

# ICBC

## International Citrus & Beverage Conference

### *Enhancement of Saltiness with Volatiles*

*Thursday, September 12, 2019 3:45-4:20 PM*

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Food Science & Human Nutrition

UF Plant Innovation Center (Food & Flavor Division)

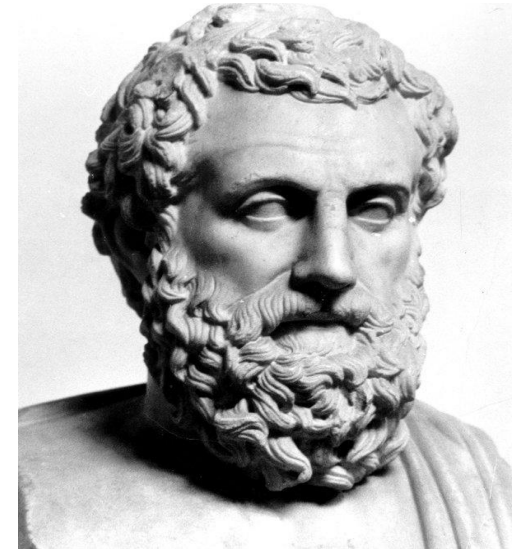
UF Smell & Taste Center

# Volatile-enhanced-taste

History of interactions between  
olfaction & taste started with an  
error.

Aristotle believed:

- taste was perceived on the tongue  
(taste was a type of touch)
- olfaction was perceived by inhaling

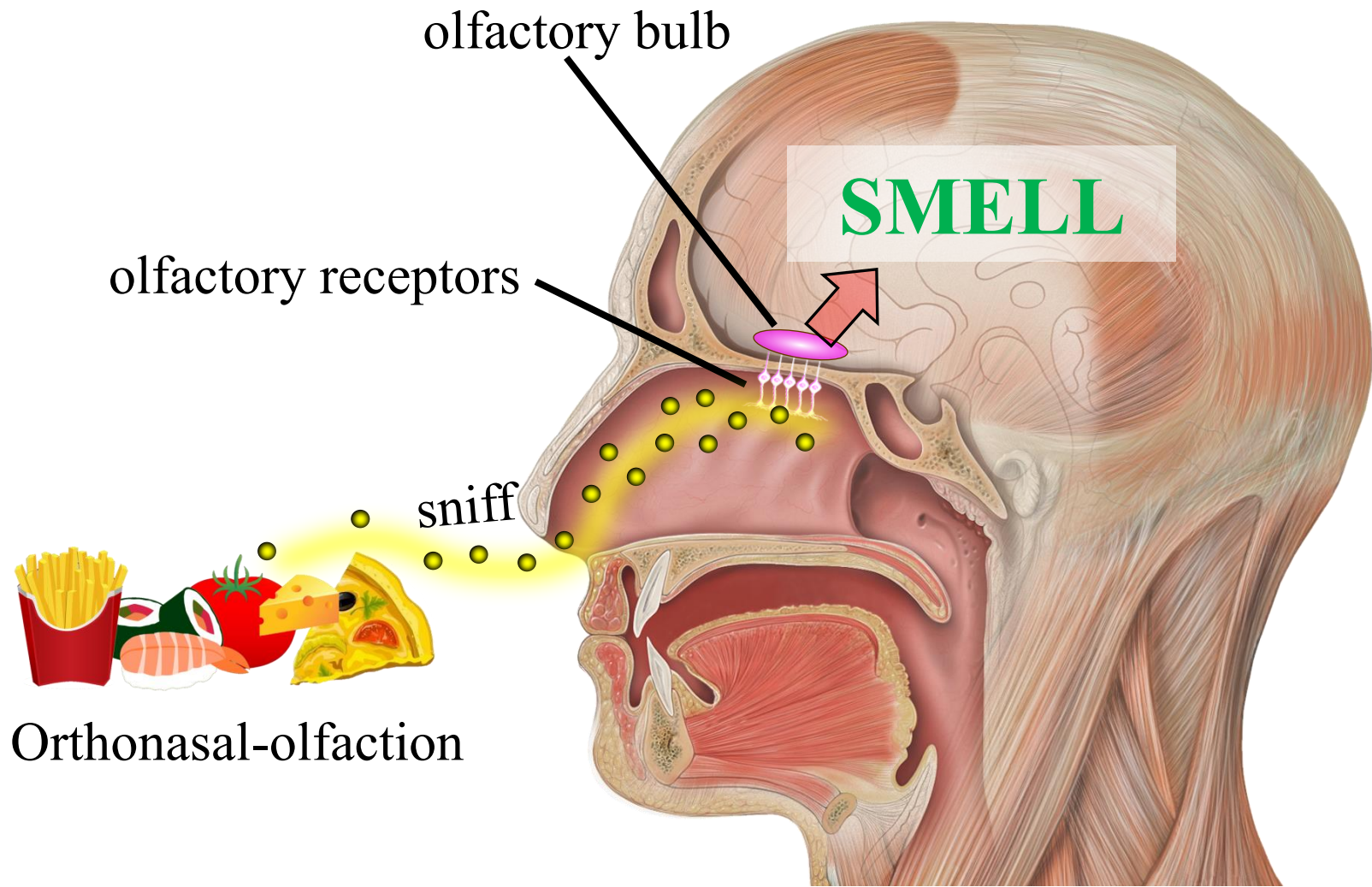


384 – 322 BCE

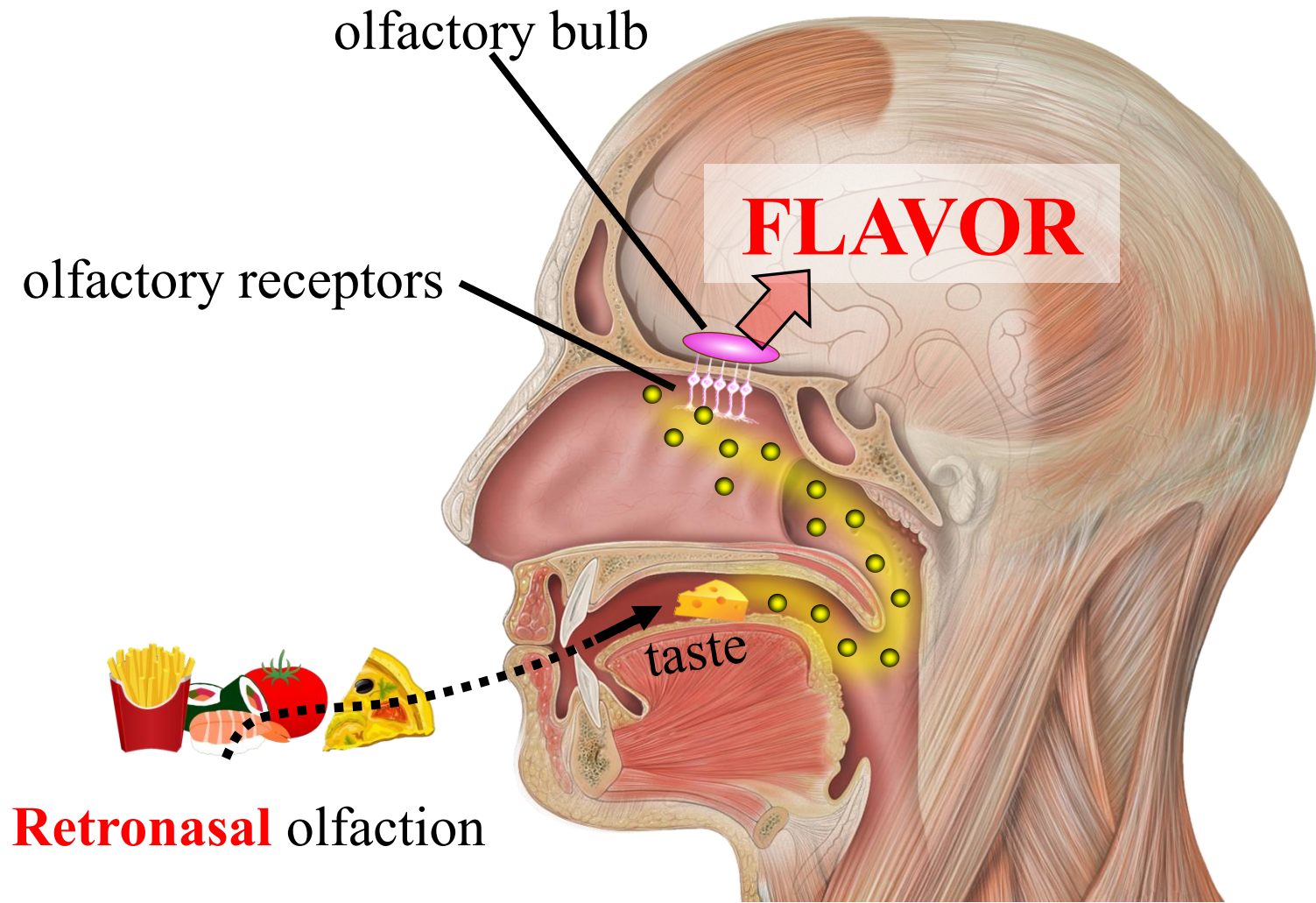
Aristotle did **not** know that when we eat, odorants (volatiles) are forced up behind the palate and enter the nose from the rear. This is retronasal olfaction (flavor). To Aristotle, taste and flavor were the same.

