

Organic Chemistry - Food Extract Laboratory

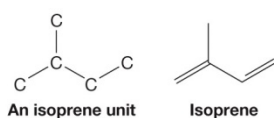
Purpose

1. To prepare several flavoring extracts from fresh flavor sources and food-grade ethanol.
2. To learn about aromatic molecules in foods responsible for flavor, and their solubility characteristics.

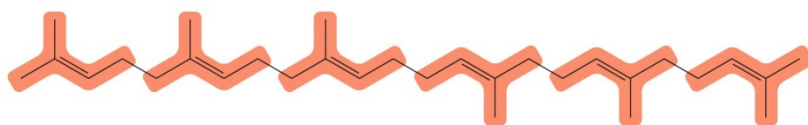
Introduction

The plant molecules that impart flavor to foods can be categorized into three major classes:

1. **Terpenes** – naturally produced hydrocarbons whose carbon backbone can be separated into five-carbon units called isoprene units. These are responsible for the aromas of natural products, such as lemon fragrance, ginger, and pine.

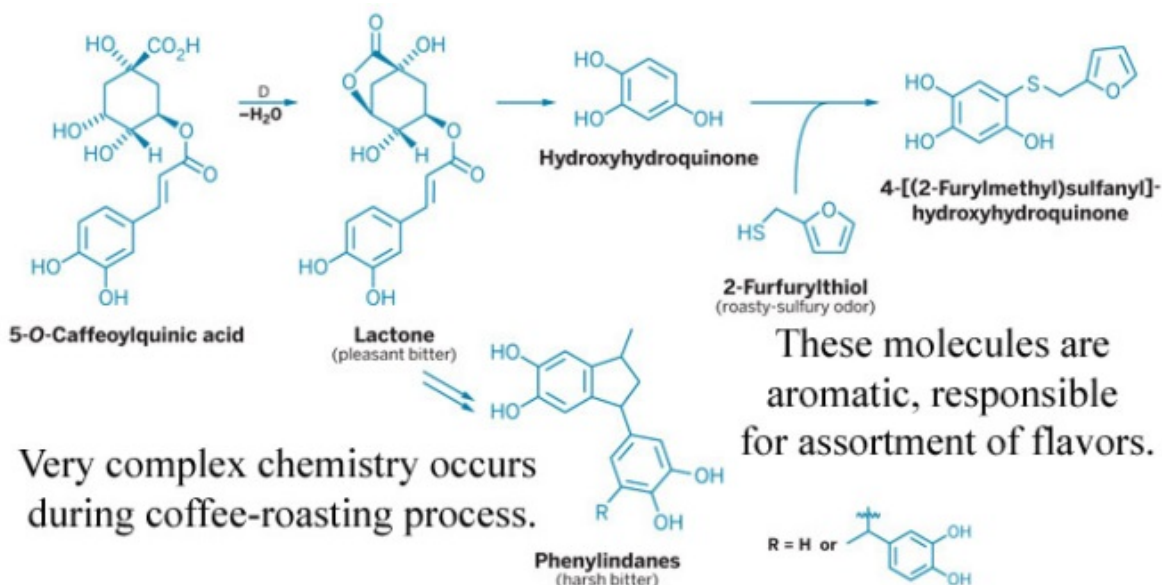


Isoprene units are highlighted in red.



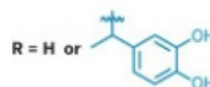
Squalene

2. **Phenolic compounds, or polyphenols** – comprised of aromatic ring(s) with one or more –OH groups attached. These are responsible for the wonderful aromas associated with vanilla, chocolate and coffee. Aromaticity is often associated with the aroma of flavor molecules, but in organic chemistry it specifically describes a very stable, flat ring structure with delocalized electrons.



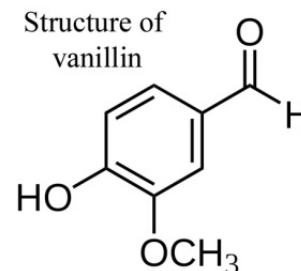
Very complex chemistry occurs during coffee-roasting process.

These molecules are aromatic, responsible for assortment of flavors.



3. **Alkaloids** – also produced naturally by plants, contain a basic nitrogen. These produce a wide range of pharmacological effects, being used as stimulants (nicotine), analgesics (morphine), antimalarial agents (quinine), and antimicrobial (to name just a few). In chocolate, theobromine is principally responsible for its taste.

