

## Hot and Spicy: Capsaicin

Krisztina Pálma Szabó  
arabellaantique@freemail.hu

### Introduction

Capsaicin (8-Methyl-*N*-vanillyl-*trans*-6-nonenamide, see Fig. 1.) is the well-known active component of chili peppers or hot paprikas (*Capsicum annuum*) [1].

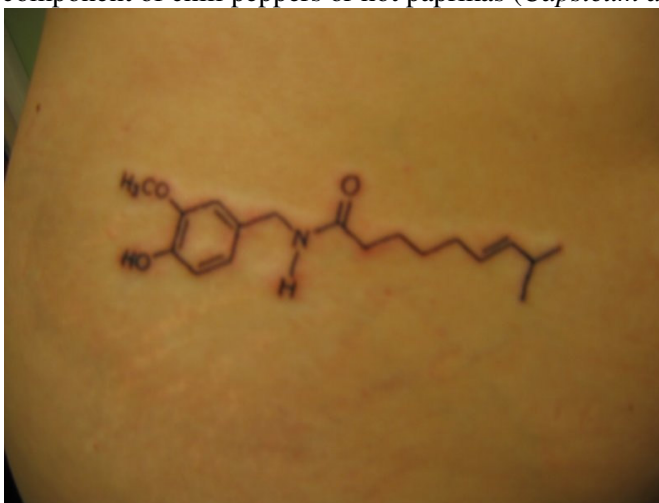


Fig. 1. “My capsaicin tattoo on my hip. I’m a food scientist.” [2]

The so-called Scoville Scale measures the heat of paprika species [3]. The method of testing a pepper’s pungency (spicy heat) units invented by Wilbur Scoville in 1912. Mr. Scoville determined his test results by taking the extracts of many types of chili peppers and diluting them in a sugared water solution until none of the heat remained. The testing was accomplished by a panel of 5 “judges” who would taste these solutions and then tell Mr. Scoville when they no longer felt any heat. This testing was very subjective thus the results were not really consistent. The hottest naturally grown pepper is Trinidad Moruga Scorpion [4] that is characterized by 15000 000-22000 000 Scoville heat units (SHU), why the earlier „gold medalist”, Bhut Jolokia or Naga Jolokia (Ghost Chilli Pepper), with „just” 855000-1460000. Jalapeño pepper, Guajillo pepper, New Mexican varieties of Anaheim pepper and paprika (Hungarian wax pepper) are characterized by 2500-8000 SHU.

Not many spectrophotometric methods are known for the quantitative measurement of capsaicin. An interesting method was developed by Davis et al [5] for the UV spectrophotometric determination of capsacinoids in Habanero peppers (*Capsicum chinense*) with the aid of chemometric analysis. The main advantage of this method is that it does not require prior separation of the components. Instead, the two major capsaicinoids (capsaicin and dihydrocapsaicin) were determined from the UV absorption spectral data obtained on alcoholic extracts of habanero peppers.

However, extraction, purification and spectroscopic characterization of capsaicinoids [6] can be embedded in practical education in the laboratory.

But what is the reason of capsaicin synthesis in chili? Tewksbury and Nabhan [7] found a possible explanation for the survival of hot chili species in nature. It was found that areas with the greatest number of fruit-eating insects had hotter chili peppers than other areas. He also found that although capsaicin did not bother insects nibbling on the peppers' flesh, it did inhibit a fungus that feeds on the seeds of chili peppers that have been scarred by insects. Thus, the capsaicin serves as a chemical weapon that helps the seeds survive intact for dispersal by fruit-eating birds, which are insensitive to capsaicin. „Wild chillies thus seem to be consumed exclusively by birds and avoided by small mammals.”

Capsaicin exhibits different types of biological activity [8]. The consumption of peppers can increase circulation and thus lowering blood pressure. Hot peppers can reduce the symptoms of the flu (by promoting sweating) and opening clogged breathing passages, which functions as an effective expectorant. Chili peppers promote endorphin production, and endorphins are natural opiates. Thus, chili can help to fight against depression. And the most well-known activity of this compound is creams containing capsaicin can also calm joint inflammation and reduce muscle pain.



Fig. 2. Paprika cultivation tradition in Hungary: a few reference books

Capsaicin is also an excellent antifungal agent. Martini et al. [9] suggested to grafting capsaicin onto cellulose using polycarboxylic acid as linking agent in order to obtain a new kind of „smart” material. The reaction between cellulose and capsaicin was observed by FT-IR and UV/Vis spectroscopy. Fungal growth inhibition test with two different fungi, *Trametes versicolor* and *Gloeophyllum trabeum* showed that modified cellulose with <2 wt% of capsaicin exhibits increased antifungal activity with respect to untreated cellulose.

The relationship between the molecular structure and the biological activity of active compounds is often studied by different theoretical modelling methods. In case of capsaicin, structure activity relationship studies were also carried out. A

good example when the analgesic potency of the discussed compound was modeled by Wrigglesworth et al [10]. After providing a possible explanation for the poor pharmacokinetic profile of this molecule, specific modification of the phenol group led to possibly more effective derivatives. Xue et al [11] summarized the results of different structure-activity relationship studies on capsaicin and its analogues.

