# Org - ID

## The check of organic farming with stable isotopes


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## Differentiating organic produce from conventional produce

The differentiation between organic and conventional produced products using current analytical methods poses a challenge. This is due to the fact that the nutritional composition of organic and conventional agricultural products is more or less identical (Woese et al. 1997).

Presently there are three types of method that can be used to differentiate organic and conventional products, each with their own strengths and limitations.

- **GMO analysis** – detects Genetically Modified Organisms
- **Pesticide/residue analysis** – detects where acceptable/unacceptable agrochemicals/pharmaceuticals have been used
- **Isotope analysis** – detects the method of fertilisation used on crops ($^{15}N/^{14}N$)

## Tracing problems back to their roots – the stable isotope method

There is considerable advantage in the stable isotope method as it offers the opportunity to trace problems back to their roots in a range of products from fruit to meat.

The stable isotope method exploits the fact bioelements (hydrogen, carbon, nitrogen, oxygen and sulfur) exist in two stable variants in natures / isotopes. For example, in addition to the "normal" nitrogen nature also has a heavy version of nitrogen (1 additional neutron). This subtle, but profound difference offers the opportunity to track produce.

## Exploiting the difference between organic and conventional: $^{15}N/^{14}N$

Since 1974, it is well known that organic fertilisers such as composts, manures and green manures show greater enrichment of heavy nitrogen ($^{15}N$) than conventional mineral fertilisers. Organic fertilisers typically have nitrogen ratios of +10‰ +/- 4 in comparison to mineral fertiliser which has nitrogen ratios of roughly 0 ‰ (Shearer 1974) (see Figure 1).

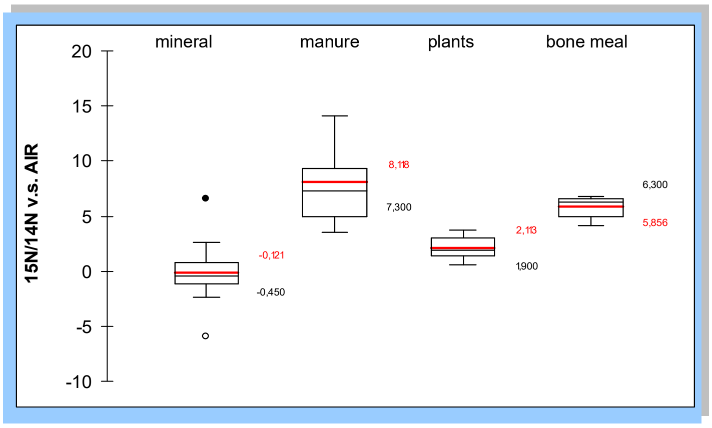


Figure 1: $^{15}N/^{14}N$ isotope ratios of various fertilisers, Bateman 2007

## The science behind checking the fertilisation using $^{15}N/^{14}N$ IRMS

The enrichment of heavy nitrogen ($^{15}N$) in biomass derived fertilisers (compost, manure, bonemeal) is the product of metabolism. Transaminase, an enzyme that exists in all organisms and is involved in protein/urea metabolism, prefers heavy nitrogen ($^{15}N$) as opposed to normal nitrogen ($^{14}N$). Further heavy nitrogen enrichment in manure based fertilisers can be attributed to the preferential volatilisation of $^{14}N$ ammonia (Sturm et al. 2011). As a result, biomass derived fertilisers are enriched in heavy nitrogen and can be easily differentiated from mineral fertilisers (figure 1).

Nitrogen ratios from the fertilisers are reflected in crops grown in the fertilised soil; if the soil was fertilised with biomass derived fertilisers (organic fertilisers) which show the enriched heavy nitrogen signature, this will be evident in the crop (Yoneyama 1990). The reverse also applies, if a crop is fertilised with mineral fertiliser ($^{15}N/^{14}N$ = 0‰) the nitrogen ratio of the crop will reflect in this signature too.

As the use of mineral fertiliser is strictly prohibited in organic farming, the use of isotope testing the nitrogen in fertilised organic products offers countless prospects in terms of authentication, surveillance and the detection of product mislabelling in products declared as organic.

To this date, there is a wealth of peer-reviewed scientific literature (Choi, 2003, Nakano 2003, Bateman 2007, Rogers 2008, Sturm 2011) demonstrating and supporting the evidence that analysing nitrogen ratios ($^{15}N/^{14}N$) in agricultural produce offers excellent opportunity to determine organic provenance in many products.

## Challenges of the stable isotope method in analysing organic produce

Considerations have to be made when interpreting results of products tested using the stable isotope method as nitrogen fixing plants (legumes) are used as an organic fertiliser, either grown the previous year or intercropped with the produce such as in banana cultivation. This is due to the fact that the range of nitrogen ratios from n-fixing plants partially overlaps with the range of nitrogen signatures produced using mineral fertilisers. Therefore if the nitrogen ratios of a crop fall within the overlap region of mineral and n-fixing fertilisers, discrimination between organic and conventional produce becomes a challenge.

