SPECIAL FEATURE

Harnessing science to counter fraud in food and beverages

By Linde Gases

The economic impact of counterfeiting products in the food and beverage industry amounts to millions in lost sales and profits to retailers, producers and suppliers. Fake claims about the content of foods and beverages also pose an unsuspected risk to consumer health, as well as those who base their food choices on ethical and religious convictions.

Consumers make their purchases in good faith, putting their confidence in the honesty and integrity of the supply chain. Counterfeiting is at odds with this reasonable assumption that a product is all that it claims to be on its labelling. In contrast to the financial losses facing businesses on the production and supply side, the consequences to consumers can range from simply being deceived about the product's content, or not benefitting from the anticipated efficacy, to the more severe outcomes of illness and death.

The world was made aware of this danger in 2008, when six babies died and 300,000 babies fell ill after drinking melamine-tainted milk products in China. Another major food scandal broke in Europe in 2013, when it was revealed that horse meat was being labelled as beef from cattle. Although horse meat is suitable for human consumption, the public health issue relates to the type of tests conducted to prove the suitability of the beef for human consumption. Since these tests differ from those applied to horse meat, applying the wrong tests to the sample could create an opportunity for hazardous substances, such as residual chemicals from veterinary medicines, to enter the food supply chain.

Food and beverage counterfeiting syndicates are motivated by greed and driven by the attraction of increased sales margins. Sometimes a reluctance to discard products that have passed their sell-by date leads to re-labelling and, in the case of exported products, there is an objective to bypass or reduce Customs and Excise duties on certain products.

Despite the best efforts of national food safety authorities such as the US Food & Drug Administration (FDA) and the European Food Safety Authority, certain food and beverage product types continue to fall prey to counterfeiting. Notable examples include olive oil, goat's milk, wines, basmati rice, honey, caviar, vanilla and saffron.

Olive oil is produced to different standards by varying methods of production and its quality is also determined by the free acidity of the soil. The production and sell-by dates are also important, because olive oil eventually oxidises and becomes rancid. Since each of these factors determine the value of the end product, falsifying any of this information amounts to counterfeiting. In a similar vein, a variety of aromatic basmati rice types are sold at premium prices on the world market and the increasing value consumers are placing on this product also makes it a prime target for counterfeiters who adulterate the product with the addition of cheaper types of long grain rice.

Likewise, goat's milk can be diluted with cow's milk and the difference is very difficult to detect by taste alone, while honey can be counterfeited in various different ways. It can be adulterated with sugar, corn syrup and other sweeteners, or the type of honey is misrepresented by a fake declaration of botanical or geographical origin to attract a higher price on the market. For example, Manuka honey is broadly hailed as a wonder product that demonstrates antiviral and antibacterial qualities. Not as sweet as normal honey, it is made by bees gathering nectar from the delicate flowers of the Manuka bush, native to New Zealand. When this rare and highly priced product is misrepresented, consumers are not only duped financially, but are also cheated of the health benefits associated with it.

Caviar is another rare and expensive product which black market dealers substitute with the roe of other fish, passing it off as the roe of the sturgeon harvested only in the waters off Russia and Iran. Expensive spices like saffron and vanilla are frequently faked by being synthetically produced or are by being substituted with cheaper spices that taste and look the same thanks to food flavouring and dyes. Meanwhile wines and brandies also lend themselves to counterfeiting through false information on the labelling, particularly as certain vintages attract far higher prices than others. This includes adulterating these liquors with the addition of cheaper products such as fruit juices, and sometimes with the addition of harmful chemicals and sweeteners to compensate for colour or flavour.

Growing focus

The increasing penetration of counterfeit food and beverages in the consumer supply chain is prompting authorities to accelerate existing measures to intercept and identify these products. For example, during 2013, Customs and Excise laboratories in France ran half a million analytical tests on wines and beers entering the country, bringing the role of scientific analysis into sharp focus. Counterfeit goods are invariably undetectable by sight and smell alone, and must be analysed using sophisticated chemical analysis techniques.

