# Bioscience at a Crossroads

## Access and Benefit Sharing in a Time of Scientific, Technological and Industry Change:

## *The Food and Beverage Sector*

CBD

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## Access and Benefit Sharing in a Time of Scientific, Technological and Industry Change: The Food and Beverage Sector

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**About the Author and Acknowledgements:**

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**Front cover**
Left: Superfoods
Centre: Baobab: PhytoTrade Africa
Right: Argan fruit

**Back cover**
Left: Cow peas
Centre: Maca roots
Right: Agave plants

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The focus of this brief is on the use of genetic resources and associated traditional knowledge in the food and beverage industry, although conclusions and recommendations have broad applicability to other subsectors. Note that separate policy briefs review access and benefit-sharing issues pertaining to the pharmaceuticals, agriculture, botanicals, industrial biotechnology and cosmetic sectors. The reader is also referred to the overview brief in this series: Laird, S. and Wynberg, R. 2012. *Bioscience at a crossroads: Implementing the Nagoya Protocol on access and benefit sharing in a time of scientific, technological and industry change*. Secretariat of the Convention on Biological Diversity, Montreal. Policy briefs can be found at: https://www.cbd.int/abs/policy-brief/default.shtml/

# INTRODUCTION

The food and beverage industry uses biological resources mainly as raw material, with genetic resources utilized less prominently than other sectors. More and more, however, scientific, technological and market changes are shifting the way in which the food and beverage sector uses biological resources, with increasing use of genetic resources in interesting and innovative ways. Sub-sectors focused on novel foods, nutrigenomics, biotechnology, nanotechnology, bioactive ingredients, processing techniques and flavours, for example, are increasingly using microorganisms in bio-processing – to create new flavours, colours or synthetic forms of natural ingredients; are investigating new species and traditional foods for interesting bioactive compounds; are adding new nutritive ingredients to functional foods; or are developing highly specialised medical and personalised foods based on genetic resources.

Although most activities pursued by the food and beverage sector do not involve research and development (R&D) on genetic resources, the small component that do are spurring greater involvement in access and benefit sharing (ABS) issues and, thus, greater relevance of the Nagoya Protocol on Access and Benefit-Sharing and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). However, ABS is very new to the food and beverage sector and is not widely known or acknowledged by many of those involved. A few larger companies are increasingly aware of international obligations, stimulated in some instances by controversial cases that have revealed the challenges of integrating ABS into supply chains, but awareness remains extremely low for most companies.

As markets and technologies have developed, and consumer choices have become more sophisticated,

Harvesting rooibos (Aspalathus linearis) in South Africa. Although traditionally used as a tea, increased R&D is leading to the incorporation of rooibos in the functional foods and cosmetics industries. *Photograph: Environmental Monitoring Group*

the food and beverage sector has progressively become intertwined with other sectors such as pharmaceuticals, agriculture, biotechnology and botanicals. In line with trends in other sectors, microbial organisms are becoming increasingly important, where, through biotechnology, they are used to produce active compounds in much higher yields.[1] Novel enzymes from microorganisms are also being used to make cheeses or create new flavours and colours. Following health trends, and an increasingly aging population in the developed world, particular food and beverage products are being developed based on their anti-oxidant properties, essential fatty acid composition, or high level of proteins. Overall consumer trends include the adoption of products promising health and wellness benefits and a greater leaning towards exotic and ethnic flavours.[2] Customers are also becoming more aware of the environmental and social footprint of the products they consume, including the use of external inputs such as pesticides and fertilisers, impacts on biodiversity and climate, the extent to which ingredients are sourced locally, and the benefits received by producers.

This brief provides an overview of the industry, summarizes key market and research and development trends, and analyzes the implications of these trends for governments and other stakeholders, including indigenous and local communities, and companies who may be involved in ABS-related activities and in the implementation of the Nagoya Protocol.

# INDUSTRY OVERVIEW AND MARKET TRENDS

### *Use of natural ingredients in the food and beverage industry*

Located between agriculture, processing, distribution and retail, the global food and beverage industry for the most part uses a range of biological raw materials that are purchased directly or indirectly from farmers or from intermediate suppliers of ingredients. These range from commodities such as palm oil, sugar, tea and coffee, through to smaller volumes of thousands of different natural ingredients. While the Nagoya Protocol does not cover the commodity trade of raw materials, nor local trade or subsistence use, it does apply to the utilization of genetic resources as defined by Article 2 (c) of the Protocol, to traditional knowledge within the scope of the Convention and to the benefits arising from the utilization of such knowledge.

Different activities of this sector may invoke ABS requirements. These include:

- Bio-processing, where novel enzymes from micro-organisms are used to make cheeses or create new flavours, colours or synthetic forms of natural ingredients;
- Innovations for existing food products that may be derived from the utilization of genetic resources. This could include the addition of a new nutritive ingredient, flavour or colour; and
- The use of 'new' species or traditional knowledge to investigate bioactive compounds of use to the food industry, or to develop a particular food product.

