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Original Research

Total Aflatoxin Levels in Coconut Oil Produced in Sri Lanka and Compliance to Specifications

TM Nanayakkara[1], NP Rajapakse[1], and EP Mendis[1*]

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ABSTRACT

Purpose: *Coconut oil is the preferred edible oil in Sri Lanka. Even though previous studies have reported high aflatoxin contamination in coconut oil produced in Sri Lanka, recent studies assessing the current situation is limited. Hence, this study aims to determine the total aflatoxin levels in different types of coconut oil produced in Sri Lanka and their compliance with national and international standards.*

Research Method: *Bulk-sold copra coconut oil, branded copra coconut oil, branded white coconut oil and branded virgin coconut oil collected from the retail market and coconut oil mills were assessed for total aflatoxin using an enzyme-linked immunosorbent assay kit. Total aflatoxin levels were compared with local and international specifications.*

Findings and Values: *Aflatoxin was detected in 70.5% of the analyzed samples, with variation among different types of coconut oil. Aflatoxin was not detected in any of the virgin coconut oil samples. Bulk-sold copra coconut oil exhibited the highest aflatoxin contamination with all samples being positive for aflatoxin and only 12%, 12%, 12% and 8% of the samples complying with the local regulation (30 µg/kg), SLS specification (10 µg/kg), limits by the Food and Drug Administration (20 g/kg) and European Union (4 µg/kg) respectively. Branded copra and white coconut oils showed higher compliance with these specifications. These results highlight the relatively higher risk in locally sold coconut oil and reiterate the importance of strict enforcement of regulations to ensure consumer safety.*

Keywords: *Copra coconut oil, ELISA, Total aflatoxin, Virgin coconut oil, White coconut oil*

INTRODUCTION

Aflatoxins are mycotoxins produced by *Aspergillus*, a fungus which grows in a range of food commodities stored especially in hot and humid climates (Liu & Wu 2010, Turna & Wu 2019). These metabolites of the fungi *Aspergillus flavus* or *Aspergillus parasiticus* (and rarely *Aspergillus nomius*) are produced on foods and feeds containing appropriate moisture levels and favorable oils enhancing fungal growth at pre-harvest and post-harvest under ambient conditions (Ehrlich *et al.* 2007, Karunarathna *et al.* 2019). *A. parasiticus* produces aflatoxin B_1 (AFB_1), aflatoxin B_2 (AFB_2), aflatoxin G_1 (AFG_1) and aflatoxin G_2 (AFG_2), whereas *A. flavus* primarily produces AFB_1 and AFB_2 (Kumar *et al.* 2017). However, *A. flavus* isolates that produce AFG_1 and AFG_2 have also been identified. Of these four aflatoxins, AFB_1 is frequently present in contaminated food commodities and AFB_2, AFG_1 and AFG_2 are generally not reported in

[1]Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Sri Lanka.
*ereshamendis@agri.pdn.ac.lk
https://orcid.org/0000-0002-0976-1346

the absence of AFB_1(Food and Agriculture Organization of the United Nations/ World Health Organization [FAO/WHO] 2017, Moore *et al.* 2017). When concentrations or maximum levels mention 'total', it refers to the sum of these four aflatoxins frequently assessed for industrial purposes. Aflatoxins are potential carcinogenic, teratogenic, hepatotoxic, mutagenic and immunosuppressive agents that may damage human and animal health (International Agency for Research on Cancer [IARC] 1993, Smith *et al.* 2017, Muhenga & Alphonce 2023). Various analytical techniques including high-performance liquid chromatography (HPLC), liquid chromatography (LC), liquid chromatography with tandem mass spectrometry (LC-MS/MS), thin layer chromatography (TLC), spectrophotometry and enzyme-linked immunosorbent assay (ELISA) are used in the analysis of aflatoxin (Wacoo *et al.* 2014, Mahfuz *et al.* 2020, Yan *et al.* 2020).