The food standards authorities associated with counterfeit goods typically make use of expert food laboratories which run sophisticated instrumentation. Gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) are routine in food and environmental laboratories, alongside High Performance Liquid Chromatography and Ultra-High Performance Liquid Chromatography (HPLC and UHPLC).

When more sophisticated analysis is required, Nuclear Magnetic Resonance (NMR) comes into play, the most advanced technique available for food counterfeiting investigations. NMR involves generating a very high magnetic field around the nuclei in a particular molecule to allow the nuclei to absorb and re-emit electromagnetic radiation. The pattern in which this occurs is detected to identify which particular molecules are present. The intense magnetic field is generated by a super-conducting magnet that can only operate in extremely cold temperatures, achieved via the use of liquid helium.

The authenticity of olive oil can be established to a certainty of about 80% by analysing the most frequently occurring chemical components through Principal Component Analysis (PCA) and developing a 'fingerprint' for a particular product. PCA typically identifies the top 50 naturally occurring chemicals and their concentrations, providing analysts with a good indication of the oil's geographical origin and how it was processed. Linear Discriminate Analysis (LDA) on some of the most occurring components compares these chemicals to the genuine article to determine how closely the sample resembles it. The instrument most likely to be used to conduct this sophisticated fingerprinting of the olive oil is NMR, harnessed to focus on isotopes of hydrogen to identify variations in the fingerprint.

> "...the demand for gases that facilitate the detection of chemicals in food is on the increase"

The most reliable technique for determining the age of a wine or a brandy is looking at the quantity of carbon isotope that exists in these liquors. This method uses radioactive carbon isotopes left in the atmosphere by atomic bomb tests carried out about 50 years ago, as well as from the burning of fossil fuels and volcanic eruptions. NMR is also used to conduct this analysis to determine the vintage of a wine.

Although NMR is being increasingly applied to detect adulterated honey, other methods include GC and LC, Near Infrared Transflectance (NIR), spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy with Attenuated Total Reflectance (ATR), Protein characterisation, High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection (HPAEC-PAD), LC coupled to Isotope Ratio Mass Spectrometry (HPLC-IRMS), calorimetric methods, stable Carbon Isotope Ratio Analysis (SCIRA), Fourier Transform (FT) Raman spectroscopy and Microscopic detection.

To determine whether caviar is from a sturgeon or another type of fish, analysts examine the product's DNA, the unique marker of a species. Sometimes enhanced with fluorescent dyes, samples can be examined by a photo spectrometer or, if more sophisticated test is required, the NMR is once again brought into play. DNA testing is also proving an effective way to identify the authenticity of basmati rice, since rice varieties have different DNA fingerprints. After saffron, vanilla is the world's most expensive spice, and counterfeiters typically substitute vanilla extract with vanilla flavouring containing synthetic vanillin and ethyl vanillin in foods and beverages to save costs. Some illegal manufacturers add coumarin – a phytochemical found in many plant species – to vanilla products to increase the vanilla flavour perception. However, coumarin has been shown to be hepatotoxic (damaging to liver cells) and prohibited from being added to food in the US since 1940. LC-MS, HPLC and UHPLC have proved effective in determining the presence of coumarin, vanillin, and ethyl vanillin in vanilla extract products.

In demand

Over and above issues of public health, fraud and tax evasion, the counterfeiting of food impacts the spheres of ethics and religion. Food analysis is, therefore, a growing market and the demand for the specialty gases that facilitate the detection of ever-lower levels of chemicals in food is on the increase. gw

ABOUT THE AUTHOR

Linde has a broad offering to the food industry through its HiQ® range, including nitrogen and helium for GC-MS, nitrogen for LC-MS, liquid helium for NMR, and helium gas for HPLC and UHPLC. Linde also ensures uncompromised delivery of these gases to the instrument via its REDLINE® range of regulators.