A Monthly e Magazine
ISSN:2583-2212
Popular Article
Oct, 2023; 3(10), 2679-2685

Why cats decline sweet dish but incline to grab fish? Is it due to killer instinct or inherent gene distinct

Tapas Goswami[1]
[1]Former Scientist Emeritus (IVRI, ICAR), Presently Professor Department of Veterinary Microbiology, Institute of Veterinary Science & Animal Husbandry, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, 751030, Odisha.

Domestication of cat, wild to mild

The domestic cat is one of the most popular companion animals of human being. As per archaeological evidence, the domestication of the cat took place nearly 10000 years in ago in the Near East region on this earth (Vigne *et al*., 2004). Domestic cat and Near Eastern wildcat are about the same size and shape with too much phenotypic resemblance. House cats exhibit enough similarity to their wild felid ancestors (Felis silvestris subspp), yet Felis silvestris is aggressive and feral, whereas the house cat, is quite tamed as pet animal. From biological perspective domestic dog (Canis lupus) and house cats are classified under the Order Carnivora. In classical sense the modern cat is not fully domesticated rather considered as a semidomesticated species. We have observed cats are keen towards fish; it is not just a killer instinct of this feline. Whether it is in their gene or their intense wish to prefer fish meal is still perplexing. Scientific evidence suggest ancestors of domestic cat were desert dwellers, therefore to expect fish on their dish is unimaginable. Humans' intervention does not influence their food habit and mating choice (Driscoll *et al*., 2009). Species like carnivores, or herbivores have selective choice for their food. Mammalian tongues are studded with several copies of taste receptors that act as sensor to receive the signals from food elements consequently the signal is transmitted to brain either to accept it as appetizing or to refute those as nonpalatable. Critical difference in the amino acid sequence of their taste receptor decides the preference of binding with certain chemical substances like amino acids and nucleotide available in their food (Toda *et al*., 2021). Obviously, question arise how and why cat has been domesticated: most of the domestic species like cattle, sheep, goat and pig, horse

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published: **28.10.2023**

donkeys were domesticated either for food or transport but cat never comes in this category. Archaeological evidence and anthropological clues suggest once ancient nomadic human ceased hunting practice and preferred to settle with farming for growing grains as their food, association of cat with humans was the beginning as a commensal, feeding on the rodent pests that infested their grain stores (Clutton-Brock 1999). At present situation traditional role of cat as a rodent controller is not in practice. Domestic cats' descendants were transported across the world by human assistance. According to Cat Fanciers' Association total 41 breeds has been recognized as natural breeds (Wastlhuber 1991). All the available breeds of domestic animals on the earth are generated by selective breeding with a purpose for food, hunting, or security whereas cat breeds are due to selective breeding for aesthetic reason. Now scientists are involved in tracing the genetic changes that drove this remarkable transformation in their behaviour.

