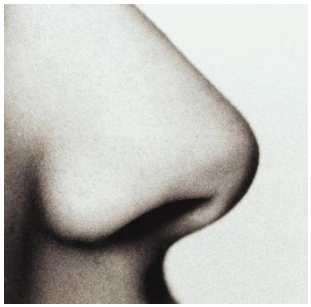
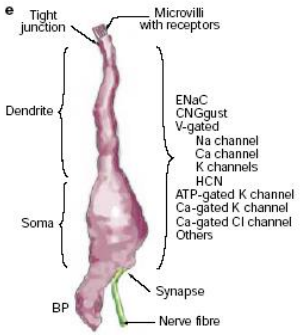
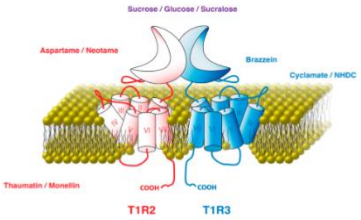
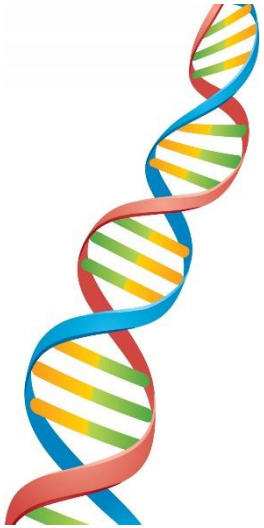
University of Reading









Personalised Sensory: Considerations of Age & Genetics

Dr Lisa Methven

Sensory Science Centre; University of Reading

Questions to Consider…

- How **big & relevant** are differences in Sensory Perception?
- How much do our screened "**Expert Panelists**" **differ** in sensitivity?
- Do they represent consumers?
- Should we be screening panellists on **genotype**?
- Will genotype become a factor we consider in consumer testing?
- If we target products of a certain group, should our sensory profiling panel represent the groups' sensitivities?

How **big & relevant** are differences in Sensory Perception?

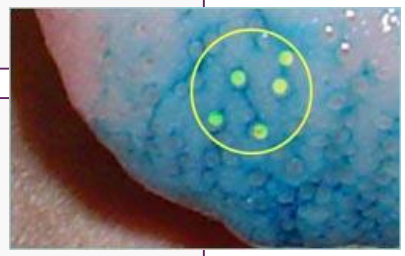
- Is it all about Supertasters & Non-tasters ?
  - But if so, what are these groups really ?

- Is it just the Bitter genotype that matters ?!
- What about differences in other basics tastes?
- What about differences in aroma perception ?

"Super" and "Non" Taster Theory

Genotype

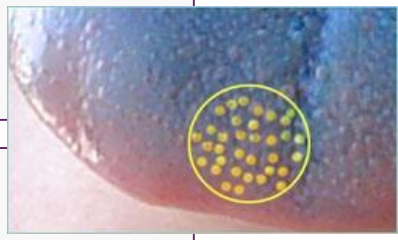
- TAS2R38 (Bitter receptor)
- CA6 (Gustin; influences number of papilla & taste cells)
- …but the list is growing !



Phenotype

SUPERTASTER:

- Densely packed papillae
- All Tastes more Intense
- Can taste bitter thiourea groups (PROP & Brassica)
- Mouthfeel more intense
- Spicy more intense



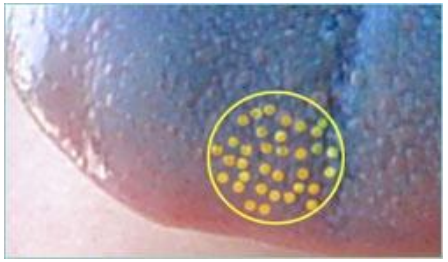
Choice & Diet

- May avoid bitter foods and alcohol
- May avoid creamy mouthfeel foods
- May avoid intensely sweet or fatty foods
- May avoid brassica veg

But this leads to more Q's !

- PROP supertasters may have both more papillae (FPD) and Tas2R38 sensitive genotype…
  - BUT that doesn't mean FPD & Tas2R38 are linked

- Gustin (CA6) genotype relates to FPD…
  - BUT doesn't seem to account for such wide variation in FPD
  - Yet it would be much easier to screen / type on Gustin than by counting papillae !



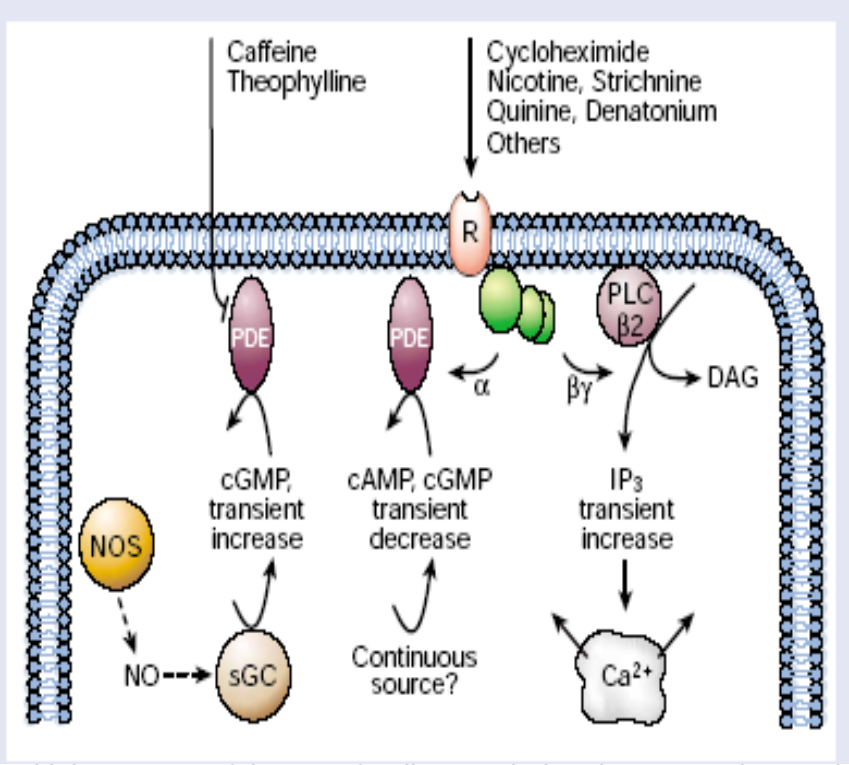
Bitter Taste Sensitivity

Bitter Taste Transduction

University of Reading

BITTER:

