

# Citrus Solutions

How shifting global production, new technologies and markets, and emerging customer needs are changing the citrus landscape.

A 2015 flavor trend report produced by flavored syrup brand Monin ([www.monin.com](http://www.monin.com)) highlights two key drivers that continue to reshape citrus. The report noted that consumers are seeking true-to-nature flavors that offer a perceived healthiness and authenticity. At the same time, they prefer citrus flavor profiles that have a unique character, such as Meyer lemon or kaffir lime. These trends are driving innovations in the flavor space at a time when orange juice consumption has hit an 18-year low point, according to figures from Euromonitor ([www.euromonitor.com](http://www.euromonitor.com)). A Bloomberg news report recently explained, “Sales of bottled water topped all juices for the first time in 2007. The waning appeal of orange juice has limited the impact of a 55% production decline since 2004 in Florida, the biggest U.S. citrus grower.” This decline is due in part to economic and climatic conditions, but also to the serious threat of citrus greening, or *huonglongbing*. This month, *P&F* takes a look at global citrus production and explores the customer- and consumer-driven innovation that is reshaping citrus.



Florida Chemical's facility in Winter Haven, Florida.

## Orange Production

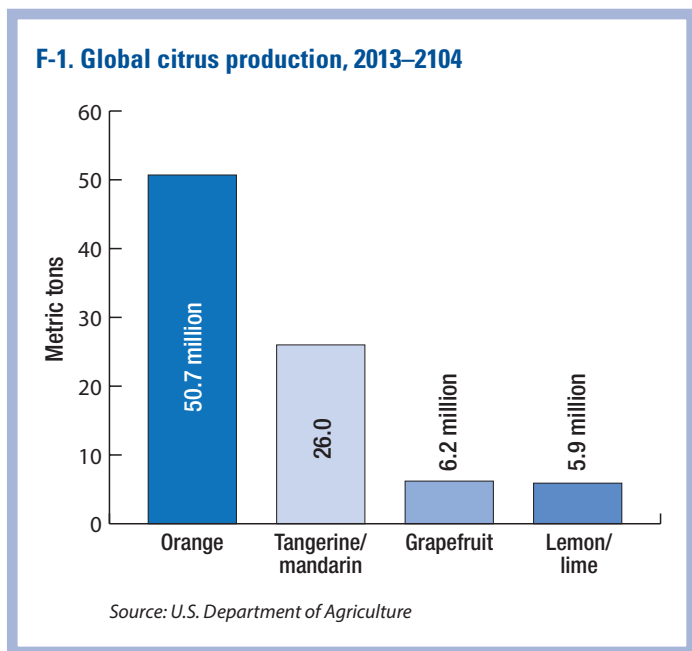
Global production of orange rose 2% in 2013–2014, totaling 50.7 million metric tons, according to the U.S. Department of Agriculture (USDA) (F-1). Declines of 16% in Florida

production, which has been impacted by a number of factors, including greening, are offset by increased production in Brazil and China.

Approximately 95% of Florida's oranges are used in juice processing, as well as essential oil production. The USDA's 2014–2015 forecast for all Florida orange production has dropped to 103.0 million boxes (as of press time); the totals comprised 48.0 million boxes of the non-Valencia oranges and 55.0 million boxes of Valencia oranges.

Brazil's production grew 6% in 2013–2014, according to the USDA, driven by higher yields and “favorable weather.” About two-thirds of the fruit are used for processing. Other production areas include China (7 million metric tons for processing in 2012–2013); the European Union (6.1 million tons in total for 2013–2014, up 3%), which is sending more of its oranges to the processing industry; South Africa (1.6 million tons in total for 2013–2014, up 3%), which trades its fruit with the European Union and Russia; and Morocco (1 million tons in total for 2013–2014, up 25%), which devotes 85% of its fruit for fresh consumption.

A recent bulletin from Flotek/Florida Chemical notes that unfavorable rainfall could impact the 2015 Florida citrus crop, in part by decreasing juice and oil yields by 15–30% and lowering aldehyde levels. d-Limonene supplies could also be impacted.



