Overview

- Flavor and Flavor Quality
- Commercial Flavors
- Product Considerations
- Legislation and Labeling Considerations
- Clean labeling and natural flavoring substances
- Final Recommendations
What is Flavor?

- Sensation (Smell/Taste/Mouthfeel)
  - Flavor perception

- Stimuli
  - Chemicals causing sensation
Significance of Flavor

- **Cultural aspects**
  - food (flavor) acceptance linked to cultural and life experiences (learned cues)

- **Emotional aspects**
  - aroma perception linked to memory and emotion

- **Nutritional aspects**
  - flavor is an important determinant of food acceptance and diet
Significance to Food Industry

- Flavor is THE main determinant or driver of:
  - consumer acceptance of a food product
  - repeat purchase intent for a food product
‘Flavor’ Sensations

Receptor Organ

Flavor Type

Sensation Descriptor

Nose

Odor

Mouth

Trigeminal

Tongue

Taste

Fruity

Green

Spicy

Woody

Burnt

Sulfury

Etc….

Pungent

Astringent

Cooling/Heat

Salty

Sweet

Bitter

Sour

Umami
Flavor is a multisensory experience.
Dimensions of Flavor (Aroma/Taste)

- Qualitative – recognized attribute (e.g. salty, vanilla)
- Intensity – dose/response behavior
- Temporal Aspects – time/intensity. Especially important in taste (e.g., clean vs. lingering aftertastes)
- Spatial – locale of stimulation/perception
- Hedonics – like or dislike
- Interactions with Other Modalities (appearance, texture)

What defines flavor quality?

*Desirable Sensory Attributes*

- Immediate impact of identifying (expected) flavor (e.g. vanilla / chocolate / Pepper)
- Rapid development of a balanced, full-bodied flavor
- Compatible mouthfeel and texture
- Lack of foreign or off-flavors
- Minimal (brief) aftertaste, i.e. “clean taste”

Flavor of natural foods is complex
e.g. Coffee Flavor

Coffee Aroma

> 800 volatile compounds identified

- $\beta$-damascenone (honey-like, fruity)
- 2-furfurylthiol (roasted coffee)
- 3-mercapto-3-methylbutylformate (catty, roasty)
- guaiacol (smoky)

Coffee Taste / Mouthfeel

**Acidity**

- aliphatic/alicyclic carboxylic acids
- chlorogenic acids
- phenolic acids

**Bitterness/Astringency**

- caffiene / chlorogenic acids
- dicaffeoylquinic acids
- phenolics
Why add flavor?

• Impart target flavor attributes (aromatics) to formulated products that lack flavor

• Compensate for flavor deficits or defects
e.g. frozen concentrated orange juice (FCOJ)

• Mask off-flavors
e.g. functional foods

• Compensate for flavor losses caused processing or storage
e.g. thermal degradation, flavor fade due to flavor interactions
Anatomy of commercial flavorings

- May contain either natural or artificial (chemically synthesized) aroma compounds or a combination of both.

- Most contain mainly aroma substances
  - taste components are generally added separately by manufacturers

- Savory flavors (e.g., spice extracts, process flavors) may contain both aroma and taste-active compounds
Formulated Flavors

- Complex blends of aromatic materials such as essential oils and aroma chemicals

- Available as concentrates, diluted flavors (in carrier), or bound to carriers (encapsulated)
Generic Flavor Creation Process

Target Flavor

**customer request**

**Raw Materials**
- Sensory evaluation
- Experience
- Analysis (R&D)

**Creation**
- composition
- imitation
- imagination

**Application**
- Product evaluation and specification
- Stability
- Storage
- Presentation

**Production**
- Technical
- Scale up
- Reproducibility
- Aging

**Marketing**
- economical aspects
- legislation
- QA / QC

**Kuentzel and Bahri (1999)**
Physical Forms of Commercial Flavors

- Liquid flavors – aroma chemicals dissolved or emulsified in carrier solvent
  - Vegetable oil based
  - Propylene glycol
  - Triacetin
  - Ethanol
- Microencapsulated flavors
- Dry blended flavors – mixtures of dried flavors, bouillons or spice/herb powders
- Extracts, concentrates, pastes
Considerations

