Nestlé
Good Food, Good Life

The science behind the savoury taste

Flavour and taste compounds have always been part of our daily diet

Flavour and taste compounds have been part of our daily diet since mankind has begun heating and processing foods. These compounds are produced naturally through for example thermal treatment such as cooking, baking, grilling, toasting, but also during fermentation and hydrolysis processes. We make use of such practices when we cook food in the home, or during the industrial preparation of foods. These reactions are pivotal, contributing to food preservation, and making food more palatable, digestible, nutritious and safe.

We distinguish between five taste modalities with distinct taste receptors associated to them, e.g. sweet, bitter, sour, salty, and umami. From the evolutionary perspective, they play an important role through nutrient-sensing and health-protective mechanisms that have influenced human behavior ever since (Efeyan et al., 2015; Yamaguchi & Ninomiya, 1998):

1. Sweet taste to provide energy (source: carbohydrates such as starch)
2. Bitterness to mitigate risk of ingesting toxic compounds from diverse fruits, plants, etc.
3. Sourness to alert against microbiological contamination (food safety)
4. Saltiness to provide essential minerals required for physiological functions
5. Umami to ensure nutritional balance (source: proteins for amino acids, in particular the essential ones that cannot be biosynthesized)

Hence, taste has always played, and today still does, an important function in human development.

The fifth taste termed umami is an integral part of savoury contributing to the taste dimension along with salty. There is a synergy observed between salt and umami taste (Halpern, 2000), meaning that one can reduce salt by umami compounds (and vice versa). However, equally important is the savoury aroma to obtain a full savoury perception.

A R&D powerhouse fueling consumer benefits and needs

Nestlé's direct access to world class research in the field of taste and flavor generation has resulted in many breakthroughs in the deeper understanding of the flavor sciences, harnessing the benefits of natural flavor reactions and translating these into consumers' benefits. Our extensive product portfolio in the culinary area reflects a deep understanding of the science behind developing and constantly improving techniques and recipes. In fact, our scientists extensively publish on taste and flavor research, that has over the years resulted in more than 50 peer reviewed scientific publications and contributions, also working in partnership with academic research organizations and world renowned universities to extend our knowledge in the field of flavor and aroma formation.

Nestlé R&D is constantly seeking new natural approaches to unlock the potential of raw materials resulting in tastier and healthier products. This may be achieved by for example using raw materials rich in proteins naturally containing glutamate such as wheat, soy, seaweed, groundnut, etc.

Proteins can also be hydrolysed through fermentation processes (e.g. Koji, Moromi), known for decades in many traditional food preparations such as hydrolysed soy protein to produce soy sauce, hydrolysed fish/seafood to produce fish and oyster sauce, hydrolysed beans to produce Soumbara, and others yielding a free glutamate concentration of up to 1300 mg / 100 g (1.3 %) (Hajeb & Jinap, 2015; Yoshida, 1998). Hydrolysis done by fermentation not only leads to tastier products but may also add further benefits, e.g. food safety by lowering the acidity (pH), at the same time providing a more balanced profile (mouthfeel) and generating other health beneficial components (e.g. fibres).

The cooking of foods that naturally contain glutamate results in Maillard reaction products (called Amadori compounds), that also elicit a glutamate taste. The natural building blocks, carbohydrates and smaller peptides, contribute to the umami taste of a savoury cooked or fermented dish by delivering taste-active glycoconjugates.

The role of glutamate - a natural amino acid – in taste creation

Glutamic acid is one of the most abundant and important amino acids of proteins, and is thus found in all protein-containing foods. Glutamate is the salt of glutamic acid, and occurs naturally in protein-containing foods such as cheese, milk, mushrooms, meat, fish and many vegetables. Alternatively, glutamate also occurs bound in protein chains, and is liberated together with other amino acids upon hydrolysis of the protein. The natural flavor-enhancing levels of glutamate in food varies greatly, but is high in foods such as tomatoes, mushrooms, soy sauce, fish sauce and parmesan cheese.

Monosodium glutamate, abbreviated as MSG, was discovered more than a century ago by the Japanese scientist Kikunae Ikeda (1909), who termed this unique taste “umami”, the fifth taste beside sweet, sour, salty and bitter. MSG is simply the sodium salt of glutamate, i.e. comprised of nothing more than sodium and glutamate. Various other salts of glutamate also exist such as for example ammonium glutamate and potassium glutamate.