- Bitter taste receptors are GPCRs, Type 2 taste receptors
- **The T2R family in humans comprises 24 GPCRs…..**



Rs = multiple GPCRs of the T2R family, coupled to the G-protein gustducin

α = α-subunit of gustducin

βγ = G-protein subunits

PLC β2 = phospholipase C subtype

IP_3 =inositol-1,4,5-triphosphate

PDE = taste specific phosphodiesterase

cAMP = cyclic adenosine monophosphate; cGMP = cyclic guanosine MP

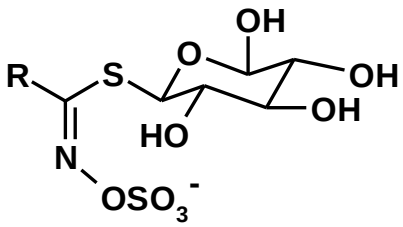
sGC = soluble guanylate cyclase

NO = nitric oxide; NOS = NO synthase

Lindemann, 2001

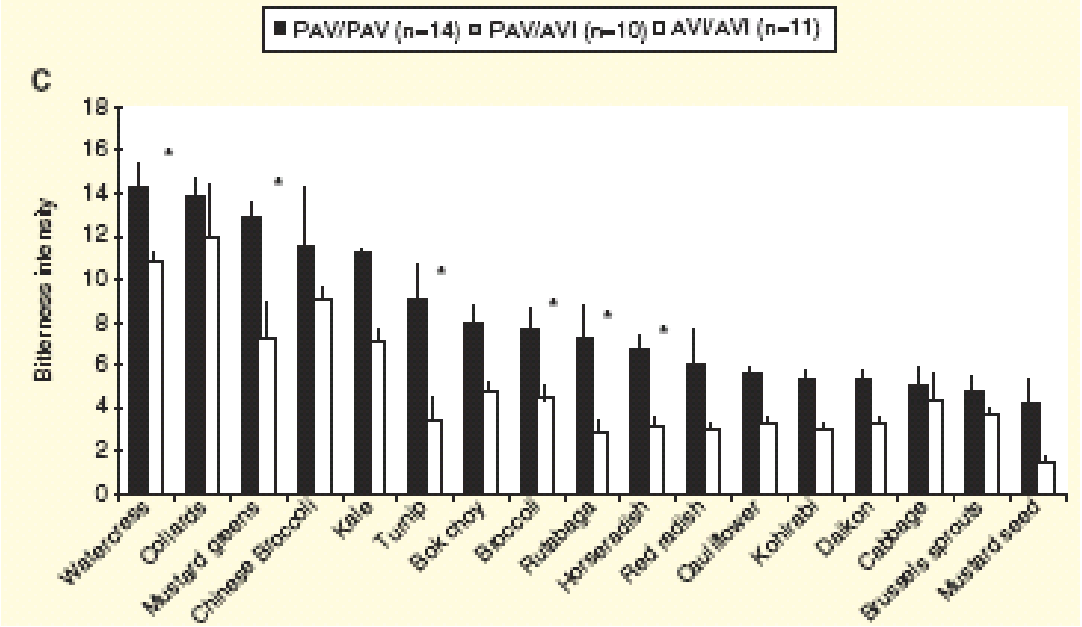
Genetic Bitter Blindness: "Nontasters"

- 1930's Arthur Fox found PTC (phenylthiocarbamide) tasted bitter to some people; but tasteless to others.
- 70 years later genetic variation in a bitter receptor, TAS2R38 found to be the major cause.
- Genetic bitter blindness to compounds with a thiourea group (**N-C=S**), such as PROP (6-n-propylthiouracil) and PTC.
- hTAS2R38 may also effect how GLUCOSINOLATE containing vegetables (BRASSICA) taste, as they also have a thiourea group:



hTAS2R38 and the Bitterness of Brassica

- **hTAS2R38 has two alleles:**
- **Sensitive allele "PAV"; insensitive allele "AVI"**
- **You can be :**
  - **PAV/PAV (25% population)**
  - **PAV/AVI (50% population)**
  - **AVI/AVI (25% population)**
- **PAV/ PAV subjects rated Brassica (glucosinolate-generating veg) 60% more bitter**



(Sandell & Breslin, 2008)

3 SNPs involved : rs10246939, rs1726866 & rs713598

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

University of Reading

Exploring the effects of genotypical and phenotypical variations in bitter taste sensitivity on perception, liking and intake of brassica vegetables in the UK

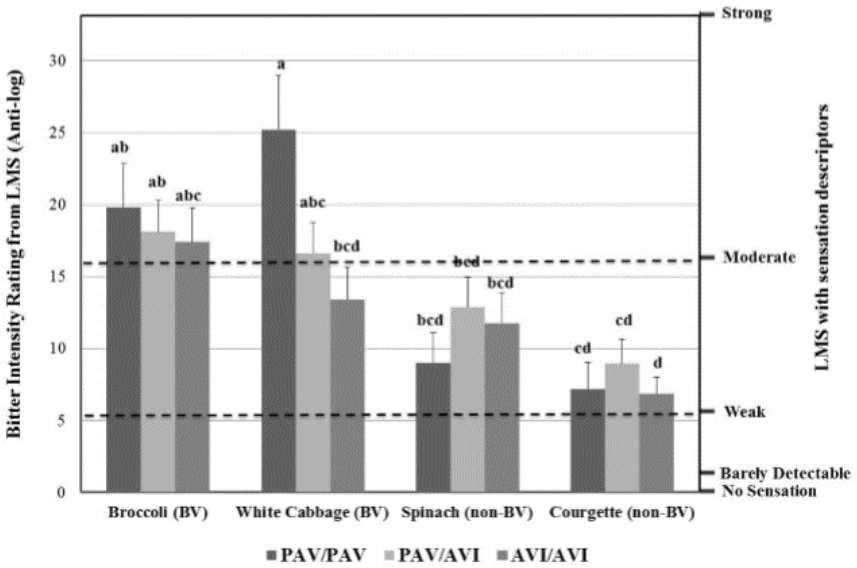
Yuchi Shen [a], Orla B. Kennedy [b], Lisa Methven [a,*]

