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Product standards, farmers' practices and global trade: a critical analysis with respect to pesticide residue levels in Indian small cardamom

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Abstract We analyse the potential export markets of Indian small cardamom and the global and importing country-specific product standards (pesticide residue level). Indian exports of small cardamom are negatively and seriously impacted by chemical pesticide residue levels fixed by major importers like Saudi Arabia. The global and country level specifications substantially vary and Indian standards are not in harmony with them. The pesticide usage, handling and trade practices in producing areas are unscientific, leading to accumulation of pesticide residues. The export potential can be fully tapped only through harmonisation of global specifications coupled with responsible interventions in research, legal, extension systems, and stringent monitoring of the production system.

Keywords SPS measures, cardamom, Pesticide residues, MRL, Codex standards, TBT

JEL codes F13, F53, Q17

Introduction

The Agreement on Sanitary and Phyto Sanitary (SPS) measures came into force with the global Agreement on WTO in 1995. This Agreement sets out basic guidelines and rules for food safety and human, plant and animal health. Each country can set standards based on scientific evidence, local situations and risk factors. However, they are encouraged to follow international standards by major global organisations like FAO/WHO *Codex Alimentarius Commission* for food safety. Increasing incomes and growing health consciousness in developed and developing economies have considerably increased the demand for quality food, causing stringent SPS measures in the world food trade. Technical Barriers to Trade (TBT) Agreement covers all technical regulations, voluntary standards and procedures. It is the type of measure which decides whether it is under the TBT agreement, while the purpose of the measure determines whether it is subject to the SPS agreement. Thus, the regulation which addresses microbial contamination and allowable chemical pesticide residue falls under the SPS agreement. However, these standards can potentially impact the global trade in food products as catalysts or barriers.

Consequently, Non-Tariff Measures (NTMs) like SPS measures are gaining greater significance in the international trade of agricultural commodities and form a powerful protectionist tool (Shepherd and Wilson 2013; Ferro, Otsuki, and Wilson 2015). The EU standards inhibit the export from developing economies, though the type and degree of impact are sector-specific (Shepherd and Wilson 2013). The food safety standards imposed by the developed countries could impede processed food export from developing countries (Jongwanich 2009). There are reports of trade restrictions between developed economies also. The EU US trade in fresh fruits and vegetables is constrained by the Maximum Residue Levels (MRL) of pesticides fixed by the EU (Hejazi et al. 2022).

The Basmati rice exports from India to European Union (EU) were down by 35 per cent to 2.5 Lakh Tonnes in 21-22 compared to the previous year, due to pesticide residues above the MRLs specified by the EU. There are reports that the exports to countries such as Qatar and Jordan are also under threat, as these countries follow EU standards. These issues have been there since 2012. As an immediate measure to manage the threat to agricultural export, the Government of Punjab has banned ten chemical formulations of pesticides during the crop season of 2022.

Food and health authorities continuously monitor pesticide residues in agricultural commodities by setting the MRL of pesticides in foods. The MRL of pesticides is the maximum concentration of pesticide residue expressed as mg/kg of food/ animal feeding stuff legally permitted in the food, indicating that the food is safe to eat. The adaptability of producers in developing countries to these measures is seriously constrained by their technical and financial capabilities (Shepherd and Wilson 2013; Jongwanich 2009), as well as local socio-economic and market conditions. Though these measures have the potential to act as a catalyst for safer production (Maertens and Swinnen 2009; Josling 2008), the farm-level practices in developing countries often substantially deviate from scientific prescriptions (Khanal and Singh 2016; Rahman et al. 2018; Devi 2009; Devi et al. 2017), especially in the case of chemical pesticide use leading to higher pesticide residue levels in agricultural commodities.

The globally accepted concepts of sustainable food production and consumption philosophies, as well as food safety concerns, necessitate strategic changes in the food production pattern in developing economies to continue in the global market. This paper analyses the status of global trade in Small Cardamom, the potential markets, major trade restricting aspects (pesticide residue) and the farm-level practices in major producing state, based on which policy suggestions are made.

Methodology

The paper is based on primary and secondary data. Secondary data on exports of cardamom from India and NTMs faced by Indian cardamom were collected from World Integrated Trade Solution (wits.worldbank.org). The export potential, ease of trade, market access and import requirements for Indian cardamom were derived from the International Trade Centre (ITC) Market potential and Market access maps.

The export potential of Indian cardamom was visualized using the Market Analysis Tool developed by the International Trade Centre (ITC) to estimate export potential. This methodology identifies the potential export value for an individual exporting country for a given product and target markets based on an economic model that combines the exporter's supply with the target market's demand, market access conditions and the bilateral links between the two countries (International Trade Centre, 2020). It is based on the decomposition of a country's potential exports of a product to a given target market into three factors: supply, demand and easiness to trade (Decreux and Spies, 2016). The potential export value means the potential value at which a country can export small cardamom to a specific target market given its current supply capacities and the target market's demand and market access conditions. The untapped potential is the gap between actual and potential exports, if any. The reasons for unrealized potential include lack of information about or difficulties in meeting consumer preferences in the target market andmarket regulations, lack of business contacts or knowledge about distribution channels, and mismatch of supplied and demanded varieties (International Trade Centre, 2020).