It is not possible to distinguish added glutamate or naturally occurring glutamate, because it's the same substance. When MSG is added to foods, it provides the same flavoring function (in simple terms described as savoury) as the glutamate that occurs naturally in foods. Today, MSG is mostly produced by a natural fermentation process that has been used for centuries to make such common foods as beer, vinegar and yogurt.

Despite more than a century of safe use of MSG, there have been concerns raised in the past due to the contribution of MSG to sodium intake via the diet. MSG contains only about one-third the amount of sodium as table salt (13 percent vs. 40 percent) and is used in much smaller amounts. When used in combination with a small amount of table salt, MSG can help reduce the total amount of sodium in a recipe by 20 to 40%, while maintaining an enhanced flavor. The level of free glutamate for example in Maggi noodles is around 0.2 g /100g, which is close to the average level of free glutamate measured in green peas (Yoshida, 1998) . The level of bound glutamic acid in lentils is approximately 4.2 g /100g (Bhatty et al., 1976).

Nutrient-sensing mechanisms

Humans must obtain energy and nutrients from external organic sources. Predicting the nutritional value of food before digestion allows for the accurate selection of food sources and for the anticipation of increased nutrient abundance. A fundamental nutrient-sensing event occurs at the level of the oral taste buds. Nutrient sensing by taste receptors is a means of sensing extracellular nutrients, however it is also a sensing mechanism that allows the interrogation of prospective food sources. In humans, taste is generated by signals elicited in taste buds, groups of cells in the tongue. Within these cells, the taste receptors are exposed in the apical membrane oriented towards the environment.

Interestingly, humans have specific taste buds in the oral cavity for umami, known as T1R1–T1R3, that bind free glutamate when food enters the mouth eliciting the umami taste that is very much appreciated in savoury dishes. In general, a taste receptor facilitates the sensation of taste, which is valid for all basic taste modalities (sweet, sour, bitter, salty, and umami).

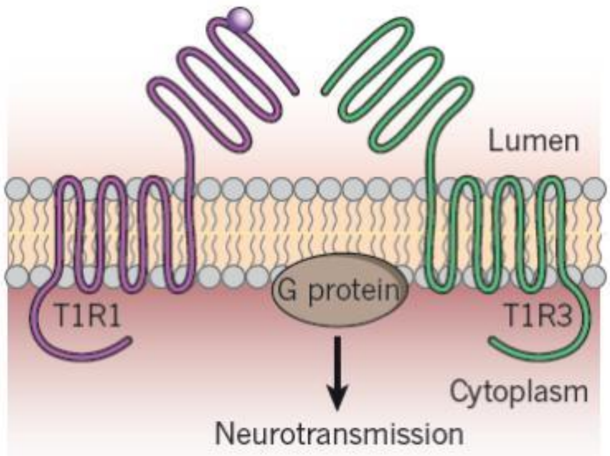
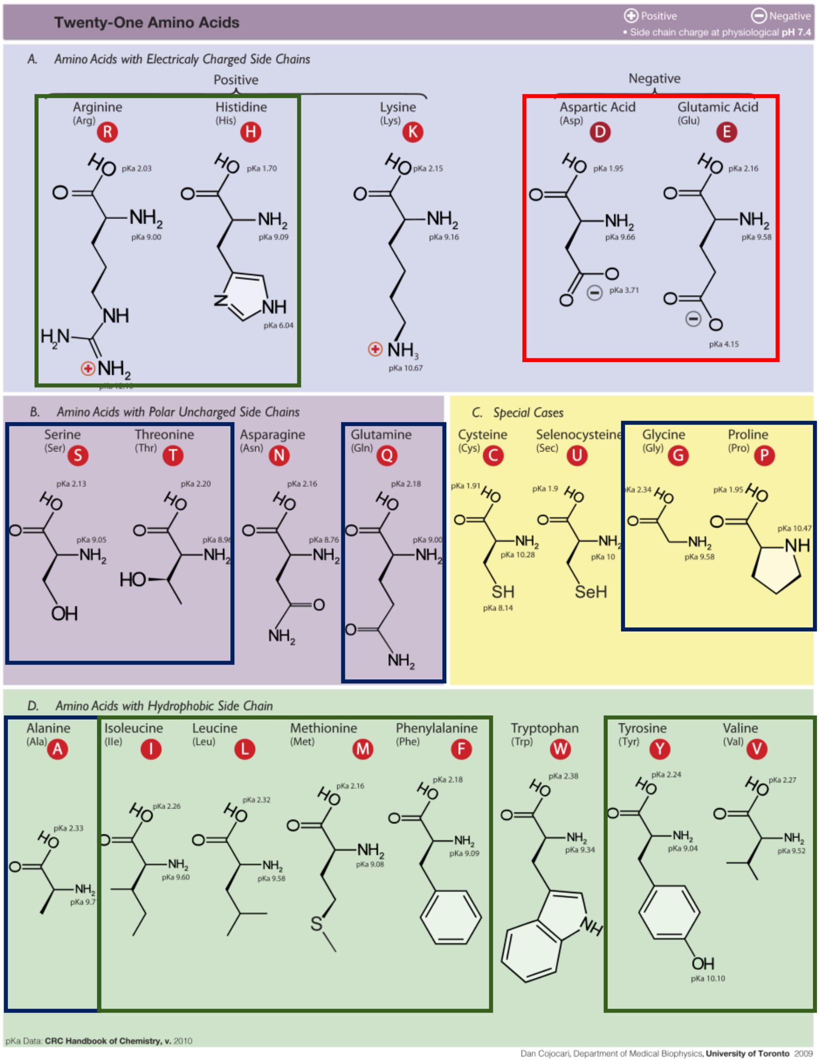