Due to the high incidence of aflatoxins in food and feed throughout the world and their potential impact on human health, nearly 100 countries have passed legislation regulating the level of aflatoxin in food and feed (FAO 2004, Reddy *et al.* 2009, Turna & Wu 2019). European Commission (EC) has set specifications for aflatoxin contamination in various foodstuffs, including nuts and related processed products intended for direct human consumption or use as an ingredient in foodstuffs at $4\,\mu g/kg$ (EC, 2006). United States Food & Drug Administration (FDA) has issued a guideline (FDA CPG 555.400) to take legal action against manufacturers for foods contaminated with aflatoxin above $20\,\mu g/kg$ (FDA 2005). Food Control Administration Unit (FCAU) of the Health Ministry in Sri Lanka continues to use $30\,\mu g/kg$ as the maximum limit of total aflatoxin for foods intended for human consumption in Sri Lanka. The standard (SLS 32: 2002) for coconut oil developed by the Sri Lanka Standards Institute (SLSI) which was valid until 2016 (SLSI 2002), did not specify a maximum limit for aflatoxin in coconut oil. Understanding the importance of harmonization of standards with international specifications, SLS coconut oil standard was revised in 2017 (SLS 32: 2017) identifying $10\,\mu g/kg$ as the maximum limit for total aflatoxin (SLSI 2017). However, the SLS standard for coconut oil is not a regulation; new amendments to existing regulations have not yet been developed, and enforcement procedures still follow $30\,\mu g/kg$ as the maximum limit for compliance. Discussions are currently ongoing in the Food Advisory Committee in Sri Lanka to amend the national regulations to identify $10\,\mu g/kg$ as the maximum limit for total aflatoxin in coconut oil marketed in Sri Lanka. Adherence to this limit allows exporters of coconut oil to comply with international specifications. Enforcement officers of FCAU collect market available products to check compliance when required. However, the Coconut Development Authority (CDA) is responsible for inspecting processing units and sampling coconut products to ensure maintenance of required standards by registering producers and coordinating with FCAU to ensure the safety of food products.

Aflatoxins are mainly produced in agricultural crops such as maize (corn), peanuts, cottonseed, and tree nuts in the field and during storage (Mahato *et al.* 2019, Fernando *et al.* 2021). Aflatoxin contamination in edible vegetable oils produced using tree nuts including coconut oil is a global concern due to the harmful effects of aflatoxins on human health associated with their relatively high daily consumption. Moreover, coconut oil is the most preferred edible oil among Sri Lankans and is one of the most important constituents of the Sri Lankan diet. Further, Sri Lanka is a significant supplier of value-added coconut products, particularly desiccated coconut and coconut oil to the world market (Central Bank of Sri Lanka 2021). In line with traditional processing, coconut oil is defined as the product obtained from the coconut (*Cocos nucifera* Linn.) kernel by expelling with or without heat control, followed by filtration (SLSI 2017). Currently, different types of edible coconut oil products are manufactured in Sri Lanka, targeting local and export markets including traditional coconut oil, virgin coconut oil, white coconut oil and refined, bleached and deodorized (RBD) coconut oil. Copra is the major raw material in traditional coconut oil production, which in this research is termed as copra coconut oil. Desiccated coconut serves as the raw material for manufacturing virgin coconut oil. The information gathered from coconut oil manufacturers reveals that white coconut oil is produced using both copra and desiccated coconut as the raw material. However, copra used in white coconut oil production is referred to as white copra as the testa is removed before the coconut oil expelling process. Among different types of oils, bulk-sold (unbranded) copra coconut oil and branded copra coconut oil are popular for local consumption whereas virgin and white coconut oil are popular for exports.

Research on aflatoxin contamination in coconut-based products including coconut oil have been conducted in the 1970s and 1980s (Arseculeratne & De Silva 1971, Samarajeewa & Arseculeratne 1983, Samarajeewa *et al.* 1983). In these studies, attention has been given to bulk-sold (unbranded) copra coconut oil obtained from coconut mills in Sri Lanka and have reported aflatoxin levels higher than the standard maximum limit ($30\,\mu g/kg$) used for several categories of foods, but not particularly coconut oil. Progressive technical and technological advancements over the period have resulted in different types of coconut oil products discussed in this research to cater the local and export demand and new product specifications. However, new research targeting aflatoxin levels in these new products is limited in Sri Lanka; thus, the scientific information provided in this study is timely and contributes greatly to improving the knowledge gaps on the safety of coconut oil, which is important for local and global markets.

