THE FOOD AND BEVERAGE INDUSTRY IS AGGRESSIVELY PURSUING A NATURAL APPROACH TO PRESERVING AND ENHANCING THE FRAGRANCES IN, AND ENJOYMENT OF, FOODS AND BEVERAGES.

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WHAT THE NOSE KNOWS

The sensation of taste is equally the science of aroma.

by **KANTHA SHELKE, PHD, CFS,** Contributing Science Editor

PEOPLE STILL RELY on the primal instinct of aroma to gauge food safety and quality. It's estimated that some 80% of flavor involves the sense of smell. Food technologists increasingly are relying on the science of smell as a key to creating consistent products in an expanding variety of flavor choices.

Driven by wellness and clean-label trends, the food and beverage industry has entered into a new era of fragrance. Whereas the field once was dominated by aromatic esters developed from chemical "scratch," today the majority of essential oils, nature-identical aromatic compounds, and naturally extracted aromatic compounds from fruit skins, spices, and botanicals — as well as maskers and aromatic enhancers — are added to foods to create or recreate specific, targeted fragrances that evoke and enhance the desired flavor profile.

From the moment a food is harvested or manufactured, it is inevitably on a journey of physical and chemical changes that manifest as deterioration of appearance, texture, taste, and nutrition. Aromatic ingredients can actually help slow down these changes, minimize spoilage, and improve the eating experience.

The impact of aroma and its ability to imbue irresistibility in a food is best illustrated by nuts. Nuts, whether tree nuts like walnuts or ground nuts

KEY POINTS

- Aromas make up the greater part of flavor, and product developers are beginning to take greater advantage of them as consumers seek ever more exotic and authentic flavor experiences.
- Ingredient technology has accelerated the development of natural fragrances for foods and beverages to replace the once-traditional artificial chemical compounds that were common a generation ago.
- Research has demonstrated that slight adjustments in the fragrance of a product can impact not only the perception of flavor but the accompanying mood experienced by the consumer. A tweak to a formulation can determine whether the experience of mint, for example, is "soothing" or "energizing."

like peanuts, abound in volatile aromatic compounds that come to the forefront when the nuts are roasted. The pleasure of eating roasted nuts lies in experiencing these volatile components that yield their characteristic aroma and are important for snacks as well as baked products like baklava.

The practice of modifying a food to release the aromatics and thus enrich the overall organoleptic experience is as old as cooking. But the targeting the sense of smell to make a food attractive was refigured with the discovery of synthetic aroma additives that are products of organic chemistry.

Using ingredients both natural and molecular, coupled with technology customization and a more direct-to-consumer distribution model, the food and beverage industry has embarked on a new approach to preserving and enhancing the fragrances in, and enjoyment of, foods and beverages.

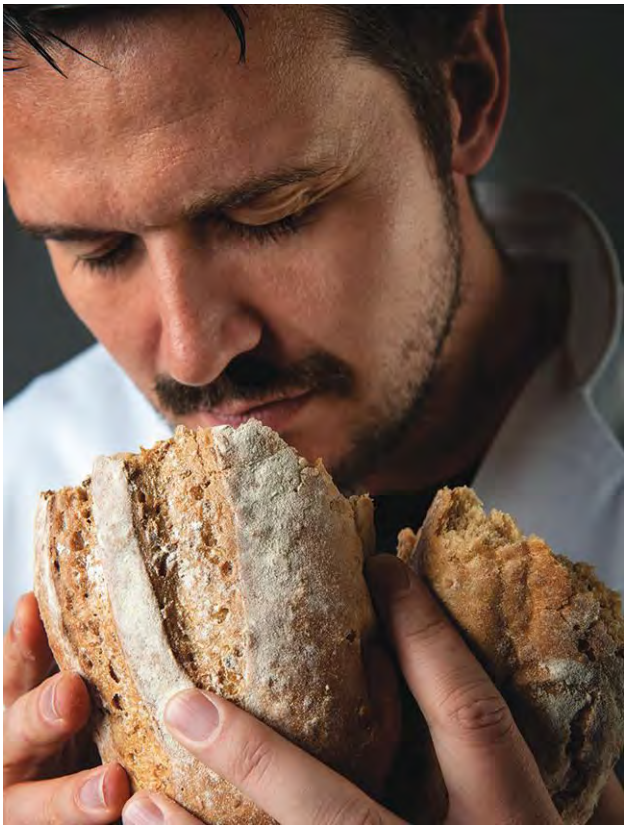
ESSENTIAL FRAGRANCE

"When industrial food manufacturing began in the early-to-mid 19th century, transforming commodities like sugar, wheat, and alcohol into new kinds of packaged foods such as candies, carbonated sodas, condiments, confectionery, and bakery products, introduced thepractice of adding synthetic molecules (mostly esters), essential oils, and other aromatic compounds to foods to make it possible to produce uniform goods in an expanding variety of flavor choices," says Nadia Berenstein, PhD, food historian and flavor science and technology expert.

