Foeniculum vulgare Mill. and Ferulic Acid-Physiological Relation

S Rajhans* & A J Fernandes & A U Mankad & H A Pandya
Department of Botany, USSC, Gujarat University, Ahmedabad.

Received: September 19, 2018 Accepted: October 30, 2018

ABSTRACT: *Indiafrom time immemorial has been known as "The home of spices". No other country in the world has such a diverse variety of spice crops as India. The spices play an important role in the pharmacological field, as they have properties like anticancerous, antioxidant, antimicrobial, insecticidal etc.Ferulic acid is an abundant phenolic phytochemical found in plant seeds, leaves, both in its free form and covalently conjugated form in the plant cell wall polysaccharides.*

Key Words: *Spices,Foeniculum vulgare Mill. (fennel), Phenols andFerulic acid.*

Introduction

There are a variety of phytochemicals present in the spices and each phytochemical has diverse properties, such as pharmacological properties,which are used to cure various ailments. *Foeniculum vulgare* Mill. (fennel) is an important spicewhich belongs to the family Apiaceae (Umbelliferae), contains a lot many compounds and among the phenols it has abundant ferulic acid. Ferulic acid was first isolated from *Ferula foetida*for its structure determination and so its name was based on the botanical name of the plant. It has many uses in various fields like, food industries (precursor of vanillin), anti-aging properties (cosmetic products), anti-diabetic, anti-inflammatory, anti-carcinogenic and neuroprotective properties (pharmaceutical industries).

Phytochemistry of *Foeniculum vulgare* Mill.

History of spices dates back to 6th century BC and most of the spices are indigenous to tropical Asia, the West Indies and South America.Being natural plant products, they are used to impart colour, aroma, and taste to food preparations and mask the undesirable odors too. The volatile oils from the spices provide the aroma having alcohols, aldehydes, amines, esters, ethers, ketones, terpenes and other miscellaneous compounds. The spices have various aromatic compounds that play a significant role in the production of flavourants in the food industry, pharmacological field(anticancerous, antioxidant, antimicrobial, insecticidal, etc.V.A. Parthasarathy, *et.al*. 2008).One among the spices is the commonly used *Foeniculum vulgare* Mill. (fennel) **(Fig: -1**) belonging to the family Apiaceae. It is a highly aromatic perennial herb, erect, glaucous green and grows to 2m tall. The leaves grow up to 40cm long; they are finely dissected, with the ultimate filiform segments. The chemical composition in fennel seed are as follows: water, proteins, fat, carbohydrate, fiber, calcium, magnesium, iron, potassium, sodium, phosphorous, zinc, Vitamin A, mucilage, sugar, starch, tannin, fixed oil, essential oil and among the phenols ferulic acid (3.555%), chlorogenic acid (6.873%), gallic acid (0.169%), caffeic acid (2.960%) and p-coumaric acid (4.325%) are present (S. B. Badgujar, *et.al.* 2008).

Fig: -1:*Foeniculum vulgare* Mill. (Whole Plant).
[http://www.ormenis.com/2164-thickbox/fenouil-racine.jpg (Retrieved on 4th Feb 2018)]

Plants are endless sources for healing various infections because of their ability to synthesize secondary metabolites like alkaloids, quinines, flavones, tannins phenols, etc. (A. J. Fernandes, *et.al.* 2015). Phenols are the cyclic compounds containing the aromatic ring with the phenyl hydroxyl or its substituted radicals like acids, aldehydes, etc. They are the largest group of secondary metabolites varying in size from a simple structure with an aromatic ring to complex ones.Plants have synthesized phenolic compounds throughout the course of evolution coping up with the constantly changing environmental challenges. The concentration of phenolic compounds ranges from 0.5 -5.0 per 100gm dry weight of plant tissues and higher plants synthesize several thousand known different phenolic compounds. Some of the naturally occurring phenols are capsin, eugenol, gallic acid, guaiacol, methyl salicylate, raspberry ketone, salicylic acid, thymol, tyrosine and sesamol. Examples of synthetic phenols are phenol, bisphenol A, BHT (butylated hydroxytolune), 4-Nonylphenol, orthophenyl phenol, picric acid, phenolphthalein and xylenol. Three different biosynthetic pathways are there through which phenolic compounds are formed namely, shikimate/ chorizmate/ succinylbenzoate, acetate/ malonate/ polyketide and acetate/ mevalonate pathway.

