

Sustainability in Flavor and Fragrance Ingredients

Securing renewable natural ingredients and establishing sustainable synthetic chemicals are important for the future of F&F.

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Until the 19th century, all basic goods for human use were derived from plants and animals. In the 20th century, the rapid development of the petroleum industry changed people's lifestyles, enabling mass production, mass consumption and mass waste. Although producing goods in a sustainable way to meet 21st century demands is no easy feat, it is well known that the use of petroleum feedstock poses problems for humanity's collective future. Such products release CO₂ stored in fossil fuels and increase CO₂ levels in the environment, thereby exacerbating climate change (**F-1**).

Furthermore, the United Nations has announced that the world population will total more than 9.6 billion in 2050.^a It is quite feasible that this population growth will cause a future shortage of water, food and energy. Similarly, it will have an impact on the flavor and fragrance (F&F) market, the size of which in 2013 was \$23.9 billion,^b which is estimated to expand about 6% annually over the next 10 years. Consequently, the

F&F industry is exploring various ways to increase sustainability in the 21st century. From a raw material procurement point of view, this report describes two main streams, securing renewable natural ingredients and establishing sustainable synthetic chemicals in F&F (**F-2**).

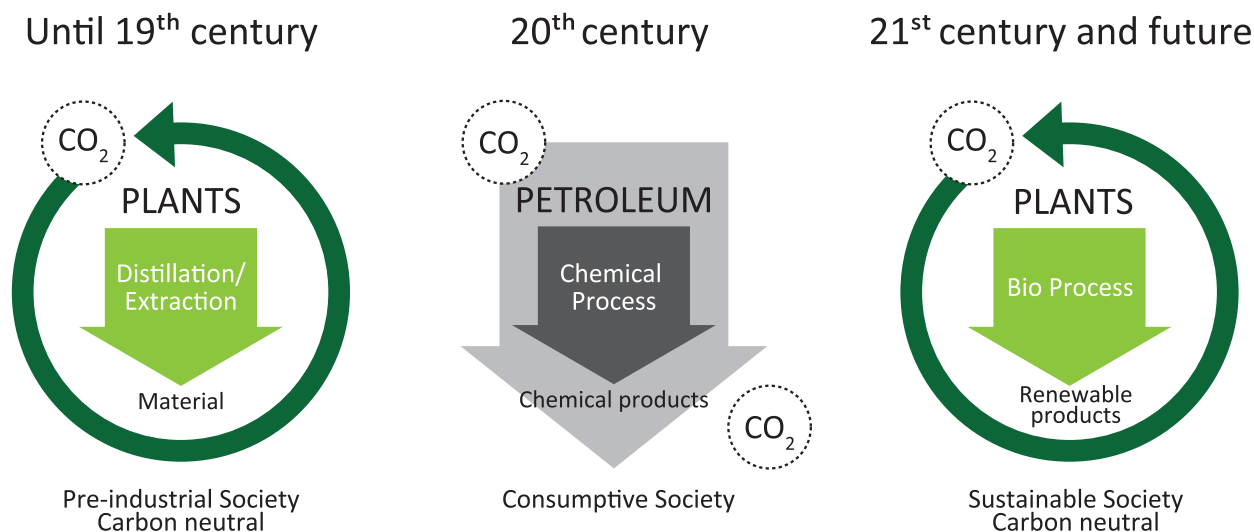
Secure Renewable Natural Ingredients

Much effort has been directed toward securing natural resources. At first, the F&F industry supported a range of different approaches, which have been undertaken to enhance the quality of life for the communities concerned. Collaborating with an organization to preserve natural resources is one way to engage in sustainable activities. Some companies are not only teaching methods and skills to improve crop yields; they are also providing health services and educational support for growing local communities (**T-1**). These activities show that industries are focusing on making long-term relationships with suppliers of natural ingredients. Consumers' strong demand for these natural ingredients is pushing industries to have a varied selection of natural ingredients, produced in a sustainable fashion (**F-3**).