Dr Yuchi Shen (Amber)

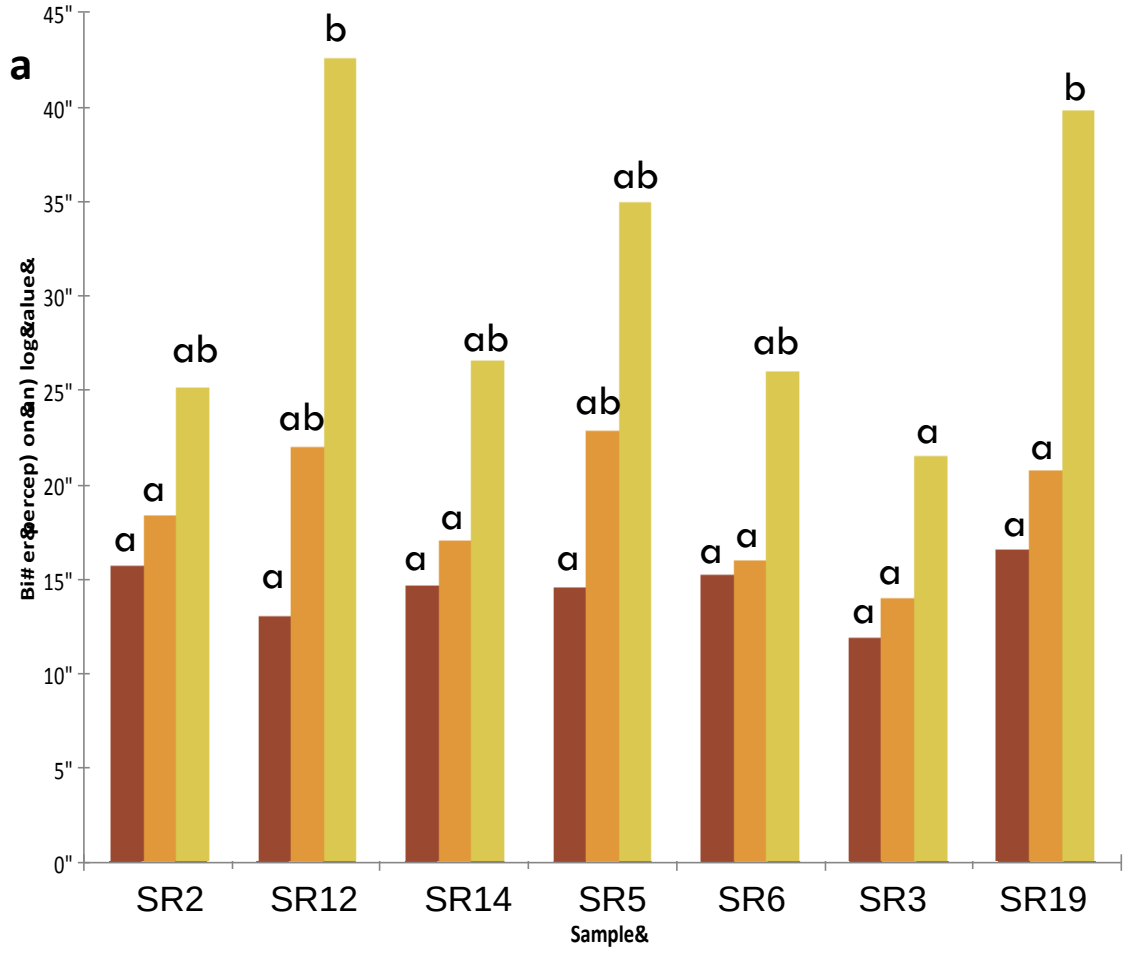
Table 1 Vegetables used for liking and bitterness intensity rating

Vegetables	Green		Non-green	
Brassica	Broccoli		White cabbage	
Non-Brassica	Spinach		Courgette (Without skin)	

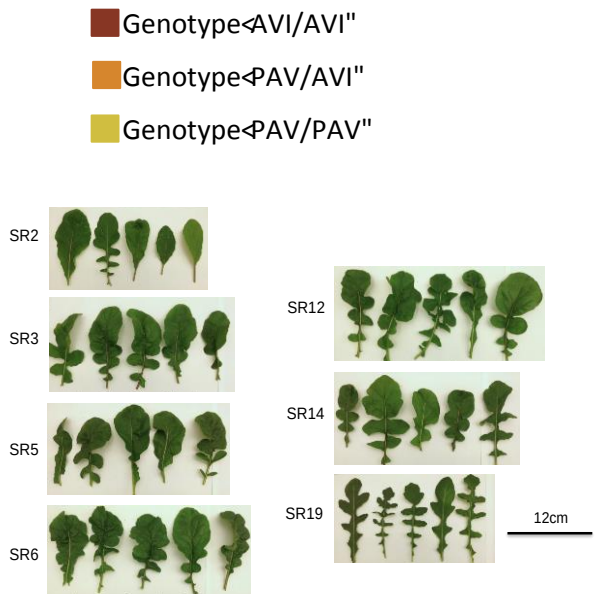
- Bitter perception differed significantly by genotype
- Only for Brassica Veg that have the **N-C=S** group