## Tangerine & Mandarin Production

Global production estimates for tangerines and mandarins are 26 million metric tons for 2013–2014, according to the USDA, a rise of 5% from the previous year, driven by growing production in China and Morocco. Much of this product is destined for the fresh market.



An interior view of Givaudan's Lakeland, Florida, facility.

## Grapefruit Production

About 6.2 million metric tons of grapefruit were produced in 2013–2014, according to the USDA, up 5% from the previous year. Growth was driven by China, which experienced a 7% rise in domestic consumption, offsetting declines in the United States and South Africa.

## Lemon & Lime Production

About 5.9 million metric tons of lemon and lime were produced worldwide in 2013–2014, according to the USDA, a decline of 5% from the previous year. Turkey and Argentina, which experienced significant frost damage, have helped sustain the global export levels.

**Key lime in Mexico:** During a recent conference of Women in Flavor & Fragrance Commerce (WFFC; [www.wffc.org](http://www.wffc.org); **Page 42**) that focused on Latin America, Citrojuogo's Luis Haro discussed Key lime (*Citrus aurantiifolia*) production in Mexico. According to Haro, Mexico produces about 76% of the world's Key lime oil. Production is moving from the Mexican state of Colima to Michoacán in order to pursue favorable temperature conditions and avoid citrus greening. Peru is the second-largest producer. In the fresh fruit market, Key limes are used in many Latin American drinks, including Pisco sours, micheladas, margaritas, mojitos and caipirinhas.

Key limes have a sharper, fresher odor compared to Persian limes (*Citrus latifolia*). The fruit is used to produce two types of cold-pressed oils. One process uses a screw press on whole fruits, which freely intermixes the juice and peel oil, unleashing chemical reactions that change the sensory impact of the material, resulting in a juicy oil. The peel-rasp process, on the other hand, draws out a purer oil that is darker and waxier than its screw-press counterpart. The resulting ingredient is highly coumarinic and woody.

Mexican Key lime trees have recently suffered from citrus greening, which was first detected in 2010 and has now infected nearly all trees, excepting the country's Michoacán growing region. Greening diminishes productivity of trees from 12 years to seven years, while also dropping productivity

by 20%. Fruit shape and size is not impacted, though infected Key limes have a pronounced bitterness in the juice. (Haro stressed that limonene levels remained flat in infected fruits.) The fight against greening has included vector insect control, replanting healthy trees, establishing new groves and intensifying fertilization. Despite these measures, Haro explained that the industry would likely have to learn to “live” with the disease for the foreseeable future.

**Argentinian lemon:** Approximately 88% of Argentina's lemon production volume comes from the province of Tucuman. About 30% of the country's fruits are processed, with the remainder headed to the fresh fruit market. Argentina produced 1.35 million metric tons of lemons and limes in 2012–2013, according to the USDA. Pablo Britti Macagno of San Miguel Global put that number at closer to 1.6 million metric tons during a presentation on Argentina's lemon industry at a recent WFFC conference. Macagno added that, for 2013–2014, Argentina would likely produce 1.1 million metric tons of lemons. This represents a significant local and global market shortage, he explained, as Argentina produces about 60% of all lemons. (The United States and Spain, on the other hand, produce 11% and 8%, respectively.) Drought and frost are the leading causes of this decline, though Macagno said that crops should return to normal, while emergency stocks of oils have buffered the market. The question, he said, was how soon these emergency stocks would be restored and what impact that restoration would have on competition and oil pricing.

## A Visit to Orange Country

To get a sense of the state of citrus in the flavor and fragrance industry, *P&F* recently visited Polk County, Florida, the epicenter of U.S. orange-growing. There, *P&F* visited several companies engaged in citrus ingredients, formulation and the business of customer-driven innovation.

## High-volume Processing in Florida

During its tour of the area, *P&F* visited Florida Chemical Co. in Winter Haven, Florida. Founded in 1942 as a molasses and alcohol manufacturer and early pioneer of citrus oil chemistry,



Givaudan's flavor group routinely visits the citrus groves at the University of California, Riverside, in search of new tonalities.