MATERIALS AND METHODS

Collection and handling of samples

A total of 85 coconut oil samples consisting of bulk-sold (unbranded) copra coconut oil (25), branded copra coconut oil (20), branded virgin coconut oil (20) and branded white coconut oil (20) were collected for this study. Sample collection was based on information obtained from the Coconut Development Authority (CDA), Sri Lanka, on the number of registered coconut oil millers and manufacturers, and numbers were determined to represent nearly 40% or more from each category. Accordingly, purposive sampling was used, and attention was paid to collect samples from coconut oil producers representing major production areas in Sri Lanka (Kurunegala, Puttlam, Gampaha, Galle and Matara). Bulk-sold (unbranded) copra coconut oil samples were collected directly from coconut oil mills. Branded coconut oil samples collected from the retail market consisted of coconut oil produced by manufacturers supplying coconut oil only to the local market and coconut oil produced by manufacturers supplying to both local and export markets.

All the collected samples were stored at ambient temperature in the dark until analysis.

Reagents, chemicals and test kits

All chemicals and reagents used in this study were of analytical grade. Methanol was obtained from Sigma-Aldrich Co. (USA), and n-hexane was purchased from Daejung (Korea). Horseradish peroxidase (HRP) conjugate, antibody working solution, substrate solutions A and B, and wash buffer were provided with Total Aflatoxin (AF) ELISA Assay kit, E-TO-E006 (catalog no. TO-0006), purchased from Elabscience Biotechnology Inc. (USA). These test kits were validated for the test purpose and were ready-to-use.

Determination of total aflatoxin by indirect competitive ELISA test kit

Total aflatoxin content in coconut oil samples was determined using a commercially available ELISA test kit (Total Aflatoxin (AF) Assay kit, E-TO-E006, Elabscience Biotechnology Inc., USA) recommended for quantitative analysis of total aflatoxin in edible oils. Samples were prepared, and aflatoxins were extracted and analyzed according to the instructions provided by the manufacturer. n-hexane (8 mL) and methanol (10 mL, 70% v/v) were added to the homogenous sample (2.00 $\pm$ 0.01 g) and oscillated for 5 min using a vortex shaker, followed by centrifugation at 4000 rpm for 10 min (model CT40, Hitachi Koki, Japan) at room temperature. The methanol layer was separated and stored at 3 $\pm$ 1 °C. HRP conjugate, antibody-working solution, substrate solutions A and B, wash buffer, and stop solution were provided with the ELISA assay kit. Deionized water (0.5 mL) was added to the methanol extract (0.5 mL) at room temperature and centrifuged at 4000 rpm for 10 min (model H-1500F, Kokusan Corporation, Japan). Standard, blank, and methanol extracted samples (50 µL) were separately added into the micro-ELISA plate wells. HRP conjugate (50 µL) was added into each well, followed by the antibody working solution (50 µL). The micro-ELISA plate was covered, gently oscillated (5 s), and incubated (30 min, 25 °C). The micro-ELISA plate was washed using wash buffer, and the washing procedure was repeated five times at 30 s intervals. Substrate solutions A (50 µL) and B (50 µL) were added into each microplate well, the micro-ELISA plate was gently oscillated (5 s), and incubated (15 min, 25 °C) under shading light. The stop solution (50 µL) was then added and gently oscillated (5 s). The absorbance of the reaction mixture was determined at 450 nm wavelength using a microplate reader (type 1510, Thermo Fisher Scientific Oy, Finland). Three replicates for each sample were used for analysis. A standard curve was obtained by plotting the relative absorbance percentage against the log-transformed concentrations, and the absorbance was inversely proportional to the aflatoxin concentration. Relative absorbance (%) was calculated as the absorbance (of the standard or sample) as a percentage of the absorbance of the zero standard as given below:

$$\text{Absorbance } (\%) = \frac{\text{average absorbance of standard or sample}}{\text{average absorbance of 0 g/kg standard}}$$

Total aflatoxin concentrations in the oil samples were calculated from the standard curve, using the mean relative absorbance (%) values of the samples and dilution factor.