Nevertheless negative stable isotope ratios of nitrogen ($^{15}N/^{14}N$ ratios more negative than 0‰) in a test sample cannot be explained if the declared fertilisation method used was nitrogen-fixing plants. This is due to the fact that n-fixing bacteria in the root nodules of leguminous plants favour the enrichment of heavy nitrogen.

For this reason it advantageous to test crops with the knowledge of their declared fertilisation method.

## The practical approach – how to make use of $^{15}N/^{14}N$ isotope testing

The stable isotope method as an authentication/surveillance tool is most powerful when used in conjunction with knowledge of the declared fertilization method used to produce a crop.

It has to be considered which agricultural products this technique is best used with. Generally the best products that show the greatest differentiation between organic and conventional varieties are the shallow root plants that have a high demand for fertilisation. However, when used appropriately, this technique can be used in finished products such as eggs.

## The use of reference databases to authenticate products

Agroisolab GmbH prefers to establish databases for each agricultural product to get the best overview which ratios of nitrogen are expected to be observed in organic and conventional produce.

Furthermore any information about the fertiliser used to cultivate the test sample is helpful draw accurate conclusions from the report.

## Testing products in the absence of a reference database

If there is no direct database of organic/conventional products available to compare a test sample to, the evaluation can be summarised in the following evaluation scheme:

**1) Abnormal ratios / mislabelled sample**

- $^{15}N/^{14}N$ values < 0‰: Not normal for organic farming, typical for crops cultivated with mineral fertiliser.

Within the current state of knowledge, a $^{15}N/^{14}N$ ratio of a test sample under 0‰ is not explainable in products declared as organic. Any organic fertiliser, biomass derived or n-fixing plants, should produce nitrogen ratios more positive than 0‰ in the plant.

**2) Conspicuous sample**

- $^{15}N/^{14}N$ values 0 - 3‰: Conspicuous, further information about the type of fertilisation used is required to reach a valid conclusion.

Normally values of <3‰ cannot be explained by the use of biomass derived (organic) fertilisers (e.g. manure, bone meal). However the $^{15}N/^{14}N$ signatures of crops fertilised using n-fixing plants fall within this range. Therefore in order to reach a valid conclusion corroborative evidence from the declared fertilisation method, analysis of samples taken from crops grown in the field, soil, and the fertiliser itself may be required.

**3) Normal sample**

- $^{15}N/^{14}N$ values > 3‰: Normal for organic products (fertilisation).

High ratios of nitrogen are indicative of the use of organic fertilisers such as biomass derived fertilisers. Nevertheless this limit is not a strict rule. Depending on the agricultural product, internal fractionation has to be taken into account. Therefore Agroisolab prefers to use reference database to define the upper and lower limits of organic produce.

# Further assessment of samples that return with 'Abnormal ratios'

## Origin testing

Especially in the case of mislabelled/abnormal samples, there is a high risk that the sample does not originate from its declared origin. Therefore it is recommended to check the origin of the sample as well.

For origin testing, the following isotopes are normally used to check the origin:

- Hydrogen D/H and Oxygen $^{18}O/^{16}O$ (regional parameter of water)
- Carbon $^{13}C/^{12}C$ (climate parameter)
- Sulfur $^{34}S/^{32}S$ and Strontium $^{87}Sr/^{86}Sr$(geological parameter)

## GMO testing

Where applicable, or where the risk of GMO adulteration is high, further evidence of non-organic status should be sought from GMO analysis. One example would be if maize/corn/prairie meal was discovered to have $^{15}N/^{14}N$ ratios more negative than 0‰, it is possible the product has been diluted/substituted with GMO maize. Agroisolab GmbH works closely with a network of labs that can be recommended to carry out this test.

## Pesticide/residue analysis

Where applicable, it is recommended that further evidence of non-organic status is also obtained from pesticide/residue analysis. It is possible for mislabelled organic products to be fertilised with mineral fertiliser and not have non-compliant pesticide residues. Agroisolab GmbH works closely with a network of labs that can be recommended to carry out this test.

## Further product/ingredient testing

In the event where finished products such as eggs are marked as organic are discovered to have nitrogen signatures that give over 95% probability they are not organic, there may be several reasons for this:

- This is a conventional product being passed off as organic
- This is a product from an organic production system where non-organic feed is being fed to the animals
- This is a product from an organic production system that is being diluted with conventional products

Further investigation is required to reach the root of the problem, we are happy to offer advice about how best to investigate and resolve the issue.

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**Literature:**

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