WE'RE HARDWIRED TO JUDGE FOODS BY SCENT BEFORE EVEN TAKING A BITE.

Packaged foods and beverages arguably could not have achieved their current proliferation without the flavor and fragrance molecules that made mass-produced foods desirable, fashionable, and delicious, she notes.

Berenstein cites soft drinks and sweets as early subjects of artificial flavors and fragrances. "For the first half of the 20th century, the aroma compounds that were used to make a soda taste like strawberry, or a hard candy lozenge like peach, bore no verified relationship to the flavor molecules in actual strawberries or peaches — or any of the other foods that artificial flavors claimed to replicate," she explains. "Flavorists aimed not to reproduce nature on a molecular level but to effectively recreate the sensory experience of eating fresh strawberries and juicy peaches."



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Even today, despite precision tools (such as gas chromatography-mass spectrometry) that can help identify the chemistry of specific aromatic compounds in foods, flavorists continue to use unrelated synthetic compounds in their formula preparations to achieve desired flavor qualities and performance.

This practice continues in the flavor industry in part because such an approach is difficult to copy

CHEMISTRY OF FRAGRANCE

Fragrances can stimulate and affect both physiological and psychological mechanisms. Chirality of odor molecules is the factor central to their biological activity. Chiral fragrances – such as the *enantiomers* (chiral pairs) ***limonene*** (a major component in the oil of citrus fruit peels) and *carvone* (the primary terpenoid found in caraway, spearmint, and dill) – affect the human autonomic nervous system.

They can influence blood pressure and produce a range of physiological and psychological effects. Yet, in spite of their similar chemical make-up, the responses they trigger are quite different.

For example, *(+)-limonene* increases systolic blood pressure, subjective alertness, and restlessness. But its chiral opposite, *(–)-limonene*, increases systolic blood pressure without any effect on psychological parameters. Similarly, *(–)-carvone* increases pulse rate, diastolic blood pressure, and subjective restlessness but its chiral opposite – *(+)-carvone* – only increases blood pressure and does not affect psychological parameters.

Adding the right chirality is therefore key to whether the citrus and mint notes will be calming or invigorating.

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DELICATE FRUIT FLAVORS CAN BE ENHANCED WITH CONCENTRATED NATURAL FRAGRANCE EXTRACT FROM THE FRUIT ITSELF TO "SIGNAL" TO THE MIND VIA SMELL WHAT FLAVOR TO EXPECT.

INGREDIENT TECHNOLOGISTS DEVELOPING TODAY'S NATURALLY DERIVED FRAGRANCE COMPOUNDS ARE LEARNING TO NAVIGATE IN AN INCREASINGLY REGULATED CLIMATE TO HELP DELIVER SOME OF THE MOST ATTRACTIVE FOODS AND BEVERAGES THAT CONFORM TO CLEAN LABEL DEMANDS.

or retro-engineer. Moreover, it provides an advantage to those who manage to hit the right aroma notes and raises the bar for entry.

The practice of adding unrelated aroma compounds is exemplified by the use of replacements for raspberry ketones. Raspberry *ketone* has a fruity aroma that is specifically raspberry, with subtle balsamic nuances. Raspberry ketones have been at the heart of almost all successful raspberry flavors, incorporated as a way to emulate nature qualitatively and quantitatively.

However, usage of these ingredients, especially at high levels, is expensive and the results are hard to balance. Fortunately, researchers discovered that a similar compound in raspberries — *zingerone 4-(4-hydroxy 3-methoxy phenyl) butan-2-one* — has similar fruity, raspberry, balsamic notes to raspberry ketone, yet is more potent. Combining zingerone with raspberry ketone yielded a notable synergistic effect, with less product required.

Almond and pistachio flavors often lack depth in snacks and liquid applications because of the preponderance of *benzaldehyde*. A modest addition of only 40ppm of zingerone can heighten the characteristic nutty aromas of nuts and thus add to the perception of richness in the final flavor.