What we know now.

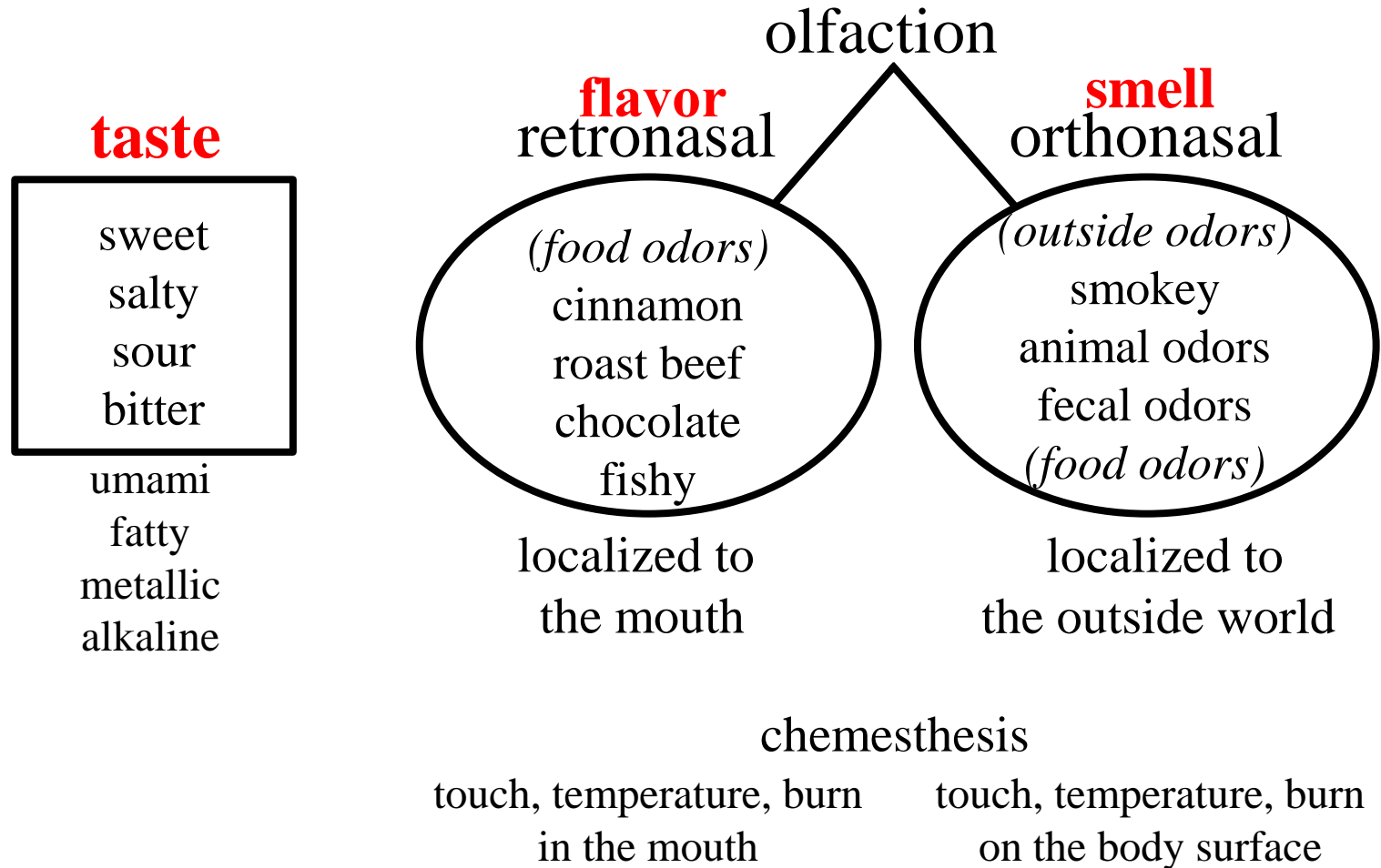
# Orthonasal Olfaction



# Retronasal Olfaction



# The Chemical Senses: what we know now



Look at our language.

**We don't have the right verbs**

- I "taste" food.
- I "smell" food.
- I "flavor" food.

Oops! We don't have a verb that describes experiencing the flavor of food, so we use

**"taste."**

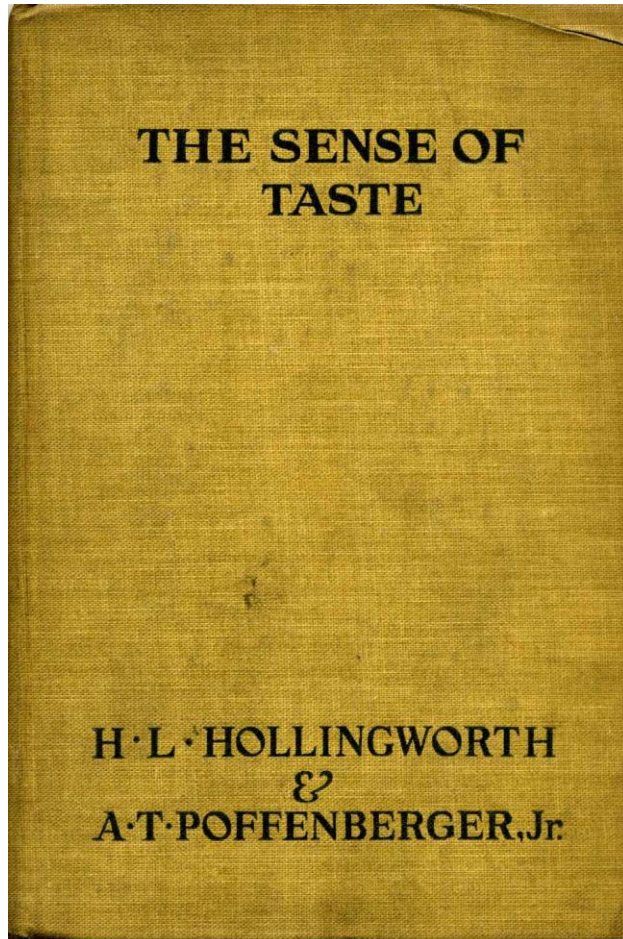


# Back to Aristotle

One of the reasons that Aristotle failed to distinguish between taste and flavor was because retronasal olfaction is perceptually localized to the mouth.

When Aristotle bit into an apple, the apple flavor seemed to come from his mouth.

# Hollingworth & Poffenberger, 1917



- Hollingworth & Poffenberger (1917) argued that “the customary presence of sensations of pressure, temperature, movement, and resistance which are localized in the mouth” caused retronasal olfaction to be localized to the mouth.
- Actually, taste is primarily responsible.



Kate Hudson  
(Goldie Hawn's daughter)

When we eat blueberry yogurt,  
the blueberry flavor seems to  
come from all over in the mouth.

But anesthetize taste on one side  
of the mouth, the blueberry  
flavor jumps to the other side.