Statistical analysis

Statistical analysis of total aflatoxin was conducted using descriptive statistics, including the mean, standard deviation, minimum and maximum values. Standard errors of percentages were used to determine significant differences among the percentage compliance to the relevant national or international standards specified.

RESULTS AND DISCUSSION

Total aflatoxin levels in coconut oil

Worldwide investigations on aflatoxin began in the 1960s to determine whether a causal relationship exists between the consumption of aflatoxin-contaminated food and the incidence of disease in the human gastrointestinal tract, including the liver (Oettlé 1964, Kraybill & Shapiro 1969). Aflatoxin contamination in coconut oil has been a topic of interest among the Sri Lankan scientific community since the 1970s (Arseculeratne & De Silva 1971) because of the possible health hazards associated with its dietary consumption.

In the present study, aflatoxin was detected in 60 (70.5%) of the 85 samples analyzed. The highest aflatoxin contamination was detected in bulk-sold (unbranded) copra coconut oil with 100% of the samples being positive for aflatoxin. Approximately 90% of branded copra coconut oil and 85% of white coconut oil samples were positive for aflatoxin contamination (Table 1). Total aflatoxin levels of all the virgin coconut oil samples tested were below the detection limit (0.2 µg/kg) of the ELISA test kit and were recorded as non-detected. The ranges of total aflatoxin values detected varied greatly based on the type of coconut oil: bulk-sold (unbranded) copra coconut oil (0.4–617.0 µg/kg), branded copra coconut oil (0.2–178.4 µg/kg) and white coconut oil (0.2–87.1 µg/kg).

As shown in Table 2, a higher value range (0.4–617.0 μg/kg) of total aflatoxin was observed in bulk-sold (unbranded) copra coconut oil compared to the other three types. Some samples showed relatively lower values, the lowest bearing 0.5±0.10 µg/kg, whereas some showed relatively higher values, the highest bearing 616.0±0.57 µg/kg.

The results of this study related copra coconut oil follow similar trends of medium to high aflatoxin contamination, as reported by Arseculeratne and De Silva (1971), and Samarajeewa et al. (1983). Samarajeewa and Arseculeratne (1983) studied the contamination of aflatoxin B_1 in

Table 1. Total aflatoxin levels in various types of coconut oil (N = 85).

Type of coconut oil	Number of samples tested	Number positive	% positive	Range (μg/kg)
Bulk-sold (unbranded) copra coconut oil	25	25	100	0.4–617.0
Branded copra coconut oil	20	18	90	0.2–178.4
White coconut oil	20	17	85	0.2–87.1
Virgin coconut oil	20	0	0	–

Table 2. Distribution of total aflatoxin levels in bulk-sold (unbranded) copra coconut oil samples (N = 25).

Range of total aflatoxin level (μg/kg)	Number of samples
<1	1*
1–50	6
51–100	3
101–150	3
151–200	2
>200	10**

*Lowest value detected: 0.5 μg/kg.
**Highest value detected: 616 μg/kg.

major coconut products, such as copra, copra press cake (copra meal and poonac) and coconut oil. They reported relatively high (more than $25\,\mu g/kg$) aflatoxin B_1 levels in coconut oil collected from 25 mills around the major coconut growing regions (coconut triangle) in Sri Lanka. Furthermore, they correlated the presence of aflatoxin in coconut oil with the rainfall patterns in Sri Lanka. According to these findings, higher levels of aflatoxins have been reported in coconut oil produced during rainy seasons due to low-quality fungal-contaminated copra with high moisture content (more than 6% after curing). In another study, Samarajeewa *et al*. (1983) reported that coconut oil produced by expelling of intermittently processed (sun-dried or smoked) substandard copra by small-scale millers had higher levels of aflatoxin B_1 (mean value 186 ppb in 115 samples of oil) than the levels found in coconut oil processed using standard quality copra by large-scale industrial millers. In recent years, Karunarathna *et al*. (2019) reported aflatoxin contamination in 12 out of 26 copra coconut oil samples in the range of $2.25–72.70\,\mu g/kg$, but none of the six virgin coconut oil samples tested positive for aflatoxin. However, these findings contradict the present study because Karunarathna *et al*. (2019) detected significantly ($p < 0.05$) higher levels of total aflatoxin and AFB_1 in branded copra coconut oil than in unbranded copra coconut oil. This could be due to adulteration of unbranded coconut oil, as the samples in the previous study were obtained from retail stores rather than directly from oil mills.