Smoke flavors are incredibly complex, but recreating the natural complex aroma of smoke is helpful in establishing authenticity with consumers. Adding 40ppm of zingerone, as inconsequential as it might seem in the swath of powerfully aromatic phenolic compounds in the mix, can help round out the profile and emphasize "authenticity."

SWEETNESS ENHANCEMENT

Sugar reduction is currently a major issue for many processors, especially because of the "added sugars" declaration on the Nutrition Facts Panel. The current food value chain is highly dependent upon added sugar. Reformulation to reduce or remove sugar disrupts not only taste but also other fundamental attributes that people associate with sweetness and sweet foods — including the smells of sweetness.

Ingredient technicians in Europe were able to home in on fragrance molecules that mimic those of full-sugar products, discovering that the addition of specific fragrances would help improve the aroma and, in turn, enhance the flavor of products made with less sugar. By enhancing the sense of sweet flavor through these fragrance molecules, they could make the resulting product more desirable to consumers.

For example, using gas chromatography and bioinformatics, coupled with a comprehensive database of aroma molecules, volatile compounds in cinnamon, cloves, or orange peel can enhance sweetness in reduced-sugar baked confections without sacrificing eating pleasure.

FRAGRANCE FOR FIDO

Recent data from Mintel show that pet treat sales rose by 29% between 2012 and 2017, and are now verging on $5B in annual sales. Pets are apparently snacking just like their owners, and the addition of aromatics plays an important role via "toppers" such as sauce and gravy in a snack or treat or as a coating.

Moreover, such ingredient technologists are also able to help product developers and manufacturers at the outset by identifying precisely how food aromas change when sugar is reduced. This allows them not only to mitigate the effects of sugar reduction on texture, sweetness, and taste, but also to shorten development time for new products and remove barriers to sugar reduction.

SENSE OF SMELL

The ability to distinguish foods from poisons is so important that it is hard-wired into the receptor cells themselves. Yet, neither nutritional value nor toxicity have been coded as a stimulus dimension. People have come to consider sweet and bitter as metaphors for nutritious and toxic, respectively. (Ironically, the reverse could be said to be true today.)

Toxicity and nutrition are not chemical properties of a stimulus. Nor are they properties of the senses. Our taste receptor cells define taste quality; T1R and T2R taste receptors respond to sugars, amino acids, and bitter stimuli. Because these occur in combination with T1R1/T1R3 (*umami*) and T1R2/T1R3 (sweet) receptors, they help define quality in terms of umami, sweet, and bitter sensations.

For many, the bitterness of cruciferous vegetables is a turn-off. The gluten-free industry uses cauliflower as a replacement for wheat to recreate one of the most favorite foods for American consumers: pizza. For supertasters, the bitterness can be masked by the addition of aromatic ingredients such as carvacrol, the major component of thyme and oregano, whose fragrance masks the sulfurous astringency of the vegetable.

The tongue conveys taste quality to the brain, but how the brain interprets these signals is significantly affected by the peripheral neurons that detect odorants. Key food odorants are most relevant for the detection, recognition, and hedonic evaluation of foods and beverages. (This explains why pinching one's nose makes it almost impossible to distinguish between mango jam and strawberry preserves!)

Odorants are detected by our olfactory senses, which are comprised of some 400 different odorant receptor types. The specific receptor activity patterns associated with the aroma percepts of foods or beverages, as well as the key food odorant agonist profiles of single-aroma receptors, are still unknown.

Flavorists have, however, established some key food odorant profiles, such as *3-methyl-2,4-nonanedione*, that are associated with a distinct "prune" note in oxidized wine. This fragrance is considered desirable in tea, in fruits like apricots, and in baked goods. Hence the success of prune paste as a fat replacement in bakery products.

Tea beverage applications use tea extracts, acids, flavors, sweeteners, and preservatives, but it is the flavor choice that seals the purchase decision for consumers. The aroma of the tea makes the experience memorable and brings consumers back for more.

Currently, lemon and peach are the most popular flavor — and aroma — choices for RTD teas; pomegranate, mint, mango, orange, and berry follow. The aromas of matcha, ginger, jasmine, and plain tea also are gaining popularity. Choosing the right chirality of the principal odorants can add aroma and also affect the consumer's mood.

