

8. THE DIFFERENCE BETWEEN COMPLIANCE WITH LEGAL LIMITS AND THE ABSENCE OF DETECTABLE RESIDUES

When we buy food, we generally take it for granted that it complies with food-safety rules. This is a fundamental condition on which the entire food marketing system rests. But what does it really mean for food to comply with the law? Does it mean that it contains no undesirable substances? That every possible contaminant has been tested for? Or that the concentrations of the substances tested are within the applicable limits?

The answer is more complex than it might appear. European legislation sets maximum levels for many pesticide residues and other contaminants, using scientific risk assessments and regulatory criteria. These limits help protect public health, but they are not designed to certify the complete absence of undesirable substances from food. Food can be fully compliant with the law and still contain quantifiable residues of several pesticides. Conversely, food in which no residues have been quantified cannot automatically be regarded as free of every contaminant. To understand why, we must distinguish legal compliance, analytical sensitivity and what is actually known about a product's chemical composition.

8.1 What does complying with the law actually mean?

Regulatory compliance means that a food product meets the requirements applicable to its sale. For pesticides, Regulation (EC) No 396/2005 establishes maximum residue levels (MRLs) for specific combinations of substances and food products. An MRL is the maximum concentration legally permitted, generally expressed in milligrams per kilogram of food.

Suppose, for example, that an MRL of 0.5 mg/kg applies to a given pesticide in apples. If a laboratory measures 0.3 mg/kg, the residue is below that limit. If it measures 0.7 mg/kg, the analytical result exceeds the limit; an official determination of non-compliance must nevertheless take measurement uncertainty and the applicable rules into account. These figures are purely illustrative.

The crucial distinction is that, in the first case, the pesticide is actually present and has been quantified, even though the food complies with the law. Staying below the limit does not mean that the substance is absent. It means that its concentration does not exceed the legally permitted value. Nor does it mean that every other contaminant potentially present in the food has been investigated. Compliance is a necessary condition for marketing a product, but it is not a complete description of its chemical quality.

8.2 Detectable, quantifiable and non-quantifiable residues

When examining food, a laboratory uses instruments capable of identifying specified chemicals and, where analytical conditions permit, measuring their concentrations. Three concepts must be distinguished to interpret the results correctly.

The first is the limit of detection, or LOD. In simplified terms, it is the lowest concentration at which a method can distinguish the presence of a substance from background signals according to predefined analytical criteria.

The second is the limit of quantification, or LOQ. It is the lowest concentration at which a method can measure a substance with precision and accuracy suitable for the purpose of the analysis.

The third is the maximum residue level, or MRL: the maximum concentration legally allowed under the relevant rules.

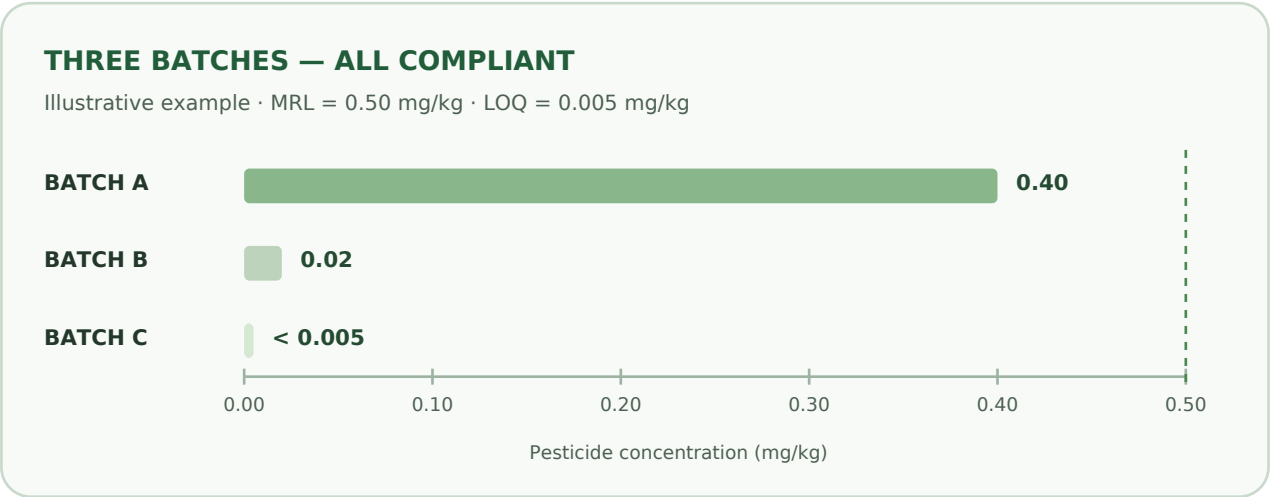
These three values need not be equal. A laboratory may be able to detect a substance without determining its concentration with sufficient reliability. It may also be able to quantify concentrations far below the legal maximum. A result reported as below the LOQ does not necessarily mean that the substance is completely absent. It means that the substance was not quantified at or above the declared quantification capability of the method.