Natural ingredients, although typically small in volume, contribute significantly to food and beverage products as flavours and fragrances, spices, herbs, colourants and enzymes and also form part of functional foods. Functional food can be defined as 'modified food or food ingredients that may provide a health benefit beyond the traditional nutrients it contains'.[3] Examples may include flavonoids such as catechin or quercetin, or carotenoids such as lycopene and lutein, which occur widely in plants, are known for their anti-oxidant properties and are believed to have a wide range of health effects[4] (Table 1).

The functional food market is a segment of the growing 'functional ingredient' market which also encompasses dietary and nutritional supplements, known as 'nutraceuticals', 'nutrigenomics' – which consider the interaction between foods or supplements and an individual's genome, and functional personal care products or 'cosmeceuticals'.[5] The incorporation of these functional

**TABLE 1. Common Types of Functional Foods[6]**

| TYPE OF FUNCTIONAL FOOD | DEFINITION | EXAMPLE |
|---|---|---|
| Fortified product | A food enriched with additional nutrients. | Bread fortified with calcium. |
| Enriched products | A food with added new nutrients or components not normally found in a particular food. | Margarine with plant sterol ester, probiotics, prebiotics. |
| Altered products | A food from which a deleterious component has been removed, reduced or replaced with another substance with beneficial effects. | Fibres as fat releasers in meat or ice cream products. |
| Enhanced commodities | A food in which one of the components has been modified or enhanced through special growing conditions, new feed composition, genetic manipulation, or otherwise. | Eggs with increased omega-3 content achieved by altered chicken feed. |

ingredients in a wide range of products is evidence of the increasing overlap between once distinct industries such as pharmaceuticals, biotechnology and food.

In the US, top selling food or spice products sold as supplements in mainstream markets have seen dramatically increased sales in recent years. Such products include: cranberry (+13%), soy (+10%), ginger (+13%), kelp (+41%), cayenne pepper (+49%), tumeric (21%), and alfalfa (+46%). Other edible or food-oriented herbs include garlic, green tea, bilberry, barley, grape seed, elderberry, spirulina, and maca root.[7]

In Japan, the top selling products also include many foods: beer yeast, propolis, Japanese plum, chlorella, barley verdure, vegetable juice, collagen, royal jelly and mulberry. In Brazil, top food supplement products include guarana, chitosan, fibers, fish oil, borage oil, lycopene, lutein, evening primrose oil, DHA, lecithin and aloe vera. In Europe, extracts from green tea, cocoa, blueberries, and tomato are becomingly increasingly popular.[8]

Given more sedentary lifestyles and increasing obesity around the world, there is also growing interest in natural alternatives to sugar, with particular attention paid now to stevia and agave. After the US Food and Drug Administration (FDA) approved stevia in 2008, sales skyrocketed from $21 million worldwide to a projected $1-2 billion by 2014. Stevia-based Truvia is now the number two branded sugar substitute in the US, overtaking the artificial sweeteners Equal and Sweet'N Low, and second only to Splenda.[9]

Proteins are of particular interest for sports drinks and meal replacements, to help build muscle mass, aid in weight loss, and combat ageing. Vegan and allergen-free sports products are gaining market share, including protein blends of hemp, sprouted brown rice, peas and grasses. The price of whey, a standard protein source, is volatile and so alternative plant sources of protein are also of interest to manufacturers and formulators.[10] The functional beverage market, which includes energy drinks, sports drinks and functional waters, ready-to-drink tea and coffee, and yoghurt drinks and smoothies, as some of the most popular items, continues to grow.[11]

Buchu (Agathosma spp), native to southern Africa, is an important flavourant in the food and beverage industry. *Photograph: Rachel Wynberg*

Although the incorporation of 'new' ingredients based on biological resources, such as the fruit of the African baobab (*Adansonia digitatis*) and marula (*Sclerocarya birrea*) trees, is taking place, the majority of functional foods are based upon waste streams of by-products from industry (e.g. grape seed extract, lycopene, soy isoflavones, green coffee extract, omega 3 and 6 oils). These are sourced via cheap and well-established supply chains, typically based on major commodities such as soya and coffee which present few ABS issues and have well-documented safety histories.[12]

## GLOBAL MARKETS

Like many other sectors, the food and beverage sector is characterised by economic uncertainty and high levels of volatility in commodity, currency and stock markets. At the same time there is dynamic growth in emerging markets, increasing affluence and numbers of consumers and significant changes in science and technology.[13]