## Seeking New Ingredients from Nature

During its trip to Florida's citrus country, *P&F* Magazine visited the Lakeland, Florida, headquarters of Taste Advantage, the sister company of Natural Advantage (Oakdale, Louisiana). Natural Advantage produces natural flavor materials, while Taste Advantage manufactures flavor systems that boost flavor longevity, modify sweetness, enhance saltiness or mask bitter compounds. The Oakdale site consists of 20,000 square feet for research and development, small-scale production and sensory evaluation. The 35,000-sq-ft site in Lakeland focuses on citrus, large-scale manufacturing—distillation, extraction, reactions, liquid blending and powder blending—and warehousing. Bob Kleinhenz, the companies' president, and Brian Byrne, the co-founder and technical director, explained that the Oakdale facility will have its square footage tripled, while its throughput capacity will quintuple. That site has a new 10,000-sq-ft production building, with a 7,500-sq-ft outdoor production area. Meanwhile, the Florida facility has added 50% production capacity.

The core of the companies' business is technology and new products, some of which are developed jointly with customers, according to Kleinhenz and Byrne. The technology and ingredients aim to create value for customers, in part by controlling prices. Research and development is customer-driven via feedback from scientists, engineers and flavorists, according to Kleinhenz and Byrne, and is centered on developing new ingredients from nature that are compliant with E.U. regulation No 793/2012.

Natural Advantage produces materials such as taste modifiers, acids, alcohols, amines, aldehydes, esters, furanones, ketones, lactones, pyrazines, sulfides and thiazoles via technologies such as biotransformation, distillation, extraction, isolation, oxidation and non-catalytic esterification. Ingredients include 2,4-decadienal, 2,4-undecadienal,  $\alpha$ - and  $\beta$ -ionone, ammonium sulfide,  $\beta$ -damascenone,  $\delta$ -decalactone,  $\delta$ -hazeltone, diethyl succinate, isobutyl thiazole,  $\gamma$ -decalactone, dimethyl sulfide, melonal, methional/methionol, methyl thiobutyrate, salt enhancers and trimethyl pyrazines. All products are natural and vegetarian, produced wholly without animal products. The company also has expertise in anaerobic fermentation, aerobic fermentation, bioreduction dilute steam recovery and gas co-product/by-product recovery.

Looking at customer-driven innovation, Byrne and Kleinhenz noted that halal ingredients are on the rise, as are demands for vegan certification. Customers are looking to source ingredients that are palm-nut- and GMO-free. The E.U. market is looking for chiral materials such as lactones. Taste modulators and sensory-active compounds are also in high demand. On the other hand, the aroma chemical market is well established and is likely to see less newness compared to the taste (sweet and salt) modulator sector, according to Byrne and Kleinhenz. Formulators are looking to push "clean salt," increase umami and boost the salty sharpness of ammonium sulfide.

While the companies look outward for innovation feedback, they also conduct a fair amount of speculative development internally. This type of exploratory research is highly unpredictable. As Byrne put it, the discoverer is the person with their eyes open.

the company has continuously invested in and expanded its facility and production capacity in creating and developing new market opportunities for citrus products. Florida Chemical produces citrus isolates and terpenes for flavor and fragrance, industrial cleaning, chemical intermediates, pharmaceuticals and the petroleum industry.

The company has the ability to process up to 16 million kg of citrus oils annually. This level of throughput is crucial for supporting demand for large-volume terpenes and from-the-named-fruit (FTNF) citrus isolates that are used in a variety of markets.

In May 2013, the company was acquired by Flotek Industries Inc.,<sup>3</sup> a developer of high-performance, renewable and sustainable chemistries for the oil and natural gas industry. The company continues to support the flavor and fragrance market from its Florida facility, offering citrus oils, terpenes, folded oils and FTNF isolates.

