

COSI SIMILI, COSI DIVERSE

3. PLAIN VANILLA

The flavor of vanilla is mainly the result of a single molecule, vanillin. Vanillin is extracted from the vanilla bean, in the seedpods of an orchid. Yet it is also made ever more cheaply synthetically, from petroleum based chemicals. And from lignin, a byproduct of wood pulping. Now popular taste comes in, and in particular our recent romance with the natural. What advantage accrues to the advertiser, if he can say “Natural Vanilla Flavor!” But...the vanilla beans are expensive.

A few years ago someone in France took a look at vanilla flavored dairy products in the country, and found that the vanillin in those labeled natural exceeded by a factor of ten the amount of the chemical in imported natural vanilla pods. The French should know, as they control a good part of the trade, from Madagascar.

Anything wrong with synthetic vanillin? No, it's as healthful as the natural, and indubitably tastes the way it should, otherwise 12,000 tons of it would not have been sold in the US last year. Synthetic vanilla definitely adds to life. But we want it natural, or the advertisers want us to want it natural. Enter the forger, the human being who labels the synthetic ingredient as natural when it isn't. The incentive is nontrivial, the price of natural vanillin more than 200 times more than that of synthetic.

So, can you tell the synthetic vanillin from the natural? Not by taste. The seeker of the natural had better train as a chemist and buy some fancy equipment. It is, however, possible to detect the natural product.

The first modern methods looked at the ratios of two isotopes of carbon, ^{13}C and ^{12}C and deuterium/hydrogen isotopes, and at the radioactive ^{14}C content in the flavor molecules. Isotopes themselves are the same and not the same. They are modifications of an element in which the number of electrons (and thus the rough chemistry) remains the same, but the mass of the nucleus deep in changes, from 12, to 13, to 14. The ^{14}C isotope moreover is radioactive.

That radioactive ^{14}C is particularly easy to find, and the technique for distinguishing natural from synthetic is simple. ^{14}C has a half life of 5730 years — that means that half its radioactivity goes away in that time, half again in the next 5730 years. That's actually used for dating object that contain carbon, but in the case at hand it's just a matter of determining

whether the vanillin is radioactive or not. In living material ^{14}C it is replenished by photosynthesis, from CO_2 made radioactive by natural cosmic rays. Petroleum is essentially devoid of ^{14}C ; it decayed a long time ago. So natural vanillin is radioactive (just a little); synthetic vanillin, made from a petroleum product, is not.

I like that, because it doesn't fit our prejudices about the natural... And don't worry about the radioactivity of the organic. It's small.

OK, so the scientific detectives tested the vanillin and found most of it not radioactive. Warnings were issued to the offending companies. But... the forgers are not stupid. They began to add small amounts of synthetic vanillin labeled with ^{14}C . And with ^{13}C . Economical, not lazy, they did not spread out the isotope over the molecule, as would be expected in a natural product. They just put it where it was cheapest to put it, in one CH_3 group in the molecule.

The dance goes on. With new nuclear magnetic resonance techniques, sort of like MRI, it is possible to measure the ^{13}C enrichment at every single carbon within one molecule. And because of the biochemical pathways involved these ratios are different and specific for every carbon around the molecular skeleton.

It is possible for a forger to overcome even this. But to do so he or she would have to synthesize the molecule in the laboratory the same way nature does. It's possible, but it would be (a) a major scientific achievement, worth publishing in some cases, and (b) very expensive. The whole point of molecular forgery is substituting the cheap for the dear. But the tools of the chemical forgery detective are also expensive. A stand off — in ingenuity, resolved by what usually resolves things: economics.