“Not quantifiable” does not mean “non-existent.” It means that reliable quantitative measurement was not possible under the analytical conditions used. This distinction is essential when interpreting any laboratory certificate.

8.3 A practical example: three food batches, all legally compliant

Imagine three batches of the same food tested for the same pesticide. Let us assume an MRL of 0.50 mg/kg and a laboratory LOQ of 0.005 mg/kg. The results might be as follows.

Batch	Analytical result	Regulatory compliance
A	0.40 mg/kg	Compliant
B	0.02 mg/kg	Compliant
C	Below 0.005 mg/kg	Compliant for the parameter tested



All three batches meet the legal limit when only this pesticide is considered. Yet their analytical profiles differ. In batch A, the residue is quantified at a concentration approaching the limit. In batch B, it is quantified at a concentration twenty times lower than in batch A. In batch C, the laboratory does not quantify the residue at the declared sensitivity level.

From the standpoint of compliance with MRLs, all three results are within the specified value. From the standpoint of analytical knowledge, they are clearly different. This difference alone does not establish that batch A is harmful or batch C completely safe. Assessing health risk would require information on the substance's toxicology, dietary exposure and other relevant factors.

Nevertheless, a consumer could legitimately prefer batch C on the basis of a selection criterion that favours a lower quantifiable presence of that substance. Regulation sets a threshold for compliance; it does not require consumers to consider all compliant foods equivalent in every qualitative respect.

8.4 Analytical sensitivity changes what a result means

One frequently overlooked issue is laboratory performance. Suppose two laboratories analyse the same food for the same pesticide. The first method has an LOQ of 0.01 mg/kg; the second has an LOQ of 0.001 mg/kg. If the actual concentration were 0.005 mg/kg, the first method could not quantify it reliably, whereas the second could measure it.

The first laboratory might report a result below 0.01 mg/kg. The second could report a concentration of 0.005 mg/kg. These results would not necessarily contradict one another. The laboratories would simply have used methods with different quantification capabilities.

This leads to an essential point: a food product does not become chemically purer because it is analysed with a less sensitive instrument. The absence of quantifiable residues must always be interpreted in light of the analytical limits used. A serious selection protocol should therefore publish not only the test results, but also the substances investigated and their respective LOQs. That information makes the real meaning of the analytical findings understandable.

8.5 Food may contain multiple residues and still comply with the law

European legislation generally specifies limits for individual substances or defined residue groups. A food product may therefore contain several pesticides at once, each at a concentration below its own limit.

This is not merely a theoretical possibility. In the European coordinated programme for samples collected in 2024, EFSA reported that 34.9% of the samples analysed contained more than one quantifiable pesticide residue. Seventeen different pesticides were identified in a single sweet-pepper sample, each within its respective MRL. This finding deserves attention.

The presence of multiple residues does not automatically demonstrate a health risk. However, the compliance of each individual substance does not, on its own, constitute a complete assessment of every possible biological effect of the mixture. As discussed in the chapter on combined effects, EFSA has already developed methods for assessing cumulative risks for groups of pesticides with shared toxicological effects. Initial assessments have generally produced reassuring findings for the particular effects and scenarios examined.

Nonetheless, present knowledge does not cover every possible combination and biological outcome. A food can therefore meet all applicable residue limits while containing a mixture for which we do not fully know every possible consequence of long-term exposure. That does not mean that the mixture is necessarily dangerous. It means that legal compliance and complete toxicological knowledge are not synonymous.

8.6 What happens when a substance is not tested for?

An analytical result provides information only about substances included in the testing protocol. If a laboratory tests for 300 pesticides, its findings cannot rule out pesticides omitted from that list, or contaminants belonging to other chemical families. The same is true of metals, mycotoxins, PFAS, dioxins and industrial contaminants.

A food may be tested for certain parameters without being analysed for many other substances that could potentially be present. This does not mean that every untested substance poses a real risk. The choice of analytical targets is often based on scientific assessments of contamination probability, product characteristics and regulatory priorities. A control system must direct resources and analytical capacity towards the situations considered most relevant. This is a rational and necessary choice when enormous quantities of food must be monitored.

Nevertheless, it creates an unavoidable limit to what is known. A substance not included in an analysis cannot be declared absent on the basis of that analysis. Missing data are not the same as a negative analytical result. This distinction is especially important when assessing food on the basis of certifications, documentary checks or general safety claims.