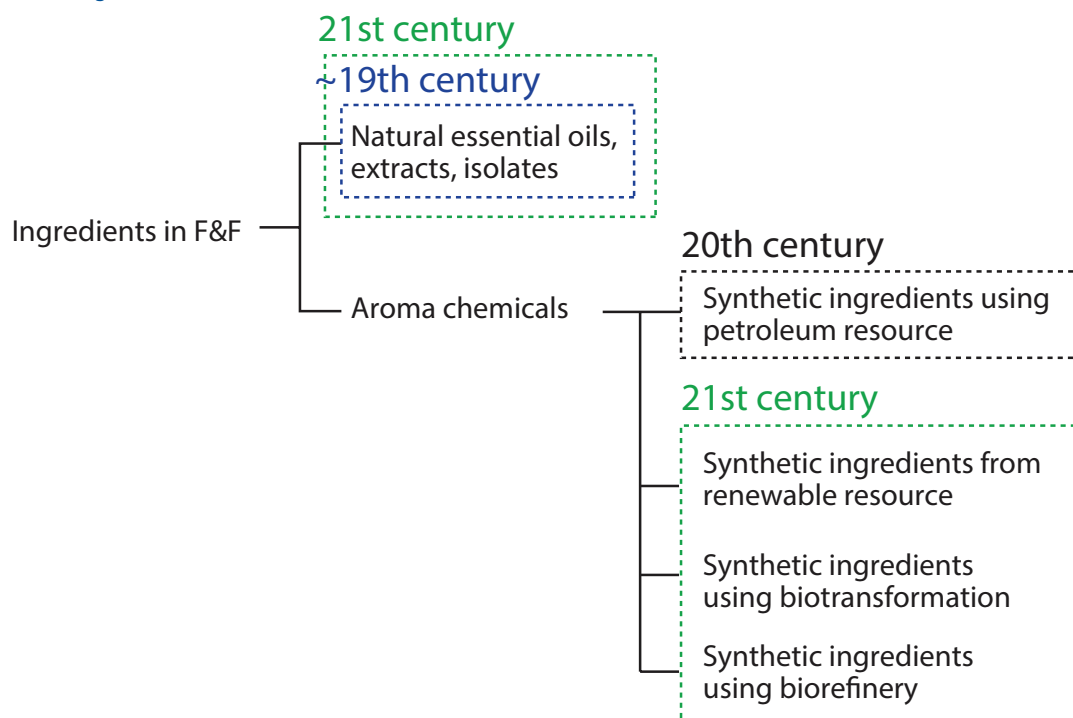
^aWorld Population Prospects: The 2012 Revision; http://esa.un.org/unpd/wpp/unpp/panel_population.htm

^bwww.leffingwell.com/top_10.htm

F-1. Paradigm shift in ingredient production



F-2. Categories of ingredients



F-3. Recent activities for securing renewable natural resources



T-1. Select sustainable ingredient activities among top F&F houses

Company	Material	Country	Activity	Source
Givaudan	Vanilla	Madagascar	Supported the community in education and infrastructure. Advised the local community how to improve the yield and quality of the vanilla crop.	Givaudan, 2010, "Translating Vision into Action"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/2010_sustainabilityReport.pdf
	Benzoin	Laos	Supported the community by building schools and introducing other fragrance ingredients to cultivate.	Givaudan, 2010, "Translating Vision into Action"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/2010_sustainabilityReport.pdf
	French lavender	France	Made an alliance with other organizations to combat a spread of a disease.	Givaudan, 2012, "Engaging the Senses"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/Giv_2012_SR.pdf
	Ylang-ylang	The Comoros	Installed new distillation stills. Expanded education supports for children.	Givaudan, 2010, "Translating Vision into Action"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/2010_sustainabilityReport.pdf
	Tonka bean	Venezuela	Provided technical and financial supports.	Givaudan, 2011, "Making Progress Together"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/2011_sustainabilityReport.pdf
	Patchouli	Malaysia	Signed an exclusive contact with GaiaOne and Kebun Rimau SDN BHD to develop sustainable plantations and local distillation.	Givaudan media release, January 24, 2014, "Givaudan Announces Exclusive Partnership for Sustainable Sourcing of Patchouli"; www.givaudan.com/Media/Media+Releases
	Vetiver	Haiti	Purchased an organic- and fair-trade-certified production stream.	Givaudan, 2012, "Engaging the Senses"; www.givaudan.com/staticweb/StaticFiles/GivaudanCom/Publications/Sustainability/Giv_2012_SR.pdf
Firmenich	Vanilla	Madagascar	Purchased Rainforest Alliance-certified vanilla. Supported community in healthcare field.	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a
	Vanilla	Uganda	Supported community in education and healthcare fields. Provided technical trainings for farmers.	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a
	Vetiver	Haiti	Supported the community "to enhance the value chain, increase farmers' incomes and crop diversification and strengthen community ecosystems."	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a
	Patchouli	Guatemala	Free patchouli seedlings were distributed to local communities.	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a

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T-1. Select sustainable ingredient activities among top F&F houses (Cont.)

