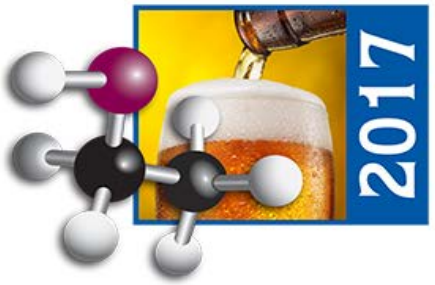


ASBC Annual Meeting

June 4–7 ■ Fort Myers, Florida

See what SCIENCE can brew for you

cara TECHNOLOGY

Sources of spirit flavor

Amaey J Mundkur

AROXA/Cara Technology Ltd.

5 June 2017

aroxa™

Overview

- Spirits flavor inputs
  - Raw materials
  - Process
  - Botanicals
  - Flavor through maturation

Spirit flavor

Ethyl hexanoate

Ethyl acetate

Chlorophenol

Smoky

Diacetyl

Earthy

Butyric

H_2S

Isovaleric

Rotten vegetable

Acetaldehyde

Solvent alcoholic

Leathery

Sweet

Bromophenol

Burnt rubber

Astringent

Mouldy

Woody

'Cooked'

Floral

Musty

Acetic

Ethyl butyrate

Honey

Metallic

Caramel

Grainy

DMS

Citrus

2017 ASBC Meeting

spirit flavor

Flavors derived from raw materials

Carbohydrate Source

Sugar source affects flavor of the final product

- **Grain – Barley, rye, wheat, maize – vodka, whisky, gin**
- **Specialty malts ie peated/smoked**
- **Fruit – Grape – vodka, brandy**
- **Plant – Agave, potato, sugarcane – vodka, tequila, aguardiente, mezcal, rum**
- **Downstream products – Molasses, grape pomace – rum, tsipuoro, raki**

Water flavor inputs

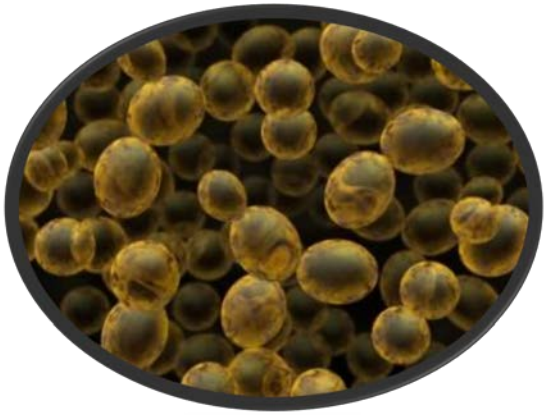
- Mainly source of taints – hence water sensory is a key part of spirits sensory
- Important to focus on water used at all points in process - process water, cleaning water, dilution water *etc*
- Geosmin
- 2-Methylisoborneol
- Halophenols
- Metals

Flavors derived from fermentation

Fermentation flavor inputs

- Free rise fermentation – uncontrolled
- Similar fermentation by-products to beer
- Distillery yeast – single use
- Discarded in pot ale (malt distillery)
- Multiple strains of *Sacch. sp.* and bacteria (*Lactobacillus*)
- Less focus on hygiene

Fermentation flavor inputs - congeners

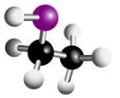


- Odor-active congeners
- Higher alcohols – propanol ete
- Esters - ethyl acetate etc.
- Aldehydes and Ketones - acetaldehyde
- Sulphur Compounds – thiols
- Organic and fatty acids – isovaleric etc.

process derived flavors

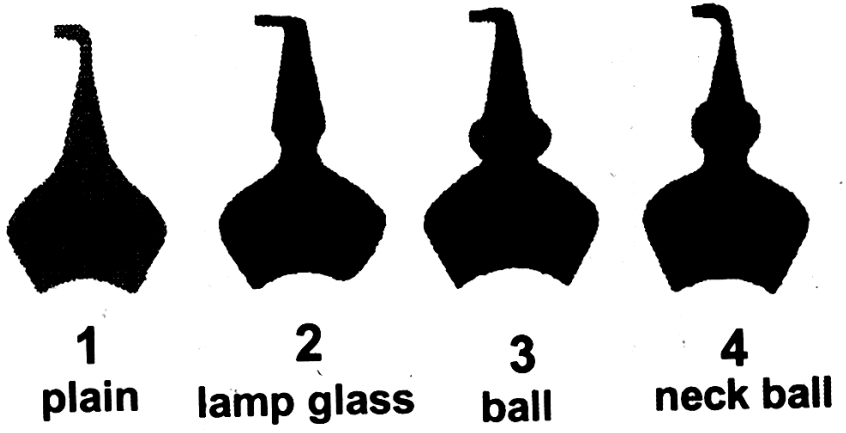
Controlling flavor in spirit production

2017 ASBC Meeting



Process flavor inputs – Single phase distillation

- Pot still – congener heavy spirit
- Still design



Process flavor inputs – Single phase distillation (contd.)

