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# Analysis of Pesticide Residues Exceeding EU Maximum Residue Limits in Rice Consignments: A Case Study of RASFF Notifications (2018-2022)

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**KEYWORDS**
Pesticide residues, Basmati rice, RASFF, MRLs

**ABSTRACT**:
Pesticides are used as plant protection agents to protect crops from various pests and diseases; however, residues of Pesticides have become a global concern as pesticide residues are harmful to human health. Most of the countries have established maximum residue limits(MRLs) against each pesticide to ensure entry of safe food in their country. The purpose of this study is to identify the most repeated pesticide residues in Rice, exported from India to EU, in five years (2018-2022) which have been reported in EU's Rapid Alert System for Food and Feed(RASFF). The MRLs of these vital few (the most repeated) pesticide residues have been compared with International Standard Setting Body i.e. Codex and National Standard Setting Body i.e. Food Safety and Standard Authority of India( FSSAI), as the variation in the MRLs is a major challenge in the Global Supply Chain of Agri Commodities including Staple food i.e. Rice. In addition, focus is also needed to control vital few pesticides against which RASFFs have been generated so that the supply chain is not affected.

## 1. Introduction:

Pesticides are chemicals designed to protect food by controlling harmful insects, diseases, rodents, weeds, bacteria and other pests. They can destroy, suppress or alter the life cycle of pests [(1)]. Chemical pesticides have consistently demonstrated their worth by increasing global agricultural productivity, reducing insect-borne, endemic diseases, and protecting/restoring plantations, forests, harvested wood products, homes, and fiber [(2)]. However, the extensive use of pesticides may result in their accumulation in the agricultural produce. Their low biodegradability has classified these chemicals as persistent toxic substances. Pesticides, biological stability, and a higher degree of lipophilicity in food commodities pose a significant effect on human and animal health, leading to certain diseases and systemic conditions.[(3,4)]

Notably, in 1992, the World Health Organization (WHO) reported approximately three million cases of pesticide poisoning in humans annually, resulting in 220,000 deaths worldwide (5). The Regulation (EC) 396/2005 on Maximum Residue Levels (MRLs) of pesticides in or on food and feed of plant and animal origin defines pesticide residues as any remnants, including active substances, their metabolites, and/or breakdown or reaction products of active substances that have been or are currently used in plant protection products. These residues can be found in or on products, including those that may arise as a result of their use in plant protection, veterinary medicine, or as biocides. MRLs represent the legally established upper limits of pesticide residue concentration in food or feeds, based on good agricultural practices and designed to ensure the lowest possible consumer exposure, especially for vulnerable consumers [(6).]

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The Rapid Alert System for Food and Feed (RASFF), established in 1979, serves as an essential mechanism for efficient information sharing among its members. These members include national food safety authorities of EU Member States, the European Commission, the European Food Safety Authority (EFSA), the European Space Agency (ESA), as well as Norway, Liechtenstein, Iceland, and Switzerland. RASFF operates around the clock, ensuring the swift and coordinated exchange of information to collectively address and respond to urgent notifications [7]. RASFF operates in accordance with Regulation (EC) 178/2002 and Regulation (EC) 16/2011, with the primary goal of providing information about food-related risks, whether direct or indirect, that pose serious threats to human health. This facilitates an immediate and coordinated response to emerging food safety hazards [8].

When a member state of the European Union identifies a feed or food safety risk within its territory through various detection mechanisms, it promptly notifies the European Commission through the RASFF system. The European Commission then disseminates this notification to other member states, enabling them to take appropriate actions in response. RASFF notifications can be categorized into three types, as outlined in Table 1.

In this study, we have conducted an analysis of RASFF notifications concerning pesticide residues in rice for the period from 2018 to 2022, covering a span of five years. Our findings indicate that while there are relatively few incidents compared to the total volume of rice exported from India, most rice consignments are safe. Nevertheless, our study highlights the more stringent Maximum Residue Levels (MRLs) set in accordance with EU regulations compared to the standards of the Food Safety and Standards Authority of India (FSSAI). Furthermore, Codex has yet to establish MRLs for key pesticides, warranting attention. Additionally, we have employed Pareto analysis to pinpoint the critical few pesticides responsible for the majority of RASFF incidents.

