

## **8. PHOSPHONIC ACID IN FOOD: ORIGIN, PERSISTENCE AND INTERPRETATION OF RESIDUES**

### **THE MYSTERY OF A RESIDUE WITHOUT TREATMENT**

Let us imagine a farmer growing lettuce.

Throughout the entire production cycle, no fosetyl-aluminium or plant protection products containing phosphonates are used.

At harvest time, the farmer decides to have the product analysed.

The laboratory detects a small amount of phosphonic acid.

How is that possible?

There may be several explanations. One of the most interesting concerns what happened in the soil before the lettuce was grown.

Perhaps, months earlier, another plant species had been grown in the same field and products containing phosphonates had been used on that crop.

Some of the phosphonic acid may have remained in the soil and later been absorbed by the lettuce roots.

The current plant, therefore, may contain a substance traceable to a treatment carried out on a previous crop.

This is not merely a hypothesis.

The studies assessed by the European Food Safety Authority, EFSA, have shown that phosphonic acid present in the soil can be absorbed by subsequent crops.

To understand this phenomenon, we must follow the path of the substance, from its formation to its presence in food.

### **A SMALL MOLECULE, BUT A PARTICULARLY INTERESTING ONE**

Phosphonic acid is an inorganic compound containing phosphorus, hydrogen and oxygen.

Its molecular formula is  $\text{H}_3\text{PO}_3$ .

The name may resemble that of phosphoric acid,  $\text{H}_3\text{PO}_4$ , but they are chemically different substances.

Phosphoric acid and its salts, phosphates, are closely linked to plant nutrition.

Phosphonic acid and phosphonates, by contrast, have different chemical and biological properties.

In particular, phosphonate contains phosphorus in a lower oxidation state than that present in phosphate.

This difference leads to different behaviour in biological systems and in the environment.

Phosphonates may be present in various products used in agriculture, especially for protecting plants against certain pathogens.

Their presence in agricultural products may therefore be linked to multiple sources.

And it is precisely this multiplicity of origins that makes the search for phosphonic acid in food particularly interesting.