Primary data was collected from the cardamom farmers in the Idukki district of Kerala, India's leading district and state in small cardamom cultivation. The data on cultivation practices and inputs were collected from a sample of 180 practising farmers drawn through proportionate sampling from different Block

Panchayaths in Idukki District based on the share of area under cardamom. The data was collected through the personal interview method using a structured interview schedule, informal discussions and direct observation. We have also discussed with chemical pesticide retailers, dealers, manufacturing company representatives, and applicators. The data collection was conducted during 2021.

We have compiled the monthly analysis reports on pesticide residue levels detected in cardamom from the Pesticide Residue Research and Analytical Laboratory located at the College of Agriculture, Vellayani, Kerala Agricultural University, corresponding to the period from 2017 to 2021. The laboratory has NABL accreditation (ISO-17025:2017) and with a facility for estimating 98 chemical pesticide residues in water, fresh fruits, vegetables, cereals, pulses, spices, meat and milk.

Results

Global trade in small cardamom and India's share and performance

Global cardamom production shows an increase of almost six times from Triennium Ending (TE) 1970 to TE 2018. India, formerly the leader, is presently the second-largest producer of cardamom after Guatemala, with an annual production of 22,520 tonnes in 2020-21(Spices Board, 2021). The share of India in the world trade of cardamom has decreased from 60 per cent in TE 1972-73 to 18 per cent in TE 2017-18 (IPC, 2020). Among the Indian states, Kerala is the largest producer, with 56 per cent of the area and 89 per cent of the production in the country and more than 90 per cent of the output value (IPC, 2020), followed by Karnataka and Tamil Nadu. Idukki district, with 31,106 ha area and 11,243 tonnes of production, accounted for more than 90 per cent of the area and production of cardamom in the state (GoK, 2021).

More than 90 per cent of the world trade in cardamom is accounted by whole cardamom or cardamom neither crushed nor ground. India is the second largest exporter, with an average annual export of 1850 tonnes in 2019-20. India is also one of the significant consumer of cardamom. The share of Indian cardamom exports in total world exports decreased from 28 per cent in 1988 to 9 per cent in 2020 in quantity and 42.5 to 9 per cent in value. The share of Indian cardamom imports in world imports also has shown a slightly declining trend over the years.

Cardamom has been one of India's most exported spices, and traditionally the prime market for Indian cardamom was the Middle East countries. The majority of small cardamom exports from India in terms of quantity and value during TE 1979-80 were to Kuwait and Saudi Arabia. UAE emerged as an export market after 2000. Nearly 61 per cent of India's small cardamom export was to Saudi Arabia, which was reduced to 30 per cent during the decade ending TE 2019-20. The Indian share in the imports to Saudi Arabia decreased to a low 1.28 per cent in quantity and 0.82 per cent in value terms in 2019, mainly due to the rejection of the consignments consequent to the detection of pesticide residue. In 2019, after the efforts by the Government of India, the export share had slightly improved to around 5 per cent.

Export potential is the value of the export of cardamom, which India can export to a specific target market or importing country, given its supply capacities and market conditions. In Figure 1, the number given for the countries indicates the export potential rank, the circle's diameter indicates the demand potential for cardamom exports, and the lines' thickness indicates the ease of trade for India with these countries. It could be observed that the countries with the highest export potential ranks were UAE, Saudi Arabia, Bangladesh, China, UK, Egypt, Germany, Kuwait and Iraq. The markets with the highest demand potential were Saudi Arabia, UAE, China, Egypt, Bangladesh, Netherlands, United Kingdom, Kuwait, Iraq and Jordan. The countries with which India had the greater ease of trade were Bangladesh, UAE, Oman, Pakistan, Qatar, Bahrain and Kuwait. The markets with the most significant untapped potential for India's cardamom exports are Saudi Arabia, Bangladesh and the United Arab Emirates. Saudi Arabia shows the highest absolute difference between potential and actual exports in value terms, leaving room to realize additional exports worth 20.8 million US$, followed by Bangladesh and UAE with 20.4 and 19.6 US$ million, respectively (Table 1). The untapped potential in the Saudi Arabian market was 51.7 per cent of the actual potential, while it was 45.4 per cent and 87.3 per cent in UAE and Bangladesh, respectively. In order to tap this potential export market in Saudi Arabia and other emerging global markets, the primary challenge is to manage the pesticide residue level.