Not to eat sweet

A recent study of genomic analysis reveals that dogs and humans walked similar evolutionary paths however domestication shaped the diet of the dog therefore dog has evolved to eat more varied diet than their wolf ancestors. Genome sequencing data derived from 22 domestic cats from different location when compared with two Near Eastern and two Near European wild cats revealed alteration of 13 gene made the cat from feral to friendly. Surprisingly 30 copies of gene for amylase an enzyme that can break down starch has been detected in the intestine of dog and only two in wolves (Axelsson *et al*., 2013). Cats are obligately carnivorous and only mammalian species unable to synthesize arachidonic acid, due to lack of Delta-6-desaturase (D6D) activity in their intestine, however it can use an alternate yet unknow pathway to synthesize these essential fatty acids to support normal health and reproduction (Bauer 2006). Despite long association of dog and cat with human population there is marked contrast towards the avidity for sweet taste. Mammalian sweet-taste receptor is formed by the dimerization of two proteins. Tas1r receptors that can sense the sweet and umami taste in human and other mammalian species comprises of three members of receptor proteins, those are Tas1r1, Tas1r2 and Tas1r3. To be functional these protein receptors act in a heterodimeric combination; for umami taste Tas1r1 and Tas1r3 act as heterodimer whereas mammalian sweet receptor is a heterodimeric combination of Tas1r2 and Tas1r3 (Li *et al*., 2002). Respective genes for these proteins are written in italic *Tas1r2* and *Tas1r3*. Most recently during August 2023 scientific group from Monell Chemical Senses Center, Philadelphia along with Waltham Centre for Pet Nutrition, UK has reported that taste receptors of cat can detect umami; the savoury or meaty taste, but reluctant and refractile towards sweet because felines have very low levels of the enzymes that break down sugars (McGrane *et al.,* 2023). Unlike dog which prefer natural sugars e.g., sucrose, glucose, fructose, and lactose, but not maltose, domestic cats (Felis silvestris catus) although having functional sense of taste, they are uninterested toward, sweet sugars and sweeteners (Ferrell 1984). Contrast to this behaviour, cats exhibit normal taste modalities for other compounds as well as preference for selected amino acids (White and Boudreau 1975). Scientists are still blind to find the exact reason of sweet blindness however amino acids substitution in taste receptors in cat may be the possible reason. Possibility of deletion of gene coding for sweet receptor can't be ruled out as sweet ''*taster*'' and ''*nontaster*'' strains of mice has been reported earlier (Max *et al*., 2001). To explore the reason behind deficit character, researchers have claimed to blame few genes which they have not seen in felines. In 2005 scientific groups from Monell Chemical Senses Center in Philadelphia, Pennsylvania headed by biophysicist Joseph Brand, while initiated screening the DNA sequences of the two known genes *Tas1r2 and Tas1r3* encode for the sweet receptor heteromeric protein Tas1r2 and Tas1r3 (also written as T1R2/T1R3) in dogs, humans, mice, and rats, surprisingly a stretch of 240 base pair of nucleotides in *Tas1r2* gene was found to be missing only in feline but not in any other species. Simply due to missing nucleotide in *Tas1r2* gene the functional sweet receptor in taste papillae of cat is not expressed. Nucleotide depleted gene (a pseudogene) of feline does not code for a functional receptor protein thereby prevents cats from tasting sweets. Practically cat family never regain the sweet receptor gene in its life time due to permanent deletion of a chunk of nucleotide in sweet receptor gene (Li *et al.*, 2005). Sweet receptor is also not expressed in tiger and cheetah due to nucleotide deletion in *Tas1r2* gene in these species. It is undefined why and when such deletion has occurred during evolution process in animal species. Possible explanation is that the cats being strict carnivorous they never get a chance to encounter sweet diet, whereas the presence of proteins and amino acids enriched food in their prey has made their sensory taste buds to be exposed more frequently to meaty diet in their life (Lei *et al.*, 2015). As compare to human, cats have less bitter taste receptors, similarly lack of sodium appetite has been observed and null effect was recorded with sodium-repleted or depleted diet in cat (Lei *et al*., 2015). Screening the gene pool of cat, it has been established that certain genes are responsible for umami taste perception with an obligate craving for meat. Once given a choice cat are too selective for high protein and high fat with umami taste but not carbohydrate in their diet (Salaun *et al*., 2017). Taste of foods are perceived under five categories those are *sweet, sour, bitter, salty and umami,* each of these is recognised by specific receptor. Additionally, few other "secondary" tastes such as fat taste, metallic taste, astringency and kokumi are also recognised by sensory taste receptors (Laffitte *et al*., 2021). In 1908 Professor Kikunae Ikeda from Imperial University of Tokyo described the term umami a delicious savoury taste derived from glutamic acid. The time line of discovery of umami taste receptors goes back to 1856 (Fig-1). Primarily glutamic acids and its salt, nucleotide such as inosine-5’-monophosphate (IMP), and guanylo-5’- monophosphate (GMP) is found to be of umami taste (Stańska and Krzeski 2016). The taste buds of cats have several copies of umami receptors; the umami receptor respond to nearly 11 amino acids in combination with nucleotide.