TEA AND TOAST

Fragrance is an important aspect of tea, and plays a part in how tea is graded, and how people select teas. RTD teas, however, lack the fragrance of freshly brewed teas. The aromatic components are lost during the blending, steeping, and sterilizing steps. This can make it difficult to produce a tea beverage product with taste and nutritional benefits equal to or exceeding that of freshly made tea. But adding artificial flavor is not necessarily the solution, for many consumers view it negatively.

How a tea is steeped and concentrated can make a difference in the fragrance quality of tea beverages and their constituent ingredients (such as powdered brewed tea). Back-filling fragrance is a process in which the base tea is steeped and subjected to vacuum distillation and a falling-film concentration

PHOTO COURTESY OF: TASTEPOINT BY IFF/INTERNATIONAL FLAVORS & FRAGRANCES, INC. (WWW.IFF.COM)

THE COUPLING OF FLORALS WITH FRUIT AS BOTH FRAGRANCE AND FLAVOR ENHANCERS ALLOWS THE WHOLE EXPERIENCE TO BECOME GREATER THAN THE SUM OF EACH.

PHOTO COURTESY OF: GETTY IMAGES

WE "EAT" FIRST WITH OUR NOSE. SMELLS PREPARE US FOR WHAT WE'RE ABOUT TO DEVOUR WHILE ALSO WARNING US IF THE FOOD'S UNSAFE.

or spinning cone column to selectively extract and collect the volatile components of the tea.

Processed under mild conditions, these extracts are concentrated and added (back-filled) to the tea beverage as a liquid concentrate. Or, they are spray-dried and added to enhance the aroma of instant tea powder.

"Our sense of smell is like no other sense," says Simran Sethi, a fellow of the Institute for Food and Development Policy and the author of "Bread, Wine, Chocolate: The Slow Loss of Foods We Love". "Olfactory receptors transmit signals to parts of the brain that include the limbic system, which is also responsible for emotional responses and the formation of memories. Combine this with the aroma of fresh-baked bread and you can understand the comfort and nostalgia that can take place."

People love the unmistakable toasty aroma that freshly baked bread makes, and this is largely attributed to Maillard reaction products produced in the browning process, which also affect color, taste, and nutritional value. But most highly processed breads on the market do not carry those aromas. Also, breads high in whole wheat and other fiber-rich ingredients lose out on those telltale characteristics, as those ingredients tend to swallow up the aromatics emitted by the Maillard process.

A class of phenolic compounds called *hydroxycinnamic acids* (HCAs, which also are the predominant type of phenolic compounds in wheat) were recently discovered to be largely responsible for the aroma of certain baked products. The addition of HCAs to a baked formula will trap transient sugar fragments as well as *2-acetyl-1-pyrroline*, the key bread aroma compound. These can thus be used to make bread, even whole-wheat bread, more aromatic and flavorful, even if consumed untoasted.

FAT CHANCE

Until recently, the common belief was that humans lacked the ability to taste fat as a specific flavor in the same way they taste sweet, sour, bitter, salt, and umami. The fat-tasting experience was believed to be one predominantly of texture.

Emerging evidence suggests that the almost universal appreciation of fat-rich foods is because the palate perceives fat not only due to the texture but also thanks to fragrant cues from semi-volatile aromatic chemicals liberated during fat oxidation.

Leveraging fatty acid biochemistry, combined with the current understanding of fat perception, has led to the identification of several compounds that are rich in short-chain fatty acids and aldehydes that are volatile enough to trigger the fatty acid receptors on the tongue. These also provide olfactive and potential taste cues that provide a heightened fat perception.

A lactone compound called *hydroxynonanoic acid delta-Nonalactone* that is naturally occurring in asparagus, beef, beer, butter, chicken, milk, pork, rum, and whiskey is known to have a slightly tallow-like aroma.

EMERGING EVIDENCE SUGGESTS THAT THE APPRECIATION OF FAT-RICH FOODS IS BECAUSE THE PALATE PERCEIVES FRAGRANT CUES FROM AROMATIC CHEMICALS RELEASED DURING FAT OXIDATION.

When added at levels of 5-10ppm, it can create a creamy, dairy and melted butter-like aroma with slight peachy undertones. It can be used to enrich fatty acid notes in animal fat replacers such as coconut oil, which does not have the olfactory richness of butter.