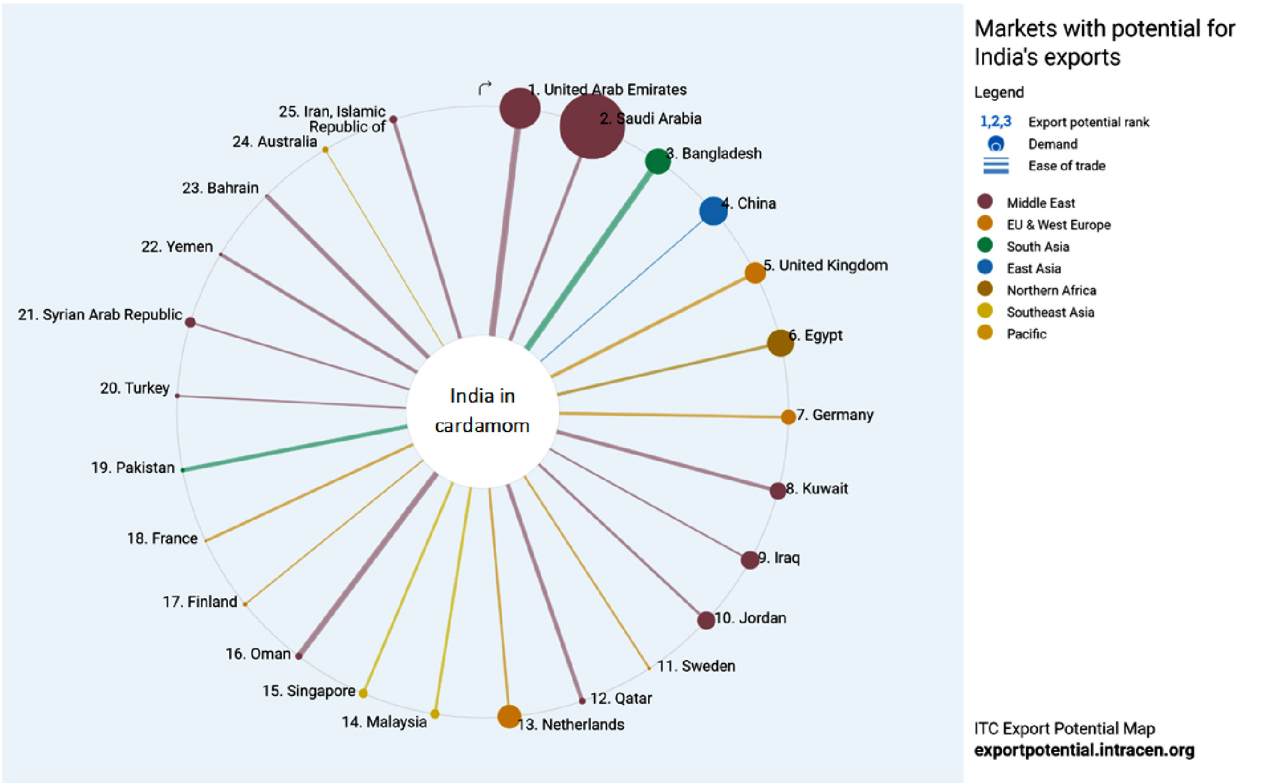

Figure 1 Export potential and ease of trade for Indian cardamom
Source Estimated using ITC export potential map

Table 1 Potential for Indian cardamom in major export markets (in US$ million)

Sl No.	Countries	Export potential	Actual exports	Untapped potential
1	UAE	43.1	23.5	19.6 (45.5)
2	Saudi Arabia	40.3	19.5	20.8 (51.6)
3	Bangladesh	23.2	2.9	20.4 (87.9)
4	China	9.2	0.1	9.1 (98.9)
5	Kuwait	7.1	7.4	- -
6	Egypt	8.1	0.3	7.8 (96.3)

Source Derived from ITC Export Potential Map
Note 1. Figures in parentheses indicate untapped potential as a percentage of total export potential
2. Potential export value of cardamom supplied by India to any country in dollars, is calculated as supply × demand (corrected for market access) × bilateral ease of trade. Supply and demand are projected into the future based on GDP and population forecasts, demand elasticities and forward-looking tariffs

NTMs - the case of pesticide residue

The MRL fixed for chemical pesticide residue in food while ensuring the health of the consuming population act as a vital barrier in global trade. The SPS and TBTs cover more products and trade value than price and quantity-control measures. Furthermore, SPS measures are more prevalent than TBT in agri-food products (WTO, 2012). The number of notifications raised by the European Union in the Rapid Alert System for Food and Feed (RASFF) portal is presented in Table 2. Of the total 11098 notifications during two years, 20.18 per cent is for exports from India. The border rejections in proportion to the notification and destruction to border rejections of the consignment were also the

Table 2 Number of notifications raised by the European Union in RASFF portal (April 1, 2005- May 31, 2017)