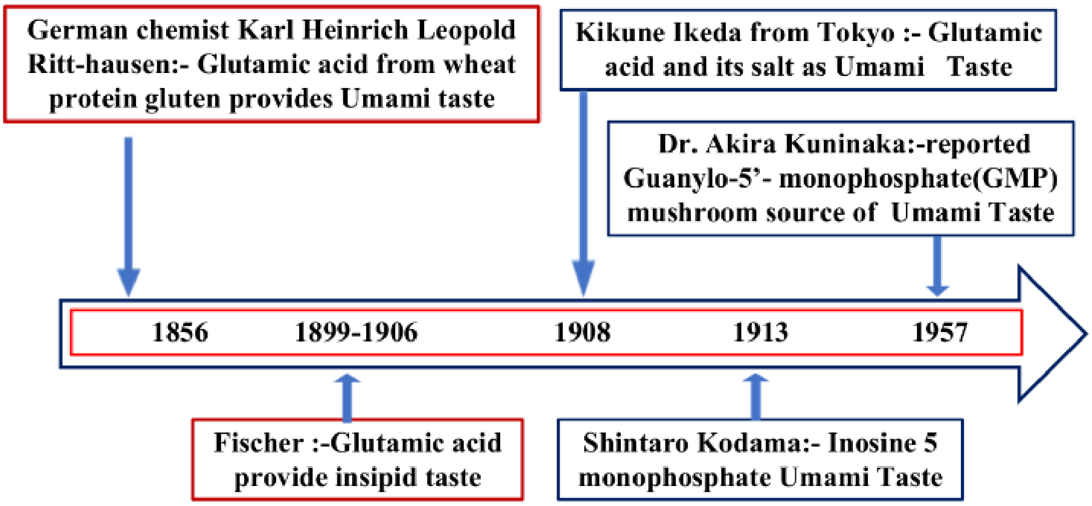

Fig-1- Time line of umami taste discovery

Keen for fish: gene or wish.

Cat shows intense affinity for fish and specifically tuna is the best choice in their dish. Among salt water fish Tuna is grouped under family Thunnini, genus *Thunnus* comprised of fifteen species. These are the only partially warm-blooded fish on earth. Any isolated or individual amino acids alone never exhibit preferential binding with umami receptor of cat, however, L-amino acids in combination with a nucleotide act as enhancers. Within nucleotides purine nucleotide is superior in binding with umami receptor of cats. It is now clear enough that L-Glutamic acid and L-Aspartic acid having umami taste not act as inducer (agonist) for the umami receptor in cat as there is subtle change of amino acids at 170-302 position the key binding site for ligand (McGrane *et al*., 2023). Response variability of umami receptor of mammalian species is not uncommon; sharp response towards glutamic acid and feeble response for aspartic acid is normally observed in human (Li *et al.*, 2002), whereas acidic amino acids have shown blunt response towards mice, contrary to it mice respond well to numerous other amino acids (Nelson *et al*., 2002). Recently during 2021 functional expression study has confirmed that purine nucleotide inosine 5’-monophosphate (IMP) and guanosine 5’-monophosphate (GMP) can

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published: 28.10.2023

strongly induce umami receptor of cat but L glutamic acid has shown inertia (Toda *et al*., 2021). Interestingly the functionality of umami taste receptor in man and cat although exhibit similarity but there is a whirling: in human the amino acid activates the receptor and nucleotide escalate the activity but in cat it is just opposite. Further investigation has pointed out the preference of cat towards food rich in histidine amino acids and inosine monophosphate nucleotide (IMP); the tuna is one such fish having plenty of these two, is an appetiser for cat. Using synthetic peptide approach to create artificial taste receptor of cat, the degree of binding affinity of taste receptors towards amino acids and nucleotide revealed the high intensity of binding by four amino acids (L-Alanine, L-Arginine, L-Histidine, and L-Isoleucine, (Fig-2) but cysteine failed to bind. Role of nucleotide inosine 5′-monophosphate (IMP) as a potentiator of L-amino acid binding has been confirmed. While screening individual nucleotides the purine nucleotides were found to be agonist for binding with taste receptor but pyrimidine nucleotides (CMP and UMP) were dull in this aspect. Among amino acids L-histidine acts as an enhancer of the cat umami receptor in combination with IMP (McGrane *et al*., 2023).