Bitter taste perception in **Rocket** accessions

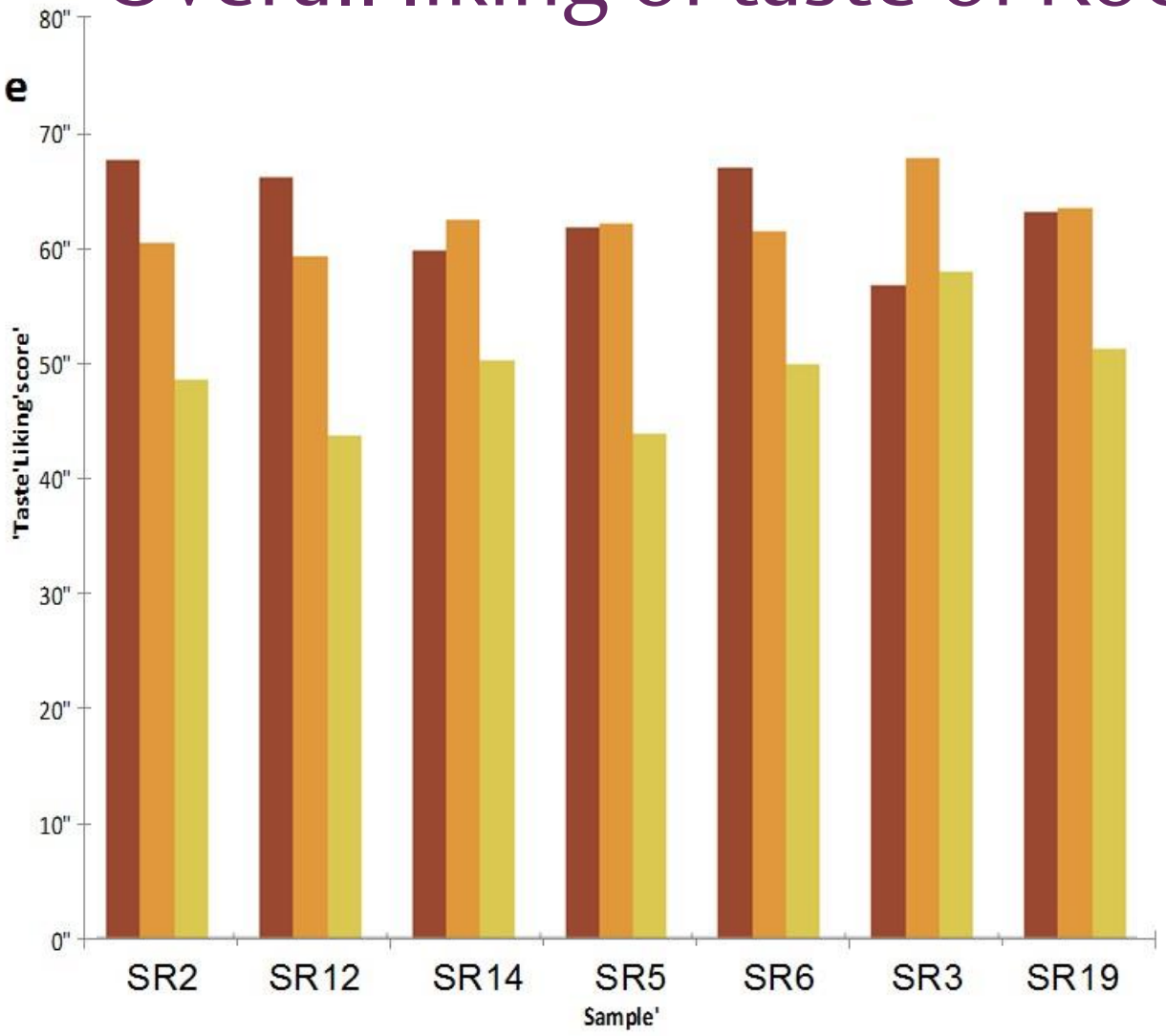


Luke Bell



Dr Lisa Methven : Dept Food & Nutritional Sciences

Overall liking of taste of Rocket lines



No significant differences
$P = >0.05$

Genotype<AVI/AVI"
Genotype<PAV/AVI"
Genotype<PAV/PAV"

Dr Lisa Methven : Dept Food & Nutritional Sciences

So, Should our Sensory Panel all be Tas2R38 PAV/PAV ?

- Most panels are screened for genetic bitter blindness
- So, they can taste bitterness in Brassica Veg
- BUT, if less sensitive to bitterness can you pick out other differences that the bitter sensitive panelist cannot ?

Sweet Taste Sensitivity

Sweet Taste Receptors

- A class C GPCR, the **T1R family**
- Two receptors involved : heterodimer between **T1R2 / T1R3.**

This responds to:

- sugars (sucrose, fructose, galactose, glucose, lactose, maltose)
- amino acids (glycine, D-trypotophan)
- sweet proteins (monellin, thaumatin)
- high potency sweeteners (eg. acesulfame K, aspartame, cyclamate, saccharin, sucralose)

The T1R2/T1R3 dimer

Class C GPCRs are composed of 3 domains:

- a large extracellular amino terminal or "N" terminal domain (ATD, NTD or"Venus flytrap" [VFD])
- a cysteine-rich domain (CRD): approx. 70 amino acids acts as a bridge
- a 7 helices transmembrane domain (7TM or TMD)
- Different sugars / sweetners can have different binding sites