**Flavor**  
is here.



block  
**taste**  
here

# History of taste/smell interactions

1672

Thomas Willis, famous for describing the blood supply to the brain (circle of Willis), was an English physician, founding member of the Royal Society and is considered to be the father or modern neurology. He wrote what is essentially a textbook on the nervous system called, “De Anima Brutorum (On the Souls of Animals) in 1672.

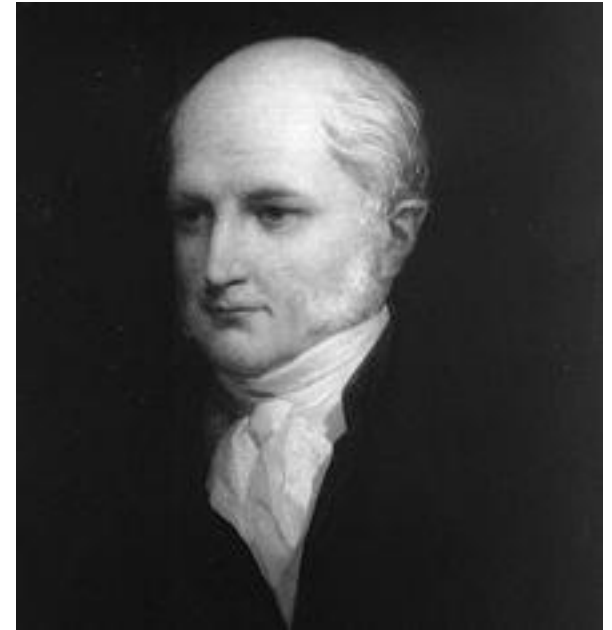


Thomas Willis  
English physician

Willis compared taste and olfaction and noted that “the loss of one of them, oftentimes brings in the defect of the other, as it is sometimes observed in a ... stopping of the head, that losing the smell, taste is lost also.”

## In **1812** Prout recognized retronasal olfaction.

Prout was an English chemist and physician. In 1812 he published an anonymous essay in the London Medicine and Physical Journal; he correctly distinguished between taste, olfaction and flavor for the first time. The identification of Prout as the author was by William H. Brock, a historian of science, in 1967 (Journal of the History of Medicine and Allied Sciences 22(2): 184-187.)



William Prout  
(1785-1850)

“***Flavor*** is that sensation which is produced when substances under certain circumstances are introduced into the mouth, ***the nostrils being at the same time open.***”

Volatile-enhanced  
sweetness dates back to  
the 1970s.

# Emergence of the idea that volatiles could enhance sweet

1812 Prout, W., *Observations upon the sensations of taste and smell.*

Correct distinction between retro and orthonasal olfaction

1977 Murphy, Cain & Bartoshuk, *Mutual action of taste and olfaction.*

Taste-smell "confusions"

1980 Murphy & Cain, *Taste and olfaction: Independence vs interaction.*

Citral enhanced the sweetness of sucrose - "illusion"

1984 Burdach, Kroeze & Köster, *Nasal, retronasal, and gustatory perception*

Several volatiles or flavorings enhanced sweetness of sucrose - "illusion"

1988 Frank & Byram, *Taste-smell interactions are tastant and odorant dependent.*

Strawberry flavoring enhanced sweetness of sucrose; peanut butter did not



*University of Florida Research Group*

Harry Klee



Elizabeth Baldwin



Charlie Sims



Denise Tieman



Thomas Colquhoun

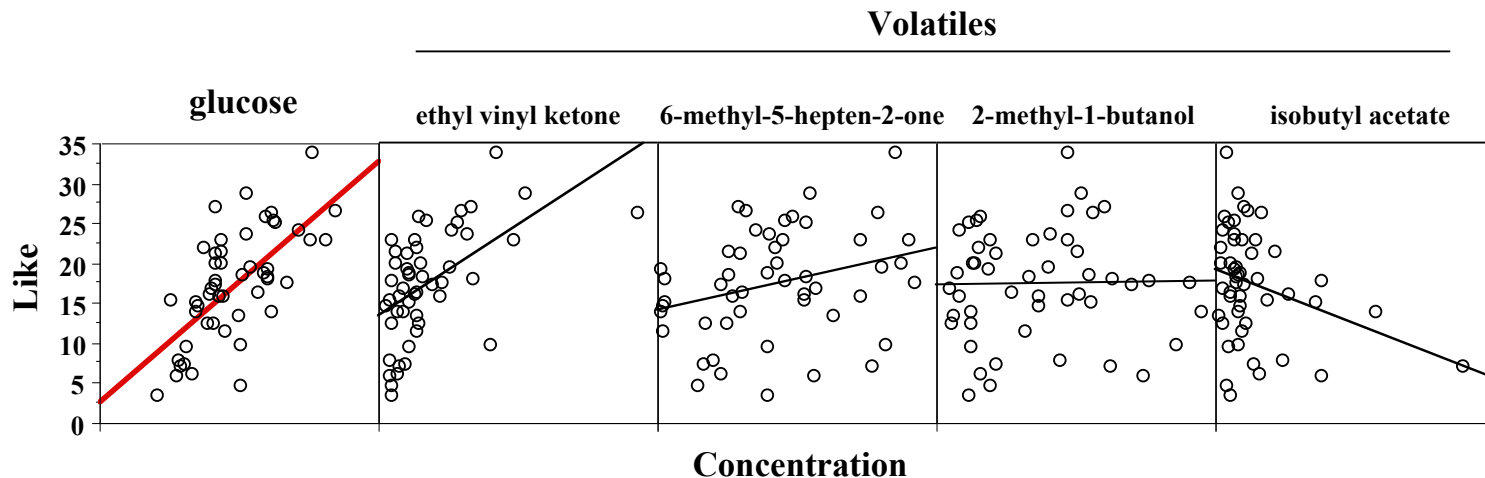
Linda Bartoshuk



# Harry Klee's Tomato Project

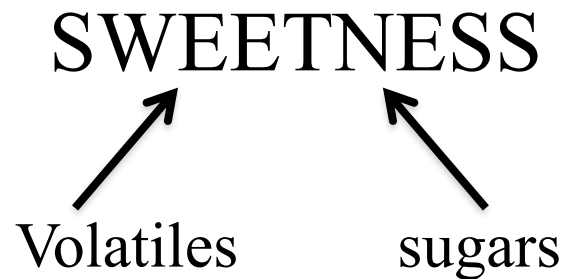
- 80 tomato varieties (selected for variation in constituents)
- Chemical analyses: sugars, acids, 60 volatiles
- Sensory analyses (N=150): taste (sweet, salty, sour, bitter), aroma, tomato flavor, liking