Heightened fat perception is, however, application dependent because the olfactive cues must be congruent with the inherent aroma of the application. So, a fat enhancer for a chicken bouillon may have a meaty/fatty aroma, while a dairy/fatty aroma will work for cream cheese and yogurt.

pH MATTERS

Acids are a commonly used food ingredient in beverages, applied not just for flavor enhancement and food safety but to effect aroma release. In soft drinks, adjusting the pH from 5.0 to 3.0-4.0 with citric acid can release esters such as *isopentyl acetate* and *ethyl hexanoate* in the headspace, enhancing the aroma of the beverage.

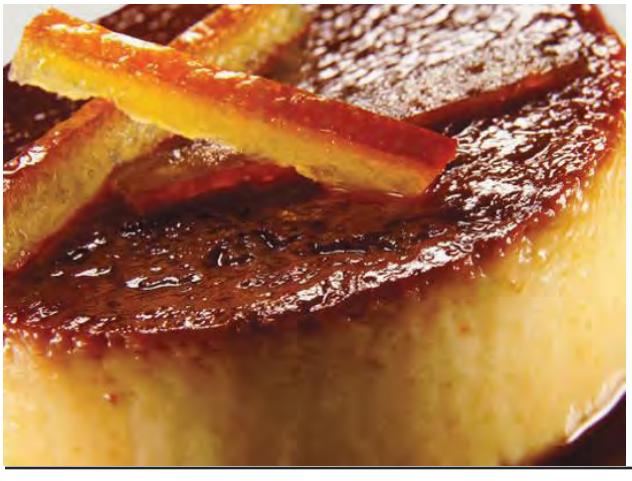
The critical pH is different for different beverages, and also unique to the flavor compounds. Too much citric acid (and thus too low a pH) will instead chelate with the esters *menthone* and *linalool* and flatten the aroma.

This technique is actually put to use by DRY Soda Co., where the addition of essential oils (listed as "natural flavor" on the label) and malic acid helps enhance the sweetness of sugar and heighten the taste and flavor of Fuji apple in its Dry Sparkling Fuji Apple soda.

The demand for clean-label solutions and the health and wellness mega-trend are driving increased application of ingredients derived from foods and botanical extracts. Their usage to make foods and beverages more fragrant also is proliferating.

Such plant-based extracts offer the clean-label perception of "authentic because it exists in nature" and are the springboard for PepsiCo's new calorie-free sparkling water 'bubly'. Touted as free from artificial flavors, sweeteners, and calories, bubly relies on essential oils extracted from fruit skins and rinds for its range of flavors that includes grapefruit, lime, strawberry, orange, lemon, apple, mango, and cherry.

AROMATIC CARAMELS SERVE AS ENHANCERS OF FRAGRANCE AS WELL AS FLAVOR AND COLOR, WITH TODAY'S CARAMEL TECHNOLOGY ABLE TO FINE-TUNE THEM TO SUIT.



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FLOURISHING FLORALS

The 2018 Whole Food Market report forecast noted that "bubbly" is bouncing back, with consumers increasingly turning to plant-derived sparkling beverages and sparkling cold brews as an alternate to soda. The report adds that floral flavors are flourishing. Botanical flavors like lavender, verbena, hibiscus, rose, and elderflower are gaining popularity in soft drinks, still waters, brewed beverages (beers, ales, and lambics as well as kombucha), lattés, teas and other beverages.

Nowhere is the importance of aroma to perceived flavor more pronounced. This is because floral flavors can have bitter notes and can be hard to moderate in a formulation. Using just enough of a floral extract to create a burst of aroma will evoke a flavor response that can be enhanced by the fruit flavor it is often paired with.

Austin, Texas-based Waterloo Sparkling Water Corp. delivers Texas-sized flavor in its two-ingredient sodas. Available in watermelon, grapefruit, black cherry, and a number of other flavors, the product is free from sugar, calories, sodium, and preservatives, and relies on the big flavor profiles of a three-class system of flavors: Class A ingredients are aromatic extracts captured from steam off boiled fruits; Class B ingredients consist of aromatic concentrated fruit oils extracted using high pressure; and Class C ingredients are "all-natural botanical elements" that help "bond Class A and Class B ingredients together."

"Once reserved for fine fragrances and personal care products, common floral fragrance ingredients — such as rose, orange flower, elderflower, honeysuckle, and lavender — are appearing in foods and beverages, including alcohol mixers, cocktails, RTD beverages, yogurt, ice cream, and chocolate," notes Amy Marks-McGee, founder of Trendincite LLC. She predicts other florals will begin showing up in foods and beverages as consumers continue to seek more enriching experiences from prepared foods and beverages. **pf**

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