- Flavoring must provide a convincing ‘match’ and perform properly in end product
- ‘Natural’ or ‘Artificial’? Must be “Natural” for clean label
- Legal status (legislative restrictions)
- Dry or liquid flavoring?
- Compatible with technology of end product
  e.g. processing – baking, retorting, extreme pH
- Practicality of manufacture and cost
Additional considerations

- Low intensity
- Flavor profile may change as a function of concentration
- Exhibit variations in strength and quality
- Supply uncertain
- Many natural flavors are unstable or contain nonflavor-active constituents that are unstable
- Costly
Product Form and Function

Bars/Cereals

- Low moisture/low water activity
  - moisture migration concerns
  - texture concerns
  - possible phase changes
- No or mild thermal process
- Immobile flavor system
- Ambient storage/long shelf-life
- Possibility of using encapsulated flavors
  - will reduce flavor interaction and loss potential

Beverages

- High moisture
  - spoilage concerns
  - viscosity/consistency concerns
- pH restrictions/limitation
- Severe thermal process (UHT)
- Integrated/mobile flavor system
- Ambient or refrigerated storage
  - variable shelf-life
- Difficult to use encapsulated flavors
Inherent off-flavors (potent odorants)
- low concentrations (ppb)/high flavor impact
- enzyme-derived volatiles
- protein degradation volatiles

Reaction-derived flavors (during processing/storage)
- lipid oxidation
- Maillard reaction (during thermal processing)
- misc. chemical breakdown (e.g. vitamins)

Off-flavor potential of functional ingredients

Flavor - Food Matrix Interactions

- Flavor partitioning, diffusion and mass transfer
  - e.g., low fat versus full fat products
  - fat modulates flavor release

- Flavor stability, retention/release
  - storage, packaging interactions
  - encapsulated flavors

- Flavor binding
  - e.g., flavor - protein interactions
  - leads to flavor loss (fade) and imbalanced flavor

How do US (FDA) and EU Flavor Regulations Differ?

Essentially same flavorings are allowed, but are designated differently

US and EU define “natural” differently

- **US** = An essential oil, oleoresin, essence or extractive, protein hydrolysate distillate, or any product of roasting, heating or enzymolysis (source material must be natural) = “Natural Flavoring”

- **EU** = Source material must be vegetable, animal or microbiological. Must be produced by a traditional food preparation process (source material vague)

... the essential oil, oleoresin, essence or extractive, protein hydrolysate, or distillate of any product of roasting, heating, or enzymolysis, which contains the flavoring constituents derived from a spice, fruit or fruit juice, edible yeast, herb, bark, bud, root, leaf or similar plant material, meat, seafood, poultry, eggs, dairy products, or fermentation products thereof, whole significant function in food is flavoring rather than nutrition.... (21CFR101.22)

- Essentially, components produced by natural or biological means may be considered *natural* provided only natural starting materials are used in the process.
What kind of flavor does the EFSA consider as “natural” and how are these usually designated on food/product labels?

- “Natural flavoring substances”
  - Only specific processes allowed in their production
    - appropriate physical (e.g. food preparation) processes
  - Labeling terminology may present the single largest problem/issue
    - “Natural “X” flavoring” (e.g. lemon) (must abide by 95/5 rule = 95% of flavoring from referenced source)
    - “Natural “X” flavor with other natural flavorings” (must be easily recognized as “X”)
    - “Natural flavoring” – various source materials, where intended flavoring function is not reflective of end use (flavor attributes)
    - The “Natural flavoring” designation is ambiguous (target flavor not declared)

How do US (FDA) and EU Flavor Regulations Differ?

- **Example: Vanillin**
  - Vanilla extracted from vanilla beans and/or purified vanillin from this source
    - “natural vanilla flavor” in both US and EU
  - Vanilla made by fermentation (e.g. from ferulic acid) or by extraction from other source material than vanilla beans.
    - “natural flavor” in both US and EU
    - FDA may require further approval of process, EU might not
  - Vanillin made by chemical process from lignin
    - “synthetic” or “artificial flavor” in both US and EU
  - Ethyl vanillin (not found in nature)
    - “artificial vanilla flavor” in US
    - “vanilla flavoring” in EU (absence of word “natural” implies artificial flavor)
Types of “Natural” Flavor and Flavoring Raw Materials

Should all Natural Flavors and Flavoring Raw Materials and Ingredients be considered “Clean Label” Ingredients?