8.7 PFAS: when the rules do not set a specific limit

PFAS provide a particularly instructive example of the gap between what is regulated and what may be present in the environment. See the related guide: <https://www.overorganic.it/pfas-in-food.html>

They are a large family of chemicals, many of which are highly persistent. Some PFAS can reach crops through contaminated soils or irrigation water. Their capacity to be absorbed and transferred into plant tissues varies according to the compound, crop and environmental conditions.

Regulation (EU) 2023/915 sets maximum levels for certain PFAS in some categories of animal-derived foods. For many plant-based matrices, such as cereals, fruit and vegetables, that same regulation does not establish specific harmonised maximum levels for these compounds. The European Commission has nevertheless recommended PFAS monitoring across a range of food categories, including plant-based foods.

The absence of a specific limit therefore does not mean that the issue is ignored or that the presence of the substance is considered irrelevant in all circumstances. There is, however, a concrete difference between recognising a potential contamination pathway, recommending monitoring, and establishing a binding maximum level for a particular food matrix.

The comparison becomes still more interesting when drinking water is considered: specific European PFAS parameters have applied to water intended for human consumption since January 2026. Drinking water and irrigation water serve different purposes and fall under different regulatory frameworks; the same limits must not automatically be applied to both.

A scientifically legitimate question nevertheless remains: if a substance can move from water into soil and, in some circumstances, enter crops, what do we actually know about its presence in foods that are not routinely tested for it? The answer depends on monitoring programmes, available studies and tests actually carried out. It cannot be inferred simply from the absence of a specific legal limit.

8.8 Statistical controls and knowledge of an individual batch

Public food-safety systems must check enormous quantities of products from very different agricultural and industrial supply chains. They use official controls, inspections, operator self-checks and sampling programmes. Some checks aim to describe the overall market; others target products and businesses considered at higher risk.

Statistical sampling is an essential scientific tool. It makes it possible to obtain reliable information about a very large population without analysing every individual item. Yet the result of a statistical monitoring programme is not equivalent to an analytical certificate for the particular product bought by a consumer.

Knowing that the great majority of tested samples comply with the law does not mean that every marketed batch was itself tested. Nor does it mean that every sample was investigated for all possible contaminant families.

Of course, even testing an individual batch relies on collecting representative samples rather than analysing every single package or particle. The reliability of the result therefore depends on the sampling plan, the distribution of contaminants and the quality of laboratory measurements.

Nevertheless, when sampling is representative and the protocol is appropriate, analysis of a specific batch provides direct information about that batch which general market statistics cannot replace. Both approaches are complementary, but they meet different needs.

8.9 What does seeking the lowest possible contamination really mean?

A voluntary analytical protocol can adopt more restrictive criteria than the mandatory ones. For example, it may exclude a batch whenever a particular substance is quantified at a concentration equal to or above the LOQ specified by the protocol, even if the residue is far below the legal MRL.

This approach selects products that meet an additional analytical condition beyond basic compliance. It does not mean that those products are completely free of every contaminant. A concentration below the LOQ is not mathematically the same as zero. Moreover, a protocol may cover only a defined set of substances.

For this reason, expressions such as “absolute absence of pesticides” or “food entirely free from contaminants” would not be scientifically appropriate except under extremely specific qualifications and definitions; in practice, a universal chemical absence cannot be demonstrated.

It is scientifically accurate, instead, to state that no residues of the substances tested were quantified at or above the declared LOQs. The distinction may appear subtle, but it is substantial. A rigorous analytical criterion does not promise the impossible: it specifies exactly which substances are investigated, with what sensitivity and which results are acceptable. Applying such a criterion is an additional quality choice that can be documented through analytical evidence.

8.10 The meaning of food excellence

Food quality encompasses many characteristics, including safety, nutritional value, sensory properties, production conditions, freshness and chemical composition. A food may have excellent nutritional and sensory characteristics and still contain contaminant residues within permitted limits. Equally, a product in which particular residues were not quantified is not automatically superior in every other respect.

Food excellence cannot therefore be reduced to a single parameter. Yet analytical knowledge can form an important, measurable dimension of quality. When a product undergoes a protocol that investigates numerous contaminant families, consumers gain information beyond what normally appears on a label. They can learn which substances were sought, the results obtained and the conditions used to accept or reject a batch.

This greater transparency allows individual selection criteria to be applied, potentially stricter than legal requirements. Regulation sets minimum compliance conditions; analytical excellence may rely on additional criteria that are declared, measurable and verifiable.