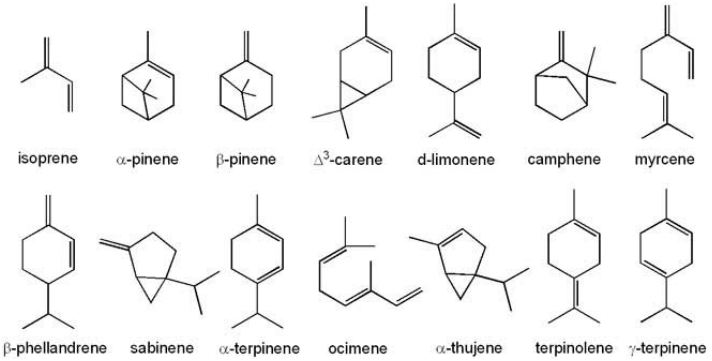
- Construction material – Copper helps in removal of undesirable congeners particularly sulphur compounds.
- - Reflux rate
- Making the cuts
- First Cut – too early and spirit will contain high quantities of fusel oils, ethyl acetate and other highly volatile esters. Too late and ethanol will collect in the foreshots.
- Second Cut – Early cut – cleaner/lighter spirit. Too late and grainy, stale and metallic notes will come through.

Process flavor inputs – Multiple phase distillation

- Column still
- Continuous distillation
- Greater control over spirit character
- Spirit collected at about 95% ABV
- Lower congener levels
- Easy venting of sulphurs
- Used to produce vodka, grain neutral spirit

Flavors derived from botanicals

Botanical flavor inputs



- Flavors in spirits come from multiple families of chemicals, primarily terpenes (primary constituents of essential oils), alcohols, ketones, aldehydes, phenols and esters.
- Early use of botanicals in spirits was for their curative and health properties
  - Aniseed, star anise and fennel – major odour active chemical component is anethole, minor are pinene, linalool, anisaldehyde, camphene etc
  - Caraway – major odour active chemical component is carvone, minor include limonene and caryophyllene

Botanical flavor inputs (contd.)

- **Cassia Bark and Cinnammon –** major odour active component is cinnamaldehyde, while minor flavor components are pinene, limonene, coumarin, benzaldehyde
- **Coriander –** major odour active component is linalool (also a major flavor input from hops). Strong anti-bacterial properties. Minor flavor compounds are pinene, limonene, geranyl acetate and myrcene (another hop component)
- **Juniper –** major odour active component is pinene. Minor flavor compounds are myrcene, carvone, linalool – both odour and flavor (bitterness) input.

Botanical flavor inputs

Botanical	Latin name	Major chemical component
Aniseed	Pimpinella anisum	trans-anethol
Caraway	Carum carvi L	Carvone
Cardamom	Elletraia cardamom	1,8-cineole
Cassia bark	C. cassia blume	Cinnamaldehye
Cinnamon	Cinnamomum aromaticum	Cinnamaldehye
Clove	Syzygium aromaticum	Eugenol
Coriander	Coriandrum sativum	Linalool
Cumin	Cuminum cyminum	Cuminaldehyde
Dill	Anethum graveolens	Carvone
Fennel	Foeniculum vulgare	Anethole
Hyssop	Hyssopus officinalus	β-pinene, anethol (strain)
Juniper berry	Juniperus communis	α-pinene
Lemon	Citrus limon	Limonene
Licorice	Glycyrrhiza glabra	Glycyrrhizin
Orange	Citrus cinensis	Limonene
Peppermint	Mentha piperita	l-menthol, l-menthone (strain)
Star Anise	Illicium verum	trans-anethole

Botanical flavor inputs – distilled spirits

Type of Spirit	Botanicals Used
Caraway Based	
Aquavit	Caraway, anise, fennel, dill, coriander, star anise, cumin, grains of paradise, amber
Brennivin	Caraway, cumin, angelica root
Juniper Based:	
Genever	Juniper
Gin	Juniper, angelica root, orris root, cassia bark, cardamom, coriander, citrus, licorice root
Aniseed Based:	
Ouzo	Aniseed, cardamom, cinnamon, coriander
Raki	Aniseed, star anise
Tsipuoro	Aniseed
Absinthe	Aniseed, Petite wormwood, Grande Wormwood, Green Anise, Fennel, hyssop, star anise, angelica, peppermint, coriander

Botanical flavor inputs – infused spirits.