Country	Notifications	Border rejections	Border rejections in proportion to notifications (%)	Destruction of consignment
Brazil	1139	717	62.9	None
China	3374	1730	51.3	391 (22.60)
India	2240	1490	66.5	583 (39.12)
Turkey	3296	2018	61.2	431 (21.36)
Vietnam	1049	372	35.5	136 (36.56)
Total	11098	6327	NA	1541

Note 1. Figures in parentheses indicate the proportion of destructed consignments to that of border rejections

highest from India compared to Brazil, China, Turkey and Vietnam. The proportion of border rejections to notifications (66.5 per cent) and the proportion of destruction of consignments to rejections were found to be the highest for exports from India. Number of import detentions for major horticultural products from India to US was also very high. Among the exports of food commodities to the US, spices faced the maximum rejections from April 2010 to March 2011 (Fig 2). This involves a very high resource burden on the economy due to investments in time, efforts and financial resources. The situation also leads to price responses as lagged behaviour, thus affecting farmer welfare as well.

Indian Cardamom is favoured in global markets for its unique quality attributes. However, SPS measures form the major NTMs in cardamom exports by all the major importing countries (Saudi Arabia, UAE, USA, Kuwait and Canada). SPS, TBT and others formed 100 specifications for imports in UAE, 87 in Saudi Arabia and 81 in Kuwait (Table 3). Even though UAE imposed the highest number of NTMs, India exported the highest quantity of Cardamom to UAE in 2020. Nevertheless, the exports to the conventional importer Saudi Arabia were the least mainly due to unacceptable levels of pesticide residue (Fig 3). The Saudi Food and Drug Authority (SFDA) detained four import consignments from India during April-May 2018 due to the detection of pesticide residues above MRLs. Consequently, the exporters stopped exporting Cardamom to Saudi Arabia, fearing detention. A delegation from SFDAvisited Spices Board's Quality Evaluation Laboratory in Kochi, spices export processing units and cardamom plantations. The Spices Board was advised to draw up a work plan to address the issue of pesticide residues in Cardamom to resume the exportsto Saudi Arabia.

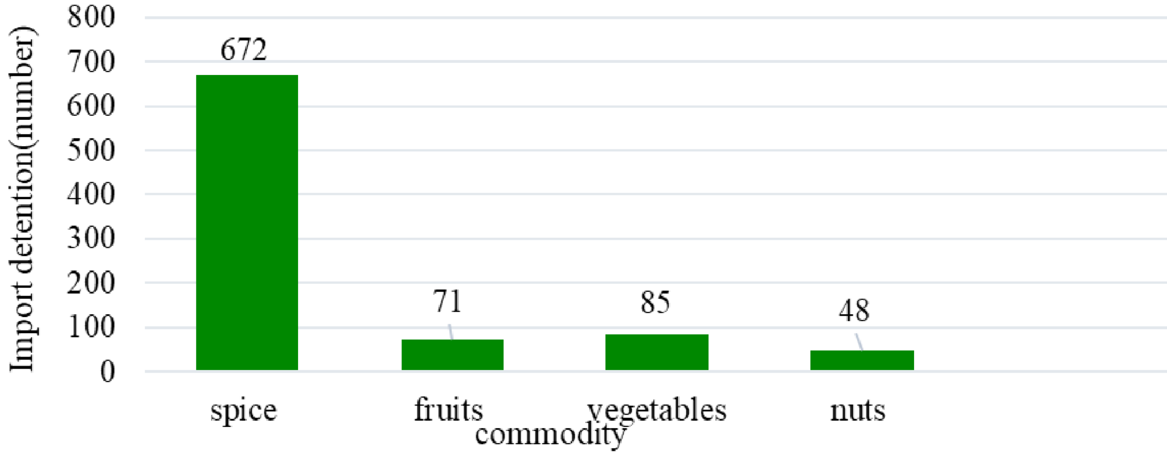

Figure 2 Number of USFDA import detentions for various horticultural products from India during 2010-2011

Table 3 NTMs affecting Indian cardamom trade by types and countries (2020)

Countries	SPS	TBT	Others	Total
Saudi Arabia	78 (89.65)	3 (3.45)	6 (6.90)	87 (100.00)
UAE	97 (97.00)	1 (1.00)	2 (2.00)	100 (100.00)
USA	33 (73.33)	11 (24.44)	1 (2.23)	45 (100.00)
Kuwait	77 (95.06)	2 (2.47)	2 (2.47)	81 (100.00)
Canada	34 (97.14)	1 (2.86)	0 (0.00)	35 (100.00)

