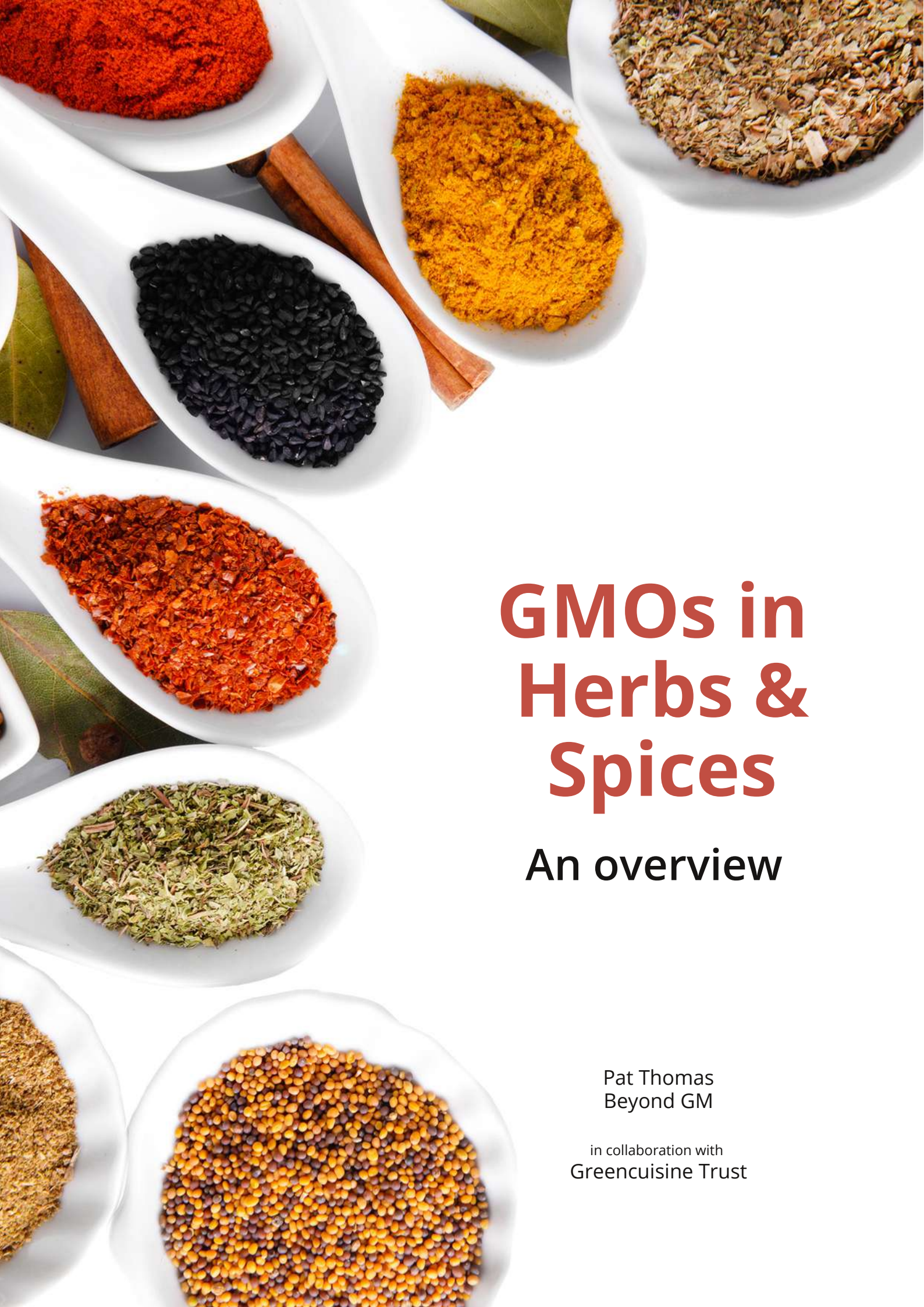

GMOs in Herbs & Spices

An overview

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Human health, wellbeing and pleasure has been intertwined with the use of herbs and spices for millennia.

The leaves, flowers, roots, berries and barks of certain plants, shrubs and trees contain a variety of aromatic compounds that can add flavour and fragrance to food. Cooking with them is a traditional way of bringing the tastes and smells of distant places and cultures to our tables. But there are other benefits too.

Many herbs and spices – even those used in everyday cooking – also have health benefits which are derived from these same aromatic compounds. Traditional Chinese medicine, Ayurveda and other folk medicine traditions are grounded in the health-giving properties of herbs and spices, and even today more than half the word relies on herbal medicine to treat uncomplicated health issues.

The complex aromas derived from some of these plants can also be distilled into essential oils, which are used to treat mind, body and emotions through the practice of aromatherapy. These same oils are also used in foods, cosmetics, perfumes and, these days, a variety of household products.