## 2. Method

Data for this study was extracted from the RASFF portal using specific search criteria. The search parameters included Pesticide Residues Notifications reported between January 1, 2018, and December 31, 2022. Furthermore, we narrowed down our search to the "Rice" product category with a specific focus on incidents related to "India." The data extracted from the RASFF portal was then downloaded in Excel format for subsequent analysis.

To refine our dataset, we utilized various data filtering tools to extract the relevant information. Specifically, we focused on identifying the type of pesticide residues that were detected in these notifications. This process was essential in preparing the data for further analysis.

In the subsequent phases of our study, we applied various analytical tools to gain insights from the dataset. This included trend analysis to identify patterns and changes over time. Additionally, we conducted Pareto analysis to pinpoint the critical pesticide residues responsible for the majority of RASFF notifications. These analyses served as the foundation for the subsequent discussion and conclusions.

In addition to the RASFF data, we conducted comprehensive literature research to supplement our findings. We utilized prominent academic databases, including Google Scholar, Scopus, Wiley Online Library, ResearchGate, PubMed, and Academia.edu, to access scholarly articles and publications related to pesticide residues in food. These sources were invaluable in providing context and relevant studies for comparison.

Furthermore, to broaden our understanding of international and federal entities related to pesticides and food safety standards, we conducted internet searches using popular search engines such as Google and Yahoo. This approach helped us identify key organizations and standards relevant to our study.

The combination of RASFF data analysis and comprehensive literature review allowed us to draw well-informed conclusions and recommendations in our research.

## 3. Results

### 3.1 RASFF Notifications Pertaining to Pesticide Residues

Table 2 lists RASFF notifications related to pesticide residues reported between 2018 and 2022. These notifications encompass all countries, including EU member states, and cover various commodities. Over this five-year period, a total of 3,568 notifications were registered, documenting incidents of pesticide residues in a range of products, including but not limited to fruits and vegetables, nuts, nut products, seeds, cereal, and bakery items.

### 3.2 RASFF Notifications Concerning Rice from India

Table 3 provides a summary of the different pesticide residues detected in RASFF notifications for rice originating from India. The data is presented year by year, from 2018 to 2022 (2018-RASSFs-Rice, 2019-RASFFs-Rice, 2020-RASFFs-Rice, 2021-RASFFs-Rice, 2022-RASFF-Rice).

Across this period, there were 12 RASFF notifications in 2018, 11 in 2019, 8 in 2020, 8 in 2021, and 29 notifications in 2022 pertaining to pesticide residues that exceeded EU Maximum Residue Limits (MRLs).

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**3.3 EU MRLs for Rice**

In accordance with Regulation EU 396/2005 and the pesticide residue database, a total of 507 pesticides have been identified for which maximum residue limits (MRLs) have been established by the EU for rice (19). It is customary for rice consignments entering the EU to undergo testing for compliance with these MRLs.

This revised presentation of your "Results" section provides a clear and organized structure for your findings, making it easier for readers to grasp the information you've presented. The use of tables to display data enhances readability and comprehension.

3.4 Most repeated pesticides in the Rice consignment Based on the data available in the table-3 in 3.2 above, it has been observed that the pesticides summarized in Table 4 are being repeated. It has been observed that out of 507 pesticides being tested in the consignment of Rice , there are only 9 pesticides which have been detected in the consignment exceeding MRL set by EU as per regulation 396/2005 , which includes Acephate, Buprofezin , carbendazim , chlorpyrifos, imidacloprid, Methamidophos, Thiamthoxam, Triazophos and Tricylazole. Out of these 9 pesticides, based on pareto analysis (Figure-1), there are three Pesticides which are the most repeated,these are Tricyclazole (occurred 59 times), Thiamethoxam (Occurred 36 times) and carbendazim (occurred 10times).