The Florida Chemical facility includes a product development lab, QC lab and pilot plant operations, as well as production plant distillation capability. The QC lab routinely performs low-level agricultural residue detection testing down

to parts per billion in incoming citrus oil streams. The pilot plant capability allows for small specialty projects and the study of advancements in plant process engineering.

In addition to producing high volumes of materials, the company has invested in vacuum distillation, batch extraction, reaction chemistry, advanced separation, and solid-phase extraction and chromatography. The Florida Chemical production technology is commercially designed to produce high-purity citrus isolates for use in the fragrance, beverage and other markets. Due to the high throughput of citrus oils, the Florida Chemical plant produces commercial volumes of  $\alpha$ -pinene, myrcene, octanal,  $\alpha$ -terpineol, orange sesquiterpenes and sinensals. The company's separation technology facilitates security of supply for such specialty citrus molecules such as valencene, nootkatone, nonanal, cadinene and sabinene.

Like many others businesses in the citrus industry, one of the greatest threats is the effect of citrus greening. Greening impacts citrus oil availability and quality. Florida Chemical has invested in the tools to provide flavorists with the necessary building blocks to ensure continuity of quality in an uncertain market. Finally, the company disclosed that it foresees new and innovative uses creating demand for citrus isolates and d-limonene in the future.

<sup>3</sup>Flotek Industries Inc. employs 600-plus people, with a market cap of approximately \$1 billion.

## Expanding on a Citrus Heritage

Trealt has a long legacy as a supplier of citrus essential oils—orange, lemon, lime and grapefruit—and maintains its U.S. headquarters in Lakeland, Florida, the heart of America's orange country. The company's background has benefited its renewed focus as an ingredients solution provider.

During a recent visit to Trealt's Lakeland site, Douglas Rash, Trealt's group vice president, global sales, explained that Trealt is focused on boosting its value-added manufacturing, and developing and innovating on new products, often with direct customer input in the process. Trealt's changing business model has required investments in labs and applications specialists, as well as a focus on key customers. In general, Rash explained, customers are seeking reduced-calorie, clean-label formulations. To address unwanted calories from sugar, as well as the taste and mouthfeel challenges of sugar replacers, the company has launched a range of blended natural flavor essences under the TrealtSweet<sup>b</sup> brand. The blends boost sweet perception without calories, and can be applied in combination with stevia and other high-intensity sweeteners.

In addition, the company's from-the-named food (FTNF) products such as tea distillates and a range of vegetable and fruit Trealtaromes are suitable for a variety of applications. For instance, Trealt's Cucumber Trealtarome and Green Bell Pepper Trealtaromes<sup>c</sup> can be dosed at levels as low as 0.05% in a range of applications, including alcoholic drinks, juices, carbonated soft drinks, smoothies and clear beverages such as flavored waters.

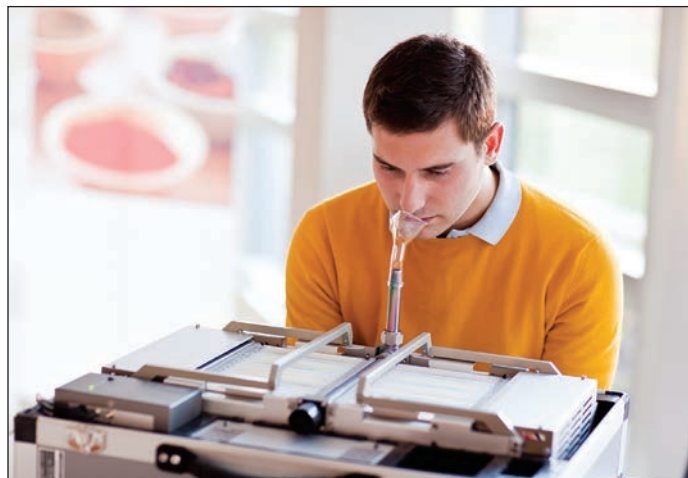
To facilitate the changing business model, the company is exploring a potential revamping or relocation of its U.K. facilities in Bury St. Edmunds, Suffolk, to enhance technical and R&D capabilities, as well as efficiencies. At the same time, the company is deemphasizing commodity-type products. In addition to increasing its in-house expertise, the company is working more closely with strategic suppliers in an effort to ensure stability of ingredient supplies.