In the present study, greater variation was observed in the total aflatoxin levels of different types of coconut oil, representing different manufacturing processes. This variation can be attributed to differences in the raw material quality, processing conditions, and manufacturing process. In copra coconut oil production, mechanical expellers are used to crush dry copra to recover oil. Even though bulk-sold (unbranded) copra coconut oil and branded copra coconut oil are manufactured using the same raw materials and processes, the majority of bulk-sold coconut oil samples showed very high levels of aflatoxin contamination compared to branded copra coconut oil. Samarajeewa *et al*. (1983) reported high levels of aflatoxin B_1 in coconut oil produced in small-scale mills compared with coconut oil produced in large-scale mills. Bulk-sold coconut oil is mainly produced in small-scale mills that do not follow good hygienic practices (GHP) or good manufacturing practices (GMP) and copra is sun-dried intermittently, resulting in inadequate curing. As a result, aflatoxin-producing fungi may infect copra during the drying process and produce aflatoxins if proper sanitary conditions are not followed. Domestic curing of copra, which leads to incomplete and inadequate drying, utilization of kernels rejected from large-scale mills and improper storage conditions are the reasons for the high level of aflatoxin in bulk-sold coconut oil. Most branded coconut oils are produced in large or medium-scale oil mills that follow GHP and GMP, other than the food safety management systems (FSMS) such as HACCP and ISO 22000 ensuring adequate drying and good quality copra used for oil production.

Virgin coconut oil, like other virgin vegetable oils undergoes mild processing conditions in order to preserve the original composition of coconut oil (Codex Alimentarius 1999). The manufacturing of virgin coconut oil involves two processing methods: the dry process and the wet process. In the dry process, virgin coconut oil is produced by expelling desiccated coconut and maintains a temperature below 60 °C. This method commonly used for producing virgin coconut oil since it is more efficient for mass production. The wet method involves the extraction of coconut milk by expelling fresh coconut kernels and separating oil from water (Wanniarachchi *et al*. 2023). The separation of oil and water occur through boiling, refrigeration, enzymes and mechanical centrifugation. In both the methods copra is not used as the raw material. Since aflatoxigenic fungi infect copra and mostly produce aflatoxins during the curing process, the possibility of aflatoxin contamination in virgin coconut oil production is absent or very low. Further, the information gathered from the manufacturers revealed that high-quality nuts are utilized in virgin coconut oil production, whereas coconuts of lower quality are utilized in the production of copra coconut oil. Moreover, low-quality nuts and copra rejected from large and medium-scale mills are used as the raw material of small-scale coconut oil mills, producing bulk-sold (unbranded) coconut oil.

In this study, 85% of white coconut oil samples were positive for total aflatoxin and the levels ranged from 0.2–$87.1\,\mu g/kg$. In Sri Lanka, white coconut oil is produced using both white copra and desiccated coconut as raw material. White copra is processed by manual removal of the testa from normal copra and which are also sun dried. These could be the reasons for the high total aflatoxin levels detected in several samples of white coconut oil studied in this study.