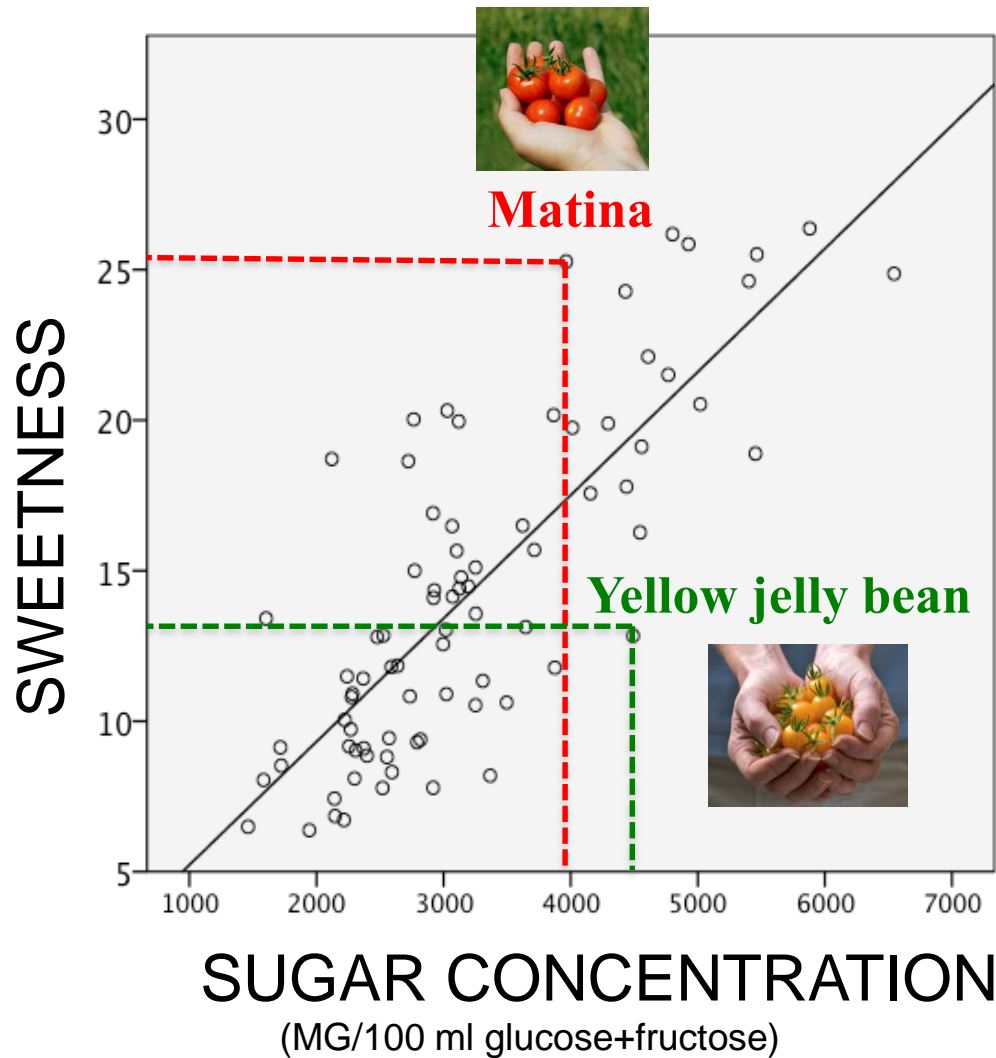
# How much does each constituent contribute to liking?



- Some volatiles correlated positively.
- Some correlated negatively.
- Some did not seem to matter.
- **“Recipe” for a better tomato:**
  - Increase volatiles with positive correlations
  - Decrease volatiles with negative correlations

Multiple regression also allowed us to identify the constituents that contribute to sweetness independent of sugars.



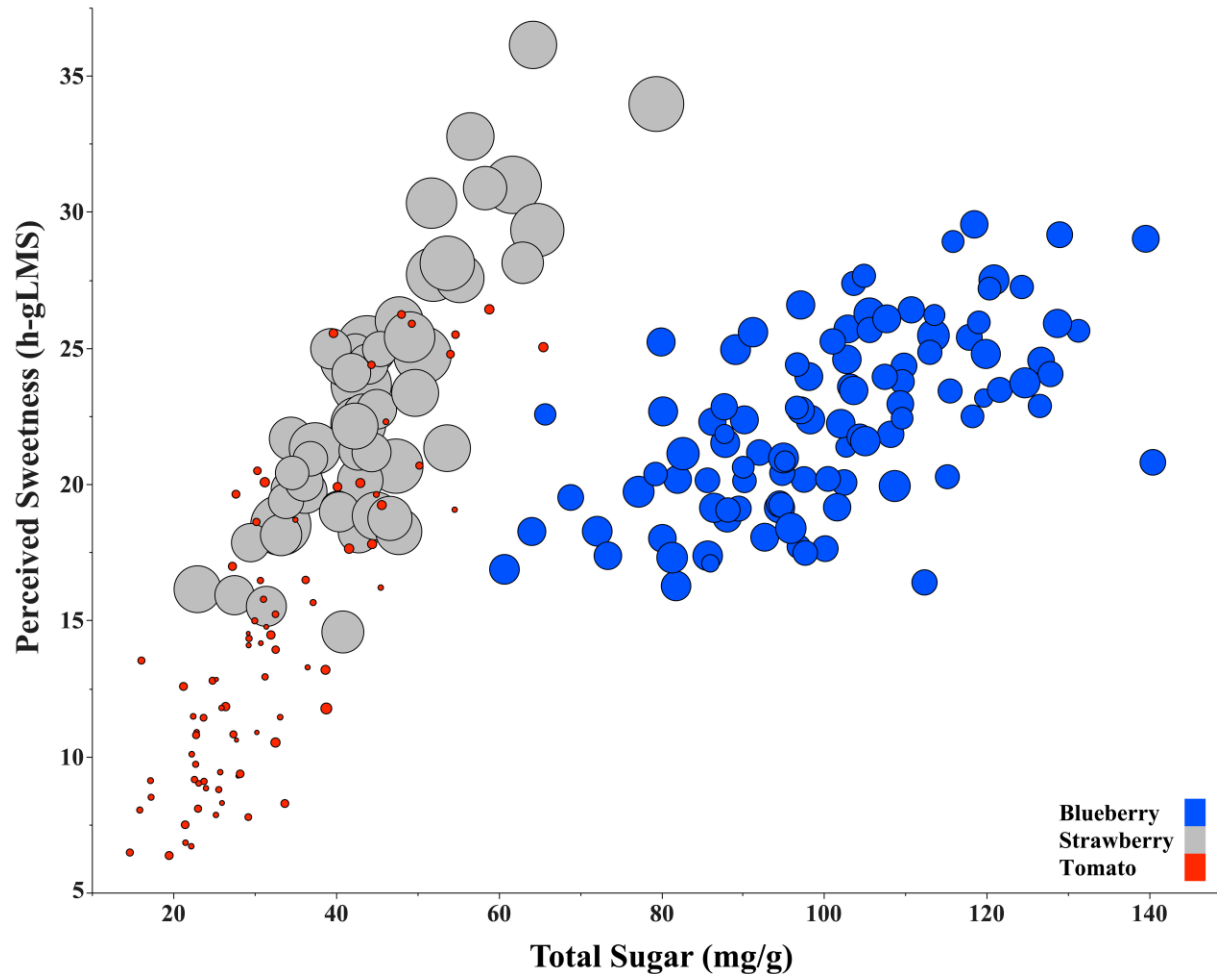


*Matina* tomatoes contain higher concentrations of the volatiles that enhance sweet and lower concentrations of those that suppress sweet.

*Yellow jelly bean* tomatoes contain lower concentrations of the volatiles that enhance sweet and higher concentrations of those that suppress sweet.

# Note the power of volatile-enhanced-sweetness

Bubble Plot of Sweetness by Total Sugar Sized by Total Volatiles



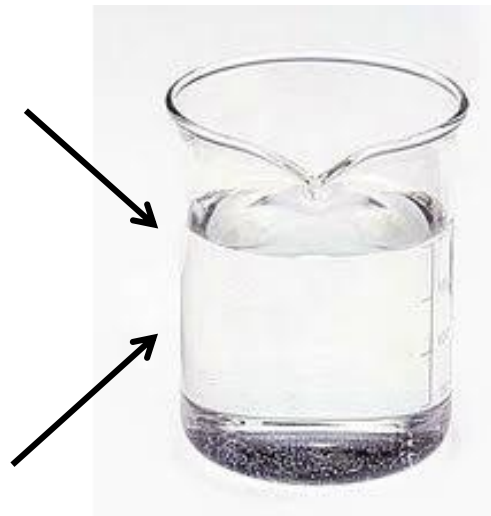
Analysis by Dr. Thomas Colquhoun, Assoc Prof, Environmental Horticulture