Meanwhile, the company continues to supply citrus oils, including terpeness varieties, folded oils, concentrated oils and citrus add-backs.

## Technology-enabled Creation

Citrus is processed at Givaudan's Lakeland, Florida, facility, transforming raw materials—orange, grapefruit, tangerine, apple and pineapple—into standardized FTNF ingredients. (Lime, lemon, mandarin and bergamot are processed at the company's East Hanover, New Jersey, site.) The operation features separation technologies and a large storage capacity. The Lakeland and East Hanover sites are part of a broader network of the company's citrus development centers in Cincinnati, Mexico, The Netherlands, United Kingdom, Brazil, China, Singapore and Japan.

Today, the centers are focused on understanding the functionalities and synergies of citrus materials, while optimizing cost and performance for a number of regional market needs. The company's technology isolates oxygenates such as aldehydes, alcohols and esters from undesirable citrus compounds, and



Givaudan's trademarked Virtual Aroma Synthesizer allows the flavor team to translate sensory experiences.

fractionates oils for specialty ingredients that can be customized for flavor creation. The Lakeland and East Hanover sites comprise traditional distillation, short-path molecular distillation, extraction, chromatography and storage. High-volume throughput is necessary to produce the needed volumes of specialties, according to the company.

While distillation is the workhorse of the citrus world, molecular distillation and other separation technologies can create unique and differentiated products. Continuous advances in technology aim to capture fresher products at a better cost. While developing new ingredients is crucial, so is the improvement of the performance of existing materials. Givaudan's technical teams standardize materials, reacting to year-to-year and season-to-season variations in natural ingredient sensory facets. The company also processes citrus oils to boost stability and other performance aspects. For instance, single-fold oils are not water-soluble; removal of terpenes increases solubility and stability in part by prohibiting acid degradation and oxidation, which creates off notes. Some low-fold oils have applications, but their use relies heavily on the give and take of each particular ingredient and application.

Improved stability can boost shelf lives of products, which may undergo various conditions during manufacturing and distribution or face packaging or base variables. As Givaudan's experts noted, there is no magic bullet; a comprehensive understanding of ingredients and base interactions is crucial. Acid/pH and light exposure are two of citrus' biggest challenges upon application. Degradation of citrus can lead to flavor loss and off-note formation. The Givaudan team notes that flavor consistency is central to a successful product.

The P&F visit included a tasting session of a range of citrus materials.

A range of lemon materials was presented, including a single-fold lemon, terpeneless lemon CitraFresh<sup>d</sup> and lemon Neo low-fold extract. An ultra-high-vacuum lemon distillate featured high stability, but no top notes; a lemon "fresh-sliced" high-fold extract also lacked top notes. The absence of top notes in these materials makes them more stable, but less lemony. In a formulation, the stable materials might serve as a base, with a top note added for character. The distillates are

<sup>b</sup>TrealtSweet is a trade name of Trealt.

<sup>c</sup>Cucumber Trealtarome and Green Bell Pepper Trealtarome are trade names of Trealt.

<sup>d</sup>CitraFresh is a Givaudan trademark.

produced via molecular distillation, a technique that eases separation from wax residues. The company is also able to produce non-thermal concentrates using chromatography. Differing pressures and thermalities create various qualities, functionalities and prices.

Givaudan's TasteTrek Citrus<sup>e</sup> program scouts new citrus varieties and tonalities at the groves of the University of California at Riverside. The participants seek out fruits with unexpected nuances and points of difference that can be modified for consumer products that deliver freshness and uniqueness. During its visit, *P&F* was able to taste several flavor profiles drawn from the TasteTrek visits.