Figure 1: Sensing of amino acids by oral taste receptors (Efeyan et al., 2015).

Taste receptors belong to the T1R and T2R families of G-protein-coupled receptors. The two T1R family members are responsible for sensing the presence of amino acids (the umami taste) (Efeyan et al., 2015).

Human amino-acid taste receptors have a particularly high affinity to glutamate, but other L-amino acids also serve as ligands. Moreover, some of the other amino acids are perceived as sweet or bitter (Figure 2).



Taste active amino acids

Umami and sour:

- Glutamate, aspartic acid

Sweet:

- Glycine, alanine, threonine, proline, serine, glutamine

Bitter:

- Phenylalanine, tyrosine, arginine, leucine, isoleucine, valine, methionine, histidine

Figure 2: Overview of taste active amino acids

Dietary exposure and synthesis of glutamate in the body

Independent studies have shown that the total daily dietary glutamate intake (free or bound) is in the range 8 – 20 g. In comparison, the daily intake of added glutamate is around 10-fold lower, i.e. 0.5 -1 g. This amount of added glutamate is the same as adding 28 – 42 g of parmesan cheese (Yoshida, 1998; Nicholas & Jones, 1991).

Glutamate is also produced by the human body, and is vital for metabolism and brain function. In fact, glutamate is the most abundant free amino acid in the human brain, and plays an important part in neuronal differentiation, synaptic maintenance and plasticity, contributing to learning and memory. As well as being a key neurotransmitter in the brain, glutamate supplies the amino group for the biosynthesis of other amino acids, and is an important energy source for tissues.

The human body treats glutamate that is added to foods in the form of MSG the same as the natural glutamate found in food. For instance, the body does not distinguish between free glutamate from tomatoes, cheese or mushrooms and the glutamate from MSG added to foods. Glutamate is glutamate, whether naturally present or from MSG.

International scientific bodies, such as the joint FAO/WHO Expert Committee on Food Additives (JECFA), and the former European Scientific Committee on Food (SCF), all concluded that the total intake of glutamate, at levels consumed in food, is not a hazard to health (JECFA, 1998; SCF, 1991; Walker & Lupien, 2000).

The Tables below (1 and 2) show published levels of glutamate (bound and free)/ MSG in selected raw materials and prepared foods (Yoshida, 1998; Nicholas & Jones, 1991; Yamaguchi & Ninomiya, 1998; Jinap & Hajeb, 2010).

Table 1: Free and bound glutamic acid in foods

Food type	Free glutamic acid (mg/100 g)	Bound glutamic acid (mg/100 g)
Green peas	200	5583
Lentils	120	4200
Tomatoes	246	238
Onions	18	208
Shiitake mushroom	71	--
Parmesan cheese	1200	9847
Emmenthaler cheese	308	--
Beef	33	2846
Duck	69	3636
Eggs	23	1583
Kelp (seaweed)	1608	--

Table 2: MSG levels in prepared foods

Food type	Free glutamic acid (mg/100 g)
Savoury spread	1960
Hydrolysed soy protein (soy sauce)	412-1264
Hydrolysed fish (fish sauce)	950-1383
Hydrolysed locust beans (soumbara)	1700
Hydrolyzed vegetable protein (HVP, HPP)	6000
Italian restaurant meals	10-230
Chinese restaurant meals	< 10-1500
Western restaurant meals	< 10-710
Condensed soups	0-480
Sauces, mixes, seasonings	20-1900

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