Company	Material	Country	Activity	Source
Firmenich	Cardamom	Guatemala	Guaranteed a stable income to farmers by direct purchasing.	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a
	Copaiba/tonka bean	Brazil	Provided technical trainings and financial support.	Firmenich, 2013, "Reflecting on Sustainability"; www.firmenich.com/filedownload.lbl%3Fuid%3D2adcf0ac-f8f8-3c5e-936b-78d859d7c01a
IFF	Vanilla	Madagascar	Supported vanilla farmers since 2007. Guaranteed fair pricing for a steady income and created an educational environment for children. In 2012, set up a program for ethical vanilla production.	IFF, 2011, "Seeds of Growth"; http://www.iff.com/custom/IFF/images/IFF_Sustainability_Report_2012_small.pdf ; IFF, 2012, "Moving Forward"; www.iff.com/company/sustainability.aspx
	Geranium oil	Egypt	Concluded a long-term relationship with a local vendor. Established the best sustainable price level for the right quality. Supported community in health, education and infrastructure.	IFF, 2011, "Seeds of Growth"; http://www.iff.com/custom/IFF/images/IFF_Sustainability_Report_2012_small.pdf ; IFF, 2012, "Moving Forward"; www.iff.com/company/sustainability.aspx
	Vetiver	Haiti	With other key stakeholders from the industry, supported community to improve its living conditions.	IFF, 2012, "Moving Forward"; www.iff.com/company/sustainability.aspx
	Ylang-ylang	The Comoros	Company's supplier supported local community by providing not only technical training but also clean water and health services.	IFF, 2012, "Moving Forward"; www.iff.com/company/sustainability.aspx
Symrise	Vanilla	Madagascar	Provided technical support and invested in infrastructure and education for communities.	Symrise, "2011 Sustainable Solutions"; www.symrise.com/sustainability/article/sustainable-solutions-symrise-publishes-its-2011-sustainability-report/
	Lemon verbena	Paraguay	Provided technical and financial support.	Symrise, "Perspectives 2010"; www.symrise.com/newsroom/article/perspectives-2010-symrise-publishes-csr-report/
Takasago	Vanilla	Madagascar	Signed a joint venture agreement with Ramanandraibe Export Co. Secured the material with stable price. Supported community environment.	Official press release, January 16, 2013; http://pdf.irpocket.com/C4914/JA1b/BJsv/Zzkr.pdf
	Myrrh	Namibia	Supported the indigenous community.	Company press release, April 3, 2013; www.takasago.com/en/sustainability/index.html
	Patchouli	Indonesia	Supported cultivation of patchouli and local living conditions.	Official R&D statement; www.takasago.com/en/rd/sustainability/index.html

Synthetic Ingredients Using Petroleum Resource

In the late 19th century, naturally identified coumarin and vanillin were chemically synthesized for the first time. Since then, with advances made in the petroleum industry, the advantages of synthetic ingredients began to outweigh the benefits of natural materials: synthetics were reasonably priced, of stable quality and available in substantial volumes. In the past, fragrances were only accessible to upper-class consumers and were applied to selected items, such as fine fragrances. The advantages of synthetic ingredients enabled fragrances to enrich consumers' lives in various daily products, ranging from household cleaners to cosmetic goods. In addition, novel synthetic ingredients contributed to the expansion of the perfumer's creativity beyond the scope of what nature alone would allow. For instance, about 2,000 synthetic ingredients are used in perfumery today.

Synthetic Ingredients from Renewable Resources

In their production of sustainable aroma ingredients, industries are looking to reduce their dependence on fossil-derived petroleum raw materials. This, in turn, raises the demand for natural renewable resources. Recently, IFF reported that a synthetic musk ingredient was developed from a bio-based material.^c Symrise announced that Ambrocenide, Symroxane, Ysamber K and limonenal have been switched to a renewable raw material.^d

^cSeeds of Growth; www.iff.com/custom/iff/books/sustainability_2011/files/inc/774950749.pdf

^dAmbrocenide, Symroxane and Ysamber K are trademarks of Symrise.