Note Figures in the parentheses indicate percent to row total

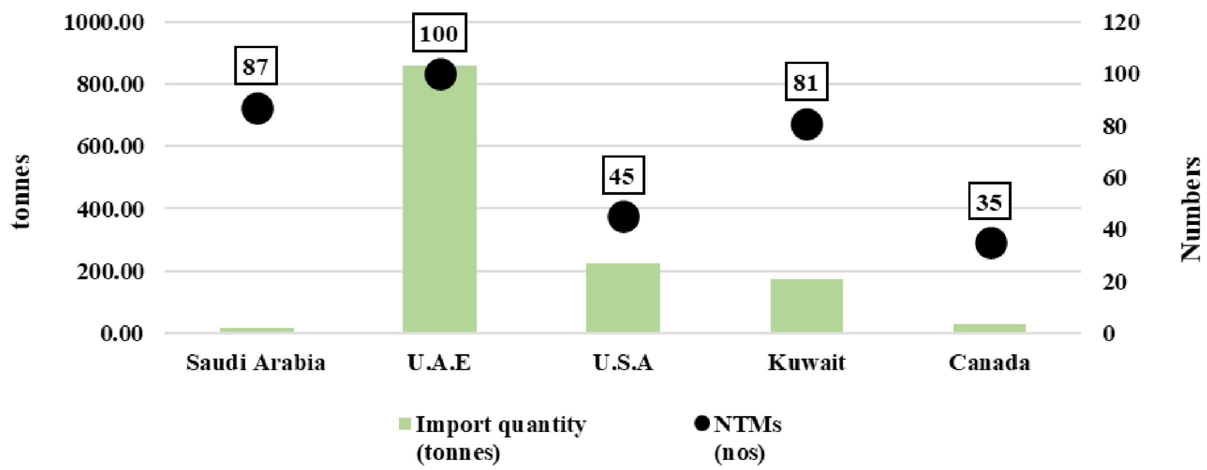

Figure 3 Imports and import requirements of Indian cardamom in major importing countries (2020)
Source Estimated using data from ITC Market Access Map

Farm level practices and pesticide residue level in cardamom

More than 95% of the total area under cardamom cultivation in Kerala is the high-yielding variety "Green Gold", which is highly susceptible to multiple biotic and abiotic stresses. This variety requires higher levels of nutrient uptake and therefore, external application of fertilizers and manures is unavoidable to maintain higher yields, especially under the acid soil conditions. The resultant luxurious growth favour pest multiplication and disease incidence. Further, the changing weather pattern (erratic rainfall coupled with warming) across all seasons favour pests multiplication, mainly the shoot and capsule borers, thrips, root grubs and whiteflies. Decreased precipitation levels in July–September have increased the population levels of significant pests, particularly thrips and capsule borers, beyond the critical levels inflicting severe damage to the developing capsules. An early start and long summer, along with increased break periods during monsoon months, provide a favourable environment for whiteflies. Continuous use of synthetic pyrethroids and combination products had led to population build-up of sucking (whiteflies) and lacerating type (thrips) pests, leading to insect resistance to pesticides, thereby tempting the farmers for more frequent application. Summer rainfall, higher mean minimum temperatures and higher relative humidity favour continuous flowering and yield and the farmers adopt regular plant protection to ensure better harvest and visual quality of the capsule. The attack of thrips on the capsules results in a scabby appearance, and the attack of borer causes the development of boreholes. Such defective product has a low market preference and is either rejected or fetch lower prices. Bold and parrot green cardamom has more market acceptance and hence farmers resort to regular plant protection measures. Continuous and sustained unscientific application of potentially lethal pesticides has substantially damaged the population of natural enemies of pests triggering the chances of rapid pest multiplication in this ecosystem. Consequently, with a desperate bid to protect the crop, farmers resort to several rounds of chemical pesticide spray. Since capsule borers are cryptic, their chances of escaping pesticide exposure are high, making repeated pesticide application inevitable. Chemical control of thrips resulted in better cardamom quality which fetched a higher price in the market (Murugan et al. 2017). Cardamom capsule has a life of 120 days and is often exposed to a minimum of six to seven chemical sprays, each spray containing a combination of two to three pesticides. More than 15 rounds of pesticide application per crop season are reported in cardamom. Table 4 furnishes the details of major chemical pesticides applied in small cardamom. Our field-level study found 38 different chemical formulations used for pest control, of which 28 are insecticides, 8 are fungicides and one is an acaricide and the other, a plant growth promoter. Most of these chemicals are sprayed as combination sprays, and the scientific prescriptions concerning concentration, method of application and precautions are seldom followed. The national level scientific prescriptions for pest management in cardamom are furnished in Appendix 1.

The majority chemicals that were sprayed in the crop (16 numbers) belong to the yellow category (Highly Toxic), 12 were BLUE (moderately toxic), eight were GREEN (slightly Toxic), and two were RED category chemicals (Extremely Toxic) as per the World Health Organization (WHO) categorization of chemical pesticides based on toxicity levels. Among these chemicals, only three chemicals (Lamda Cyhalothrin (YELLOW), Quinalphos (YELLOW) and Diafenthiuron (BLUE) have the label claim for use in cardamom. Label claim, issued based on scientific evidence, prescribes the chemical for specific crops and pests. This ensures legal protection for using the chemical in the specified crop against specified pests, as per technical prescriptions.