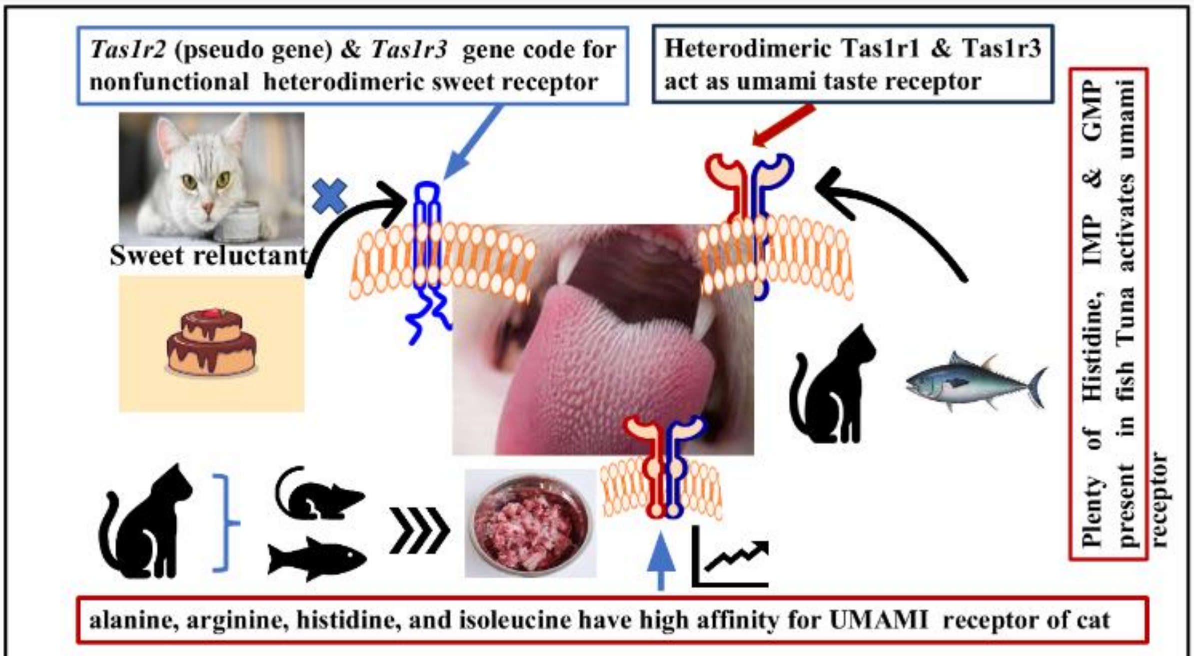

Fig-2. Activation of sweet receptor and umami receptor of cat

Conclusion

Now question arise is there any significant output from this finding? To summarize the research reports, it has shown insight of sensory world of cat for its taste receptors. To be realistic the findings will narrow down the preference of cat for selective diets having protein and fat contents rather than carbohydrate in pet food. Even though we know cats are unable to adjust sugar yet several ready to use marketable cat food contain rice or other grains as source of carbohydrate to an extent of 20% in their composition, that may be the reason of more diabetes in domestic cats. The present information can be used by pet food manufacturer for scientific formulation of palatable diets for cats. Similarly, adding umami taste in oral medicine for feline can be easily administered without much brawl. It is an added advantages for veterinarian to manage the feline species in captivity.

References

Axelsson E, Ratnakumar A, Arendt M L, Maqbool K, Webster M T, Perloski M *et al.*, (2013). The genomic signature of dog domestication reveals adaptation to a starch-rich diet. *Nature.* 495(7441): 360–364.

Bauer J E (2006), Metabolic basis for the essential nature of fatty acids and the unique dietary fatty acid requirements of cats. *J Am Vet Med Assoc*. 229(11) 1729–1732.