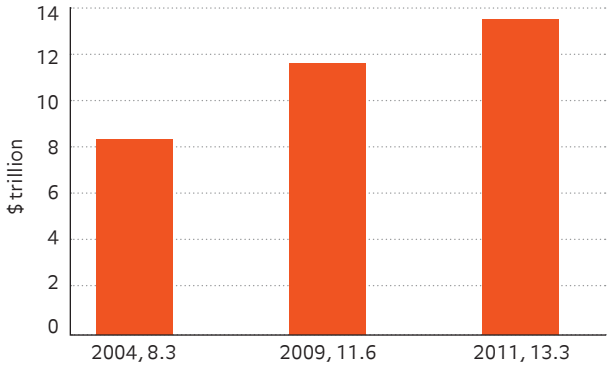


**FIGURE 1. Global Food and Beverage Retail Revenues, 2004–2011[19]**

**TABLE 2. Total Food and Drink Sales in the Top Ten Countries and Regions, 2010[20]**

| | | TOTAL SALES ($ billion)[21] |
|---|---|---|
| **1** | European Union | 1,268 |
| **2** | United States | 636 |
| **3** | China** | 504 |
| **4** | Japan | 342 |
| **5** | Brazil** | 138 |
| **6** | Canada | 89 |
| **7** | Mexico | 79 |
| **8** | Australia* | 65 |
| **9** | South Korea | 56 |
| **10** | New Zealand | 28 |

(*2009 data; **2008 data)

Retail sales of food and beverages worldwide reached US$11.6 trillion in 2009 and are predicted to top $15 trillion in 2014 (Figure 1). In 2010, functional food markets were estimated at $7-63 billion, expected to reach $90.5 billion by 2013.[14] The US is the largest market for functional foods, followed by Japan and Europe, which combined attract 90% of total sales. The number of functional food introductions in the North American market increased from 200 in 2006 to over 2000 in 2008.[15] Global sales in functional beverages increased from $19 billion in 2006 to $23.4 billion in 2010, with sales of energy drinks the highest in this sector, topping $7 billion in 2012.[16]

In 2011, natural and organic foods were estimated to be worth about $53 billion.[17] Although the Fairtrade certified market has tripled since 2008, it was valued at under $5 billion in 2009 and accounts for less than 2% of the overall food and beverage retail market.

Tables 2 and 3 illustrate total food and drink sales and top exporters of food and drink products. The European Union (EU) is both the largest exporter and importer of food and drink globally. Due to rising market share in emerging economies, however, its share of world trade has been shrinking from 20.1% in 2001 to 17.8% in 2010.[18]

## CONSOLIDATION AND INTEGRATION

Scientific, technological and market changes are leading to greater consolidation and integration both within the food and beverage sector – the so-called 'farm to fork' supply chain – and across the multitude of sectors upon which it relies. Supply chains for the food and beverage sector are highly variable, and have traditionally comprised firms focused on agricultural production; companies which process raw food materials for further manufacture; those that are consumer oriented and which manufacture highly processed convenience food; as well as the array of firms dealing with logistics, packaging and transport, information and communication. Increasingly, however, companies are taking an integrated approach

Coffee, like these unroasted Ethiopian beans, was one of the first agricultural commodities to be marketed through the fair trade system.

Native to the Americas, the sweet leaves of stevia are increasingly being used as a sugar substitute.

**TABLE 3. Top 10 Exporters and Importers of Food and Drink Products, 2011**[22]

| | EXPORTERS | | | IMPORTERS | | |
|---|---|---|---|---|---|---|
| | | Exports ($ billion) | Share of worldwide total exports (%) | | Imports ($ billion) | Share of worldwide total imports (%) |
| 1 | European Union | 97.2 | 16.5 | European Union | 89.1 | 15.1 |
| 2 | United States | 72.0 | 12.2 | United States | 83.7 | 14.2 |
| 3 | Brazil | 46.8 | 8.0 | Japan | 52.5 | 8.9 |
| 4 | China | 44.2 | 7.5 | China | 36.9 | 6.3 |
| 5 | Thailand | 30.6 | 5.2 | Russia | 24.3 | 4.1 |
| 6 | Malaysia | 28.8 | 4.9 | Canada | 23.9 | 4.1 |
| 7 | Indonesia | 27.9 | 4.7 | South Korea | 17.6 | 3.0 |
| 8 | Argentina | 27.5 | 4.7 | Hong Kong | 15.7 | 2.7 |
| 9 | Canada | 23.5 | 4.0 | Mexico | 14.9 | 2.5 |
| 10 | India | 20.8 | 3.5 | Nigeria | 13.4 | 2.3 |