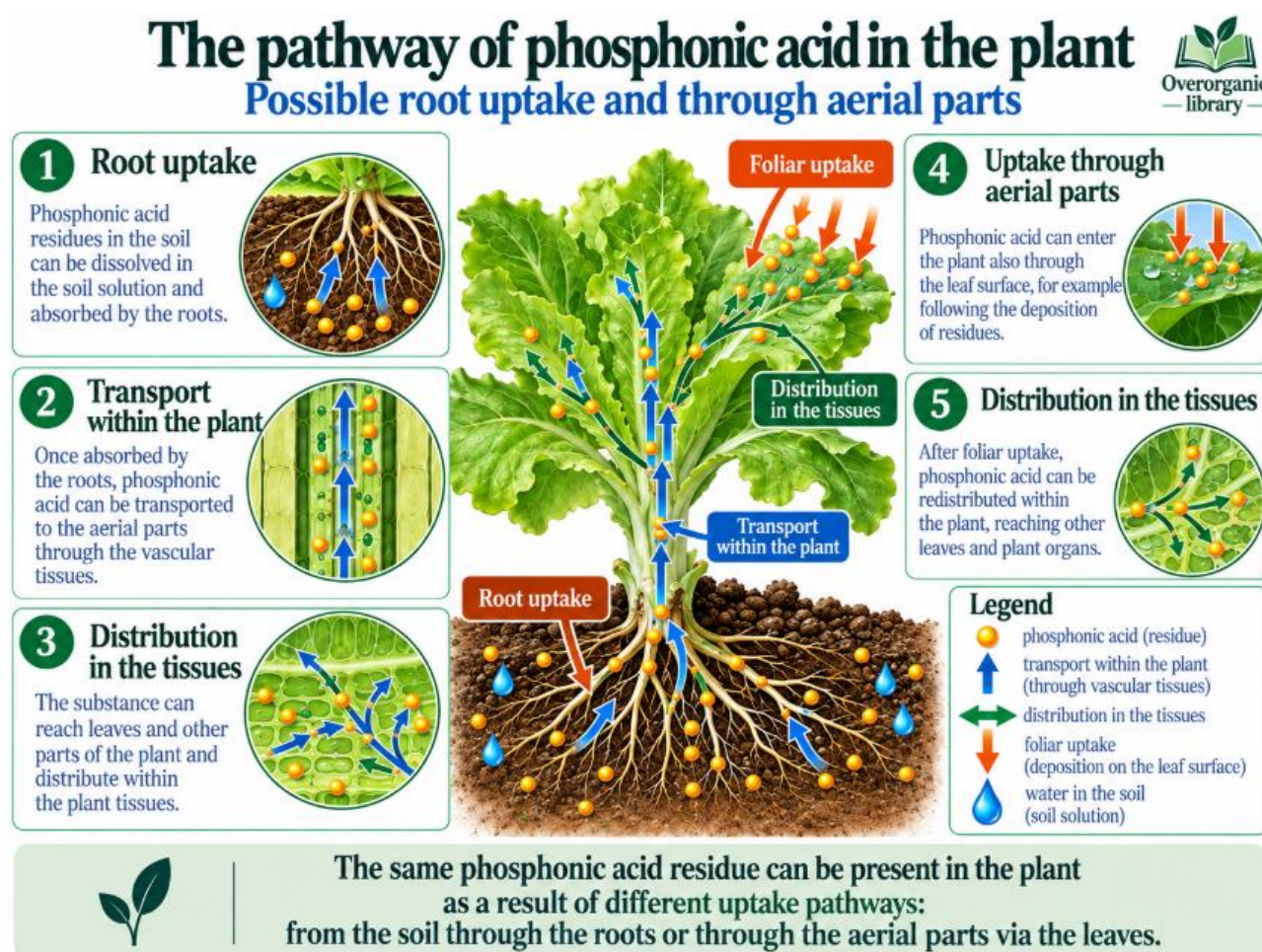
## HOW DOES PHOSPHONIC ACID REACH PLANTS?

There are two main entry routes: through the aerial parts or through the roots.

In the first case, a product containing fosetyl-aluminium or phosphonates is applied to the vegetation.

The substance can be absorbed by plant tissues and, in the case of fosetyl-aluminium, rapidly transformed into phosphonic acid.

In the second case, the plant can absorb phosphonates present in the circulating soil solution.



Roots, in fact, do not absorb only water.

Through complex transport systems, they allow the uptake of numerous ions and other dissolved substances.

Some of these compounds are essential nutrients; others can be absorbed even though they do not perform a fundamental nutritional function.

Once inside the plant, phosphonates can be transported to different organs.

Studies on plant metabolism have shown that they can reach leaves, roots and fruits.

This explains why residues are not necessarily confined to the surface of foods.

Phosphonic acid present inside a fruit cannot be removed simply by washing its peel.

Washing can remove part of the surface deposits, but it does not guarantee the elimination of substances that have already penetrated the tissues.

## **HOW LONG CAN IT REMAIN IN THE SOIL?**

One of the most important characteristics of phosphonic acid is its possible persistence in the soil.

As we have seen in previous chapters, a chemical substance may degrade rapidly or remain in the environment for longer periods.

Phosphonic acid shows behaviour that depends on environmental conditions.

Its persistence in the soil can be influenced by soil type, microbial activity, moisture and other factors.

The studies considered by EFSA reported DT90 values ranging from 91 days to more than 1,000 days.

Let us recall that DT90 indicates the time required for 90% of the quantity initially present to dissipate under the specific conditions of the study.

This does not mean, therefore, that all soils necessarily retain phosphonic acid for the same length of time.

It does mean, however, that under certain circumstances the substance may remain available long enough to affect subsequent crops.