The poor monitoring and regulatory system in the trade sector add to the unscientific behaviour of the users as the retailers form the primary source of technical information regarding the choice of chemicals and related aspects. Farmers opt for plant protection based on technical advice, personal experience, advice from other farmers, and advice from company representatives or pesticide dealers. Farmers were more inclined to suggestions and recommendations from pesticide companies or input dealers. The field-level representatives of major manufacturing firms are actively present in the cardamom growing areas. There are several reports on the unscientific practices of trade, use and handling of chemical pesticides in India (Devi 2010; Shetty, Murugan, and Sreeja 2008) and cardamom plantations of Kerala in particular and related ecological health issues (Usha 2007; Murugan et al. 2017; Sreedharan et al. 2014). It is reported that 50 per cent of the total pesticide consumption in the state is used in cardamom. On average, farmers apply pesticides every 15-18 days, resulting in 18-25 sprays per year as against the need-based recommendation by KAU. Insecticides form the primary group of pest control chemicals, possessing high levels of insect and mammalian toxicity. The unscientific use of dangerously high levels of pesticides in cardamom plantations is hazardous to the environment's biotic and abiotic components.

The unregulated market conditions, weather factors and conventional farmer behaviour result in unscientific use and handling practices and lead to high levels of the residue of chemical pesticides in the products offered for sale, apart from the ecological and health damages. The micro-level crop health management practices are to be redesigned to ensure clean production practices and safe produce.

Pesticide residue levels and barriers to trade

Kerala Agricultural University and the Kerala State Department of Agriculture conduct periodic analyses of farm products produced and traded in the state. The presence of pesticide residue in cardamom as per these reports (from January 2017 to December 2021) is furnished in Table 4. Out of the 38 chemicals sprayed in cardamom, residues of 15 chemicals were found of which only one belongs to the GREEN category. The residue is above MRL for two of the three chemicals with label claim, i.e. Lamda Cyhalothrin and

Table 4 Common insecticides used in small cardamom production in Idukki district, Kerala state

Sl. No	Classification	Chemical name	Residue status	MRL Level
1	Green	Azoxystrobin		2
2		Carbendazim	Reported	2
3		Chlorantranilprole		2
4		Cyanthraniliprole		2
5		Flubendiamide		2
6		Novaluron		2
7		Spinetoram		2
8		Sulphur		2
9	Yellow	Acetamiprid		2
10		Alpha Cypermethrin	Reported	2
11		Bifenthrin	Reported	2
12		Cartap Hydrochloride		2
13		Chlorpyriphos	Reported	2
14		Cypermethrin		2
15		Ethion	Reported	2
16		Fenpyroximate		2
17		Fipronil		2
18		Imidacloprid	Reported	2
19		Indoxacarb	Reported	2
20		Lamdacyhalothrin * (4.9 CS)	Reported	
21		Phenthoate		2
22		Profenophos	Reported	2
23		Quinalphos * (25% EC)	Reported	1
24		Thiodicarb		2
25	Blue	Acephate	Reported	2
26		Diafenthiuron* (50% WP)		Below MRL
27		Difenconazole	Reported	2
28		Emamectin Benzoate		2
29		Fluopyrum		2
30		Fluensulfone		2
31		Metalaxyl	Reported	2
32		Propiconazole		2
33		Spinosad		2
34		Spiromesifen		2
35		Tebuconazole		2
36		Thiamethoxam	Reported	2
37	Red	Carbosulfan		2
38		Methomyl	Reported	2

Note * denotes having label claim
**1 if it is above MRL and 2 if MRL is not fixed

Quinalphos. Most of the pesticides used by cardamom farmers have no label claim for the crop; hence, the MRL is not fixed. Food Safety and Standards Authority of India (FSSAI) is the agency to fix the MRL for major pesticides and regulations to ensure domestic food safety. The agency fixes the MRL for only those pesticides with label claims for the crop.

Table 5 furnishes the details of the MRLs fixed by the four major agencies (WHO/FAO Codex Alimentarius, European Union (EU), FSSAI and SFDA for major chemicals used for pest management in small cardamom. These four agencies have fixed the MRLs for only 14 chemicals, while the chemicals differ across agencies. Codex standards are there for nine chemicals, EU for eight, SFDA for six and FSAAI for four chemicals. The chemicals and levels of MRL are specified at a uniform level by the Codex, EU and SFDA for five major chemicals, *viz*. Triazophos, Dithiocarbamate, Cypermethrin, Profenophos and Lambda cyhalothrin. Though chemical compounds are the same for Codex and EU in the case of nine chemicals, one differs in MRL level specification. In the case of Bifenthrin, Codex standard of MRL is lower (0.03 mg per kg) than 0.1 mg per kg of EU.

SFDA standards for six chemicals are almost on par with Codex levels, though Acetamiprid does not find a place in the Codex list. Interestingly, none of the chemicals for which FSSAI fixes MRL, finds a place in the Codex, EU and SFDA specifications.