**TABLE 4. Ranking of the Top 10 Food and Beverage Companies, 2012[26]**

| Rank | Company | Headquarters | Food and Beverage Sales ($ Million) | Year Ending |
|---|---|---|---|---|
| 1 | Nestlé | Switzerland | 83,505 | Dec 11 |
| 2 | PepsiCo Inc | United States | 65,881 | Dec 11 |
| 3 | Kraft Foods | United States | 54,365 | Dec 11 |
| 4 | The Coca Cola Company | United States | 46,524 | Dec 11 |
| 5 | Archer Daniels Midland Company | United States | 42,639 | Jun 11 |
| 6 | Anheuser-Busch InBev | Belgium-Brazil | 39,046 | Dec 11 |
| 7 | JBS | Brazil | 34,770 | Dec 11 |
| 8 | Tyson Foods | United States | 32,246 | Sep 11 |
| 9 | Unilever | United Kingdom-Netherlands | 31,930 | Dec 11 |
| 10 | SABMiller | South Africa | 31,388 | Mar 12 |

Chia seeds – well known as a superfood, have been cultivated in central America since the time of the Aztecs.

to the food supply chain with less separation of these functions between them. A new scientific consortium led by the company Unilever, for example, aims to "identify nutritionally valuable varieties of fruits and vegetables from the past, in order to produce natural health ingredients for the future".[23] If the project is successful in identifying nutrient-rich plants, the long-term aim would be to incorporate them into Unilever's food products.

At the same time, there has been strong consolidation within ingredient suppliers, with the purchase of large and small firms by Archer Daniels Midland, BASF, DSM, Naturex and Nexira. Such companies will typically supply a range of ingredients to markets for food and beverage, nutrition and health, and personal care. One of the primary motivations for this trend is to market 'authentic' brands. One industry commentator noted: "If they buy smaller brands they tend to keep the brand separate as opposed to 15-20 years ago when they would subsume the brand." In 2008, the largest 20 food processors commanded 20% of the global market, and further consolidation is predicted over time.[24] The US dominates the world agri-food market, with seven of the top ten companies in this sector originating there (Table 4). The Swiss company

Nestlé, now reconfigured as a "nutrition, health and wellness company", was the top ranked food and beverage company in 2012, with sales of 85,5 billion.[25]

## ETHICAL AND SUSTAINABLE SOURCING

Some companies are setting in place clear plans for environmental and social sustainability as 'green' and 'local' become more important to consumers.[27] Unilever, for example, has produced a Sustainable Living Plan to reduce its environmental footprint as well as a Code for Sustainable Agriculture while Nestlé has Responsible Sourcing Guidelines for seafood and for palm oil, soya, milk, coffee, cocoa, sugar and hazelnuts. Despite these trends, the Union for Ethical BioTrade notes that less than one-third of the global top 100 food companies report on biodiversity sourcing practices along their supply chain.[28] Nonetheless, the environmental footprint of products has become mainstream in marketing with labels like 'organic', 'fairtrade', 'natural', 'food miles', 'locally grown', 'purity' and 'true to nature' increasingly gaining currency with consumers.

Sustainability, fair trade and organic sourcing are only part of the landscape for ethical sourcing for the food and beverage sector. Increasingly, ABS issues are emerging related to gaining access to traditional knowledge and ingredients new to the market. However, ABS awareness in the sector is very low and is often confused with the ethical sourcing of raw materials, which are outside the scope of the Nagoya Protocol.[29] While sustainable raw material sourcing is important for achieving the objectives of the CBD, in particular those on sustainable use, it does not in itself include the type of research arrangements typical of biodiscovery.

A range of environmental and social certification systems and standards has been developed in the food and beverage sector, some emphasising the way ingredients are produced and supplied and others guaranteeing the quality and safety of the product. "Certified environmentally sustainable and socially responsible products are a whole new segment" noted one industry analyst.[30] Fair Trade and organic certification are well-developed in this sector and are likely to continue to play an increasingly important role in commodity supply chains. However, the 'ingredientization' of commodities, with more and more materials being tapped, will likely require the development and adoption of alternative certification approaches by the food and beverage sector such as FairWild, which focuses on the ethical and sustainable sourcing of wild-harvested species.[31] An important new standard to emerge in recent years is that developed by the Union for Ethical BioTrade (UEBT), a non-profit organisation that promotes the 'sourcing with respect' of ingredients that come from biodiversity.[32] The UEBT has also recently published a practical guide on benefit sharing to assist companies that source natural ingredients, including the different approaches that might be followed when sourcing biological resources or conducting R&D on genetic resources.[33]

There is increasing interest in the new functional food ingredients from marine algae.

# RESEARCH, DEVELOPMENT AND TECHNOLOGICAL CHANGE

## ON THE BRINK OF A TRANSFORMATION

Research and development in the food and beverage sector represents only a small proportion of industry investment (ranging from 0.53% as a percentage of turnover in the EU to 0.8% in Japan)[34], with innovation often 'invisible' in the final end product, typically occurring at earlier stages of the supply chain, for example in seed development.[35] Although new products have to be formulated constantly – amounting to 1,200-1,500 individual products per year for a company with in-house research capacity, innovation primarily comes from know-how and on-going process improvements to existing ingredients rather than formal R&D using new ingredients which may be sourced from genetic resources.[36] New ingredients that can contribute towards good brain health, lowered cholesterol and reduced obesity, will always be in demand[37] but the food sector is also inherently conservative, relying on tried and tested ingredients with no known toxicity side effects.[38] This also spills over into other sectors, due to the tightening up of regulations for claims and toxicity. R&D investment is also impacted by lower profit margins in this sector, and a lack of willingness by the public to pay high prices for foods and drinks that are seen as essential, rather than luxury items.