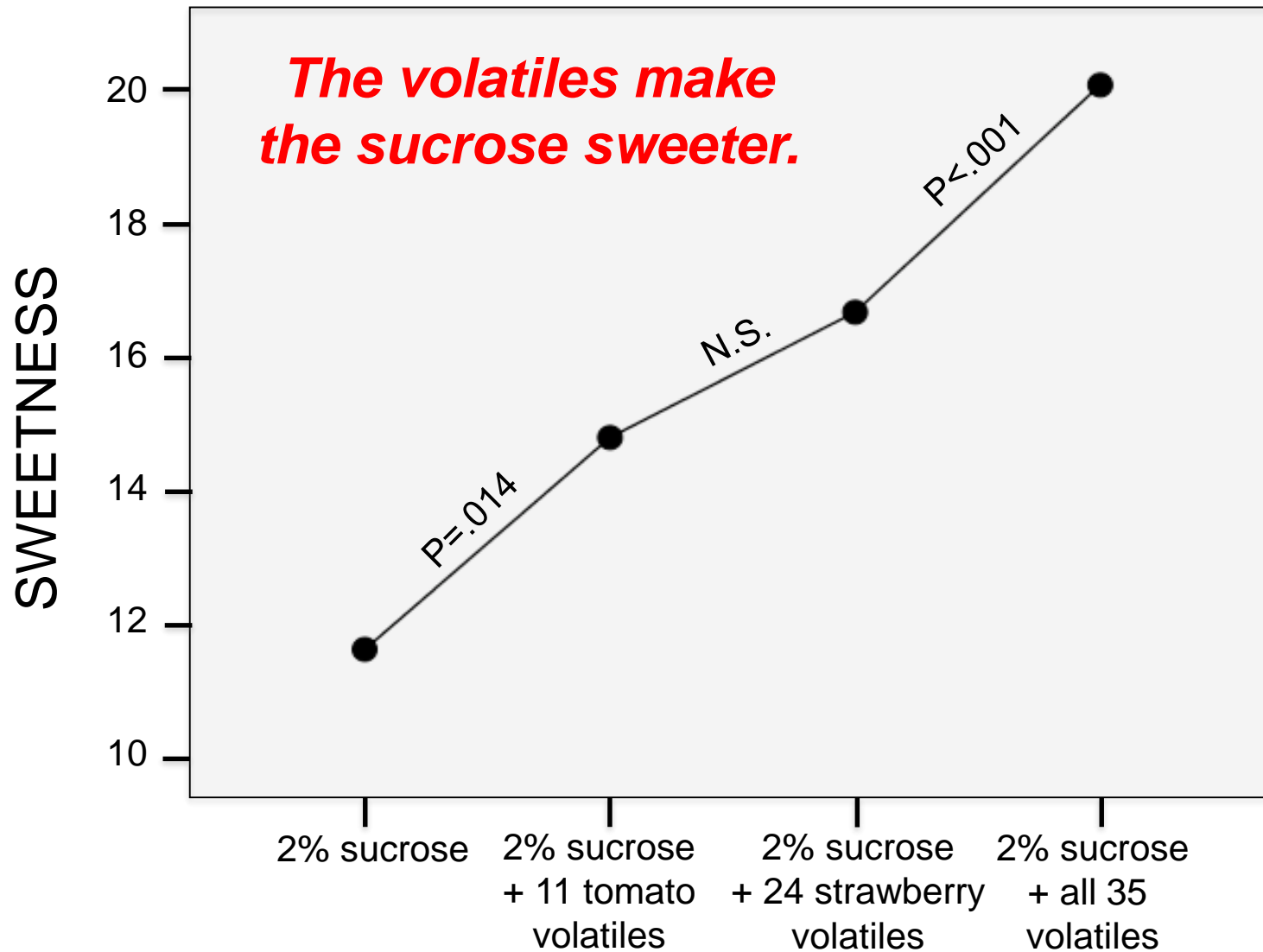
# Additivity of volatiles across different fruits

Take the volatiles  
out of the  
tomatoes and  
strawberries.



Put the volatiles  
into a 2% sucrose  
solution.







Volatile-enhanced-saltiness

SWEETNESS			SALTINESS		
year	authors	volatiles or name of source	year	authors	volatiles or name of source
1977	Stevens et al	2 volatiles			
1979	Watada & Aulenbach	4 volatiles			
1980	Murphy & Cain	citral			
1984	Burdach, Kroeze & Köster	amyl acetate			
1988	Frank & Byram	strawberry			
1990	Cliff & Noble	peach			
1990	Bingham et al	maltol			
1996	Rothe & Schrodter	ethanol			
1998	Lavin & Lawless	vanilla			
	Baldwin et al	8 volatiles from tomato			
1999	Prescott	pineapple, raspberry, caramel			
	Stevenson, Prescott & Boakes	lychee, passion fruit			
			2004	Pionnier et al	model cheese
				Lawrence et al	anchovy, bacon, sardine, peanuts, ham, chicken, cheese, tuna
				Kremer, Mojet & Shimogo	soy sauce
2008	Baldwin et al	beta ionone, ethanol			
2012	Tieman et al	6 volatiles from tomato			
	Bartoshuk et al	6 volatiles from tomato			
			2011	Batenburg & van der Velden	beef
				Lawrence et al	sardine
				Nasri et al	sardine
			2013	Nasri et al	sardine
				Seo et al	bacon
2014	Schwieterman et al	38 volatiles from strawberries			
	upublished	36 volatiles from oranges			
			2015	Emorine et al	ham
2016	unpublished	12 volatiles from peaches	2016	Lee, Lee & Kim	soy sauce
				Chokumnoporn et al	soy sauce
				Syarifuddin et al	sardine
			2016	Xu et al	36 food flavors
			2018	Onuma, Maruyama & Sakai	soy sauce

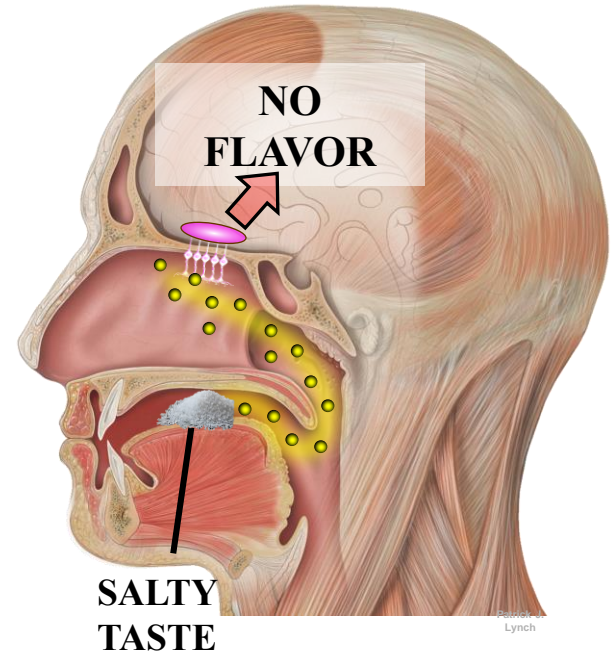
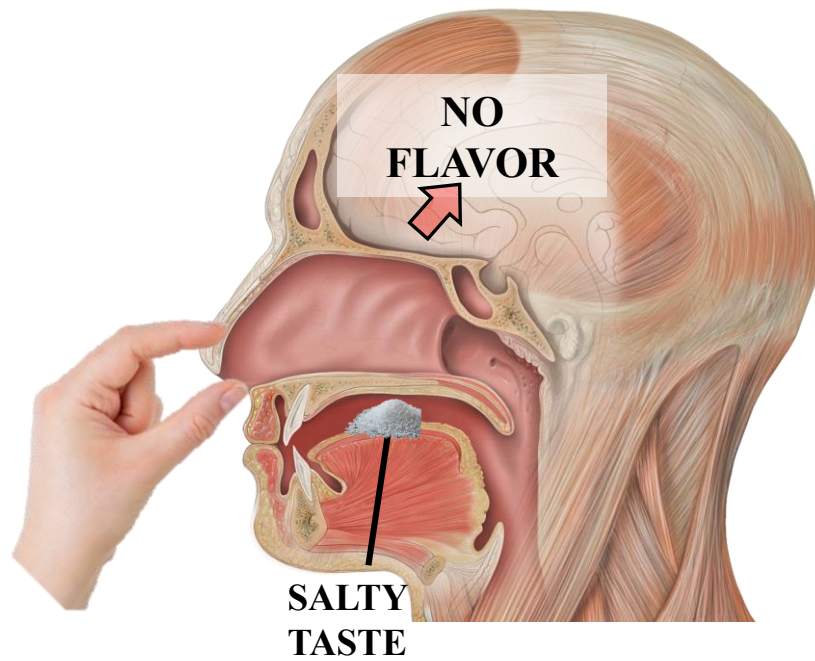
# Focus was on food odors typically paired with saltiness (Congruency Theory)

year	author(s)	odorant
2004	Plonnier et al	model cheese
2004	Lawrence et al	anchovy
		bacon
		sardine
		anchovy
		peanuts
		ham
		chicken
		Roquefort cheese
		tuna
		comté cheese
		concentrated cheese
2004	Kremer, Mojet & Shimojo	soy-sauce
2011	Batenburg & van der Velden	beef
2011	Lawrence et al	sardine
2011	Nasri et al	sardine
2013	Nasri et al	sardine
2013	Seo et al	bacon
2015	Emorine et al	ham
2015	Lee, Lee & Kim	soy sauce
2015	Chokumnoyporn et al	soy sauce
2016	Syarifuddin et al	sardine
2018	Onuma, Maruyama & Sakai	soy sauce

