Genetic Variation in Chemosensory Receptors: Linking Genetics and Food Choice

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Overview

• Taste as a driver of food choice
• Taste & flavour
• Genetic differences in taste and smell
• Variations linked to food preferences
• Considerations for the consumer
TASTE: Can influence our food choice

- Personal food values
- Used to make choices
- Influenced over life course
- Can vary from person to person and within eating situation

- Taste: important food-related value

Fig. 1
The Food Choice Process Model
Connors et al., (2001)
Taste – consistently no.1 factor in purchasing for last decade
What is taste?

- What we perceive in absence of smell

Also chemosensations:
- Burning (TRPV1)
- Cooling (TRPM8)
Flavour: A multisensory perception

- taste
- smell
- trigeminal sensation
Flavour – a multisensory perception

- Taste
- Smell
- Trigeminal sensation
- Vision, sound

Figure 5. Impact of colour on taste intensity
Individual Differences in Perception
• Classic example: Bi-modal distribution of PROP / PTC intensity
Irish children: Supertasters ½ as likely to have tried green veg

Fig. 6. Data from Feeney et al, (2014) Genetic and environmental influences on liking and reported intakes of vegetables in Irish Children- Food quality and Preference
Supertaster tongue? Probably not....

Supertaster tongue doesn’t seem to exist...

(Feeney & Hayes, Chemical Senses, 2014; Feeney & Hayes, Chemosensory. Percept, 2014)

Females have a greater density of FP than males

Fig. 7. Feeney and Hayes, 2014, Chemosensory Perception.
Genetic variation in bitter taste...

• Now known – 25-30 bitter taste genes

• TAS2R38 discovered in 2003

• Encodes PTC receptor

• Also binds other N-C=S compounds

• Each codes for a receptor

• Receptors may bind multiple compounds

Figure 8. Phylogenetic tree of TAS2R gene family

(Adapted from Behrens & Meyerhof, 2006)
Bitter taste receptors - GCPRs

Figure 9. Typical structure of GCPRs
Figure 10. TRC in mammals and their ligands, adapted from Yarmonlinsky et al, (2009) Cell
Genetic variation in umami and sweet receptor genes

<table>
<thead>
<tr>
<th>Gene</th>
<th>SNP</th>
<th>Association and possible mechanism, if known</th>
<th>Taste quality affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAS1R1</td>
<td>A372T&lt;sup&gt;(30)&lt;/sup&gt;</td>
<td>T associated with high sensitivity. Mechanism unknown</td>
<td>Umami</td>
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<tr>
<td></td>
<td>G1114A&lt;sup&gt;(92)&lt;/sup&gt;</td>
<td>A associated with high sensitivity. Mechanism unknown</td>
<td>Umami</td>
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<td>C329T&lt;sup&gt;(95)&lt;/sup&gt;</td>
<td>T associated with low sensitivity. Mechanism unknown</td>
<td>Umami</td>
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<td>TAS1R3</td>
<td>R757C&lt;sup&gt;(30), (30)&lt;/sup&gt;</td>
<td>C associated with lower sensitivity. Mechanism unknown</td>
<td>Umami</td>
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<td>R247H&lt;sup&gt;(30)&lt;/sup&gt;</td>
<td>H associated with increased sensitivity. Possibly influences binding with L-glutamate resulting in stronger activation of taste system.</td>
<td>Umami</td>
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<tr>
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<td>A5T&lt;sup&gt;(43)&lt;/sup&gt;</td>
<td>A associated with heightened perception.</td>
<td>Umami</td>
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<td>C2269T&lt;sup&gt;(59)&lt;/sup&gt;</td>
<td>T more frequent in nontasters. Mechanism unknown</td>
<td>Umami</td>
</tr>
<tr>
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<td>C1266T&lt;sup&gt;(41)&lt;/sup&gt;</td>
<td>T alleles result in reduced promoter activity</td>
<td>Sweet</td>
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<tr>
<td></td>
<td>C1572T&lt;sup&gt;(41)&lt;/sup&gt;</td>
<td>T alleles also result in reduced promoter activity in this mutation</td>
<td>Sweet</td>
</tr>
</tbody>
</table>

Table 1. Known SNP associations with umami and sweet perception in the TAS1R gene family, adapted from Feeney et al., (2010)
Taste genetics – may affect coffee intake

Fig. 11. Mean daily coffee intake (ml/day) across variations of TAS2R43, which responds to caffeine (left) and TAS2R38, which responds to PTC (right). Davis and Feeney (2015), presented at Pangborn, Sweden
Taste genetics: Can affect sweetener preference
Odor receptors are also implicated in food preferences.

Table 2. Functional SNPs in chemosensory genes

<table>
<thead>
<tr>
<th>SNP ID/Position</th>
<th>Gene</th>
<th>Region</th>
<th>Chemosensation</th>
<th>Reference</th>
<th>Liking / Intake</th>
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<tbody>
<tr>
<td>R88W, T133M</td>
<td>OR7D4</td>
<td></td>
<td>Androstenone odor, androstadionone odor</td>
<td>Keller (2007); Knaapilla</td>
<td>May affect acceptance of boar tainted pork</td>
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<tr>
<td>Not actually a SNP – the non-functional allele is a pseudogene</td>
<td>OR11H7P</td>
<td>Coding region</td>
<td>Isovaleric acid</td>
<td>Menashe, (2007)</td>
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<tr>
<td>rs 7277172</td>
<td>OR4N5</td>
<td></td>
<td>?</td>
<td></td>
<td>Cilantro preference</td>
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<tr>
<td>rs427871</td>
<td>TAS2R1</td>
<td></td>
<td>Bitter receptor</td>
<td></td>
<td>Cilantro preference</td>
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</table>

Adapted from Hayes, Feeney and Allen (2013) Food Quality and Preference 30; 202–216

Ihatecilantro.com
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<th>Odorants</th>
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**Description**

- A: Rancid, sour, goat-like
- B: Sweet, herbal, woody
- C: Rancid, sour, sweaty
- D: Violet, sweet, woody
- E: Rancid, sour, repulsive
- F: Sweet, orange, rose
- G: Waxy, cheese, nut-like
- H: Fresh, rose, oily floral

*Figure 12. Schematic of odor perception*
Strongest Imaginable

Very Strong

Strong

Moderate

Weak

Barely Detectable

- Person 1

- Person 2

736

277

347
Becomes more complicated with real beverages & foods - interaction of many compounds and tastes:
Suprathreshold measures of taste perception in children - Association with dietary quality and body weight
Taste receptors also found in the gut

- TAS2R38 - association with glucose homeostasis
- Gnat3 is involved in sweet taste variations - sweet perception
- Implicated in GWAS study of metabolic syndrome
- How? Interaction / signalling in gut?

(Fushan et al, Chem senses, 2010; Feeney et al 2013, Nutrient Sensing in the Gut, Hamburg)
Challenges: Complexity of human perception

- Separating genetic variation from other taste intensity influences?
- Modeling all known genetic variations in chemoreceptors together to predict taste perception?
- Modeling signaling in gut?
- Modeling the interaction of receptors with real foods?
- Relating this to food liking?
- These are just taste-Odor receptors (flavour)—over 400 known—predicting interaction??-Machine learning?
Summary – taste is important!

• Taste is a key driver of food choices
• Taste & odour perception can vary considerably
• Individual differences in perception – a key consideration
  – Affects food choice, liking, drives market segmentation
  – Important to know your data, and your target group
  – Sometimes choices may be necessary