Compliance with local and international regulations

Considering both local and international trade of coconut oil, it is worthwhile to check compliance with both international and local standards. Therefore, the total aflatoxin levels detected in the samples were compared with the maximum limit specified for total aflatoxin in Sri Lankan regulation for food products ($30\,\mu g/kg$), the standard specified by the European Union ($4\,\mu g/kg$) (EC 2006), the action level for total aflatoxin given by FDA guidelines ($20\,\mu g/kg$) (FDA 2005) and the SLS specification for total aflatoxin in coconut oil ($10\,\mu g/kg$) (SLSI 2017), (Table 3). All virgin coconut oil samples were compliant with local regulation ($30\,\mu g/kg$), specification of SLS (10 μg/kg), international limits of the EU ($4\,\mu g/kg$) and FDA ($20\,\mu g/kg$). Bulk-sold (unbranded) copra coconut oil showed the lowest percentage of compliance with local (only 12%), EU (only 8%), FDA (only 12%) and SLS specifications (only 12%) for total aflatoxin (Table 3). Branded copra coconut oil and white coconut oil showed relatively higher compliance with the above four specifications as 75%, 55%, 60% & 55% and 85%, 70%, 75% & 70%, respectively in the same sequence. When comparing the percentage values of coconut oil types complying with a specific standard, significant differences ($p < 0.05$) were

Table 3. Compliance of different types of coconut oil produced by manufacturers supplying coconut oil to both local and international markets, with local and international maximum limits for total aflatoxin.

Type of coconut oil	Percentage of samples complying with Sri Lankan regulation (<30 µg/kg)	Percentage of samples complying with SLS specification (<10 µg/kg)	Percentage of samples complying with FDA guideline (<20 µg/kg)	Percentage of samples complying with EU standard (<4 µg/kg)
Bulk sold (unbranded) copra coconut oil	12^a	12^a	12^a	8^a
Branded copra coconut oil	75^b	55^b	60^b	55^b
White coconut oil	85^b	70^c	75^c	70^c
Virgin coconut oil	100^c	100^d	100^d	100^d

Percentage values of coconut oil types complying with a specific standard followed by different letters indicate significant differences ($p < 0.05$).

observed in all four standards, exhibiting a wide variation in coconut oil types with regard to food safety associated with aflatoxin contamination. Therefore, with regard to compliance with a particular standard, all four groups of coconut oil types were significantly different ($p < 0.05$) with the exception of branded copra oil and white coconut oil in complying with Sri Lankan regulation (30 µg/kg).

Levels of total aflatoxin in relation to the intended market

Among the different coconut oil samples evaluated, some represented manufacturers supplying their products to both local and export markets, while others represented manufacturers supplying their products only to the local market. It was observed that the total aflatoxin levels in coconut oil samples produced by manufacturers supplying coconut oil to both local and export markets were lower than those of coconut oil manufactured targeting only the local market. This was observed in branded copra coconut oil, white coconut oil, and virgin coconut oil, as bulk sold (unbranded) coconut oil is only available for local consumption. As shown in Table 4, when comparing the percentage compliance of different coconut oil types complying with a specific standard, significant differences ($p < 0.05$) were observed among the different oil types manufactured targeting the local market. Branded copra coconut oil available in the local market had significantly ($p < 0.05$) higher compliance with the maximum total aflatoxin level specified by all four standards compared to that of bulk sold (unbranded) copra coconut oil. The white coconut oil produced by the above producers for the local market had a significantly ($p < 0.05$) higher compliance with the maximum total aflatoxin level specified by standards compared to that of branded copra coconut oil. More importantly, all the virgin coconut oil samples from the above manufacturers fully complied with all four standards, whereas only 12% of bulk-sold (unbranded) copra coconut oil samples produced by the producers supplying their products only to the local market comply with the maximum limits of total aflatoxin specified by the Sri Lankan regulation for total aflatoxin in coconut oil. This could be because Sri Lankan virgin coconut oil production mainly focuses on the export market and only a small volume is sold locally. Therefore, manufacturers follow FSMS other than GMP and GHP to meet the specifications given by the importing countries.

Furthermore, white coconut oil manufactured

Table 4. Compliance of different types of coconut oil produced by manufacturers supplying coconut oil only to the local market, with local and international maximum limits for total aflatoxin.