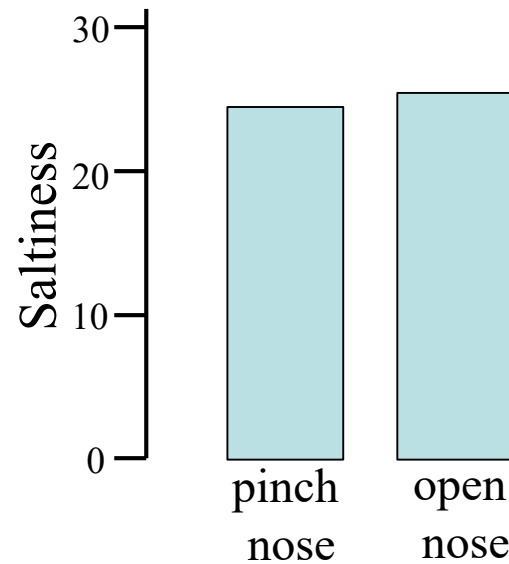
Anchovy  
 Bacon  
 Beef  
 Cheese  
 Chicken  
 Ham  
 Peanuts  
 Sardines  
 Soy sauce  
 Tuna

# The “Nose-Bump” technique

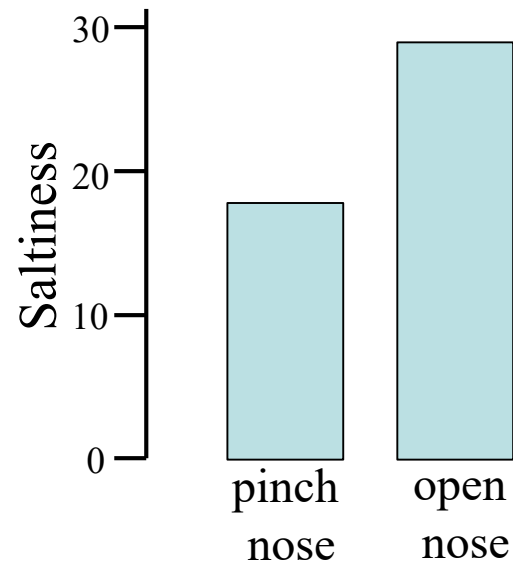
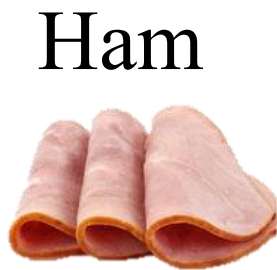
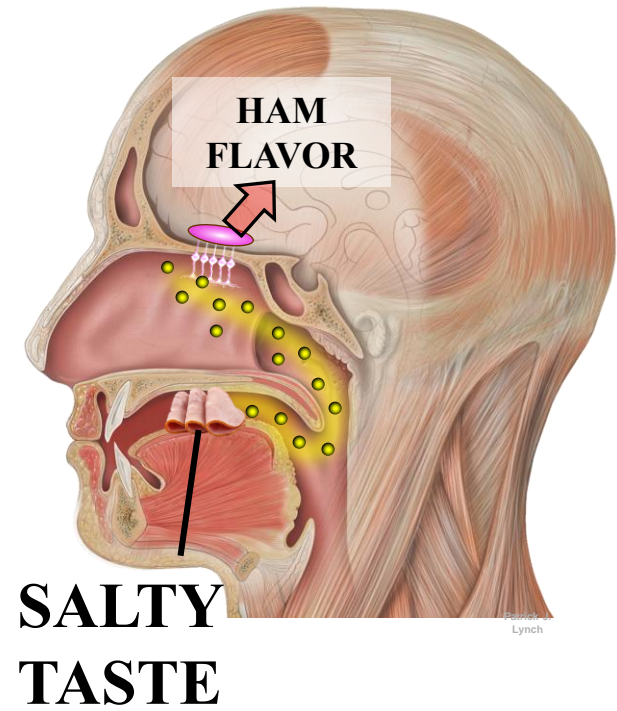
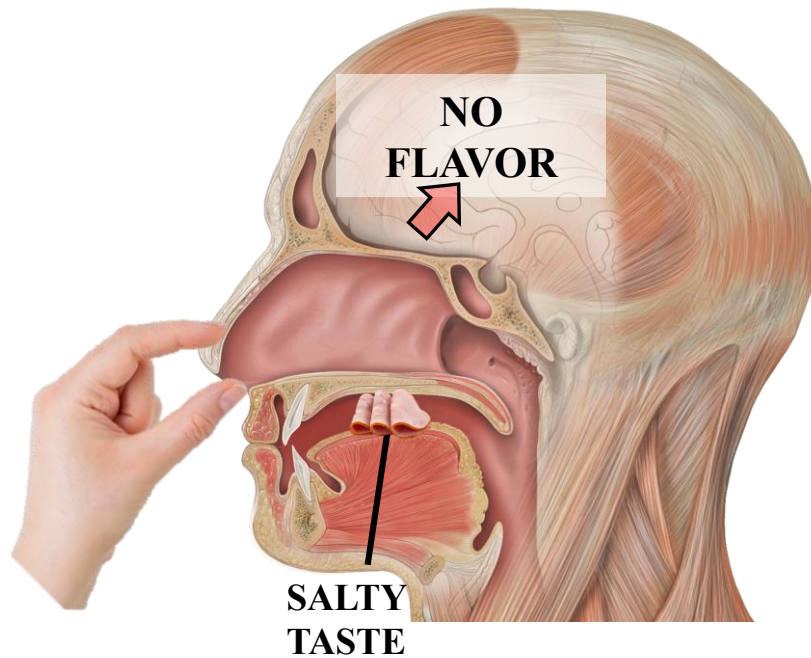
- This allows us to identify any food or beverage that contains volatiles that enhance taste.