ChatGPT

Here's an improved presentation of the "Results" section, specifically focusing on the most repeated pesticides in rice consignments:

**3.4 Most Repeated Pesticides in Rice Consignments**

As evident from the data provided in Table 3 in section 3.2, it is apparent that certain pesticides have recurrently surfaced in RASFF notifications concerning rice consignments. The pesticides summarized in Table 4 are notable for their repetition.

Out of the 507 pesticides subjected to testing in rice consignments for compliance with EU-established Maximum Residue Limits (MRLs) as per Regulation 396/2005, a mere nine pesticides have been found to exceed these limits. These pesticides are Acephate, Buprofezin, Carbendazim, Chlorpyrifos, Imidacloprid, Methamidophos, Thiamethoxam, Triazophos, and Tricyclazole.

A Pareto analysis, depicted in Figure 1, has been conducted to identify the most frequently recurring pesticides among these nine. It reveals that three pesticides stand out as the most repeated culprits. These are Tricyclazole, which occurred 59 times in the notifications, Thiamethoxam, with 36 occurrences, and Carbendazim, which was reported 10 times.

This presentation offers a clear and structured overview of the most frequently detected pesticides in rice consignments, providing readers with key insights into the data. The use of a Pareto analysis and visual representation in Figure 1 enhances the clarity of the findings.

**4. Discussion**

**4.1 Comparison of MRLs for Tricyclazole, Thiamethoxam, and Carbendazim**

In the context of food safety, regulatory bodies like the Food Safety and Standards Authority of India (FSSAI), the European Union (EU), and the Codex Alimentarius Commission play vital roles in setting Maximum Residue Limits (MRLs) for pesticides. These MRLs serve as critical standards to ensure the safety of food products for domestic consumption and international trade. It is essential to compare the MRLs set by these bodies for three pesticides—Tricyclazole, Thiamethoxam, and Carbendazim—repeatedly detected during 2018-2022 in RASFF notifications related to rice. Table 5 presents a comparative analysis of MRLs for these pesticides. Notably, the MRL for Tricyclazole set by FSSAI is 300 times higher than that of the EU. However, it is important to mention that Codex has not established an MRL for Tricyclazole in rice. In the case of Thiamethoxam, FSSAI's MRL is twice as high as the EU's MRL, and again, Codex has not set an MRL for this pesticide in rice. Similarly, the MRL for Carbendazim, as defined by FSSAI, is 200 times greater than that of the EU. Once more, Codex has not specified an MRL for Carbendazim in rice.

**4.2 Focus on Vital Few**

The data presented in Table 3 and the Pareto analysis in Figure 1 highlight the significance of three pesticides: Tricyclazole (59 occurrences), Thiamethoxam (36 occurrences), and Carbendazim (10 occurrences), which together account for 89% of the RASFF notifications (105 out of 118). This underscores the importance of giving special attention to these three pesticides. Training farmers in the strict implementation of Good Agricultural Practices can significantly reduce RASFF notifications, despite their relatively low frequency in comparison to the total volume of rice exports. It's important to note that addressing these three pesticides may not completely prevent all food safety incidents, as there may be other potential contaminants that require monitoring. Continuous improvement in food safety practices throughout the supply chain remains essential for ensuring safe and high-quality food production.

**4.3 Harmonization of MRLs**

Differences in MRLs among countries can lead to situations where the same food product is considered safe in one country but unsafe in another. Such variations can impact international trade and food safety standards. The importance of harmonizing MRLs is highlighted by Article 3, clause 1 of the SPS (Sanitary and Phytosanitary) agreement, which emphasizes the

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harmonization of sanitary and phytosanitary measures based on international standards, guidelines, or recommendations. Furthermore, as per clause 4 of the SPS agreement, members are encouraged to participate in relevant international organizations like the Codex Alimentarius Commission to develop and periodically review standards, guidelines, and recommendations for sanitary and phytosanitary measures.