Clutton-Brock J. A (1999) Natural History of Domesticated Mammals. 2nd ed. Cambridge University Press, Cambridge. 238 pp. ISBN 0-521-63495-4

Driscoll C A, Macdonald D W, O'Brien, S J (2009). "From wild animals to domestic pets, an evolutionary view of domestication. *Proc Natl Acad Sci USA*" 106 Suppl.1(Suppl.1): 9971-8. doi: 10.1073/pnas.0901586106

Ferrell F. (1984) "Preference for sugars and nonnutritive sweeteners in young beagles." *Neurosci Biobehav Rev*. 8(2): 199-203. doi:10.1016/0149-7634(84)90041-1

Laffitte A, Gibbs M, Hernangomez de Alvaro C. et al. (2021). Kokumi taste perception is functional in a model carnivore, the domestic cat (Felis catus). *Sci Rep* (11): 10527. doi:10.1038/s41598-021-89558-w

Lei W, Ravoninjohary A, Li X, Margolskee R F., Reed, D.R., Beauchamp, G.K., and Jiang, P.(2015). Functional analyses of bitter taste receptors in domestic cats (Felis catus). *PLoS One*. 10: 10 e0139670. doi: 10.1371/journal.pone.0139670

Li X, Li W, Wang H, Cao J, Maehashi K, Huang L, Bachmanov A A, Reed D R, Legrand-Defretin V, Beauchamp G K, Brand J G (2005)."Pseudogenization of a sweet-receptor gene accounts for cats' indifference toward sugar." *PLoS genetics* 1(1):27-35. doi: 10.1371/journal.pgen.0010003.

Li X, Staszewski L, Xu H, Durick K, Zoller M, Adler E (2002). Human receptors for sweet and umami taste. *Proc Natl Acad Sci* USA. 99(7):4692–4696. doi: 10.1073/pnas.072090199.

Max M, Shanker YG, Huang L, Rong M, Liu Z, et al. (2001) Tas1r3, encoding a new candidate taste receptor, is allelic to the sweet responsiveness locus Sac. *Nat Genet* 28(1): 58–63. doi: 10.1038/ng0501-58.

McGrane S J, Gibbs M, de Alvaro C H, Dunlop N, Winnig M, Klebansky B, Waller D (2023). Umami taste perception and preferences of the domestic cat (Felis catus), an obligate carnivore, *Chemical. Senses*, 48,1-17. doi: 10.1093/chemse/bjad026

Nelson G, Chandrashekar J, Hoon MA, Feng L, Zhao G, Ryba NJP, Zuker CS (2002). An amino-acid taste receptor. *Nature*. 416(6877):199-202. doi: 10.1038/nature726.

Salaun F, Blanchard G, Le Paih L, Roberti F, Niceron C (2017). Impact of macronutrient composition and palatability in wet diets on food selection in cats. *J Anim Physiol Anim Nutr* (Berl). 101(2):320-328. doi: 10.1111/jpn.12542.

Stańska K, and Krzeski A. (2016) "The umami taste: from discovery to clinical use." Otolaryngol Pol. The Polish otolaryngology 70(4): F0-5. doi:10.5604/00306657.1199991

Toda Y, Hayakawa T, Itoigawa A, Kurihara Y, Nakagita T, Hayashi M, Ashino R, Melin AD, Ishimaru Y, Kawamura S, et al(2021). Evolution of the primate glutamate taste sensor from a nucleotide sensor. *Curr Biol*. 31(20):4675-4676. doi: 10.1016/j.cub.2021.09.079

Vigne J D, Guilaine J, Debue K , Haye L , Gerard P (2004). Early taming of the cat in Cyprus.

Science, 304(5668):259. doi: 10.1126/science.1095335

Wastlhuber J (1991). In: History of domestic cats and cat breeds. Pedersen NC, editor. Feline Husbandry, *American Veterinary Publications*, Inc.; Goleta, CA, USA:. pp. 1–59

White TD, Boudreau JC (1975) Taste preferences of the cat for neurophysiologically active compounds. *Physiological Psychology*. 3(4): 405–410