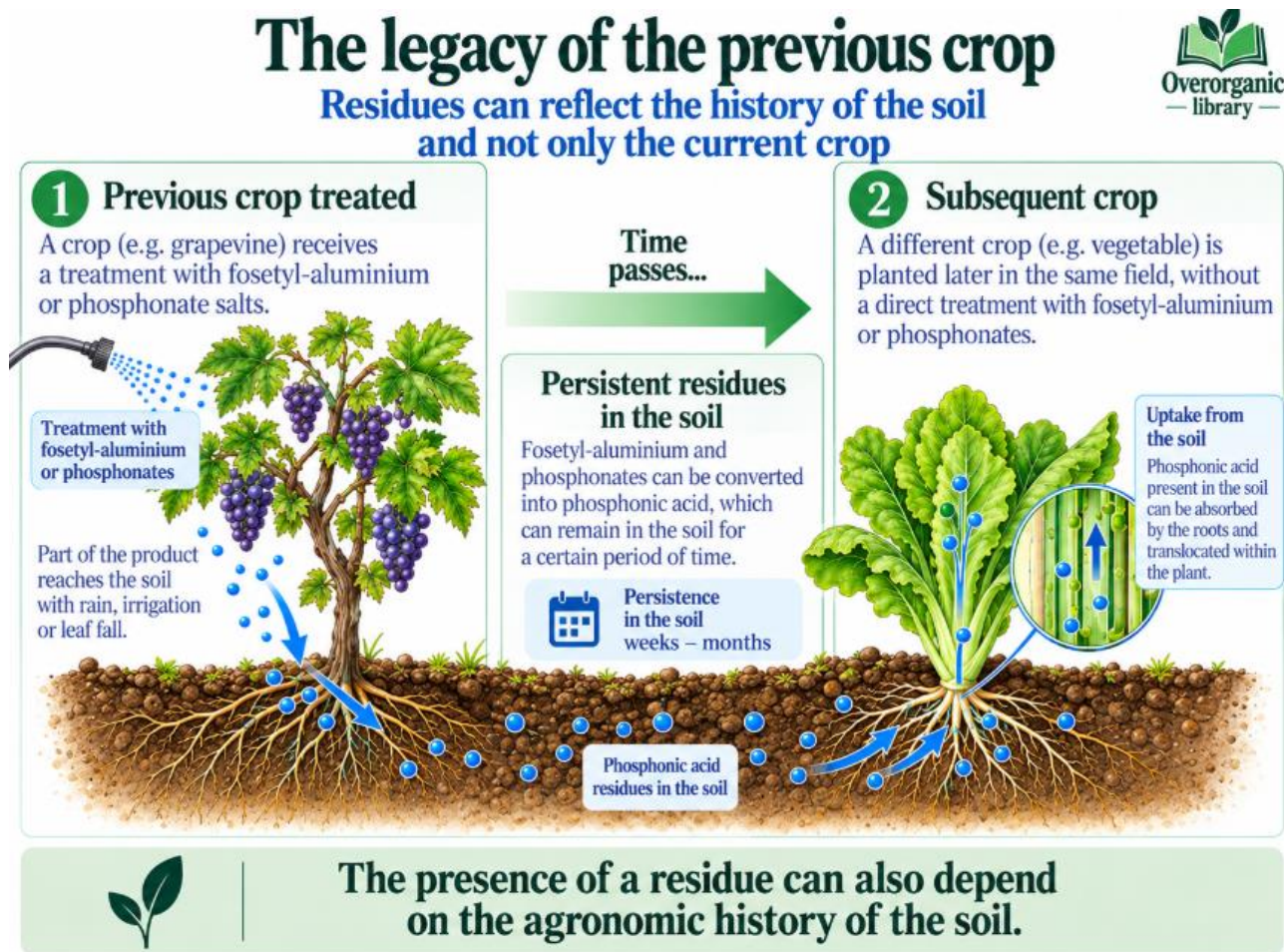
For this reason, when phosphonate residues are studied, it is necessary to consider the history of the soil and not only the treatments carried out in the year of harvest.

## **WHEN A CROP INHERITS THE RESIDUES OF THE PREVIOUS ONE**

Let us return to our lettuce field.

Let us imagine that, the previous year, a plant species had been grown there on which products capable of leaving phosphonic acid in the soil had been used.