Analyzing the results of the pesticide residue levels reported from 2017 to 2021 (Table 6), it could be seen that the residue levels of all the chemicals vary across the period and was higher than the MRL in the case of chemicals that global agencies specify. For instance, the MRL for Ehion is fixed at 5mg per kg by Codex and EU and the residue level was as high as 7.79 in at least one year and was very close to the value in two years. The residue level of Lambda-cyhalothrin was higher than the MRL of 2 mg per kg fixed by Codex, EU and SFDA in all the years. Profenphos, for which the MRL is 3mg per kg (Codex, EU and SFDA), the residue was reported at more than that level (3.01) as well as very close to 3 (2.95). The residue level was five times the specified level in the case of Chlorpyriphos at least in one year though it was within limits on many occasions. Bifenthrin, for which there are different standards for Codex (0.03) and EU (0.01), the residue level was as high as 4.13 and was always higher than the specifications. Acetamiprid, for which MRL is specified only by SFDA, at 0.1 mg per kg, was detected at a residue level of more than 1 mg per kg. Dithiocarbamate and Triazophos, included in the SFDA, are not reported to be used by the farmers. Cypermethrin residue is not detected in any samples analyzed during the period. It is a matter of concern that the small cardamom grown in the high ranges of the state follows unscientific pest management practices that lead to undesirable levels of chemical

Table 5 Comparison of MRLs of chemical pesticides in small cardamom (mg/Kg) specified by different agencies

Sl. No.	Name of the chemical	Codex Alimetarius	EU	SFDA	FSSAI
1	Dithiocarbamates	0.1	0.1	0.1	-
2	Cypermethrin	3	3	3	-
3	Profenophos	3	3	3	-
4	LamdaCyhalothrin	2	2	2	-
5	Triazophos	4	4	4	-
6	Ethion	5	5	-	-
7	Chlorpyrifos	1	1	-	-
8	Bifenthrin	0.03	0.1	-	-
9	Cyhalothrin L	2	2	-	-
10	Monocrotophos	-	-	-	0.50
11	Quinalphos	-	-	-	0.01
12	Diafenthiuron	-	-	-	0.50
13	Fosetyl Al	-	-	-	0.2
14	Acetamiprid	-	-	0.1	-

Table 6 Year-wise changes in the pesticide residue status in small cardamom (2017-2021)

Sl. No.	Category	Chemical name	2017	2018	2019	2020	2021
1	Green	Azoxystrobin	ND	ND	ND	ND	0.06-0.25
2		Carbendazim	0.11-0.61	0.04-1.7	0.05-3.04	0.05-0.43	0.07-0.21
3		Chlorantranilprole	ND	ND	ND	ND	ND
4		Cyanthraniliprole	ND	ND	ND	ND	ND
5		Flubendiamide	ND	ND	ND	ND	ND
6		Novaluron	ND	ND	ND	ND	ND
7		Spinetoram	ND	ND	ND	ND	ND
8		Sulphur	ND	ND	ND	ND	ND
9	Yellow	Acetamiprid	ND	ND	ND	ND	ND
10		Alpha Cypermethrin	ND	ND	2.05-2.61	0.065-1.44	0.07-1.68
11		Bifenthrin	0.11-0.87	0.05-0.7	0.05-4.13	0.05-0.68	0.05-1.27
12		Cartap Hydrochloride	ND	ND	ND	ND	ND
13		Chlorpyriphos	0.06-0.54	0.06-0.82	0.05-5.22	0.10-0.586	0.06-0.71
14		Cypermethrin	ND	ND	ND	ND	ND
15		Ethion	0.06-1.00	0.10-7.79	0.06-2.58	0.06-5.3	0.07-4.54
16		Fenpyroximate	ND	ND	ND	ND	ND
17		Fipronil	ND	ND	ND	ND	ND
18		Imidacloprid	0.08-0.43	0.05-0.48	0.05-1.01	0.05-1.04	0.07-0.38
19		Indoxacarb	ND	ND	0.13	0.15-0.239	0.05
20		Lamdacyhalothrin * (4.9 CS)	0.11-2.90	0.23-2.05	0.10-5.42	0.08-2.55	0.09-2.02
21		Phenthoate	ND	ND	ND	ND	ND
22		Profenophos	0.74-3.01	0.06-1.44	0.07-1.39	0.1522-1.04	0.06-2.95
23		Quinalphos * (25% EC)	0.23-9.49	0.2-2.22	0.10-9.45	0.21-13.38	0.07-3.19
24		Thiodicarb	ND	ND	ND	ND	0.18-0.34
25	Blue	Acephate	ND	0.46	0.05-0.052	0.118-0.736	0.08
26		Diafenthiuron* (50% WP)	ND	ND	ND	ND	ND
27		Difenconazole	0.13	0.05-0.12	ND	0.05-1.95	0.06-0.57
28		Emamectin Benzoate	ND	ND	ND	ND	ND
29		Fluopyrum	ND	ND	ND	ND	ND
30		Fluensulfone	ND	ND	ND	ND	ND
31		Metalaxyl	ND	0.14-0.47	0.09-0.45	0.05-0.37	0.07-3.61
32		Propiconazole	ND	ND	ND	0.237-1.43	0.06-0.38
33		Spinosad	ND	ND	ND	ND	ND
34		Spiromesifen	ND	ND	ND	ND	ND
35		Tebuconazole	ND	ND	ND	0.05-0.33	0.07-0.91
36		Thiamethoxam	ND	0.05-0.68	0.07-1.19	0.05-0.68	0.06-0.09
37	Red	Carbosulfan	ND	ND	ND	ND	ND
38		Methomyl	0.07-0.56	0.05-0.36	0.11	0.062-0.169	0.07-2.62