Parts of the food and beverage sector are, however, "on the brink of transformation", or have already transformed from a low-medium technology industry to a medium-high technology industry with greater reliance on innovation and research.[39] This includes sub-sectors focused on novel foods, nutrigenomics, biotechnology, nanotechnology, bioactive ingredients, processing techniques and flavours. These are also the sub-sectors in which genetic resources are more likely to be used.

Increased health and wellness represent a major focus of these R&D activities. As one researcher remarked: "If you look at the food sector, the whole drive is about moving away from the bad, so it's about salt reduction, obesity, weight management, reducing calorie intake and removing the sugar but keeping the sweetness".[40] Bioactive ingredients from new species, traditional knowledge, novel enzymes, or new nutritive ingredients have an important role to play in this process, evidenced by the success of *Stevia rebaudiana* as a naturally-sourced sugar substitute, or the use of *Hoodia gordonii*, an appetite suppressant developed on the back of traditional knowledge of the indigenous San peoples.[41]

Other examples point to the increasing intersection of new molecular approaches and food innovation. New technology, for example, has made the identification of taste receptors on the human tongue possible; researchers are screening hundreds of thousands of molecules arising from natural compounds to find ones that can enhance or reduce sweet, salty, bitter, savoury (umami) and sour tastes in products.[42] "Scientists and flavour chemists are going to be searching every blade of grass and every leaf in the Amazon for something that might potentiate taste", remarked one culinary scientist.[43] The chemical profiles of different heirloom varieties of vegetables are also being investigated to identify genetic characteristics that lead to good taste.[44]

Nanotechnology, the science of dealing with matter at an atomic and molecular scale, is also becoming a greater focus in the food industry, with a global market of $5.6 billion in 2012, an increase of $5.46 billion since 2006.[45] To date nanotechnology has been used for largely functional purposes such as the encapsulation of nutraceuticals, packaging and the extension of shelf-life but new

Vanilla pods drying in the sun in Madagascar. Synthetic biology companies are now producing vanillin from glucose.

Larger food and beverage companies have in-house capacity to pursue R&D. *Photo: Rachel Wynberg*

uses are on the horizon that may well challenge the way in which the use of genetic resources is currently understood. The intersection of nanotechnology and biology, for example, is allowing scientists to imagine and create biological systems as the inspirations for technologies not yet created - with profound implications for a range of sectors, and for society at large. The use of microorganisms to synthesise functional nanoparticles is also receiving increased interest. What this means for ABS is still uncertain, but what is clear is that new regulatory approaches will need to be developed as these technologies unfold.

Processing techniques may also increasingly use genetic resources, especially with increased demand for natural preservatives. The company Aquapharm Biodiscovery, for example, has identified a range of ingredients mined from the world's oceans that have anti-bacterial ingredients, including bacteriocins, so-called friendly bacteria that neutralise pathogens.[46]

In another example, the emerging field of nutrigenomics aims to provide tailored nutritional advice or to develop specialist food products specific to particular individuals or populations.[47] Several studies, for instance, have investigated the interactions between certain botanical extracts on a particular genotype causing chronic intestinal inflammation. Although this science is still embryonic, it suggests an increase in the use of techniques aimed towards personalized nutrition.[48] In a similar vein, there is increasing use of genetic resources in the field of medical foods, meaning foods "intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, based on recognized scientific principles, are established by medical evaluation".[49]

Some of the larger food and beverage companies have in-house research capacity to pursue such research. Nestlé, for example, has a research centre focused on plant science, designed to find ways of improving the quality of plants, the sustainability of supply, and determining the right varieties for best flavour.[50] Other

Labelled 'superfruit' due to their high level of anti-oxidants, açai berries are made into wine in the Brazilian Amazon.

companies will rely on smaller specialized companies for innovation. A common trend is for smaller biotechnology companies to do much of the discovery work to identify novel compounds, and to then license use of the material to food, pharmaceutical and cosmetic companies.[51]

Regulatory requirements in this sector are not as stringent as for botanical medicines or pharmaceuticals but due to increased costs of the development cycle, nonetheless play a role in determining the levels of innovation.[52] This is particularly relevant for novel ingredients. For instance, the registration of baobab as a novel food ingredient in the EU, despite its long history of traditional use in Africa, cost between Euro 250,000 and 450,000 and took up to five years to secure.[53] Of interest is that these costs were covered by PhytoTrade Africa, a non-profit organisation working to secure markets for rural African producers, rather than by the industry itself.