This does not establish that every product selected using stricter criteria yields a specific health benefit. Appropriate studies would be required to make that claim. But recognising the value of information and consumer choice does not require proof of an additional health effect. Seeking greater knowledge can be a legitimate objective independently of any regulatory obligation.

8.11 The consumer's right to know

Food labels provide many mandatory details: product name, ingredients, allergens, nutritional information and other legally required particulars. Generally, however, they do not list all pesticide residues potentially present or the concentrations of contaminants investigated by chemical analysis. Reading a label alone cannot therefore reveal a food's detailed chemical composition.

This situation also reflects the regulatory distinction between verifying safety and the information that must be communicated to consumers. But information that is not legally mandatory can still be provided voluntarily. A producer or distributor may choose to publish laboratory results, specifying the substances tested, methods used and selection criteria applied.

Such transparency allows consumers to compare information that is normally unavailable. It does not eliminate every scientific uncertainty, replace public controls or automatically establish a health benefit. It can, however, reduce some of the information asymmetry in the food market: the gap between what producers and sellers know and what buyers can find out.

Consumers should not have to choose solely on the basis of what the law requires to be disclosed when tools exist that can provide more detailed information.

8.12 Food safety and what we still do not know

European food safety rests on decades of scientific research, regulation and the development of official controls. These mechanisms have made an important contribution to protecting public health. Scientific institutions, including EFSA, play an essential role in assessing risks affecting millions of consumers and a very large number of chemicals.

Nevertheless, the scale of the task necessarily requires prioritisation. Not every substance is tested in every food matrix. Not every conceivable mixture of contaminants has been assessed for every biological effect. Not all marketed foods undergo detailed batch-specific analyses. New findings can also change previously available scientific assessments.

These limitations do not necessarily result from professional failings or lack of attention. They are also a consequence of the immense complexity of the subject. The European food-safety system provides essential protection, but it cannot amount to complete and final knowledge of every possible

contamination. Recognising this does not discredit science; it acknowledges the scientific method and its continuing evolution.

New analytical technologies now allow researchers to investigate substances that were not routinely measured in the past and to detect increasingly low concentrations. Research continues to identify toxicological mechanisms, potential combined effects and different routes of environmental contamination. Every advance expands knowledge, but it can also reveal problems that were previously unknown.

More extensive voluntary analytical controls are therefore another means of obtaining knowledge, complementary to the public system. Compliance with the law is the starting point. Knowledge is the next step.

Conclusion to Chapter 8

There is a substantial difference between food that complies with the law and food in which specified pesticide residues have not been quantified. In the first case, the product meets the relevant legal requirements. In the second, a laboratory analysis documents that the substances investigated did not reach the method's limits of quantification. These are not equivalent conditions and must not be confused.

At the same time, no analysis can demonstrate the universal absence of every contaminant: findings always concern a specific sample, a defined set of substances and particular analytical performance characteristics. The quality of a protocol therefore depends on its scope, method sensitivity, sample representativeness and transparency of the information provided.

The public food-safety system must manage risk across the entire market. Extensive analytical selection of individual batches can provide consumers with additional information about a product's composition. These are distinct but complementary activities.

Compliance with the law is indispensable. But it does not exhaust everything that can be known about food. Greater knowledge does not necessarily mean fearing what we might find: it means having the tools to understand, compare and choose.

Science has already illuminated an important part of the complex world of food contamination. Yet vast areas remain to be explored. Excellence does not arise from pretending that risk has been completely eliminated. It also comes from a commitment to seeking out, measuring and making transparent what would otherwise remain unknown.

Scientific and regulatory sources

Regulation (EC) No 396/2005 — Maximum pesticide residue levels in food and feed.
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32005R0396>

European Commission — Legislation on maximum residue levels: principles and general reference values. https://food.ec.europa.eu/plants/pesticides/maximum-residue-levels/eu-legislation-mrls_en

European Commission — EU Pesticides Database: residue limits by pesticide and commodity.
https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en

EFSA — The 2024 European Union Report on Pesticide Residues in Food (published in 2026).
<https://multimedia.efsa.europa.eu/pesticides-report-2024>

EFSA — Pesticide residues in food: latest data released, 5 May 2026.
<https://www.efsa.europa.eu/en/news/pesticide-residues-food-latest-data-released>

Regulation (EU) 2023/915 — Maximum levels for certain contaminants in food.
<https://eur-lex.europa.eu/eli/reg/2023/915/oj/eng>

Commission Recommendation (EU) 2022/1431 — Monitoring of perfluoroalkyl substances in food.
<https://eur-lex.europa.eu/eli/reco/2022/1431/oj/eng>

Directive (EU) 2020/2184 — Quality of water intended for human consumption.
<https://eur-lex.europa.eu/eli/dir/2020/2184/oj/eng>