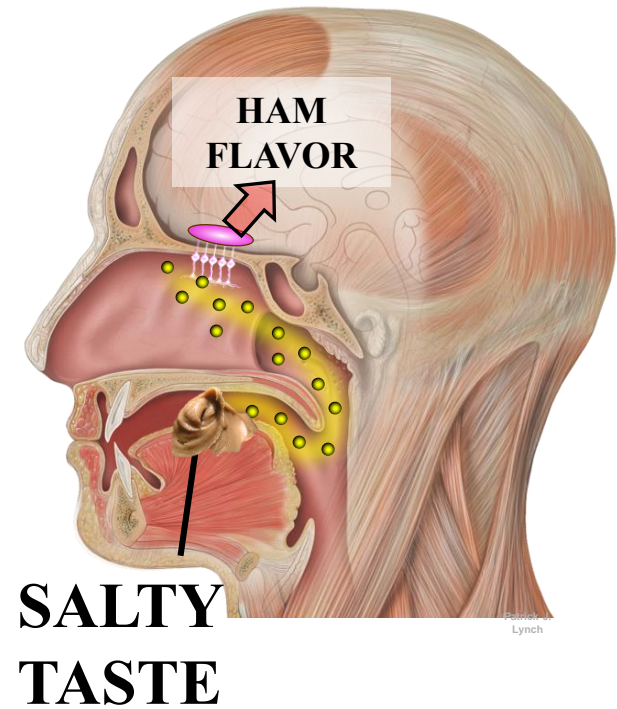
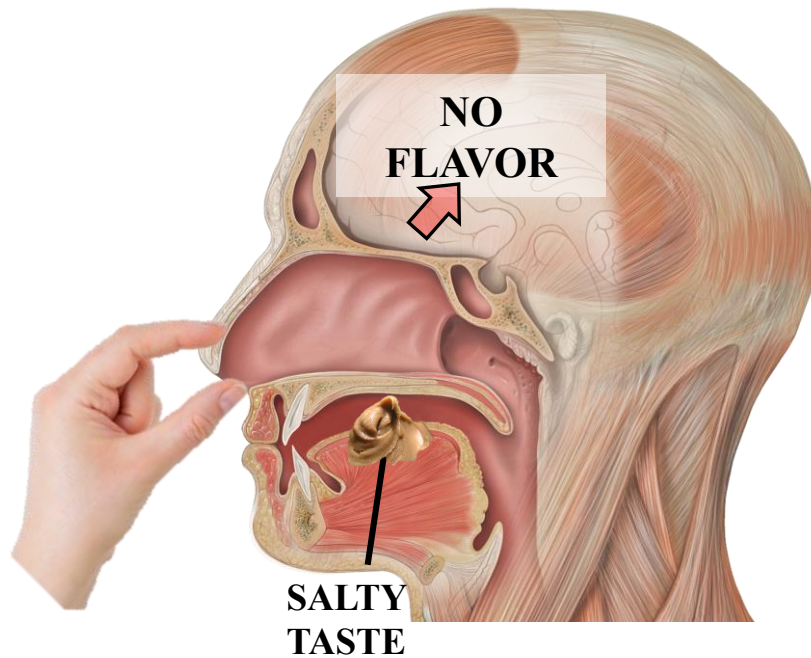
NaCl solution



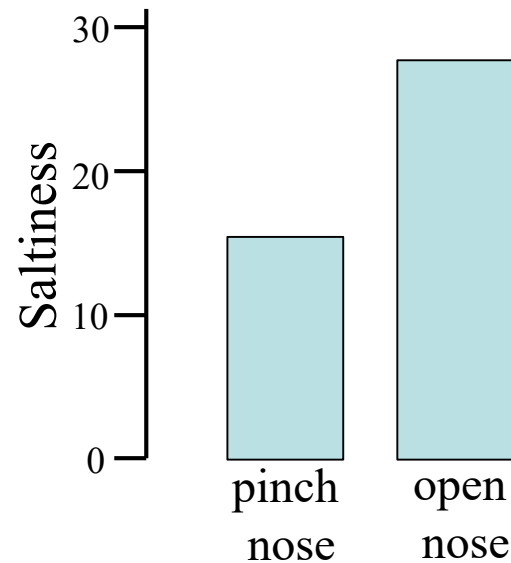
Modified from  
Dr. G. Lowe, Monell



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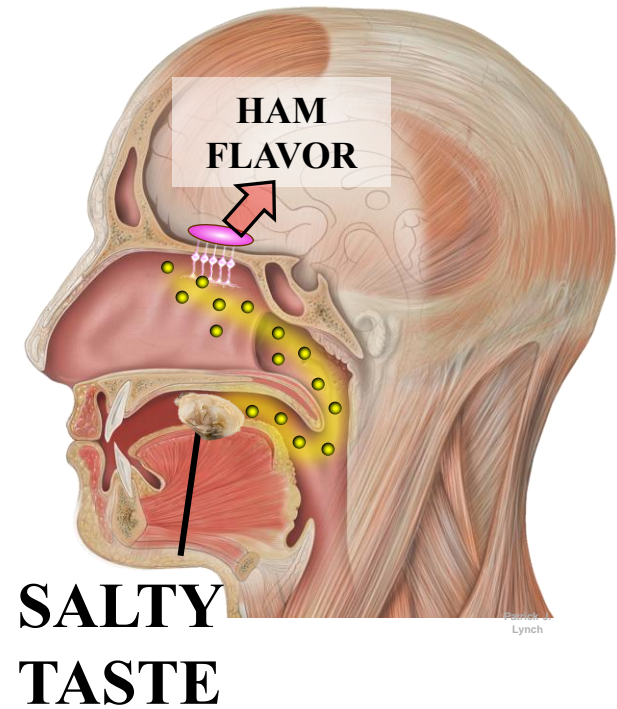
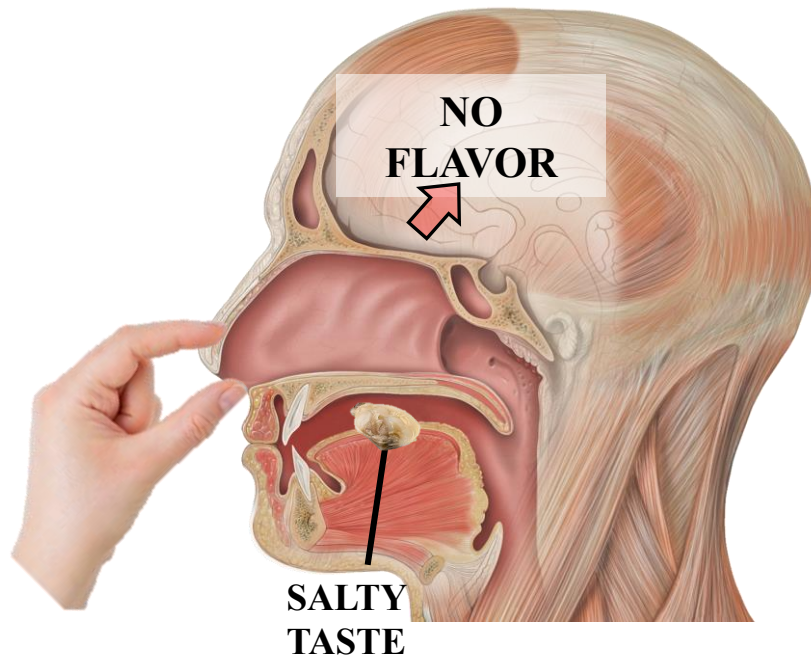