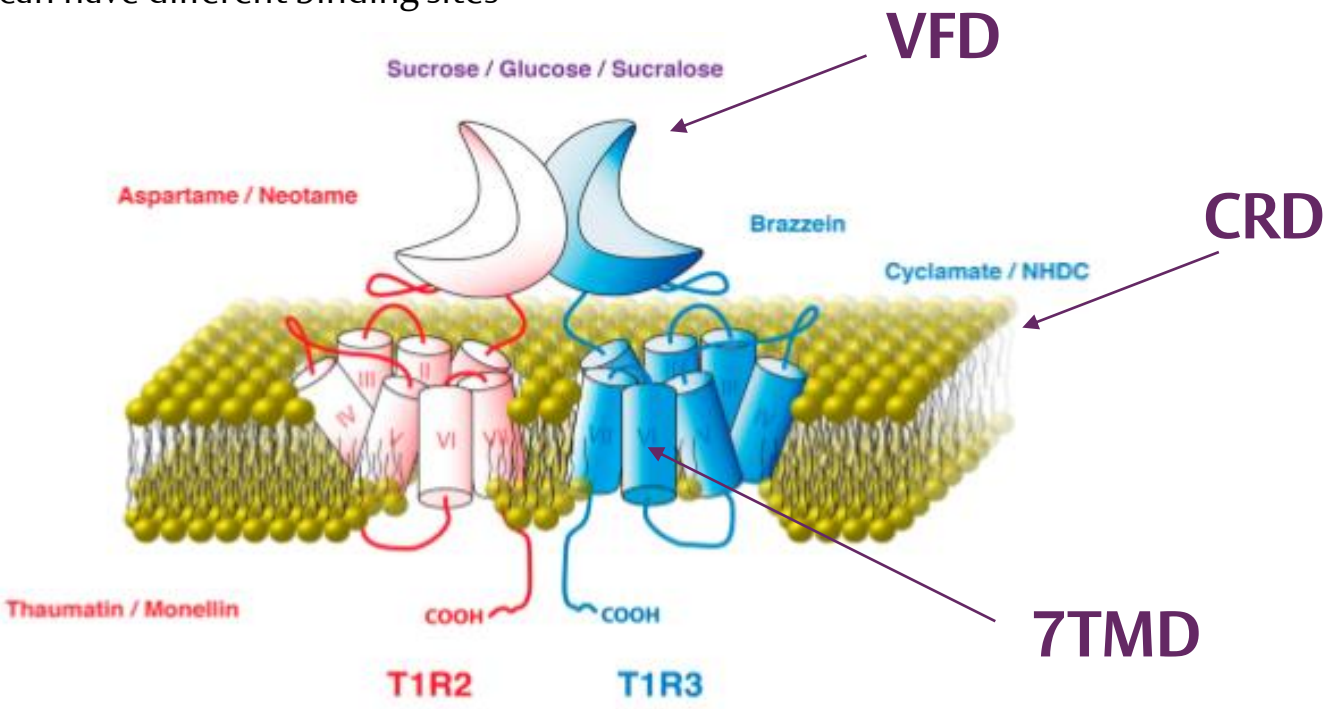


FIGURE 1 T1R2 and T1R3 and the compounds that can activate them. Font colors indicate sweet compounds that bind T1R2 (red), T1R3 (blue), or both subunits (purple). Modified from Vigues et al. (12) with permission. T1R, type 1 taste receptor.

Fernstrom et al (2012). The Journal of Nutrition, doi: 10.3945/jn.111.149567, 1S-8S

Sweet Transduction

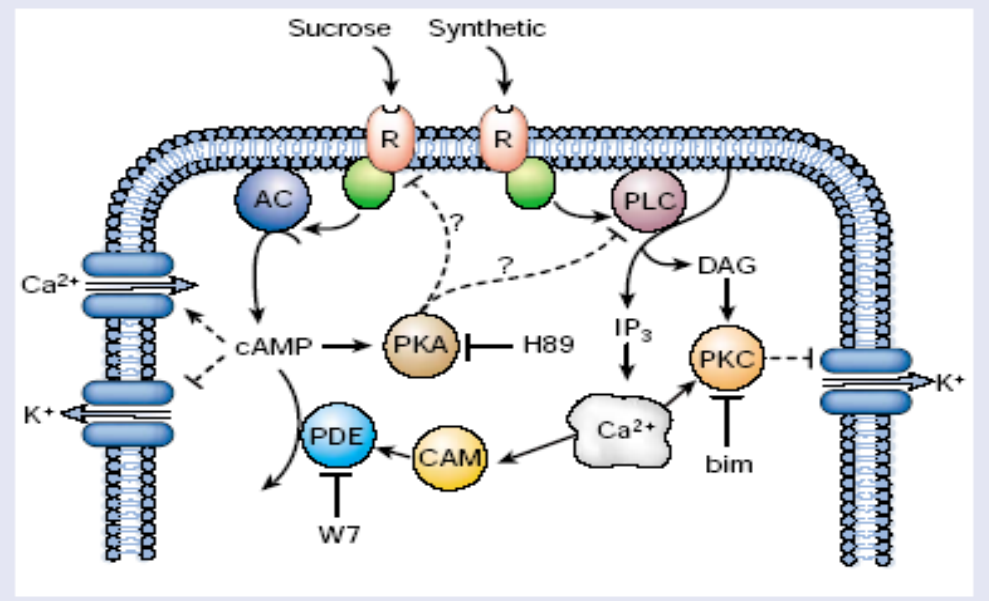
University of Reading

Sugars and sweeteners may have slightly different transduction pathways :

- **Sugars** bind to GPCR, activate G-protein which activates AC & generates cAMP. This acts directly (via ion channel) or indirectly (via activation of a protein kinase) to depolarise the cell via a release of Ca^{2+}

- **Sweetners** bind to GPCR, activate PLC generating IP_3 and DAG causing Ca^{2+} release from internal stores.

- More recently, it was concluded that signalling was more diverse (Ohtsu, 2014):
  - Sucarlose & saccahrin increased cytoplasmic Ca^{2+}
  - Acesulfame K & glycyrrhizin reduced it !