Type of spirit	Botanical used for flavor
Vodka	Cucumber, peach, apple, raspberry, kaffir lime, cranberry, vanilla, cherry, pomegranate, tangerine, coconut, mango, hibiscus, strawberry, red liquorice, mint, cilantro, grape, apricot, banana, cinnamon, black currant, melon, ginger, pepper, pineapple, watermelon
Gin	Cucumber, apple, grape, lime, pineapple, raspberry
Tequila	Almond, banana, coffee
Aquavit	Saffron, lingonberry, cucumber, lime, ginger, lemongrass, pumpkin
Whisky	Blackberry, black cherry, honey, maple, cinnamon, vanilla

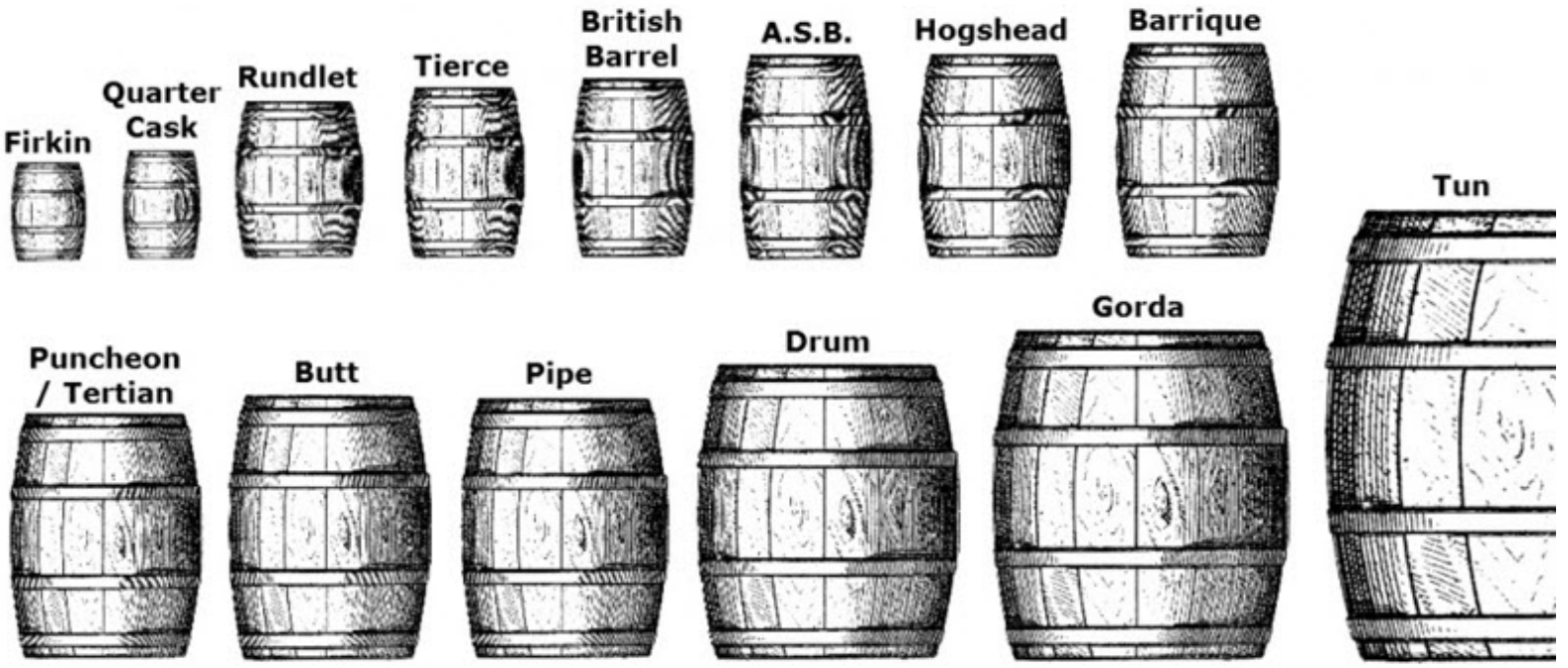
Flavors derived from barrel aging

Aged spirits

- Barrels/Casks first used as storage vessels. It was increasingly realised that the quality of the contents improved with age
- Pliny the Elder (1st Century AD) described how wine producers in the alps matured wine in oak casks
- Aging of spirits. flavor in and flavor out
  - Whisky, Whiskey
  - Rum
  - Tequila
  - Gin

Aged spirits – Oak Barrels

- Types of barrels:



Aged spirits – Oak Barrels

- American or European Oak – limited number of oak species – different flavor input on final spirit
- Attempts to use other kinds of wood for barrel production. The wood either contributed undesirable flavors to the spirit or had issues with porosity.
- Charring and toasting provide flavor
- Type and age of cask affect flavor profile of spirit

Aged spirits – Oak Barrels (contd.)