In light of the global challenges associated with food security and food safety, the harmonization of MRLs has become a necessity. By aligning these standards, countries can facilitate safer international trade and enhance overall food safety measures.

This revised "Discussion" section offers a more structured and clear discussion of your findings, emphasizing the importance of MRL harmonization and the significance of the identified pesticides in food safety.

**5.0 Conclusion**

The findings of this study reveal that the number of RASFF notifications related to rice from India, between 2018 and 2022, due to the presence of pesticide residues exceeding Maximum Residue Limits (MRLs) is relatively low, constituting just 1.9% of the total RASFF notifications generated during this period across all countries and food categories. It is noteworthy that out of the 507 pesticides for which the European Union (EU) has set MRLs for rice, only three pesticides—Tricylazole, Thiamethoxam, and Carbendazim—are responsible for a substantial 89% of these notifications. By focusing on these three pesticides and promoting the adoption of Good Agricultural Practices while raising awareness among farmers, a significant reduction in RASFF notifications stemming from MRL exceedances can be achieved.

A major challenge in the supply chain of agricultural commodities, including essential staples like rice, is the variation in MRLs set by different countries. Such differences can result in the same food product being considered safe in one country while being deemed unsafe in another due to varying MRLs established by respective nations. Harmonization of MRLs, as underscored in the Sanitary and Phytosanitary (SPS) Agreement, is a critical necessity. International standard-setting bodies, such as the Codex Alimentarius Commission, need to actively address this issue to facilitate safer international trade and ensure consistent food safety measures.

In conclusion, this study emphasizes the need for targeted attention to specific pesticides, the importance of harmonizing MRLs on a global scale, and the potential for significant improvements in food safety practices within the agricultural supply chain.

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**Table 1:** Type of RASFF Notifications

| **Notification** | **Description**[8] |
|---|---|
| Alert | A food or feed presenting a risk is on the market and rapid action is required |
| Information | A food or feed presenting a risk has been identified but other members in the network do not need to take rapid action because the product has not reached their market |
| Border Rejection | Notification that a consignment of food, feed or food contact material was refused entry into a member state |

**Table 2:** RASFF notifications between 2018-2022

| RASFF related to Pesticide Residues | Border rejection+alert+information for attention+information for follow up |
|---|---|
| 2018[9] | 276 |
| 2019[10] | 297 |
| 2020[11] | 776 |
| 2021[12] | 1231 |
| 2022[13] | 988 |
| Total | 3568 |

**Table -3**[14]/[15]/[16]/[17]/[18]

| 2018- RASSF -Rice | | |
|---|---|---|
| **S.No.** | **RASFF No.** | **Pesticide Residues detected above EU MRLs** |
| 1 | 2018.1132 | Thiamethoxam |
| | | Methamidophos |
| | | Acephate |
| | | Carbendazim |
| | | Tricyclazole |
| 2 | 2018.1225 | Triazophos |
| | | Tricyclazole |
| 3 | 2018.1291 | Triazophos |
| | | Tricylazole |
| 4 | 2018.1436 | Thiamethoxam |
| | | Methamidophos |
| | | Acephate |

