

The Universal Hotness, Part 2: Piperine^a

Chemistry and application in flavor and fragrance

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Piperine (FEMA#2909, CAS# 94-62-2) (**F-1**) occurs in pepper, has a pungent, aromatic, tasty flavor, and is applied in spicy formulations.^b It has a value of 200,000 Scoville units (SU) in comparison to capsaicin^c (CAS# 404-86-4), which has 30,000,000 SU. It has been established that the isomers of piperine have almost no pungency and that the slow photoisomerization observed in solutions of piperine explain the observed reduction in the pungency of pepper products under certain conditions. It is suggested that old samples of pepper may contain relatively large amounts of the almost non-pungent isomer isochavicine.¹

Piperine (5-benzo[1,3]dioxol-5-yl-1-piperidin-1-yl-penta-2E,4E-dien-1-one) has two double bonds within its C5 section, which can have four different stereoisomers, including 2E,4E, 2Z,4Z (isopiperine), 2Z,4Z (chavicin) and 2E,4Z (isochavicin) (**F-2**).

The pungency caused by piperine is caused by activation of the heat- and acidity-sensing transient receptor potential channel vanilloid (TRPV) ion channel type 1 (TRPV1) on nociceptors, or the pain-sensing nerve cells. The effects of piperine were characterized on the human vanilloid receptor TRPV1 using whole-cell patch-clamp electrophysiology. Piperine produced a clear agonist activity at the human TRPV1 receptor, yielding rapidly activating whole-cell currents that were antagonized by the competitive TRPV1 antagonist capsazepine (CAS# 138977-28-3) (**F-3**).²

It has been shown that TRPV1 is able to sense a vast range of stimuli and exerts multiple functions under physiological or pathophysiological conditions. TRPV1 not only plays a fundamental role in pain signaling but is also involved in many other physiological or pathophysiological functions, including beneficial effects on cardiovascular and gastrointestinal function.³

Piperine can also stimulate pigmentation in the skin together with exposure to UVB light.⁴

^aPart 1 of this series, which ran in the October 2011 issue of *Perfumer & Flavorist* magazine, dealt with allyl isothiocyanate (The Universal Hotness, Part 1: Allyl Isothiocyanate, pp. 66–69). Part 3 will deal with capsicum, ginger and curcumin hotness, and with Sichuan peppercorn's special characteristics.

^bSome information on organoleptic properties and uses are taken from *e.g.* FRM 2001 *Database of Perfumery Materials & Performance*, Boelens Aroma Chemicals Information Services, The Netherlands.

^cCapsaicin will be discussed in the next installment of this series.



Physical Data for Piperine

Appearance: White to yellow crystalline powder

Molecular weight: 285.34

Molecular formula: C₁₇H₁₉NO₃

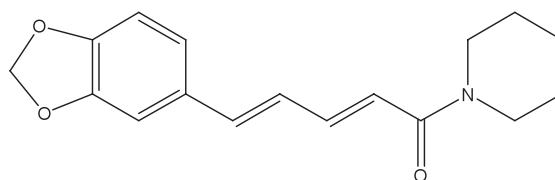
Melting point: 131–135°C

Log P: 2.66 (estd.)

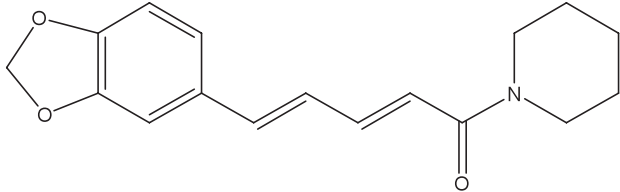
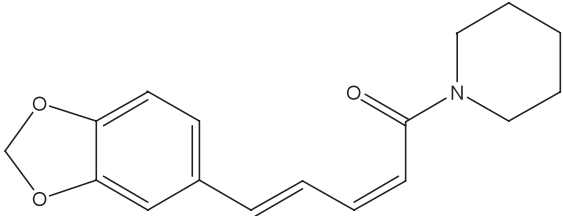
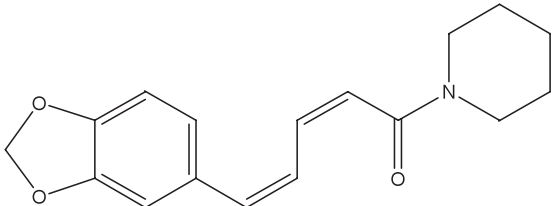
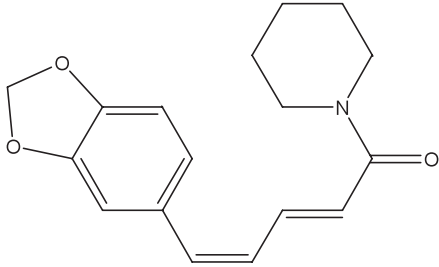
Piperine can be prepared synthetically from a piperidine (FEMA# 4244, CAS# 109-05-7) and bromoacetyl bromide reaction with 3-benzo[1,3]dioxol-5-yl-acrylic acid ethyl ester (CAS# 81581-27-3). The latter is prepared by reacting piperonal and ethoxy acetyl bromide (**F-4**).⁵

