



Centre for Environment & Agriculture

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White Paper

Why a Default Pesticide MRL of 0.01 ppm for Tea Risks Unreliable Results, Unwarranted Rejections and Product Recalls

Applying a default maximum residue limit (MRL) of **0.01 ppm** to pesticides in tea can produce unreliable and difficult-to-reproduce results because of the commodity's chemical complexity and the practical limitations of ultra-trace analysis.

Tea is a particularly challenging dry matrix. Its dehydrated leaf structure contains a dense network of naturally occurring compounds that influence the beverage's flavour, aroma, colour and perceived health benefits. During residue testing, many of these compounds may be extracted together with the target pesticide.

The Complex Chemical Composition of Tea

- **Polyphenols:** These account for about **30%** of the dry weight of tea leaves. They contribute antioxidant properties as well as tea's characteristics of astringency and bitterness.
- **Caffeine:** This natural stimulant dissolves readily in hot water and contributes a mild bitterness to tea's flavour profile.
- **Pigments:**
 - **Chlorophyll:** Gives unoxidized green tea its distinctive colour.
 - **Carotenoids:** Yellow-orange pigments that break down during processing and help form complex aroma compounds.
- **Essential oils:** Although present at less than **0.1%**, these volatile compounds are largely responsible for the distinct **aroma and** flavour of different tea varieties.

During residue analysis, these co-extractives can interfere with the measurement of pesticides. In gas chromatography-mass spectrometry (GC-MS), co-eluting plant compounds may overlap with pesticide signals, distort peak response and, in some cases, contribute to false-positive findings.



This interference is known as the matrix effect.

The matrix effect becomes especially significant when a default MRL of **0.01 ppm** (0.01 mg/kg) is applied. FSSAI currently prescribes this tolerance for many pesticides in tea, placing regulatory decisions at a concentration where small analytical variations can materially influence compliance outcomes.

Consequently, applying a default MRL of **0.01 ppm** to tea can make results less reliable, less reproducible and more vulnerable to misinterpretation.

At **0.01 ppm** - equivalent to **one gram of pesticide in 100 tonnes** of tea - background signals from the sample matrix can readily distort the response of the target pesticide.

The recognized way to minimize this interference is to prepare calibration standards in a blank tea-matrix extract rather than in pure solvent. Although matrix-matched calibration is considered the preferred approach for accuracy, it is costly, time-consuming and therefore not routinely followed by many laboratories.

Why laboratories struggle to control the matrix effect

- **Sourcing a true blank matrix:** Obtaining tea that is demonstrably free from the relevant pesticide below **0.01 ppm** can be difficult and expensive.
- **Higher sample-preparation costs:** Laboratories must perform the full extraction process for the test samples and again produce sufficient blank extract for the calibration curve.
- **Limited shelf life:** Matrix-matched standards can degrade faster than solvent-based standards because of co-extracted material and may need to be prepared frequently.
- **Instrument contamination and maintenance:** Repeated injections of matrix-rich extracts can contaminate LC-MS/MS and GC-MS systems, increasing downtime, cleaning requirements and maintenance costs.

For these reasons, matrix-matched calibration is not commonly practiced across laboratories in India.

A default MRL of **0.01 mg/kg** places regulatory decision-making at the extreme lower end of analytical capability for many pesticides - matrix combinations. Modern LC-MS and GC-MS instruments may detect residues at this level under controlled conditions, but the ability to detect a signal should not be equated with the ability to quantify it accurately and consistently.



Regulatory limits should be set at concentrations at which validated methods demonstrate acceptable accuracy, precision, reproducibility and measurement uncertainty. In a complex commodity such as tea, these performance characteristics can deteriorate substantially at 0.01 ppm.

Requiring laboratories to adopt a limit of quantification of **0.01 ppm** can push instruments such as GC-MS close to their practical limits and increase the scope for analytical error.

At this concentration, even microscopic carry-over from a previous test can generate an apparent residue and potentially lead to an incorrect failure report.

Moreover, the default tolerance of **0.01 ppm** is not derived from a pesticide-specific human-health risk assessment; toxicological thresholds established through risk assessment may be considerably higher.

At ultra-trace levels (**0.01 ppm**), analytical systems are also highly vulnerable to contamination and carry-over.

Potential sources include:

- Trace impurities in solvents;
- Background contamination within the laboratory;
- Carry-over from previous instrument injections;
- Contaminated consumables; and
- Environmental contamination in the laboratory.

Because **0.01 ppm** is only **10 micrograms per kilogram**, even minute contamination can produce an apparently positive finding.

In practice, an MRL of **0.01 ppm** functions as a near-zero-tolerance standard.

Such a standard may be difficult to meet even under organic production because low-level pesticide contamination can occur through environmental exposure, drift, shared infrastructure and other pathways beyond a producer's direct control.

Taken together, these scientific and operational constraints make the blanket application of a **0.01 ppm** tolerance to tea problematic.

A default tolerance of **0.01 ppm** for tea offers limited regulatory value unless laboratories can demonstrate that results at this level are accurate, reproducible and supported by fit-for-purpose methods.

Spices and herbs present comparable analytical challenges because pigments, essential oils, lipids



and phenolic compounds can alter ionization efficiency in LC-MS systems. In the year 2024, for these commodities, the Food Safety and Standards Authority of India (FSSAI) issued an order raising the default Maximum Residue Limit (MRL) for pesticide residues in spices and culinary herbs from **0.01 mg/kg** (ppm) to **0.1 mg/kg**. A similar corrective action is needed in case of tea also.

Concluding Remarks

The detection of a pesticide residue at **0.01 ppm** in a tea sample does not automatically imply that consumer exposure exceeds established safety limits. Therefore, the detection of a pesticide residue at **0.01 ppm** in a tea consignment or batch should not, by itself, trigger destruction or disposal of the product as inedible. Such regulatory decisions should be based on a scientific consumer risk assessment, taking into account actual dietary exposure and toxicological reference values.

It is also important to understand that pesticide MRLs are not toxicological thresholds. MRLs are primarily trade and compliance standards. In setting MRLs, extensive safety factors are applied, and they are generally kept **100 times lower** than the **No Observed Adverse Effect Level (NOAEL)**.

Basing food safety enforcement in tea on a default MRL of **0.01 ppm** carries significant risks as it introduces substantial, analytical, environmental, and economic vulnerabilities. It penalizes stakeholders for technically unavoidable causes rather than non-compliance.

A **0.01 ppm** level of pesticide residue in dry tea leaves is toxicologically insignificant for the consumer considering the "**brew factor**" (or transfer rate), which dictates how much of a substance leaches into the liquid infusion that people drink. Studies show that **fewer than 5% to 10%** of these residues leach into a hot water brew; the remaining **90% +** stays trapped harmlessly in the discarded wet leaves.

A standard cup uses roughly **2 grams of tea leaves per 100–200 mL of water**. This preparation creates an automatic **50-to-100-fold** physical dilution of any surface residue before factoring in chemical behaviour.

The Indian tea industry unnecessarily pays a heavy price due to unscientific regulatory decisions. **This needs to be reviewed and addressed.**

Centre for Environment & Agriculture (CENTEGRO)

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