After harvest, the soil is worked and allocated to the new crop.



The lettuce grows normally, without receiving any direct treatment with fosetyl-aluminium or phosphonates.

Yet it may absorb part of the residues still present in the soil.

This phenomenon is known as uptake by rotational crops.

EFSA examined experimental studies in which the soil was treated with phosphonic acid and then sown with different plant species.

In one of these experiments, conducted under controlled conditions, residues were observed in crops planted about 30 days after the soil treatment.

The measured concentrations included:

- 0.76 mg/kg in lettuce leaves;
- 0.80 mg/kg in radish roots;
- 0.14 mg/kg in barley grain.

These results refer to a specific experiment, with a defined application dose, and should not be interpreted as typical concentrations in foods on the market.

They do show, however, that transfer from the soil to subsequent crops is possible.

It is a concrete example of how the behaviour of contaminants must be studied over time, following the transformations and movements of substances in the agricultural environment.

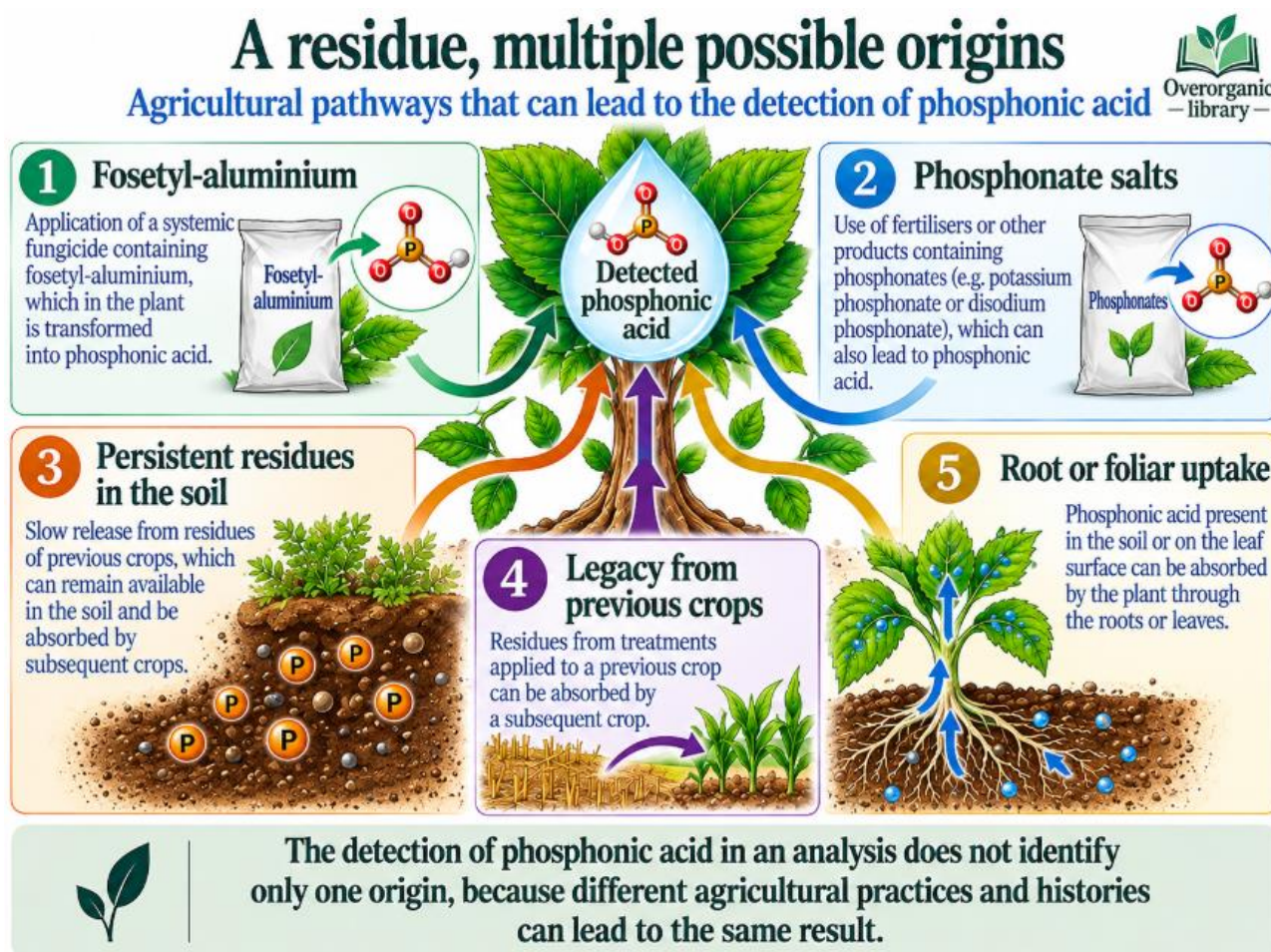
## POSSIBLE ALTERNATIVE SOURCES

Fosetyl-aluminium and plant protection products based on phosphonates are not the only possible sources of phosphonic acid in food.

The European Commission itself has recognised that phosphonates may also be present in other products used in agriculture.

Depending on their composition, these include certain fertilisers, plant-strengthening products, soil improvers and materials of organic origin.

The presence of phosphonates in these categories does not mean that every product belonging to them necessarily contains such substances.



Moreover, any use must be assessed in the light of the rules applicable to the specific type of product.

The scientifically important point is another.

A phosphonic acid residue may derive from sources other than a direct treatment with fosetyl-aluminium.

For this reason as well, when its origin is to be reconstructed, the entire agronomic management must be considered: products used, inputs added to the soil, treatments on previous crops and possible contamination.

The European Commission explicitly recognised this complexity in Regulation 2024/2619, taking into account possible sources not directly attributable to plant protection products when defining maximum residue levels.

## **WHAT HAPPENS DURING FOOD PROCESSING?**

Let us imagine harvesting a tomato containing a small amount of phosphonic acid.