## SECTORAL CROSS-OVERS

Scientific, technological and market changes are affecting the configuration and nature of the food and beverage industry, along with increasing integration of the pharmaceutical, agricultural, biotechnology, cosmetic, and herbal medicine industries. Growing partnerships between producers of food ingredients, flavours and fragrances and synthetic biology companies, for example, are developing biosynthetic versions of high value natural commodities.[54] The Swiss-based synthetic biology company Evolva, Inc. has created a pathway to produce vanillin from glucose and has also begun work on a biosynthetic route to express saffron-derived genes in engineered microbes.[55] Work is also underway to replace the botanical sources of vetiver and patchouli with biosynthetic versions.[56] Such developments will have considerable implications for the $22 billion global flavour and fragrance market and, through reduced demand for natural vanilla, could have profound impacts on the thousands of families that depend on the production of these commodities for their livelihoods.

Breakthroughs in genetics and molecular science have also led to greater similarities in scientific approaches between food and pharmaceutical sectors. Figure 2 illustrates the interface between nutrition and pharma in these two sectors, and the evolution of traditional diets towards functional foods, dietary supplements, medical foods and pharmaceuticals. In an example that illustrates the fuzzy boundaries between sectors, food giant Nestlé, has established Nestlé Health Science to develop "patient-centric healthcare and science-based personalized nutritional solutions" and to "expand the boundaries of nutrition". A partnership – Nutrition Science Partners, with healthcare group Chi-Med, aims to bring innovative nutritional and medicinal products derived from plants to market. Nutrition Science Partners will have access to Chi-Med's extensive collection of medicinal extracts based on more than a thousand different herbal plants. Nutrition Science Partners has recently announced the

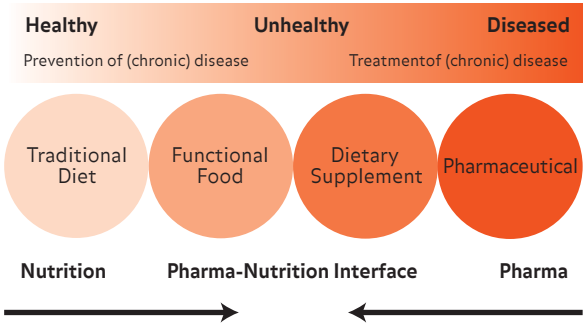


**FIGURE 2. Pharma-Nutrition interface.**

*Adapted from Eussen, S.R.B.M., Verhagen, H., Klungel, O.H., Garssen, J., van Loveren, H., van Kranen, H.J. and Rompelberg, C.J.M. 2011. Functional foods and dietary supplements: products at the interface between pharma and nutrition. European Journal of Pharmacology 668:S2-9.*

enrolment of the first patient for a multi-centre Phase III clinical trial of an extract of *Andrographis paniculata* 'king of bitters' for ulcerative colitis.

Trends towards convergence between the food and beverage and pharmaceuticals sectors have been accompanied by pressure from governments to reduce public healthcare costs, and a desire from consumers to 'self-medicate'. The rise of diet-related illnesses such as obesity and diabetes, together with an aging population in the developed world, has led to increased recognition of the power of food and nutrients to maintain health.[57] As examples of these convergence trends, Pfizer has recently purchased a food supplement company, GlaxoSmithKline has invested in sports drinks and Nestlé has established the Nestlé Health Science company, and the Nestlé Institute for Health Sciences.

In a similar development, large pharmaceutical companies such as Novartis Consumer Health, GlaxoSmithKline and Johnson & Johnson have begun showing an interest in functional foods. These companies, which have extensive experience in conducting clinical trials to substantiate health claims, are attracted by the relatively lower product development costs and shorter development times in this sector.[58]

There are also strong overlaps between the food and beverage and cosmetic sectors. The idea that one can "eat yourself beautiful" has resulted in nutraceuticals which claim to restore healthy skin and have been recommended as an alternative to cosmetic surgery. Innéov products, for example, are promoted as "nutritional concentrates for skin and hair beauty", emerging from a joint venture between Nestlé and L'Oréal.[59]

As a means of by-passing stringent and costly toxicity tests, the cosmetics industry is also increasingly looking at known food ingredients.[60] Argan oil, extracted from the nut of the Argan tree (*Argania spinosa*) which is endemic to Morocco, has traditionally been used medicinally, for culinary purposes as well as for cosmetics. In a similar vein, baobab fruit powder is being used as a cosmetic ingredient.[61] These well-documented uses, particularly the fact that they can be safely ingested, mean that modern research into cosmetic applications is simplified.[62]