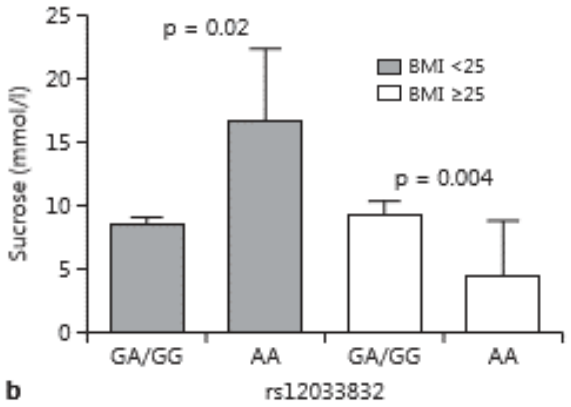
R = candidate receptor
AC = adenyl cyclase; cAMP = cyclic adenosine monophosphate
PDE = phosphodiesterase; W7 = inhiitor
CAM = calmodulin
PKA = protein kinase A; H89 = inhibitor
PLC = phospholipase C
DAG = diacylglycerol
IP_3 =inositol-1,4,5-triphosphate
PKC = protein kinase C; bim = inhibitor

Lindemann, 2001; Margolskee 2002;

Meyers 2008; Ohtsu, 2014

Variation in T1R2

- **Variants of *TAS1R2 (rs12033832)*** have been associated with sucrose perception and sugar intake (Dias, 2015), but the effects is modified by BMI.
- **Variants of *TAS1R2 (rs35874116)*** have been associated with carbohydrate intake (Ramos-Lopez, 2016)



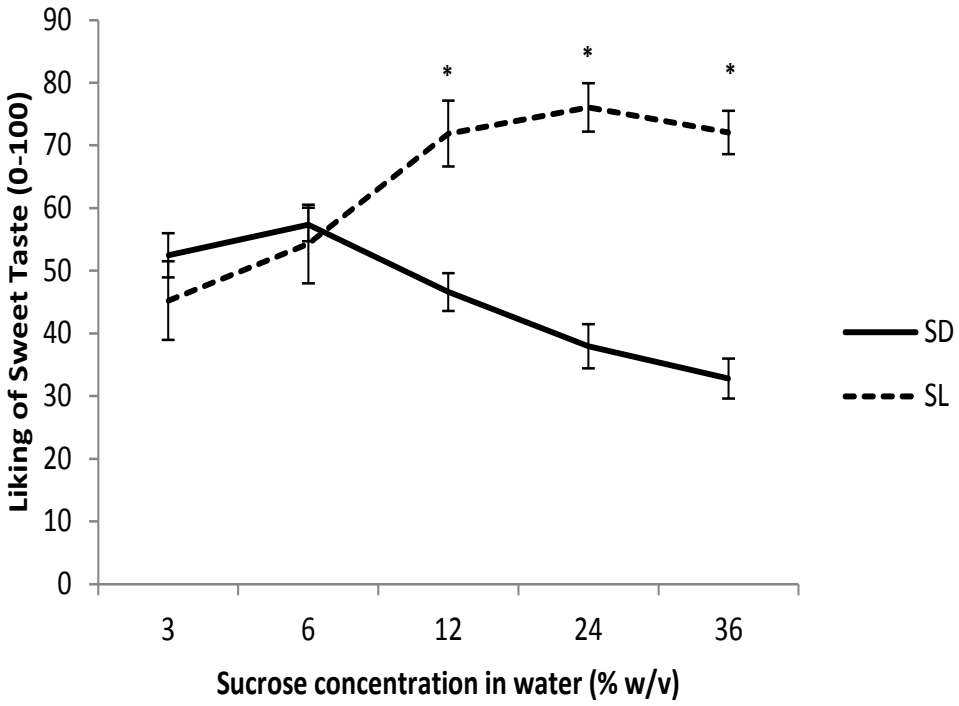
Sweet taste thresholds between individuals homozygous for the A allele and carriers of the G allele for rs12033832 SNP, stratified by BMI

	BMI <25		p	BMI ≥25		p
	GA/GG	AA		GA/GG	AA	
Subjects	494	44		152	17	
Calories	2,027±29	2,158±97	0.05	2,167±54	1,770±160	0.11
Fat, g/day	69±1	73±4	0.33	73±2	65±7	0.53
Protein, g/day	84±1	88.0±5	0.27	93±3	79±8	0.27
Carbohydrates, g/day	265±4	292±14	**0.03**	277±6	214±23	**0.03**
Total sugar, g/day	122±2	145±8	**0.004**	130±4	94±13	**0.009**
Sucrose, g/day	47±1	58±4	**0.02**	50±2	36±6	**0.008**

Dietary intake and rs12033832 genotypes stratified by BMI

Dias, et al. (2015). J Nutrigenetics & Nutrigenomics, 8(2), 81-90.
Ramos-Lopez et al. (2016) Nutrients, (8) doi:10.3390/nu8020101

Sweet Liking does Vary….



Rejection Thresholds (RjT) of Sweet Likers and Dislikers

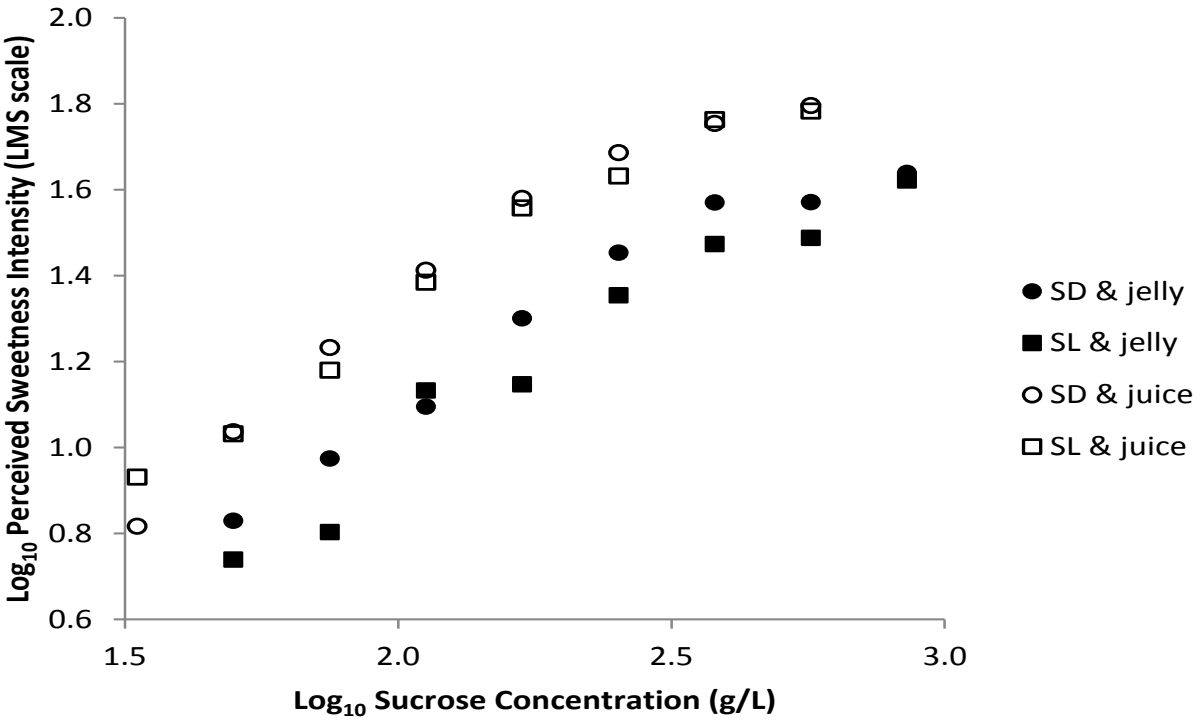
L. Methven[a*], C. Xiao[a], M. Cai[a], J. Prescott[b]