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| | | |
|---|---|---|
| | | Carbendazim |
| | | Tricylazole |
| 5 | 2018.1487 | Triazophos |
| | | Tricyclazole |
| 6 | 2018.1518 | Tricyclazole |
| 7 | 2018.2589 | Thiamethoxam |
| | | Tricyclazole |
| 8 | 2018.3086 | Carbendazim |
| | | Thiamethoxam |
| | | Tricyclazole |
| 9 | 2018.3345 | Carbendazim |
| | | Thiamethoxam |
| | | Tricyclazole |
| 10 | 2018.3383 | Tricyclazole |
| 11 | 2018.3442 | Tricyclazole |
| 12 | 2018.3502 | Acephate |
| | | Carbendazim |
| | | Tricyclazole |
| **2019- RASSF- Rice** | | |
| 1 | 2019.0441 | Thiamethoxam |
| | | Tricyclazole |
| 2 | 2019.0473 | Acephate |
| | | Tricyclazole |
| 3 | 2019.0627 | Thiamethoxam |
| | | Tricyclazole |
| 4 | 2019.0902 | Acephate |
| | | Thiamethoxam |
| | | Methamidophos |
| | | Tricyclazole |
| 5 | 2019.1013 | Tricyclazole |
| 6 | 2019.1748 | Tricyclazole |
| 7 | 2019.2047 | Tricyclazole |
| 8 | 209.2526 ) | Tricyclazole |
| 9 | 2019.3312 | Tricyclazole |
| 10 | 2019.3471 | Thiamethoxam |
| | | Tricyclazole |
| 11 | 2019.3551 | Thiamethoxam |
| | | Tricyclazole |
| **2020-RASFF-Rice** | | |
| 1 | 2020.1154 | Thiamethoxam |
| | | Tricyclazole |
| 2 | 2020.1289 | Buprofezin |
| 3 | 2020.1483 | Tricyclazole |
| 4 | 2020.1999 | Thiamethoxam |
| | | Tricyclazole |
| 5 | 2020.1995 | Thiamethoxam |
| | | Tricyclazole |
| 6 | 2020.3482 | Tricyclazole |
| | | Carbendazim |
| 7 | 2020.4243 | Buprofezin |
| | | Tricyclazole |
| 8 | 2020.4283 | Tricyclazole |
| **2021-RASFF-Rice** | | |
| 1 | 2021.1139 | Thiamethoxam |
| | | Tricyclazole |

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| | | |
|---|---|---|
| 2 | 2021.1186 | Thiamethoxam |
| | | Carbendazim |
| | | Tricyclazole |
| 3 | 2021.1193 | Thiamethoxam |
| | | Carbendazim |
| | | Tricyclazole |
| 4 | 2021.5493 | Thiamethoxam |
| | | Tricyclazole |
| 5 | 2021.6289 | Thiamethoxam |
| | | Tricyclazole |
| 6 | 2021.6705 | Thiamethoxam |
| | | Tricyclazole |
| 7 | 2021.6599 | Thiamethoxam |
| | | Tricyclazole |
| 8 | 2021.7101 | Chlorpyrifos |
| 2022-RASFF-Rice | | |
| 1 | 2022.7263 | Tricyclazole |
| 2 | 2022.6939 | Thiamethoxam |
| | | Tricyclazole |
| 3 | 2022.6891 | Tricyclazole |
| | | Thiamethoxam |
| 4 | 2022.6864 | Tricyclazole |
| 5 | 2022.6671 | Thiamethoxam |
| 6 | 2022.6624 | Tricyclazole |
| 7 | 2022.6485 | Tricyclazole |
| 8 | 2022.6481 | imidacloprid |
| | | Tricyclazole |
| 9 | 2022.6288 | Chlorpyrifos |
| | | Tricyclazole |
| | | Thiamethoxam |
| 10 | 2022.612 | Thiamethoxam |
| | | Tricyclazole |
| | | Propicanzole |
| 11 | 2022.5733 | Thiamethoxam |
| | | Tricyclazole |
| 12 | 2022.5658 | Tricyclazole |
| 13 | 2022.5442 | Thiamethoxam |
| | | Tricyclazole |
| | | Imidacloprid |
| 14 | 2022.52 | Thiamethoxam |
| | | Tricyclazole |
| 15 | 2022.5057 | Thiamethoxam |
| | | Tricyclazole |
| 16 | 2022.4997 | thiamethoxam |
| | | Tricyclazole |
| 17 | 2022.4575 | Tricyclazole |
| 18 | 2022.4266 | Tricyclazole |
| 19 | 2022.4235 | Tricyclazole |
| 20 | 2022.4035 | Tricyclazole |
| 21 | 2022.374 | Thiamethoxam |
| | | Tricyclazole |
| 22 | 2022.3142 | Tricyclazole |
| 23 | 2022.2958 | Tricyclazole |
| | | Thiamethoxam |
| 24 | 2022.257 | Chlorpyrifos |