The tomato may be consumed fresh or used to produce purée, concentrate or other processed foods.

During processing it may be washed, crushed, heated and concentrated.

What happens to phosphonic acid?

Unlike some substances that degrade easily with heat, phosphonic acid has shown considerable stability under the experimental conditions used to study food processing treatments.

EFSA examined hydrolysis studies simulating processes such as pasteurisation, boiling and sterilisation.

The results indicated that phosphonic acid remains essentially stable under such conditions.

This means that heat treatment cannot be considered a reliable way to eliminate it.

However, the final concentration in a processed food also depends on other factors.

If the product loses water during processing, the concentration expressed in milligrams per kilogram may increase.

If, on the other hand, part of the substance is removed together with liquid or solid fractions discarded during the process, the concentration may decrease.

For this reason, it is not correct to state that a processed food always contains either more or less phosphonic acid than the raw material.

It is necessary to know the production process and to have specific experimental data.

## **WHAT DOES THE LABORATORY REALLY MEASURE?**

When a food sample is analysed, the laboratory can directly look for phosphonic acid and determine its concentration.

The determination can be carried out by chromatographic methods coupled with mass spectrometry, appropriately developed and validated for this substance.

The result is generally expressed in milligrams per kilogram of food.

Let us suppose that a concentration of 0.5 mg/kg of phosphonic acid is detected in a sample of apples.

What do we know?

We know that, according to the method used, that concentration was quantified in the sample.

But can we determine whether the residue comes from fosetyl-aluminium, potassium phosphonates or another source?

Not necessarily.

And this is where we must distinguish the case of phosphonic acid from that of dithiocarbamates.

In the case of dithiocarbamates, the laboratory can measure the CS<sub>2</sub> produced during a chemical transformation carried out on the sample. The compound measured may also derive from natural substances present in plants.

In the case of phosphonic acid, by contrast, the laboratory can directly identify and quantify the substance actually present in the sample.

The problem, therefore, is not necessarily to distinguish phosphonic acid from other molecules.

The problem is to establish which of the various possible sources caused its presence in the food.