### *ABS IMPLICATIONS*

A range of activities may invoke ABS requirements in the food and beverage sector, from the use of microorganisms to make new flavours or synthetic forms of natural ingredients, the investigation of new species for interesting bioactive compounds, the dependence on traditional knowledge and use to indicate safety and efficacy of an ingredient,[63] research into traditional foods, new uses of existing food and beverage ingredients, or the addition of new nutritive ingredients to functional foods. The range of issues introduced through using agricultural genetic resources adds a further dimension to the complex ways in which genetic resources and traditional knowledge are used in the food and beverage sector.[64] A growing interest in biodiversity as a source of new ingredients, the increasing integration of food with other sectors, and height-

ened consumer interest in natural products, suggests an upward trend of using genetic resources in this sector. At the same time, greater use of synthetic biology in the long term implies less dependence on certain natural ingredients and a greater self-reliance among some sectors of the food and beverage industry (although others will always prefer naturally-derived ingredients). Nonetheless, ABS-relevant activities in this sector are likely to continue to represent a relatively small proportion of its overall portfolio and profits.

Industry awareness of ABS remains extremely low in this sector with one analyst stating that "eighty per cent have not heard of ABS" and a recent survey noting that only 6% of the top 100 food companies mention biodiversity-related issues like traditional knowledge in annual reports.[65] A few larger companies are increasingly embedding ABS in their policies and procedures. For example, one company reported the requirement for Material Transfer Agreements to state that providers must be compliant with national laws and the CBD, and had established internal mandatory procedures for every product using traditional ingredients as well as an early warning compliance monitoring system to stop projects that don't comply. "We do biodiversity compliance training and all patent officers are briefed and are up to speed on the issues. We realise biodiversity awareness must be built early on in the process", remarked a representative from this company.[66]

Some negative experiences have also turned companies away from using new ingredients and traditional knowledge. As noted by one researcher: "Investors are much more sensitive to ABS and regulations and some are turning away because the risk is considered too high. There is a fear of being labelled a biopirate. However, in countries such as South Africa where ABS legislation is already in place, researchers report increased interest from industry in local biodiversity, helped by an institutional environment that provides them with a local collaborator to navigate procedures to access biodiversity".[67]

The low profit margins in this sector make it especially vulnerable to additional regulatory hurdles. Countries with similar biological resources but less stringent or clearer regulations than other countries may be approached to source the material, or replacement ingredients will be found if certain species become difficult to access. In a remark that is common to many other sectors, one company representative stated: "We have tried to establish benefit-sharing agreements and tried very hard to find the right authority but it failed. It was frustrating – we invested a lot of resources in getting a good hypothesis but it was a waste and we went elsewhere. We can't hang around for five years trying to find the right person to speak to so we move on and look for something else".[68] This lack of regulatory and administrative clarity also has an impact on innovation. "We are looking at an oil coming from Africa", noted one company, "but there is not a lot of literature. We have asked toxicologists to do an evaluation but safety studies will cost 150,000 Euros. It does not give us specific advantages over olive oil because the regulatory hurdles are so high, and the ABS hurdles are now also high. All of this is stopping innovation".[69]

The increasing integration of supply chains in this sector means that agricultural production, traditionally separated from food processing and manufacturing, is becoming more central to strategies and operations. Some food and beverage companies are also engaging more and more with new molecular developments in the agricultural sciences, for example by investigating new varieties for improved taste, flavour and climate adaptation. More and more, therefore, the food and beverage sector will be affected by ABS issues that pertain both to the Nagoya Protocol and to the International Treaty on Plant Genetic Resources for Food and Agriculture.[70] The nuances of these treaties and their national implementation have important implications for the food and beverage sector, but are not yet fully understood by providers and users in the sector. These gaps emphasize the need for ongoing capacity development and awareness among those utilizing genetic resources.

# THE NAGOYA PROTOCOL: RESPONDING TO SCIENTIFIC, TECHNOLOGICAL, POLICY AND MARKET CHANGE

ABS is very new to the food and beverage sector and the fact that biological resources are mostly used as raw materials and commodities also means that ABS issues may not be relevant to many users and providers. Lower profit margins, differing times and levels of investment for R&D, the varied shelf life of different ingredients, the role of ingredients in the final product, and the relevance of the 'natural' component in marketing are all factors that need wider consideration in the uptake of ABS in this sector. At the same time, the increasing utilisation of genetic resources by the food and beverage sector in functional foods, medical foods, personalised nutrition products, new agricultural products, novel foods and new flavours, among other uses, means that ABS will become more and more relevant. Implementation of the Nagoya Protocol can support this process in the following ways:

***Providing legal certainty, clear and workable regulations and effective and streamlined measures –*** Difficult, time-consuming and bureaucratic regulations and permitting procedures, and an absence of legal certainty when acquiring genetic resources from some countries, are regarded by many companies as major stumbling blocks in research to develop innovative food and beverage products. The Nagoya Protocol seeks to address these concerns and create an environment of legal certainty and mutual trust by requiring Parties to designate a national ABS focal point to make information available on procedures for