'Millsweet' limetta (*Citrus limetta* Risso) had a black pepper note not traditionally seen in citrus flavors. In a flavor translation, this would be a background note, but not overpowering. The 'Millsweet' limetta was interpreted in a soft drink base; the result was appealing more to an adult taste, and could potentially work as a mixer. An Indio mandarinquat (*Citrofortunella* sp.) typically develops a pleasant flavor profile in late season, crossing the floralcy of kumquat and the juiciness of mandarin. The Ellendale tangor (*Citrus reticulata* Blanco) was a cross between a tangerine and orange, and was very sweet and pineapple-like, with tropical and sulfury notes appropriate for flavor profiles for kids. Amber Eureka lemon (*Citrus × limon* L. Burm.f.) was fruity, with slight berry notes that were appropriate for pink lemonade profiles. Lo Porto lemon (*Citrus × limon* L. Burm.f.) had hints of mandarin and grapefruit; it was very floral, almost gardenialike, with a slight spiciness.

The Givaudan team explained that the TasteTrek groups write notes as they examine and sample unique citrus in the groves, while the company uses a portable GC lab to sample fruit aromas directly from the tree. The teams also use the company's Virtual Aroma Synthesizer<sup>f</sup> to create a logarithmic formula of aromas, providing a way to accurately translate what is being smelled.

It's important to keep up with pace of creation, the Givaudan team explained. Developing long-term understanding and applying it to fast-reaction groups such as flavorists, who are addressing short-term briefs, is crucial to successful formulations. While citrus is a globally desirable tonality, driven by a perception of healthfulness and freshness, every region around the globe has its own local taste and flavor preferences. As a result, Givaudan's TasteTrek<sup>g</sup> program extends to regional visits. For instance, the company conducted a lime-oriented trip to India, studying what Indian consumers are looking for. The team explained that *nimbu pani*, a fresh squeezed lime or lemon beverage served with salt, is very popular in the country. There is an emotional attachment among consumers to the beverage's flavor profile. It is this level of understanding of global markets that the flavor teams key in on. In another example, Givaudan's teams have examined yuzu in Asia and how the character of grapefruit changes as it ripens, becoming sweeter and juicier in late season.

The Givaudan team acknowledged that citrus raw material challenges have increased in recent years. Price pressures on materials such as lemons and limes, combined with fallout from



Consumers are seeking more true-to-nature flavors, driving new innovations in the citrus and beverage sectors.

the 2004 grapefruit oil shock, have led to the development of sustainable solutions for stable supplies. For instance, the company has launched a line of SunThesis<sup>h</sup> engineered oils (WONF flavors) to mimic the original citrus and overcome seasonal aromatic variations and supply shortfalls. These engineered oils are easier to sustain and offer price competitiveness, while maximizing flavor impact. In addition, expertise in procurement is crucial, the Givaudan group explained. Knowing the growers and having a presence on the ground can give suppliers an edge and move them away from volatility. The team added that the sustainable supply strategies that have been applied to vanilla in recent years are now being brought to bear in the citrus sector.

*P&F*'s visit to Givaudan's Lakeland site included a tour. The site features a holding room with tanks for orange, lemon, lime and grapefruit materials. The orange oil tank farm allows the company to hold and store large volumes. (Interestingly, while citrus is a core competency, apple essence is an important ingredient category for the Lakeland site, which continues to grow.) Large-scale storage requires significant inventory management capabilities. Meanwhile, the facility also includes a lab for fractionation, a dry storage space, a GC lab for quality control, a wet chemistry lab and a tasting lab.

Whether the goal is to find new ways to achieve the same familiar flavor profiles or mitigate supply disruptions, it is crucial that customers and consumers notice nothing amiss. As for citrus, the Givaudan team agreed that the category will continue to grow and delight consumers. The only question is what unique twists or profiles will deliver new experiences and excitement.

<sup>h</sup>SunThesis is a Givaudan trademark.

<sup>e</sup>TasteTrek Citrus is a Givaudan trademark.

<sup>f</sup>Virtual Aroma Synthesizer is a trademark of Givaudan.

<sup>g</sup>TasteTrek is a trademark of Givaudan.

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