FQP, 2016

Mean liking of sweet taste for the sucrose solutions for sweet likers (SL) and "dislikers" (SD)

Everyone likes sweet taste at birth; but adults like sweet taste at very different levels

Sweet Perception in Orange Juice



Sweetness intensity as a function of sucrose concentration (Log-Log data) in orange juice and jelly

- **Matrix effects perception of sweetness**
- **SL & SD significantly different: BUT differences very small**

So, Should we screen out *TAS1R2 (rs12033832)* AA genotype?

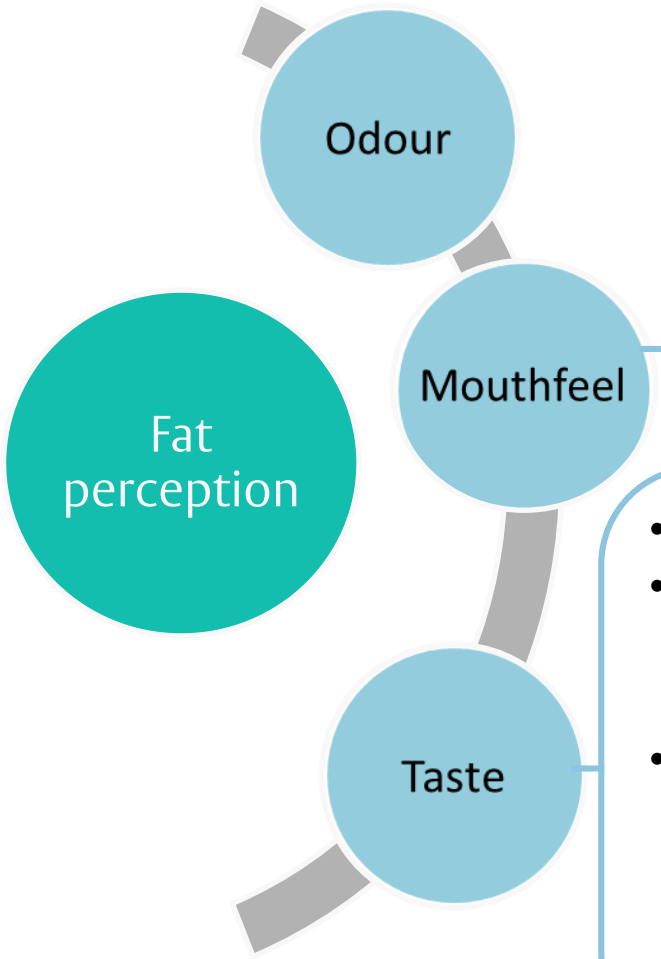
- Certainly not enough evidence to suggest this yet…and would we then have to screen on BMI as well ?

- Is screening out on genotype ethical ?
- Would screening out on BMI be ethical ?

Oleogustus : The Taste of fat

Xirui Zhou (Sherrie)

Fat perception (Xirui Zhou; Sherrie)



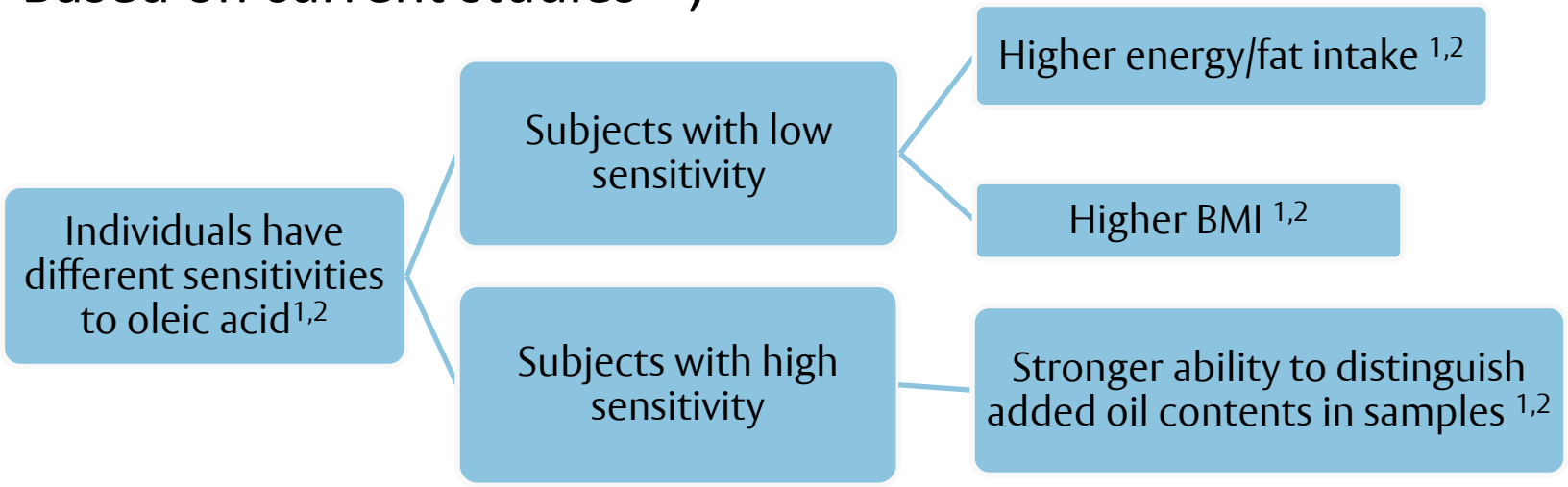
Creaminess, thickness, oiliness, etc.