- During maturation additive, subtractive and reactive mechanisms operate that change the flavor of the spirit.
- Size of barrel affects rate of maturation – surface are to volume ratio
- Previous contents of barrel affect spirit character

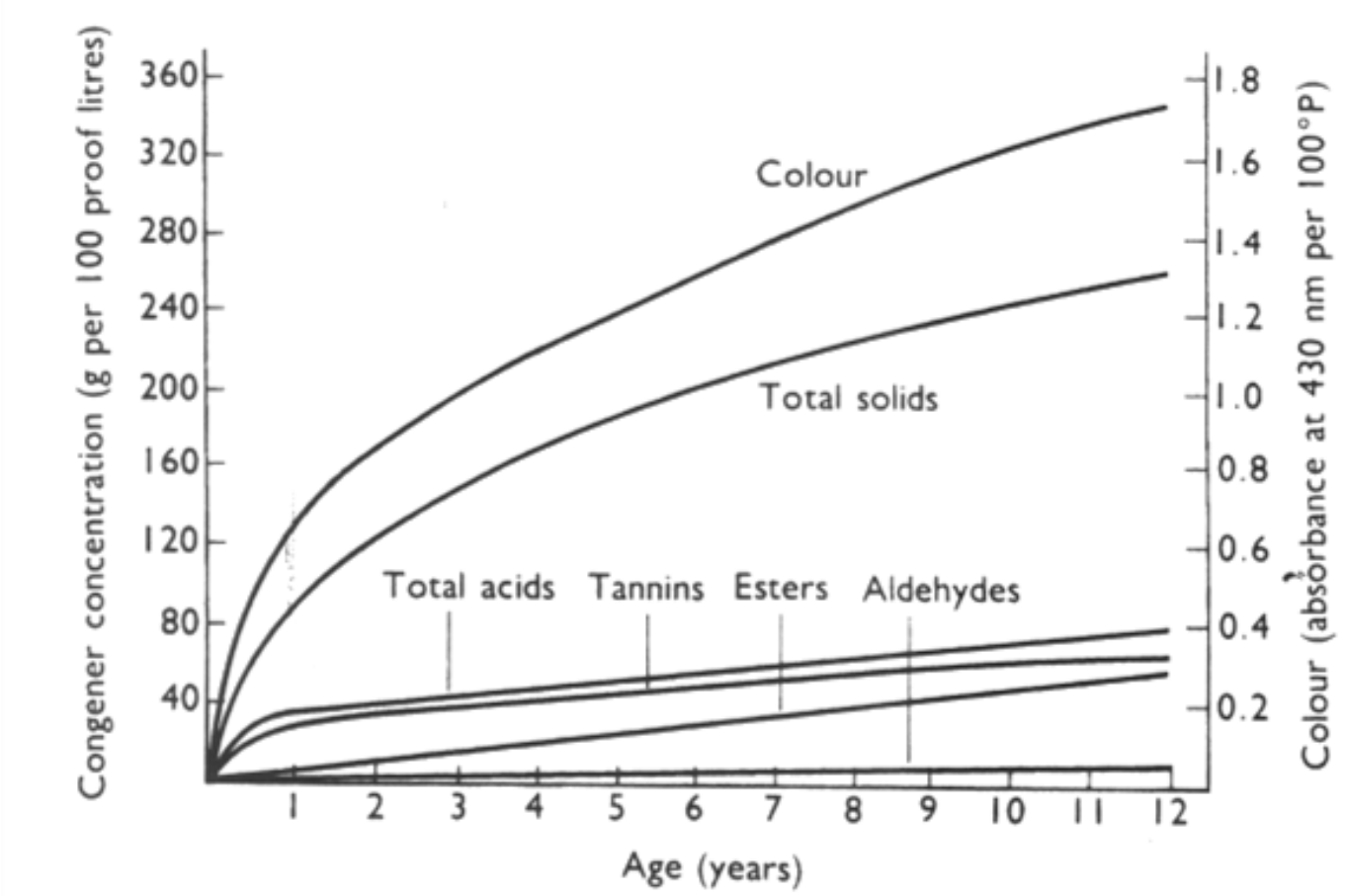
Aged spirits – flavor changes

- Subtractive reactions – removal of undesirable sulphurs – benzenethiol, Dimethyl sulphide, Dimethyl Disulphide, Dimethyl Trisulphide
- Losses of volatiles through evaporation – higher alcohols (fusel oil).