Peanut butter

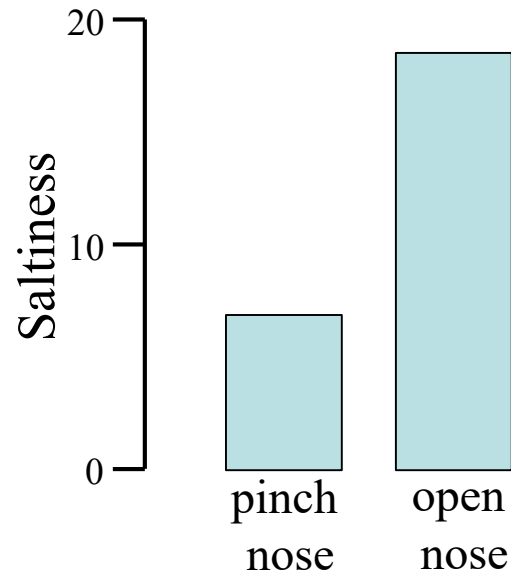


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Baby clams



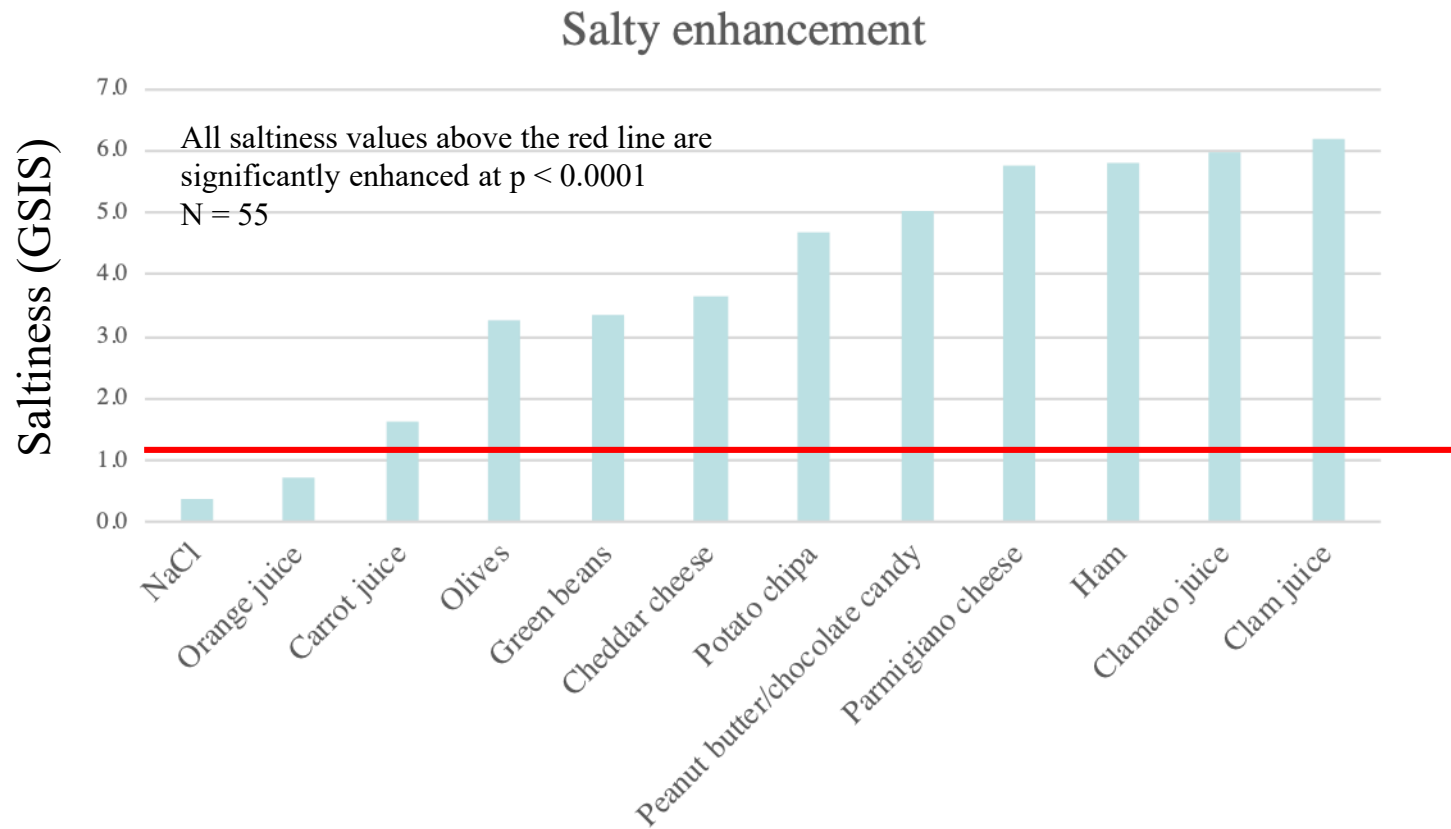
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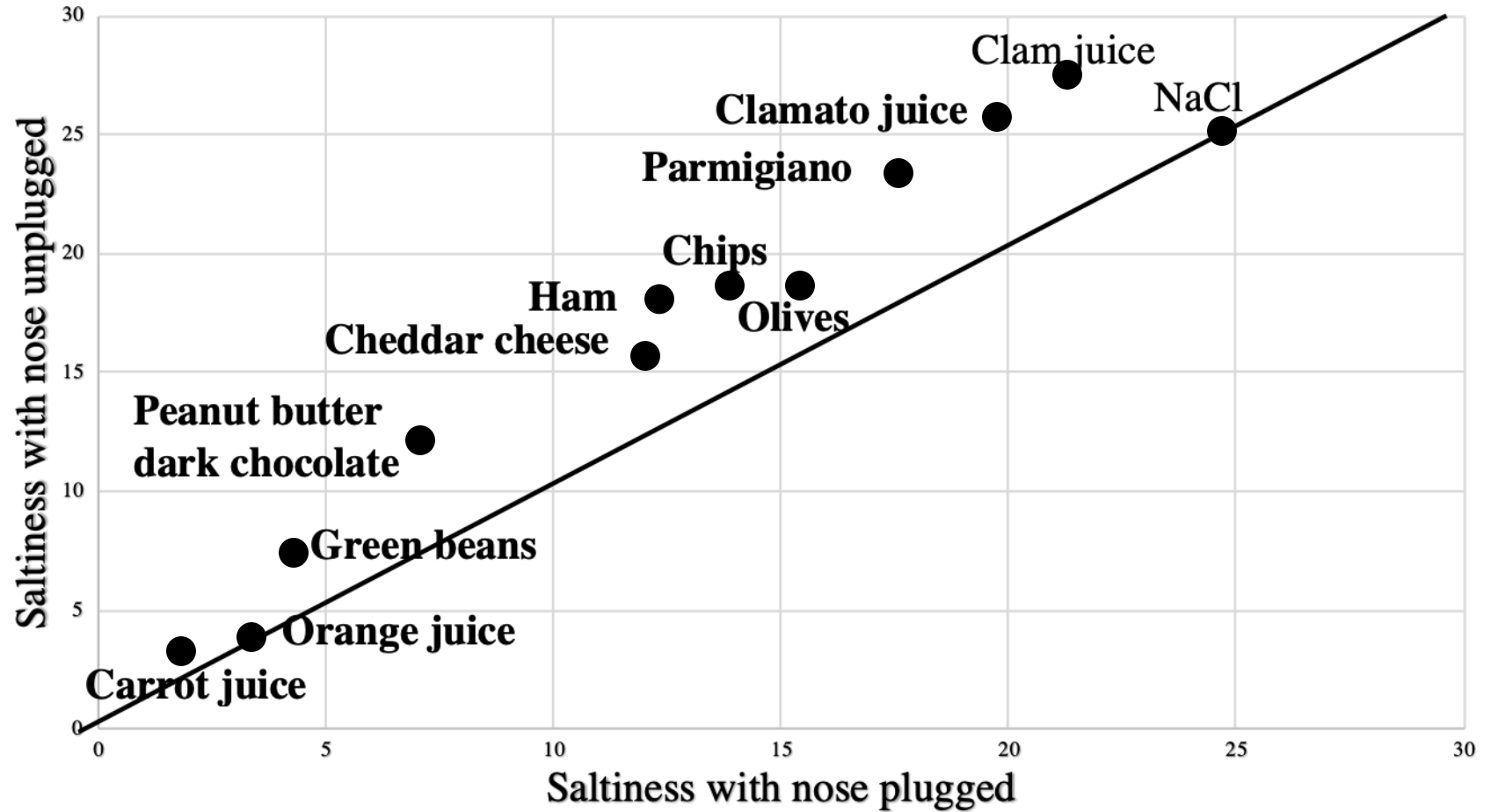
N = 12

food/beverage	enhancement		food/beverage	enhancement
Apple juice	0.50 N.S.		Sea salt & Pepper potato chips	7.20
Orange juice	0.90 N.S.		Sea salt tomato juice	7.40
Carrot juice	1.36 N.S.		Clamato juice	7.87
Gatorade® (glacier freeze)	1.64 N.S.		Sea salt popcorn	8.00
Reduced sodium canned vegetables	2.70		Black ripe olives	8.17
Campbell's tomato juice	2.75		Black forest ham	8.33
Cut green beans	4.09		Kalamata olives	8.83
Capers	4.17		Sea salt tomato juice	8.95
Almonds	4.70		Vienna sausage	9.30
Italian wedding soup	4.86		Chicken noodle soup	9.35
Low sodium tomato juice	5.00		Sweet BBQ potato chips	10.00
Green ripe olives	5.00		Spanish olives	10.17
Publix tomato juice	5.13		Peanuts	10.50
Greenwise tomato juice	5.25		Sweet & spicy potato chips	10.70
Tiny shrimp	6.28		Cheddar cheese	11.10
Smoked ham	6.50		Oysters	11.20
Garden vegetable soup	6.70		Baby clams	11.80
Virginia brand ham	7.00		Peanut butter	11.81
Blackeyed peas	7.20		Clam juice	13.37
			Parmigiano cheese	26.70

Kaipeng Xu's Master's thesis, 2016



Kaipeng Xu's Master's thesis, 2016



# Clinical Implications

We can restore lost taste with retronasal olfaction