Note 1. Unit- mg /Kg
2. ND denotes Not Detected

pesticide residue that hamper the prospects of export markets.

The prospects of exploiting the potential markets can be ensured through the harmonisation of FSSAI and Codex standards and .scientific pest control practices.

Conclusion

India is among the countries with significant potential to export small cardamom. However, it has realized less than fifty per cent of its export potential, leaving an untapped potential worth 134.6 million US$. The primary destinations are United Arab Emirates, Saudi Arabia and Bangladesh. Saudi Arabia is the market with the highest export potential for Indian Cardamom. Despite this favourable condition, the share of imports of Saudi Arabia of Indian small cardamom shows a declining trend, mainly owing to food quality concerns (pesticide residue). This situation is mainly attributed to the farm-level undesirable production practices, which are influenced by the poorly monitored pesticide trade system, legal and technical aspects, and market responses. Unscientific practices of pesticide use have a bearing on the financial, ecological and social dimensions of the local, regional and global economy, both in the short term and long term. The situation necessitates policy interventions that include research for technology development, farmer education, supply regulations, monitoring and residue analysis, and global consensus on standards.

The use of plant protection chemicals in cardamom should achieve sustainability in the system through Integrated Pest Management (IPM), application and promotion of bio-control agents, and judicious and supervised application of chemical plant protection formulations. The chemical pesticides under the IPM protocol need to be specified by the scientific community. It is desired if such chemicals are those for which global specifications of pesticide residue standards are already fixed. The legal compliance for using these chemicals must be ensured by assigning label claims. Consequently, FSSAI may fix the MRL for such chemicals to comply with global standards.

A traceability system in the trade sector needs to be established by applying modern technologies like blockchain. Correspondingly, educating the stakeholders of the value chain (with a focus on consumers as well) on the quality aspects and appearance, as well as scientific grading practices, can signal the farmers for the adoption of greener technologies. Knowledge and skill development on safe and scientific use of chemicals in farming is the collective responsibility of the public sector and the manufacturers of chemicals.

In the short run, we need to comply with the specifications of importing nations. Hence, the use of pest control chemicals in cardamom must be restricted to only those permitted by importing countries like Saudi Arabia, coupled with a compliance mechanism to ensure field-level adoption. As a long-term strategy, efforts at the policy level may be taken to adopt uniform standards by importing countries. Internationally harmonized EU standards facilitate the global trade of developing countries as they favour better cost management, especially fixed costs.

It is also to be mentioned that the concept of sustainable food production principles, which the EU establishes, includes broader aspects like social, ecological, climatic and economic dimensions of crop production. Apart from the food quality and ecological safety aspects, it includes a reduction in greenhouse gas emissions during agri-food production and supply, which corresponds to the main goal of the EU Green Deal 57, aimed at decarbonization and achieving climate neutrality. Thus, the food trade may take into consideration the aspects like food quality (nutritive value), climate change influence (greenhouse gas emissions), ecological impacts (use of chemical pesticides, prevention of land degradation, biodiversity loss) and social angle (employees' rights, use and rights of women and child labour). Developing countries must design a mix of policy, technology and governance interventions to transform the production systems to meet the future global market specifications.

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Appendix

A1 Insecticides having label claim for cardamom under Central Insecticide Board and Registration Committee (CIB &RC)

Crop	Name of pests	Dosage / ha			Waiting period (days)	MRL levels
		a.i (gm)	Formulation (gm/ml)	Dilution in water (Litre)		
Diafenthiuron 50% WP	Thrips, Capsule borer	400	800	1000	7	0.5
Monocrotophos 36% SL	Thrips	375	937	500-1000		0.5
Quinalphos 25% EC	Thrips	0.03%	600-1200	500-1000	30	0.01

Source Major uses of Pesticides, (UPTO - 31/01/2020) Directorate of Plant Protection, Quarantine & Storage Central Insecticide Board & Registration Committee N.H.-IV, Faridabad-121 001 (Haryana)