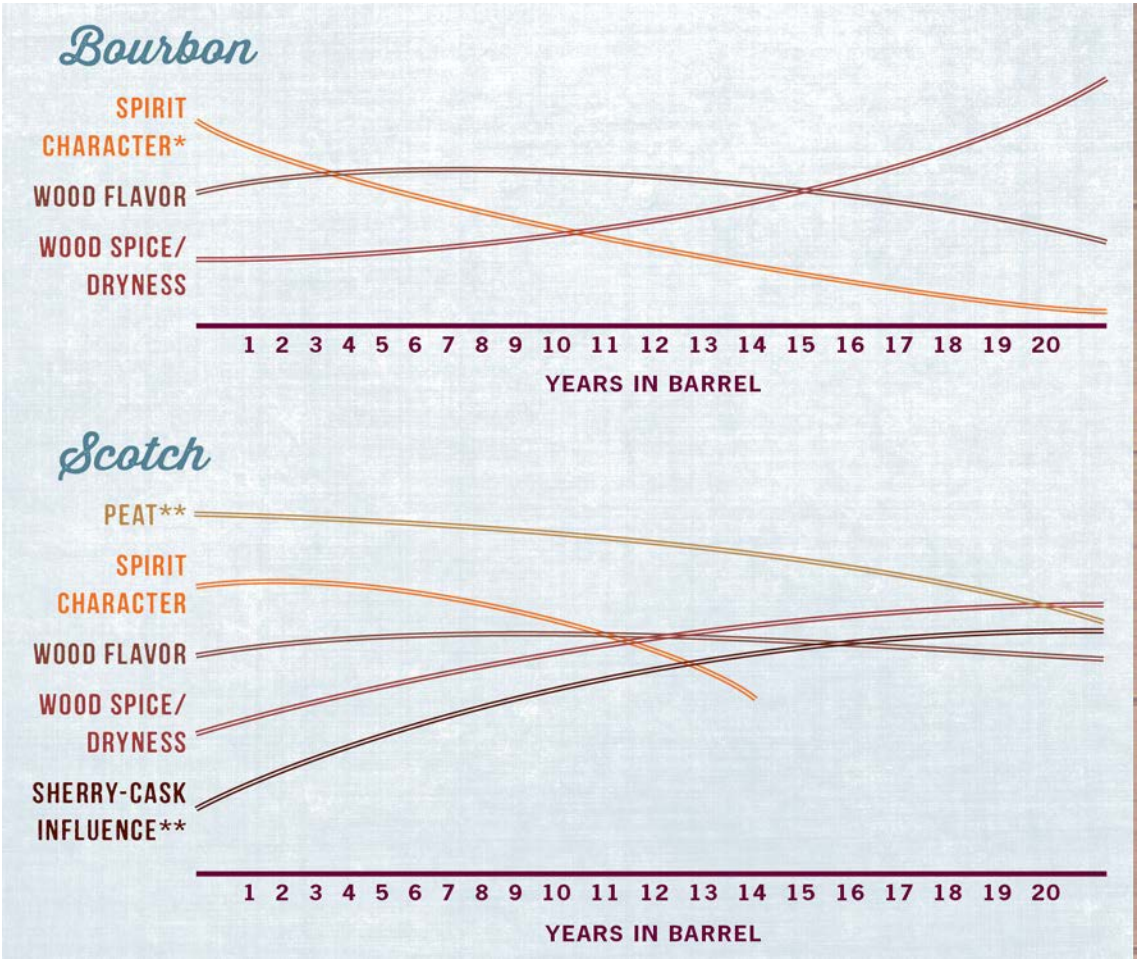
Aged spirits – flavor changes

- **Additive reactions –** increases in aldehydes and esters during maturation. Lactones and phenols added from the wood (woody, vanilla, coconut). Compounds include vanillin, oak/whisky lactone.
- Acetaldehyde is formed from oxidation of ethanol (green apple characteristic). Other aldehydes include syringaldehyde, coniferaldehyde and benzaldehyde.
- Increase in levels of ethyl acetate. Other ester levels either remain unchanged or drop slightly
- Tannins from oak might increase astringency and drying effect.

Aged spirits – flavor progression



Aged spirits – flavor progression



Summary

- **Spirit flavor comes from various sources**
  - **Raw materials**
  - **Fermentation**
  - **Distillation process**
  - **Botanicals**
  - **Aging process and materials**
  - **Time!**

Questions?