Maintaining Natural Flavors in Baked Goods

Flavors are the substances found in baked goods that give them their distinctive taste perception beyond the five basic tastes of salty, sweet, sour, bitter, and umami. These compounds tend to be volatile and aromatic, allowing our senses to pick up on them. The chemicals that make up flavors can come in two forms – natural or synthetic.

Natural flavors are essential oils or extracts of the volatile aroma compounds found in herbs, spices, fermentations, and other pungent plant sources. Some natural flavors are derived from the high-temperature, flavor-producing reaction between sugars and amino acids, known as the Maillard reaction. These are reproducible processes used to generate caramel, baked, chocolatey, or meat-like flavors.

Synthetic, or artificial, flavors are produced from chemical synthesis using petrochemical molecules as starting materials. They are designed to mimic the natural flavors found in foods, herbs, and spices, and can also be produced from the Maillard reaction using synthetic sugars and amino acids.

Flavors in Food

Regardless of origin, the main molecules that elicit the subjective experience of what we know as flavor tend to be the same as those found in nature. For example, the compound vanillin is found in both artificial and natural extracts of vanilla flavoring and is largely responsible for what we know as 'vanilla'. Minute levels of other compounds found in natural flavors contribute to a more complex and authentic flavor.

Examples of flavor compounds:

- Vanillin (Vanilla)
- Diacetyl (Butter)
- Limonene (Lemon)
- Isoamyl Acetate (Banana)
- Methional (Potato Chips)
- Piperine (Black Pepper)

How Do Flavors Work?

Unlike the sense of taste, which interacts with molecules primarily through the tongue, flavors are mostly experienced by the sense of smell, or the olfactory system. When food is chewed, the volatile compounds trapped inside the food are released and vaporized by the heat of the body, where they travel beyond the tongue and into the nasal cavity in a process known as retro nasal olfaction. Flavor is experienced when this retro nasal olfaction is combined with the taste and texture of the food, which the brain integrates as 'flavor'.

Vapor pressure is the measure of how much a compound turns into a vapor at ambient conditions. For example, alcohol has a higher vapor pressure than water at room temperature. Molecules cannot be smelled if they are not vaporized. Compounds that are not volatile enough, like salt or sugar, do not activate the experience of flavor. That means only molecules with enough vapor pressure to rapidly transform into a vapor at body temperature can be flavors.

Due to the intensity of most flavorings, only small amounts of these compounds are needed to activate the senses. Most of the time, concentrations of flavors are kept low when formulated with a baking good. Otherwise, too much flavor would overwhelm the senses, leading to off-flavors and poor consumer reception.

How Flavor is Lost Through Baking

Since flavor compounds are volatile, fragile, and low in concentration, once flavor is lost, it cannot be restored. Flavor can be lost in a variety of ways during the process of baking and frying:

- The high temperatures directly vaporize the flavors.
- The Maillard reaction is activated during baking, which leads to cross reactions between the flavor molecules and the sugars and amino acids inside the dough.
- Components of the dough, such as gluten proteins, starches, and fibers, physically bind to the flavor molecules and inhibit their release.
- Dough conditioners, such as L-cysteine or potassium bromate, chemically react to flavor molecules.
- Minute levels of metal ions catalyze the production of oxidants from oxygen (accelerated by elevated temperatures), which damage flavor compounds and produce off-flavors.

Flavor compounds may interact with a food's components, such as proteins, acids, fats and carbohydrates and these interactions can affect flavor perception. Good flavors have positive aroma, balance, flavor release and mouth sensations with no unpleasant notes.

How to Handle & Preserve Flavors During Baking

Flavors need to be controlled so that they are not lost to the high-temperature chemical reactions that occur during baking and frying and reduce their negative impact on the development of dough structure. Flavors, which tend to be oils, also need to be easily measured so that the precise amount is used in every production run.

There are several approaches to minimizing the impact that baking and frying has on the flavor of the final product and successfully handle these aromatic compounds:

- Adding higher concentrations of flavors before baking to make up for losses. With either a power or liquid flavor, higher usage levels can have a negative effect on dough rheology.
- Adding ethylenediaminetetraacetic acid (EDTA) to chelate to metal ions and limit the formation of oxidizing species that damage flavors or produce off-flavors.
- Using plated flavors, in which a flavor is dissolved in an organic solvent with a low flash point, combined with a plating agent like salt, starch, etc. the solvent evaporates to leave the flavors bound to the solid carrier.
- Use spray-dried/encapsulated flavors, in which flavors are mixed with a carrier and solvent (i.e. water), and sprayed into extremely hot air (400° F or more) to produce a flavor-enriched solid powder. Some encapsulated flavors are coated with a material wall of wax, or gums during spray drying as well. Not all encapsulations and powder products are of equal quality. Density, size, morphology, and flavor uniformity in the starch matrix are highly dependent on the technology used to create them.

Approaches for Natural Flavors

While adding more flavor to a dough before baking or frying may work in limited cases, the problem is that overcompensating for losses could result in an excessive or imbalanced flavor in the finished good. It is challenging to tune into precisely how much additional flavor is needed when most flavors are complex mixtures of compounds, each with different vaporization, reaction, and binding rates.

EDTA has some utility in reducing the effects of metal ions on flavors and creating off-flavors, especially during long-term product storage. However, EDTA cannot prevent the loss of flavors through vaporization, reaction with other dough components, or the Maillard reaction.

Plating flavors allows manufacturers to use highly viscous natural flavors, like black pepper oleoresin, and transform those oily flavors into an easily measurable powder. However, plated flavors can suffer from low flavor concentration, poor shelf life due to flavor evaporation, and higher rates of oxidation due to the larger surface area of the powder compared to the oleoresin alone. The flavors are also not protected from vaporization or side reactions.

Powder & Encapsulation

The current industry standard is powder flavors. These are created by emulsifying liquid flavor compounds with a starch carrier, emulsifying agent, water and solvent, ingredients that transform them into encapsulated flavors after spray drying the mixture. The advantage of this approach is that the encapsulation matrix protects the flavors from vaporization, oxidation, and reactions with dough components. Encapsulation extends the shelf-life and improves the performance of flavors in baking applications.

However, the high temperatures needed to produce encapsulated flours can vaporize or damage the flavor molecules and limit the ability of flavor manufacturers to produce authentic flavors. New technology is exploring ways to produce flavors at lower temperatures to avoid this.