Manufacturers have long sought ways of replicating the flavours and aromas of natural plants with synthetic chemicals. Many of the food and cosmetic products we use today contain these synthetic aromas. Often they are made from petrochemicals and as the hazardous nature of these substances has been revealed, customers have begun to demand a return to natural flavourings and aromas.

With synbio, genetic codes can be written on a computer and new DNA strands printed off on 3D bio-printers and used to create new life forms.

Big brands know that products that claim to be 'natural' can also claim a price premium. But with the advent of extreme genetic engineering technologies such as synthetic biology, the line between natural and unnatural is increasingly, and some would say cynically, being blurred.

What is ‘synbio’?

Synthetic biology, or 'synbio', is a relatively new form of genetic engineering and is part of a suite of technologies colloquially known as GMO 2.0.

Broadly speaking, the term synbio refers to two different ways of producing substances. One way is to re-engineered micro-organisms such as bacteria, yeast and algae to become living 'factories' for producing a variety of substances including chemicals used for flavours and fragrances. These genetically engineered organisms can be made to produce greater quantities of substances they might naturally produce, or to produce substances that they would not normally produce.

But synbio can also describe a process whereby genetic codes can be written on a computer and new DNA strands printed off on 3D bio-printers. These are then used to create new life forms. As companies seek to control their supply chains – and benefit financially from exclusive patents on the organisms and processes they use – research and development in this area is advancing quickly.

Foods and flavourings

Food and health supplements are an important market for synbio ingredients. There are already several synbio supplement ingredients on the market including astaxanthin, resveratrol and omega-3 fatty acids – and more are on the way.

There are also several synbio flavourings that mimic expensive flavourings and aromas which are either on the market or in the pipeline right now.

Of all the synbio flavourings, vanillan is the most widely used and well known. Natural vanilla – derived from the seedpods of the orchid species *Vanilla planifolia* – is the world's second most expensive spice.

Its popularity in ice cream, sweet treats and baked goods means synbio vanilla is in high demand. Synbio vanillan is made in large vats using synthetic DNA and genetically re-engineered yeast. It can go into food unlabelled and can even be included in products that claim to be ‘all natural’.

Saffron, is a spice derived from the stigma of the *Crocus sativus* flower, most of which is cultivated in Iran. The flowers are harvested by hand, the stigma removed and quickly dried to preserve its flavour.

Natural saffron is the world's most expensive spice. Due to its high value, adulteration is common and biotech companies claim that synbio saffron is a more economical and consistent product. But true saffron is a complex mixture of aroma molecules and synbio saffron only replicates a few of these.

Another product, called EverSweet, is a synbio version of the herbal sweetener stevia. Natural stevia is derived from the plant species *Stevia rebaudiana*. The synbio version is made by re-engineered yeasts but can still be labelled ‘natural’.

A synbio version of the sweetener xylitol – a sugar alcohol widely used in 'sugar free' foods and in products like chewing gum and toothpastes – is also currently under development.

Even the complex flavours of wine, which would normally develop over time and according to the quality and unique properties of the grape and the soil, or terroir, in which it is grown, are being artificially enhanced with synbio yeasts.

Some North American wines make use of genetically re-engineered *Saccharomyces cerevisiae* yeast strains (ML01 and ECMo01, P1Y0) to improve complexity and add flavour notes like raspberry and vanilla as well as boost levels of resveratrol – an antioxidant naturally found in red wine.

Recently scientists have developed a re-engineered yeast that adds a range of flavours to beers. There is even a yeast that can impart the hoppy flavour and aroma of beer, which the producers claim could allow brewers to do away with using natural hops as a starting material.

New flavourings coming to market include synbio versions of ginger flavouring (beta-elemene) as well as a variety of citrus flavours like grapefruit (nootkatone) and bitter orange (valencene), all of which are intended for use in baked goods, sodas, liqueurs and other processed foods.

Medicinal and recreational herbs

Artemisinin, the key ingredient in the world's most effective anti-malarial drug, occurs naturally in *Artemesia annua* (sweet wormwood).

The pharmaceutical industry has historically sourced natural artemisinin from thousands of small farmers in Asia and Africa. But now biotech companies have found a way to re-engineer yeast to produce artemisinic acid, which is then converted to artemisinin via a proprietary chemical process. This product – SSA, or Semi-Synthetic Artemisinin – has been on the market as an antimalarial since 2013.

With the increasing decriminalisation of cannabis around the world and the recognition of the medicinal properties of the cannabis plant, a new and legitimate global market is opening up.

Biotech companies are working at full pelt to produce – and patent – synbio cannabinoids in the hope of creating new recreational products as well as medicines to treat pain, cancer, insomnia, epilepsy and many other health problems.

A rose by any other name?