- **Fatty acid:** effective stimuli in fat taste
- **Receptors:**
  - CD36
  - G protein coupled receptors
- **Transduction pathways:**
  - Delayed rectifying potassium (DRK) channels
  - Transient receptor potential type M5 (TRPM5) channels

University of Reading

Fat Sensitivity (Fatty acid sensitivity)

Based on current studies[1,2],



Potential factors causing these individual difference in fat sensitivity

- Differences in lipase activity [3,4]
- Different CD36 genotypes at rs1761667 [5,6]
- Other – e.g. differences in expression of receptors

[1] Stewart et al. (2010). *Br J Nutr, 104*(1), 145-152.
[2] Stewart, Newman, & Keast. (2011). *Clin Nutr, 30*(6), 838-844.
[3] Mounayar, et al. (2013). *Chem Percep*, 6, 118-126.
[4] Voigt, et al. (2014). J Lip Res, 55, 870–882.
[5] Melis et al, (2015). *Nutrients*, 7(3), 2068-2084.
[6] Mrizak et al, (2015). *Br J Nutr*, 1-8.

Dr Lisa Methven : Dept Food & Nutritional Sciences

University of Reading

Fat Taste: Which is most important to determine individual differences in ?

CD36 genotype	• Influences of CD36 genotype on fat perception
The effect of salivary lipase	• Analysis the amount of fatty acid produced during oral processing by using GC • Role of saliva on fatty acid sensitivity and dietary fat perception

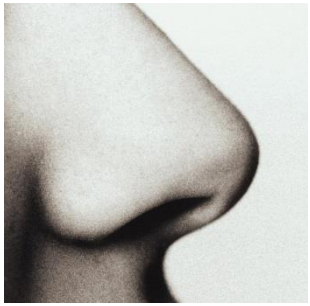
Dr Lisa Methven : Dept Food & Nutritional Sciences

So, Should we screen for fatty acid thresholds?

- Levels of free fatty acids in foods very low
- But some people producing them in mouth

- We don't know how relevant it is yet.

Olfactory Receptor Variations



- Anosmia's to certain aroma's well known: genetic causes under investigation

- Hasin et al (2008) concluded there are many OR variants

- ***OR5A1*** (rs6591536)
  - variants lead to differences in β-ionone perception (Jaeger, 2014).
  - either perceived as pleasant floral or sour/sharp.
- ***OR2J3*** (rs28757581)
  - ability to detect "grassy/green" odour of 3-hexen-1-ol (McRae, 2012).

In the future, could we screen for OR genotype rather than ability to identify a large array of aroma compounds?

How does **taste** change with age?

- We cannot recruit (or dismiss) panel on basis of age, only on ability.
- Taste does deteriorate with age but it is gradual and individual

- Meta-analysis of **23 studies**
- Consensus was that taste detection **thresholds increased** with age ($p < 0.001$) across all taste modalities.

Identification thresholds higher for older adults in 17 out of 18 studies.

16 out of 25 studies reported **perception of taste intensity at supra-threshold levels to be significantly lower** for older adults,

Methven, Allen, Withers & Gosney (2012) Ageing and Taste. *Proceeding of the Nutrition Society*, 71 (4): 556-65

BUT some mouthfeel sensations may increase with age…

- Thickness & Mouthcoating in Milk :
  - No Differences between young (YV) & old (OV)
- Milk-based **Mouth drying**
  - ➢ Heat treated rennet whey compared to skimmed milk
  - ➢ OV found whey significantly more mouthdrying than skimmed milk (p=0.03)
  - ➢ YV found no significant difference
  - ➢ **Older Adults detected mouthdrying more easily**

Withers, Gosney & Methven(2013), ***JSS*, 28(3) 230-237**

So, should we recruit older as well as younger sensory panels?

Raija-Liisa Heiniö runs a trained seniors panel at VTT

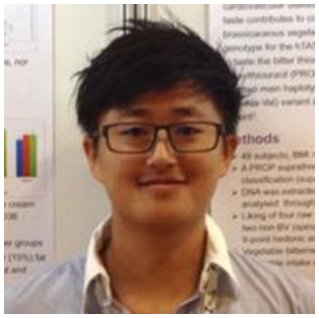
Figure 4 Members of the Senior panel trained in the project by VTT.

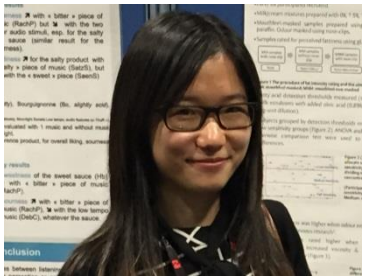
Conclusions of Personalised Sensory:

- Taste differences are not as simple as super & non taster
- There are a number of different genotypes contributing
- We have more aroma receptors than taste, and OR variants may be vast
- What is “average”, what is a “screened expert” & how relevant are they ??

Acknowledgements

- Our Volunteers
- Dr Yuchi Shen (Amber)
- Xirui Zhou (Sherrie)
- Luke Bell
- Dr Caroline Withers
- Project Students
- MMR Sensory panel





Thank you