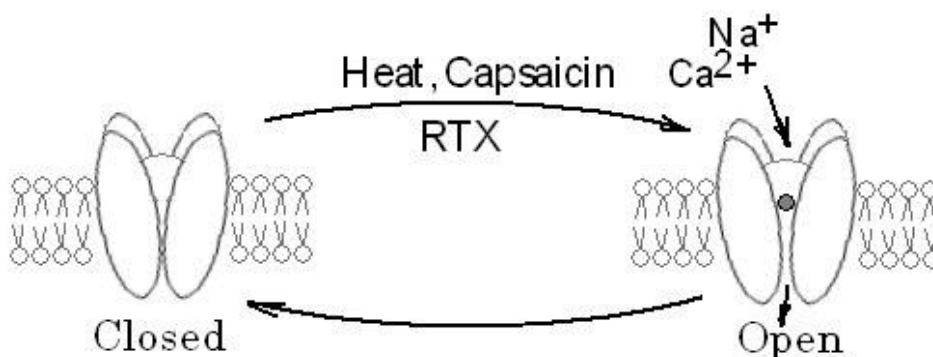


Fig. 3. Action of capsaicin on TRPV1 (RTX = resiniferatoxin antagonist) (by the author based on ref [13])

As it was evidenced the mechanism of action is the following: capsaicin binds to the transient receptor potential vanilloid 1 receptor which is expressed predominantly by sensory neurons [12]. In other words, a protein receptor binds with capsaicin to aid with chronic pain which allows the influx of calcium and sodium ions to react to nerve cells. That is why capsaicin is effective against some types of joint pain (but not recommended for Rheumatoid Arthritis). Consequently, the capsaicin receptor TRPV1 is important in pain sensation. A study suggests that this nonselective cation channel shows dynamic alterations in ion permeability, which may contribute to mechanisms of pain hypersensitivity [13]. Thus, modelling of ion channels are also in the focus of research activities (see e.g. [14]).

Felhasznált irodalom:

- 1) Somogyi N., Moór A., Pék M.: The preservation and production of *Capsicum* in Hungary (Chapt. 9.) In: Amit Krishna De (Ed.) *Capsicum: the genus Capsicum*, CRC Press, London and New York, 2004.
- 2) Zimmer, Carl: Science Tattoo Emporium: Capsaicin, Discover Magazin, (2008).  
<http://blogs.discovermagazine.com/loom/2008/02/17/capsaicin/#.U0ljbKLPttc>
- 3) Peter, K.V. (Ed): *Handbook of Herbs and Spices*, Vol 1, CRC Press, Boca Raton, 2001. ISBN 0-8493-1217-5. see also  
[http://www.cd3wd.com/data/10038\\_dvdp\\_zip/mc\\_herb\\_pharma\\_herbs\\_spices\\_data\\_3\\_vols\\_rd\\_short\\_180090\\_.pdf](http://www.cd3wd.com/data/10038_dvdp_zip/mc_herb_pharma_herbs_spices_data_3_vols_rd_short_180090_.pdf)
- 4) Anon.: Chile experts identify Trinidad Moruga Scorpion as world's hottest, The Daily Telegraph (UK). 2012-02-16.

[http://www.telegraph.co.uk/news/newsttopics\\_/howaboutthat/9085820/Chile-experts-identify-Trinidad-Moruga-Scorpion-as-worlds-hottest.html](http://www.telegraph.co.uk/news/newsttopics_/howaboutthat/9085820/Chile-experts-identify-Trinidad-Moruga-Scorpion-as-worlds-hottest.html)

- 5) Davis, C.B., Markey, C.E, Busch, M.A, Kenneth W. Busch, K.W: Determination of Capsaicinoids in Habanero Peppers by Chemometric Analysis of UV Spectral Data, *J Agric. Food Chem.*, 55(15), 5925–5933 (2007).
- 6) Wagner, C.E., Cahill, T.M., Marshall, P.A.: Extraction, Purification, and Spectroscopic Characterization of a Mixture of Capsaicinoids, *J. Chem. Educ.*, 88(11), 1574–1579 (2011).
- 7) Tewksbury, J.J., Nabhan, G.P.: Directed deterrence by capsaicin in chillies, *Nature*, 412, 403-404 (2001).
- 8) Anogianaki, A., Negrev, N.N., Shaik, Y.B., Castellani, M.L., Frydas, S., Vecchiet, J., Tete, S., Salini, V., De Amicis, D., De Lutiis, M.A., Conti, F., Caraffa, A., Cerulli, G.: *J Biol Regul Homeost Agents*; 21(1-2), 1-4 (2007).
- 9) Martini, R., Serrano, L., Barbosa, S., Labidi, J.: Antifungal cellulose by capsaicin grafting, *Cellulose*, 21, 1909-1919 (2014).
- 10) Wrigglesworth, R., Walpole, C.S.J., Bevan, S., Campbell, E.A., Dray, A., Hughes, G.A., James, I., Masdin, K.J., Winter, J.: Analogues of Capsaicin with Agonist Activity as Novel Analgesic Agents: Structure–Activity Studies. 4. Potent, Orally Active Analgesics, *J. Med. Chem.*, 39(25), 4942–4951 (1996).
- 11) Huang, X.-F.; Xue, J.-Y.; Jiang, A.-Q.; Zhu, H.-L.: Capsaicin and Its Analogues: Structure-Activity Relationship Study, *Curr. Med Chem.*, 20(21), 2661-2672 (2013).
- 12) Szallasi, A, Blumberg, P.M.: Vanilloid (Capsaicin) Receptors and Mechanisms, *Pharmacol. Rev.*, 51(2), 159-211 (1999).
- 13) Chung, M.K., Güler, A.D., Caterina, M.J.: TRPV1 shows dynamic ionic selectivity during agonist stimulation, *Nature Neuroscience*, 11, 555-564 (2008).
- 14) Billes F., Mohammed-Ziegler, I., Mikosch, H.: Transportation Behavior of Alkali Ions through a Cell Membrane Ion Channel. A Quantum Chemical Description of a Simplified Isolated Model, *J. Mol. Modeling* 18(8), 3627-3637 (2012).