Piperine

F-1



(E,E)-1-Piperoylpiperidine

Molecule, chemical name	Name, FEMA# (if applicable), CAS#
 <p>5-Benzo[1,3]dioxol-5-yl-1-piperidin-1-yl-penta-2E,4E-dien-1-one</p>	Piperine, FEMA# 94-62-2, CAS# 94-62-2
 <p>5-Benzo[1,3]dioxol-5-yl-1-piperidin-1-yl-penta-2Z,4E-dien-1-one</p>	Isopiperine, CAS# 30511-76-3
 <p>5-Benzo[1,3]dioxol-5-yl-1-piperidin-1-yl-penta-2Z,4Z-dien-1-one</p>	Chavicin, CAS# 495-91-0
 <p>5-Benzo[1,3]dioxol-5-yl-1-piperidin-1-yl-penta-2E,4Z-dien-1-one</p>	Isochavicin, CAS# 30511-77-4

Piperine has a burning feeling. It is used in flavors at 0.01 ppm, and in fragrances at 0.01%.^d

Black pepper oil (FEMA# 2845, CAS# 8006-82-4) has an aromatic, spicy, slightly woody-balsamic, warm, terpeny, herbaceous odor and flavor. It is used in aromatic, spicy formulations such as meat preparations. The essential oil is distilled from the berries of *Piper nigrum*.

^dData from The Good Scents Company.

Additionally, pepper is not only among the most important spices of international trade for foods, but its essential oil has also become increasingly fashionable in perfumery. One prominent example is *Parfum Sacré* (Caron, 1990), which features a combination of coriander (6%), nutmeg (2%), cardamom (0.5%), clove (0.7%), cinnamon bark (0.5%) and black pepper oil (1%). In *Les Belles: Delices d'Épices* (Nina Ricci, 1999), cardamom, cinnamon, clove and pepper were also combined.⁶

Caron's *Poivre* (1954) included a spicy, peppery character, a floral heart note, and woody base notes. Also, in 1957, Caron launched *Coup De Fouet – Eau de Cologne Poivrée*, a fragrance with a base of rose and peppery undertones.

In the spicy-aromatic-musky male fragrance *Extreme Polo Sport* (Ralph Lauren, 1998) ~6% black pepper oil dominates the fragrance. The use of black pepper oil in *Contradiction* (Calvin Klein, 1997) at 0.2% provides more of a sparkling and piquant effect than a peppery note.

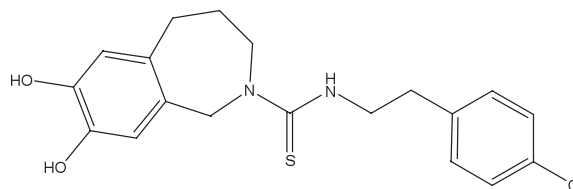
Black pepper oil has an intense, spicy and peppery odor, reminiscent of cubeb (the dried unripe berry of an Indonesian pepper shrub), but a milder taste that lacks the pungency of the spice. An oil of pink pepper berries (*Shinus molle*), has been used in *Pleasures* (Estée Lauder, 1995). It brings diffusivity, adds a creamy aspect, and blends well with musks.⁶

References

1. HB Heath, *Source Book of Flavors*, Van Nostrand Reinhold, New York (1981).
2. FN McNamara, A Randall and MJ Gunthorpe, *British J Pharmacology*, **144**(6), 781–790 (2005).

Capsazepine

F-3



3. J Peng and YJ Li, *European J Pharmacology*, **627**(1–3), 1–7 (2010).
4. L Faas, R Venkatasamy, RC Hider, AR Young and A Soumyanath, *British J Dermatology*, **158**(5), 941–950 (2008).
5. PSW Leung, et al, *Organic Letters*, **12**(21), 4996–4999 (2010).
6. P Kraft, JA Bajgrowicz, C Denis and G Frater, *Angew Chem Int Ed*, **39**, 2980 (2000).

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A reaction of piperonal and ethoxy acetyl bromide to create 3-benzo[1,3]dioxol-5-yl-acrylic acid ethyl ester

F-4