Furthermore, Terranol^e was developed utilizing a renewable resource.^f Takasago has substituted bio-ethanol for the production of Thesaron^g for a 100% bio-based product. Switching feedstock from petroleum to renewable resources may seem like a recent trend, but there are several precedents. The drastic price increase of petroleum in the 1970s emboldened Takasago to alter the starting material of *l*-menthol from a petroleum-derived one to a renewable resource. Takasago celebrated the 30th anniversary of the asymmetric synthetic process using renewable myrcene in 2013.

Synthetic Ingredients Using Biotransformation

Biological processes play a major role in green and sustainable approaches by utilizing microorganisms or enzymes from a renewable resource. These starting materials require less organic solvent and generate less chemical waste from the process, compared to conventional means of production. In addition, some of these ingredients can be labeled as natural in accordance with CFR21 Sec. 101.22 and E.U. Flavor Regulation 1334/2008/EC. Today, many biotransformed flavor ingredients have been developed and used in the market. It will be more important to the industry to uncover the potential of enzymes and microorganisms. However, developed products are currently limited since enzyme reactions for the substrate are highly specific.

^eTerranol is a trademark of Symrise

^fPerspectives 2010; www.symrise.com/newsroom/article/perspectives-2010-symrise-publishes-csr-report/

^gThesaron is a trademark of Takasago.

Synthetic Ingredients Using Biorefinery Methods

The recent development of synthetic biology, which employs genetically engineered microorganisms intentionally designed with a desired synthase, is a powerful tool to address the aforementioned specificity of biotransformation capability. This biorefinery process uses abundantly available and inexpensive renewable biomass. This allows for the industry to develop structurally complex or highly functionalized ingredients that would never work in a practical way via chemical synthesis. As a result, synthetic biology can provide highly desirable natural products with the stable and steady supply benefit of synthetic products. For example, vanillin, which is labeled as natural when produced via synthetic biology, is one of the most popular flavors in the world; however, extraction from pods alone cannot fulfill the worldwide demand for it. Only 2% of vanillin can be obtained from a cured vanilla pod, while 33% of it can be acquired from a biorefinery technology.¹

Synthetic biology's potential has driven many companies to enter this field of research. In 2011, Firmenich partnered with Amyris to develop several sustainable materials. Their first product is patchouli oil, which will be launched in 2014.^h IFF and Evolva have been developing vanillin, which will be launched later this year.ⁱ Givaudan and IFF have also signed an agreement to produce new materials with Amyris.^{j,k} It is obvious that the F&F industry is paying close attention to this area, and one should expect more materials to come.

Conclusion

Natural and synthetic ingredients must complement each other for future F&F. It is necessary to maintain natural ingredients and supply the sufficient amount of product in a renewable and sustainable way as the worldwide population increases. Synthetic ingredients have a short history compared to traditional natural

ingredients; however, given technological advancement, world affairs and increasing consumer demand, the development of synthetic ingredients is burgeoning. The quest for more environmentally friendly products is one of the biggest requests from customers nowadays, and the industry is turning from the 20th century's petroleum-based practices toward the 21st century's sustainable alternatives. To answer these demands, the production of synthetic ingredients using renewable bio-based resources is already underway. Synthetic biology surely brings an unprecedented era of aroma ingredient development, which past technology never realized, and the possibility for perfumers and flavorists to broaden their creativity. The F&F industry is committed to collaborating with others outside of its industry, in order to pursue a sustainable society.

^h"Amyris Enters into Collaboration and Joint Development Agreement with Firmenich"; www.amyris.com/News/141/Amyris-Enters-into-Collaboration-and-Joint-Development-Agreement-with-Firmenich

ⁱ"Evolva enters into collaboration with International Flavors & Fragrances Inc."; www.evolva.com/sites/default/files/press-releases/eve-iff-jan2011-en.pdf

^j"Amyris Partners with Givaudan to Develop Key Fragrance Ingredient from Biofen"; www.amyris.com/News/137/Amyris-Partners-with-Givaudan-to-Develop-Key-Fragrance-Ingredient-from-Biofen

^k"IFF and Amyris Advance Innovative Collaboration to Develop Ingredients for the Flavors and Fragrances Market"; <http://phx.corporate-ir.net/phoenix.zhtml?c=65743&p=irol-newsArticle&ID=1903270&highlight=>

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