“Natural” = “Clean”? 
Natural Flavoring Raw Materials

Plant-Based Flavoring Materials

- Essential Oils and Aqueous Essences
- Oleoresins, Tinctures and Extracts
Two Types of Essential Oils

- Preexisting in source material (e.g. citrus oils)

- Formed as a result of enzymatic action after maceration of source material (e.g. onion and garlic oils)
Common approaches . . . .

Cold pressing and distillation

e.g. Citrus
Oleoresins, Tinctures, Extracts

- Oleoresins – gums/exudates/extracts from trees, barks, herbs & spices, etc. - balsams
  
  e.g. capsicum oleoresin

- Tinctures – water infusions (e.g. coffee)
  – alcohol tinctures – herbs and spices
    e.g. ginger root – used in beverages

- Absolutes – alcohol extract of a plant material
  – possess the “heart” of the flavor
    e.g. vanilla absolute
Derived Essential Oils and Flavors

**e.g. Alliaceous Flavors**

- *Allium* - Garlic, Onion, Leeks

- Flavor is formed through enzymatic processes in disrupted tissues and through cooking

- Garlic contains 0.1 to 0.25% volatile compounds – generally recovered by distillation

- Other flavoring forms (e.g. garlic):
  - **garlic powder/salt** – prepared by dehydration of cloves
  - **garlic oleoresin** – prepared by dehydration of garlic juice (~ 5% garlic oil)
Meat and Meat-Derived Flavors

- Animal musks or secretions
  - primarily used in perfumery products

- Processing or modification of animal by-products or underutilized species
  - bouillons (concentrated/dried stock or aqueous extract)
  - enzyme modified – protein hydrolysates
Flavorings or flavor ingredients made by processing or modification of precursor materials

- enzymatic modification
- thermal processing

Complex flavoring materials

- contain flavor enhancers
- complex and balanced aroma profiles
- more closely resemble ‘real’ flavor systems
Process Flavorings . . . .

Common Types

- Hydrolyzed vegetable protein (HVP)
- Autolyzed yeast extracts
- Other types of “reaction flavors”
Hydrolyzed Vegetable Protein (HVP)

- produced by acid, alkaline, enzymatic hydrolysis
- flavor enhancing properties (MSG)
- **Process flavoring**: cysteine, lipids, and/or thiamine added to generate meat-like flavor
**Autolyzed Yeast Extracts**

- Endogenous enzymes create flavor profile and generate aroma precursors.
- Nucleotides provide (umami) flavor enhancement.
- Contain thiamine - an important precursor to S-containing heterocyclic aroma compounds.

2-methyl-3-furanthiol
(odor thresh, 0.4 pptr)

bis-(2-methyl-3-furyl)disulfide
(odor thresh, 0.02 pptr)
Smoke-Based ‘Reaction Flavors’

- Liquid Smoke - a natural aqueous condensate of wood smoke (GRAS status).
  - Early development - 1880s
  - Commercially viable - early 1970s
Smoke-Based Flavors . . .

Controlled pyrolysis of wood components

**Wood Components**
- Cellulose
- Hemicellulose
- Lignin
- Miscellaneous

**Volatile**
- Phenols/Guaiacols
- Acids
- Carbonyls
- Esters
- Alcohols
- Miscellaneous

![Chemical structures](image)
Natural Flavoring Raw Materials . . . .

Biotechnology and Natural Flavors

- Crop Improvement – plant genomics and genetics
  - Control and direction of microbial biosynthetic Pathways
  - Improve yield and quality of plant-derived flavors

- Cost effective, industrial scale biosynthetic production of natural flavor compounds
  - Development of natural processes for natural flavor production
Final Recommendations

• Involve a flavor house early in the process
  • greatly reduces development time

• Must consider the composition of your product
  • protein, moisture, gums/stabilizers, pH, water activity
  • minor components that could impact flavor
    - vitamins, minerals, phytochemicals
  • levels of other flavor ingredients (sugar, sweeteners)

• Must consider impact of processing and/or storage
  • thermal process (e.g., UHT) conditions
  • packaging and storage considerations

• Natural flavors = “clean” ingredients?