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| | | |
|---|---|---|
| 25 | 2022.24 | Tricyclazole |
| | | Thiamethoxam |
| 26 | 2022.2316 | Chlorpyrifos |
| 27 | 2022.23 | Thiamethoxam |
| | | Tricyclazole |
| | | Propiconazole |
| 28 | 2022.2047 | Thiamethoxam |
| | | Tricyclazole |
| 29 | 2022.1819 | Thiamethoxam |
| | | Tricyclazole |
| | | Carbendazim |

**Table -4**

| Name of Pesticides | Frequency of Occurrence of Pesticide Residues exceeding MRL set by EU | | | | | |
|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| Acephate | 3 | 0 | 0 | 0 | 0 | 3 |
| Burpofezin | 0 | 0 | 1 | 0 | 0 | 1 |
| Carbendazim | 5 | 0 | 1 | 2 | 2 | 10 |
| Chlorpyrifos | 0 | 0 | 0 | 1 | 1 | 2 |
| Imidacloprid | 0 | 0 | 0 | 0 | 2 | 2 |
| Methamidophos | 2 | 0 | 0 | 0 | 0 | 2 |
| Thiamethoxam | 5 | 5 | 3 | 7 | 16 | 36 |
| Triazophos | 3 | 0 | 0 | 0 | 0 | 3 |
| Tricyclazole | 8 | 11 | 7 | 7 | 26 | 59 |

**Figure -1**

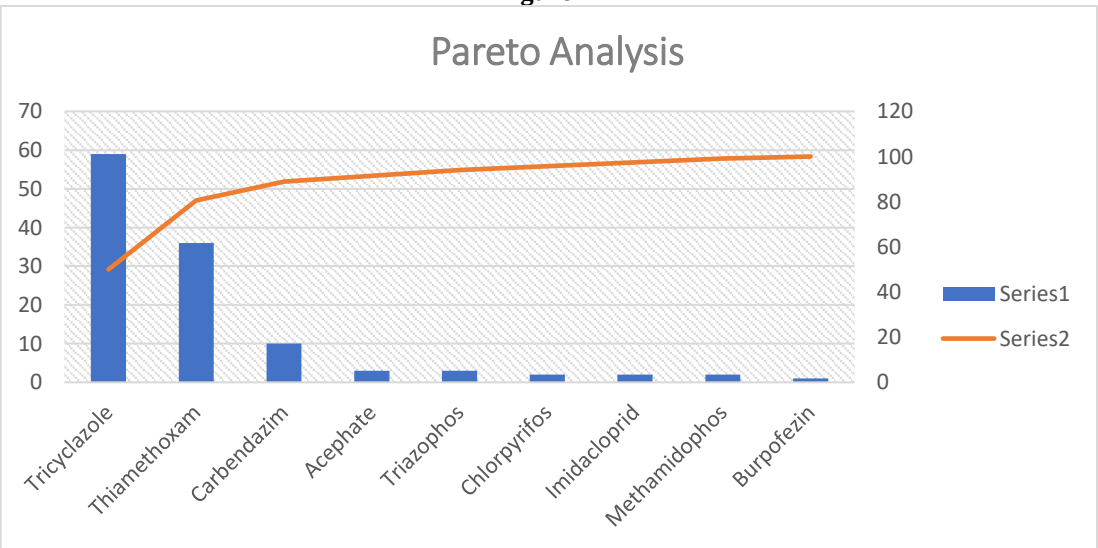


**Table 5:** Comparison of the MRLs of most repeated Pesticide Residues

| Commodity -Rice | MRLs as per FSSAI[20] | MRLS as per Codex Alimentarius Commission [21] | MRLs as per EU[22] |
|---|---|---|---|
| Tricyclazole | 3 | No MRL has been set | 0.01 |
| Thiamethoxam | 0.02 | No MRL has been set | 0.01 |
| Carbendazim | 2 | No MRL has been set | 0.01 |