Type of coconut oil	Percentage of samples complying with Sri Lankan regulations (<30 $\mu g/kg$)	Percentage of samples complying with SLS specification (<30 $\mu g/kg$)	Percentage of samples complying with FDA guideline (<20 $\mu g/kg$)	Percentage of samples complying with EU standard (<4 $\mu g/kg$)
Bulk sold (unbranded) copra coconut oil	12^a	12^a	12^a	8^a
Branded copra coconut oil	69^b	44^b	50^b	44^b
White coconut oil	81^c	69^c	75^c	69^c
Virgin coconut oil	100^d	100^d	100^d	100^d

Percentage values of coconut oil types complying with a specific standard, followed by a different letter indicate significant differences ($p < 0.05$).

targeting the export market employs only desiccated coconut as the raw material, thus complying with maximum total aflatoxin limits. Aflatoxin in all test samples produced by manufacturers supplying coconut oil to the export market, comprising branded copra coconut oil, white coconut oil, and virgin coconut oil, was either undetected or was below the maximum limit (<4 $\mu g/kg$) specified by the EU standard. Therefore, the level of aflatoxin in coconut oil is not economically significant in relation to the export market. Further, in exporting coconut oil from Sri Lanka, manufacturers are required to provide test reports obtained from laboratories accredited for testing contaminants, including aflatoxin, which controls food safety hazards.

However, an alarming health risk is prevalent in locally consumed bulk-sold (unbranded) copra coconut oil, branded copra coconut oil, and white coconut oil. Since coconut oil is the most utilized edible oil in Sri Lankan cuisine, this situation poses a considerable threat to the Sri Lankan community and requires urgent attention. In Sri Lanka, the CDA is the authoritative body responsible for following up the application of best practices (GMP and HACCP as appropriate) by coconut product manufacturers to ensure the absence of food safety hazards in coconut products, including aflatoxins. In this context, the CDA conducts inspection, supervision, regulation, and control of factories, stores, yards, buildings, premises, equipment, and machinery used for the manufacture, packing, or storage of coconut products. However, an issue exists with some bulk-sold coconut oil millers who do not register under the registration scheme of the CDA, thus escaping inspection. It is impossible to expect good practices from these unregistered millers, and the supply of oil from these millers can be unsafe for human consumption, considering the presence of food safety hazards, including aflatoxin. Identifying the issue with bulk-sold copra coconut oil, the Consumer Affairs Authority (CAA) in Sri Lanka enacted a regulation prohibiting the manufacture, import, distribution, and trade of unlabeled edible oils (Consumer Affairs Authority 2017). However, this is not properly enforced due to practical difficulties at the field level. At present, coconut oil in the local market is not routinely monitored for aflatoxin contamination, and the awareness of consumers and coconut oil manufacturers on the contamination of coconut oil by aflatoxin and its adverse health effects is relatively low. The CDA tests only a limited number of samples from registered producers of both branded and bulk-sold coconut oil for aflatoxin using their accredited laboratory, due to prevailing resource limitations in analytical capacity. Moreover, the number of officers serving as CDA inspectorates is not adequate to conduct routine enforcement activities to ensure the safety of coconut products, including coconut oil. Therefore, this study reiterates the need for functional regulations to monitor the issue of aflatoxin contamination in coconut oil available in the local market and effective enforcement. Considering the present context, it is proposed to improve the analytical capacities of the competent authority (CDA) and strengthen the CDA inspectorate to ensure compliance of the millers and manufacturers of coconut oil to regulate the food safety aspects of locally available coconut oil.

CONCLUSION

This study revealed that the total aflatoxin levels detected in coconut oil produced in Sri Lanka vary among the types of coconut oil and the intended market. Coconut oil types studied in this research—that is, bulk-sold (unbranded) copra coconut oil, branded copra coconut oil, and white coconut oil supplied to the local market—do not satisfactorily comply with the local maximum limits set for total aflatoxin in coconut oil intended for human consumption. The highest risk is associated with the consumption of bulk-sold (unbranded) copra coconut oil, with only 12% of the analyzed samples complying with the SLS specification, followed by branded copra coconut oil and white coconut oil, with 55% and 70% of the samples complying with the SLS specification, respectively. However, total aflatoxin levels in different coconut oil types intended for sale in export markets comply with both EU and FDA-accepted maximum limits, ensuring the safety and high quality of coconut oil exported from Sri Lanka. This study emphasizes the implementation of stringent regulations and enforcement activities targeting safe levels of aflatoxin in coconut oil sold in Sri Lanka, ensuring the safety of local consumers.

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