This is a fundamental difference.

A laboratory may correctly measure the concentration of a substance without being able to reconstruct, from that measurement alone, the entire agronomic history of the product.

## **CAN WE RECOGNISE THE USE OF FOSETYL-ALUMINIUM?**

There is one analytical element that can provide some additional information.

In addition to phosphonic acid, it is possible to look for fosetyl, that is, the organic compound associated with the active substance fosetyl-aluminium.

If both fosetyl and phosphonic acid are identified in a food, the presence of the former may provide a more specific indication of the use of products containing fosetyl.

But the interpretation requires caution.

Fosetyl may degrade and transform into phosphonic acid.

Consequently, the absence of fosetyl accompanied by the presence of phosphonic acid does not prove that fosetyl-aluminium was not used.

Likewise, the presence of phosphonic acid does not prove that it was used.

To reconstruct an agricultural treatment, information independent of the analytical result may therefore be necessary, such as treatment records, the characteristics of the products used and the cultivation history.

Chemical analysis provides important information, but it is not always sufficient to identify the cause of the contamination.

## **WHAT DOES EUROPEAN LEGISLATION SAY?**

Until a few years ago, European legislation used a residue definition that included the sum of fosetyl, phosphonic acid and the related salts, expressed as fosetyl.

This was a choice that made it possible to assess closely related substances jointly.

With the progress of scientific knowledge, however, the need emerged to modify this approach.

Regulation (EU) 2024/2619 introduced a specific definition for phosphonic acid and its salts, expressed as phosphonic acid, distinguishing it from fosetyl.

The new provisions apply from 29 April 2025.

The Regulation also takes into account the possibility that phosphonic acid may derive from agricultural sources other than the direct use of plant protection products.

It is important to understand that maximum residue levels do not necessarily represent the concentration at which a substance begins to cause harm to health.

They are regulatory values established on the basis of the conditions of use considered, residue data and risk assessments for consumers.

The compliance of a food must be verified by comparing the analytical result with the limit applicable to the specific food category.

The presence of phosphonic acid, therefore, does not automatically imply a breach of the legislation.

At the same time, compliance with the legal limit does not mean that the substance is absent.

## **THE CASE OF ORGANIC PRODUCTS**

The issue of phosphonic acid becomes particularly interesting when it concerns food from organic farming.

Organic farming is governed by specific rules that limit the use of plant protection products to permitted substances.

We might therefore expect that an organic food would not contain residues attributable to products that are not allowed.

But, as we have seen, the presence of phosphonic acid does not necessarily prove that an unauthorised treatment was carried out on the crop analysed.

The residue may come from previous inputs to the soil, indirect sources or products used at other times in the agronomic history.

These possibilities do not automatically prove that a crop complies with the rules of organic farming.

They mean, more simply, that the presence of a residue and proof of unauthorised use are not necessarily the same thing.

To assess any irregularities, all available information must be considered and the procedures laid down by the legislation must be applied.

It is an exemplary case of how the search for contaminants must be accompanied by correct scientific interpretation.

## **A RESIDUE IS NOT A VERDICT**

We have followed the path of phosphonic acid from agricultural applications to food.

We have discovered that it can form from the transformation of different substances, be absorbed through leaves and roots, remain in the soil and reach subsequent crops.

We have seen that it can withstand the heat treatments commonly used in food processing.

And we have understood that a laboratory can measure it accurately without necessarily identifying its origin.

All this leads us to an important conclusion.

The result of a chemical analysis is a scientific datum, not an automatic reconstruction of the history of a food.

Knowing that a substance is present means having acquired a piece of information.

Understanding why it is present requires further knowledge.

Establishing whether its concentration involves a health risk requires yet another assessment.

These are three different questions, and they should not be confused.

And it is precisely this distinction that makes the case of phosphonic acid particularly interesting.

In the next chapter, we will address the final major question concerning these substances: what effects can they have on health, and how are consumer risks assessed?

## **SCIENTIFIC REFERENCES FOR CHAPTER 8**

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