The use of synbio to produce facsimile aromas for perfumes and cosmetics is growing, especially when it comes to replicating expensive and rare fragrances

Agarwood, or oud, is derived from the resinous heartwood of trees belonging to the genus *Aquilaria*. These trees, which are native to many parts of tropical Asia, are highly-prized but endangered.
Status: *in development*

Ambergris/Clary sage Ambergris is a waxy excretion produced by endangered sperm whales. Its active component, ambroxide, is prized as a 'fixative' that intensifies and adds longevity to perfumes. Today manufacturers use a synthetic ambroxide derived from sclareol – a key compound extracted from the herb clary sage (*Salvia sclarea*). Synbio producers are now using specially re-engineered yeast to produce sclareol.
Status: *on the market as Ambrox®, AMBROX®SUPER 909158 and Sclareol Bio*

Neroli is derived from the blossoms of the bitter orange tree. It is used widely in fine perfumery and is a classic ingredient of traditional eau de cologne.
Status: *under development*

Patchouli is extracted from a member of the mint family, *Pogostemon cablin*. It's used in perfumes, soaps, candles and other household products.
Status: *on the market as Clearwood™*

Rose is one of the world's most precious and expensive essential oils. Distilled from freshly harvested petals of *Rosa damascene*, it takes nearly a quarter of a million rose petals to distil 5 ml of oil.
Status: *imminent market release*

Sandalwood is derived from the heartwood of *Santalum* trees. It is used in perfume, cosmetics and as incense for religious uses and rituals.
Status: *imminent market release*

Vetiver is distilled from a perennial grass (*Chrysopogon zizanioides*). It's native to India but Haiti is the world's largest source of quality vetiver oil. It is a major ingredient in many brand-name perfumes, toiletires and household goods.
Status: *under development*

No plants are needed for this process; the THC, CBD and other cannabinoids are produced in a large industrial facilities via a re-engineered yeast.

More conventional forms of genetic engineering are also being used to create patented cannabis plants that grow faster and yield more seeds and are resistant to pests, disease, drought and salty soils.

In the same vein, tobacco plants are being conventionally genetically engineered to use less water and improve photosynthesis in order to significantly increase yield.

Counting consequences

The process of synthetic biology carries with it an alarming amount of hubris; scientists using this technology claim there are practically no limits to what they can create and concede no risks nor consequences in the process; and yet there are multiple consequences to the continued growth of the synbio flavouring and aroma industry.

What happens, for instance, if these re-engineered microorganisms escape into the wider environment? Manufacturers say this is impossible – but is it?

Consumers who wish to avoid genetically engineered foods may find avoiding these synbio products more difficult.

Companies further argue that cheap, artificial versions of some ingredients – including vanillin, nootkatone, oud and sandalwood – are already made using petrochemicals and that this process is a more 'natural' way to produce chemicals.

But like their petrochemical counterparts these products are, at best, facsimiles that lack the real complexity of natural flavours and aromas.

In addition, this argument further blurs the line between natural and synthetic, real and fake. Allowing synbio products to be labelled natural sets a dangerous precedent for other genetically engineered foods and ingredients to be ushered, unchallenged and unlabelled into the food system.

Farmers – and natural systems – at risk

Synthetic biology is also a way of concentrating power into fewer hands. The flavour and fragrance industry, like the agricultural industry as a whole, is dominated by only a handful of global companies.

According to the ETC group, which has led the way in exposing the growth of the synbio industry, six of the top 10 companies in this field are now engaged in synbio research and development.

Many of the high-end products that synbio aims to replicate come from plants native to countries in the developing world. They often require intensive and delicate hands-on work in order to process them. They, therefore, provide both jobs and income to those most in need.

It could even be argued that, unlike buying green beans from rain-starved countries like Kenya, buying herbs and spices that are legitimate indigenous agricultural products is a good way to invest in developing countries and to give them access to the world market without destroying their food cultures in the process.

What happens to the farmers who have been growing these crops for generations and whose livelihood depends on them?

Synbio companies say this new industry will create new jobs, but it is unlikely that these farmers will be able to find employment in this field. Moving production to high-tech Western laboratories will make these farmers irrelevant and entrench poverty and ill-health in vulnerable countries.

In addition, some of these natural products play key roles in local and regional ecosystems. Farmers growing vanilla orchids, for example, protect intact tropical rain forests on which their crops depend. Shifting market demand in favour of synbio vanilla could also, ironically, see these rainforests cleared to make way for soya, palm oil and, in particular, sugar which is the feedstock for synbio organisms.

Using consumer power

Synbio flavourings and fragrances are being quietly ushered into the marketplace via processed foods. They are also being sold to large catering companies and chefs with an eye on their bottom lines.

As the synbio industry grows, consumers who wish to avoid these ingredients may find this increasingly difficult. Truthfully labelled, the same consumers who reject petrochemical flavourings are also likely to reject synbio for many of the same reasons.

It's easy to feel powerless, but consumers who don't want to eat or use products with synbio ingredients have a tremendous amount of power in this marketplace: to be selective, to change their diets to include fresh rather than highly-processed foods, to ask questions – and to refuse to buy misleadingly labelled products that are being used to 're-engineer' food and farming in ways that are potentially unsustainable and unsafe.