There are a number of means by which these molecules produced in roasted coffee and chocolate can be extracted. Since polyphenols and alkaloids have regions within their molecules that are both water- and lipid-soluble, an effective solvent should have both water and lipid soluble properties. There are many solvents which are quite effective at extracting these molecules, such as methanol (for lower molecular weight polyphenols), and acetone; unfortunately, both of these solvents are toxic. For a food-grade extract, we need a solvent that can be ingested. While water is very accessible and ingestible, its lack of a lipid soluble moiety, makes its ineffective in extracting polyphenols and alkaloids. A solvent of 45% concentrated ethanol, has been experimentally determined to be quite effective at extracting flavor molecules from coffee and chocolate. In industry, it is the solvent of choice for vanilla extracts as well.



In the coffee-roasting process, many aromatic molecules imparting flavors we perceive as fruity, chocolate, nutty, spice, caramel and vanilla are produced. These are readily captured in a solvent of 80-proof vodka or whiskey.

Recipes

Fresh-Roasted Coffee Extract

Prep time: 10 minutes

Yield: 200 ml

Ingredients

- 70 g fresh-roasted coffee beans
- 200 ml flavorless, food-grade 40% ethanol by volume (80-proof vodka will work)

Equipment/ tools

- mortar and pestle
- graduated cylinder to measure ethanol
- 600-mL beaker to hold the ethanol and coffee beans
- stirring rod
- laboratory stir-plate and magnetic stir-bar
- ½ pint capacity Ball canning jar, rim, and lid

Protocol

1. On the balance, weigh out 100. g of fresh-roasted coffee beans.
2. Using a mortar and pestle, gently crack the beans - the intent is not to grind them, but to gently break them open. Place the cracked beans in the 600-mL beaker.
3. Measure 350. ml of ethanol using the graduated cylinder, and pour over the beans.
4. With the stirring rod, stir the mixture well.
5. Place a magnetic stir bar in bottom of jar and allow to stir over magnetic stir plate for a few minutes.
6. When done stirring, cap the jar and shake, ensuring the seal is tight.
7. Store the jar in a dark, cool place and shake daily. After 14 days the extract can be used similarly to vanilla extract in recipes. For optimal flavor, allow the extraction to proceed for one month.
8. When ready to use or package, strain out the coffee beans using a sieve.

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WHY DOES YOUR COFFEE TASTE AND SMELL DELICIOUS?

The major difference between coffee roasts comes from the chemical reactions that occur in the coffee beans at certain temperatures. As a result of these chemical reactions, aromatics, acids and other flavor components are created, balanced or altered in a way to build the perfect flavor, acidity, aftertaste and body of coffee.

1 MAILLARD REACTION

A key reaction for the development of roasted coffee flavor and color is the Maillard reaction. At temperatures from 150-200°C, carbonyl groups (from sugars) and amino groups in proteins react to form aroma and flavor compounds. Hundreds of coffee flavor compounds are formed from Maillard chemistry, including the potent coffee aroma flavor compound, 2-furfurylthiol.

FLAVOR COMPOUNDS



The roasted flavor in coffee comes from 2-furfurylthiol

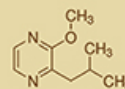


Trigonelline gives coffee that bitter taste

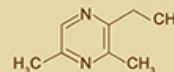
5 SECOND CRACK

Pyrolysis continues as temperatures reach 225-230°C, causing the second crack in the bean. That second crack is the cellulose in the cell wall of the bean breaking apart. The bean is now medium-dark brown in color and has an oily sheen. It's during this step where the aromatic compounds are released, contributing to coffee's classic flavor.

AROMATIC COMPOUNDS



2-isobutyl-3-methoxypyrazine gives coffee an earthy scent

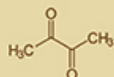


2-ethyl-3,5-dimethylpyrazine adds earthy, roasted notes

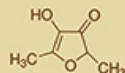
2 CAMELIZATION

From 170-200°C the sugars in coffee start caramelizing, which browns the sugar and releases aromatic and acidic compounds. During roasting, most of the sucrose is converted to caramelized compounds, but if you roast the coffee too lightly, the bitter tasting compounds won't degrade.

CAMELIZED COMPOUNDS



Diacetyl gives coffee a buttery or butterscotch flavor



Furanones have a burnt sugar flavor

3 FIRST CRACK

Around 205°C water inside the bean vaporizes, causing the bean to expand and crack (both physically and audibly). This first crack makes the bean double in size. Prior to first crack, the bean changes from a green/yellow color to a light brown color. At this point, the bean loses about 5% of its weight from water loss.



Acetaldehyde is produced during pyrolysis and has a green apple aroma

4 PYROLYSIS

At approximately 220°C, the heat causes a chemical change inside the bean, leading to the release of carbon dioxide. This process is called pyrolysis. The color changes to a medium brown and the bean loses 13% of its weight. Light roasts are done after this step.

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Sources:
Scientific Consultant: Robert McGarrin, Ph.D.
<http://www.coffeeresearch.org/coffee/roasting.htm>
<http://www.sweetmarias.com/roast.carlstaub.html>