Young cultivated Hoodia gordonnii plants. The stems have appetite suppressing properties, developed based on the traditional knowledge of the indigenous San. *Photo: Rachel Wynberg*

obtaining prior informed consent and reaching mutually agreed terms. The Nagoya Protocol also establishes one or more competent national authorities to grant access (Article 13). Establishment of an ABS Clearing-House (Article 14) for sharing information will help to ensure transparency and enhance legal certainty. The particularities of the food and beverage sector, and the challenges of isolating ABS-related R&D activities suggest that it would be especially useful to develop model contractual clauses (Article 19) which can provide additional legal certainty and clarity and reduce transaction costs.

***Supporting benefit sharing arising from the use of traditional knowledge –*** Traditional knowledge associated with genetic resources may be of interest to some segments of

Top: Quinoa, a grain-like seed believed to have been domesticated in the Peruvian Andes, has gained popularity as a 'superfood' in the West.

Bottom: Dried mopane worms – the caterpillar of a moth species, are an important protein source for millions of Africans. There is increasing interest in insects as novel foods.

the food and beverage sector, both as a source of leads for potentially bioactive compounds, and, to a lesser extent, as new opportunities for marketing. Through Parties' implementation of Articles 7 and 12, the Nagoya Protocol can help Parties, companies and indigenous and local communities to ensure that prior informed consent is secured and mutually agreed terms are established when traditional knowledge associated with genetic resources is accessed and used.

This can be supported by the establishment of mechanisms pursuant to Article 12 to inform potential users of traditional knowledge associated with genetic resources about their obligations. The Nagoya Protocol encourages Parties to take into consideration indigenous and local communities' customary laws and to support the development by indigenous and local communities of community protocols, minimum requirements for mutually agreed terms and model contractual clauses for benefit sharing (Article 12, Paragraph 3).

***Providing clarity on scope –*** Most food and beverage products are based on commodity trade in large volumes, as well as multiple ingredients, many of which are known ingredients with established supply chains that involve little R&D. The Nagoya Protocol, however, focuses on the utilization of genetic resources as defined by Article 2 (c) of the Protocol, and does not include commodities in its scope, or ingredients that are used as raw material. Local trade or subsistence use are also excluded. Implementation of the Protocol can help to provide further guidance to users and providers about which resources and activities fall within its scope, thus providing surety and clarity about ABS implications and requirements. The Protocol also helps to provide clarity on its relationship with the ITPGRFA. The ITPGRFA was negotiated in harmony with the CBD, and the Protocol acknowledges the fundamental role of plant genetic resources for food and agriculture. Furthermore, Article 4, paragraph 3, provides that the Protocol is to be implemented in a mutually supportive manner with other relevant international

instruments, thus providing an important opportunity to further enhance coordination and policy coherence between the agricultural and environmental sectors as regards ABS issues.

***Building the capacity of governments, researchers and companies to engage with ABS and changing scientific and technological developments –*** Understanding of ABS among all user and provider groups in the food and beverage sector is still embryonic, aside from a few notable exceptions. Considerable awareness-raising and capacity development is thus required to ensure the effective and mutually supportive implementation of the Nagoya Protocol and the ITPGRFA. Such needs are well recognized by the Nagoya Protocol (Articles 21 and 22) which promotes awareness-raising and capacity development and calls for a strengthening of human resources and institutional capacities for effective implementation. The importance of building the capacity of governments to implement ABS measures is also well recognised, including the development, implementation and enforcement of domestic legislation, the negotiation of mutually agreed terms, and the development of research capabilities to add value to genetic resources. The use of codes of conduct, guidelines and best practices and/or standards (Article 20) can help to enhance capacity and compliance with ABS requirements.

***Improving monitoring of the use of genetic resources –*** The monitoring of ingredients incorporated into food and beverage products presents significant challenges due to the multiple ingredients and product lines that are involved across several sectors. Through the checkpoints described in Article 17, the internationally recognized certificate of compliance, and the ABS Clearing-House, the Nagoya Protocol can help to monitor the use of genetic resources throughout supply chains and provide evidence that prior informed consent has been obtained, that mutually agreed terms have been negotiated, and that benefits are have been shared.

New molecular developments are investigating traditional varieties for improved taste, flavour and climate adaptation. *Photo: Rachel Wynberg*

***Developing regional ABS approaches –*** Many species used in the food and beverage sector are distributed across political boundaries, as is traditional knowledge associated with genetic resources incorporated into novel foods and drinks. Implementation of Article 11 on transboundary cooperation provides important opportunities to investigate common regional or sub-regional approaches for such resources and knowledge. Consideration of the need for and modalities of a global multilateral benefit-sharing mechanism, as stipulated by Article 10 of the Protocol, may also be important in this context.

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