/171022/news/tainted-food-fruit-veggies-and-cooking-oil-galore-265175.html> (accessed 19.04.20.).

Vishnuraj, M.R., Kandeepan, G., Rao, K.H., Chand, S., Kumbhar, V., 2016. Occurrence, public health hazards and detection methods of antibiotic residues in foods of animal origin: a comprehensive review. Cogent Food Agric. 2 (1). Available from: https://doi.org/10.1080/23311932.2016.1235458.

Waduwawara, S., Manage, P.M., 2009. Spoilage after cooking of some rice varieties commonly consumed in Sri Lanka. Vidyodaya J. Sci. 14 (1), 131–141.

Weerasekara, P., Withanachchi, C., Ginigaddara, G., Ploeger, A., 2018. Nutrition transition and traditional food cultural changes in Sri Lanka during colonization and post-colonization. Foods 7 (7), 111. Available from: https://doi.org/10.3390/foods7070111.

World Health Organization, 2017.Food Safety Fact Sheet. <https://www.who.int/en/news-room/fact-sheets/detail/food-safety> (accessed 19.01.20.).

Yogendrarajah, P., Deschuyffeleer, N., Jacxsens, L., Sneyers, P.-J., Maene, P., De Saeger, S., et al., 2014a. Mycological quality and mycotoxin contamination of Sri Lankan peppers (*Piper nigrum* L.) and subsequent exposure assessment. Food Control 41, 219–230. Available from: https://doi.org/10.1016/j.foodcont.2014.01.025.

Yogendrarajah, P., Jacxsens, L., De Saeger, S., De Meulenaer, B., 2014b. Co-occurrence of multiple mycotoxins in dry chilli (*Capsicum annum* L.) samples from the markets of Sri Lanka and Belgium. Food Control 46, 26–34. Available from: https://doi.org/10.1016/j.foodcont.2014.04.043.