Ferulic Acid

Ferulic acid is an abundant phenolic phytochemical found in plant seeds, leaves, both in its free form and covalently conjugated form in the plant cell wall polysaccharides (N. Kumar, *et.al*. 2014). It is also known as 4-hydroxy-3-methoxycinnamic acid with the chemical formula $C_{10}H_{10}O_4$ (**Fig: -2**). The pH ranges from 4 to 5and appearance is in the form of crystalline powder and soluble in water. It plays a vital role in providing the rigidity to the cell wall and formation of other important organic compounds like coniferyl alcohol, vanillin, diferulic acid and curcumin. The biosynthesis of ferulic acid in plants occurs through the metabolic route of shikimate pathway starting with aromatic amino acids, phenylalanine and tyrosine as key entities. Ferulic acid has many properties resulting in its pharmacological, culinary, and industrial uses.The plant species having ferulic acid are Bamboo shoots(243.6mg), eggplant(7.3-35mg), soya bean(12mg), peanut(8.7mg), spinach(7.4mg), tomato(0.29-6mg), radish(4.6mg), broccoli(4.1mg), carrot(1.2-2.8mg), grapefruit(10.7-11.6mg), orange(9.2-9.9mg), banana(5.4mg),apples(0.27-0.85mg), sugar beet pulp (800mg) and coffee(9.1-14.3mg).

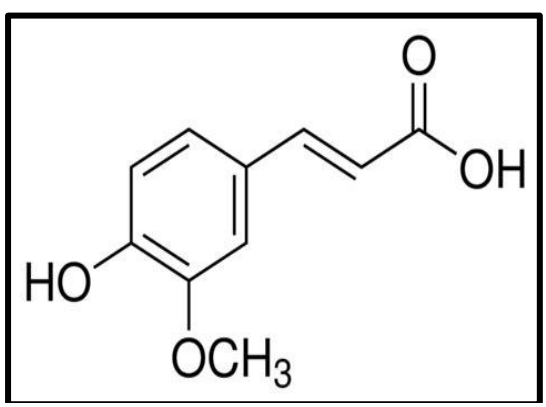

Fig: -2: Structure of ferulic acid.

[http://aperturegames.com/wp-content/uploads/2017/02/Ferulic-Acid-Market.png(Retrieved on11th Feb 2018)]

Ferulic acid isolation and separation methods

L. V. Mabinya, *et.al.* 2006have described thin layer chromatography to isolate ferulic acid from any sample for this aliquots of a standard ferulic acid solution was applied as a spot on the silica plate. Chloroform:methanol:formic acid (85:15:1)was taken as the solvent system. Further these plateswere dried in a steam of hot air and visualized under 254nm and 366nm UV light. Ferulic acid absorbed strongly at 254nm on these plates and fluoresces blue at 366nm. For better viewing of the spots, spray of 1% ferulic acid was used.The band width of 2nm within thewavelength ranging from 190-500nm was noted for ferulic acid using UV/ VIS Spectroscopy (P. Jankovska*et.al*., 2001). Another methodused for detection of ferulic acid wasreverse- phase HPLC.The standard equipment's were used such as LCP 4000, glass guard column 30×3.3mm CGC3.3-30 SZ, 250×4mm Separon SGX C18 column and variable wavelength UV/VIS- detector SpectroMonitor 3200.Citrate buffer (c=0.01 mol per 1, pH=5.4 and methanol (88:12, V/V) were taken as the elutants. The column was elutedisocratically at a rate of 1ml/min. The measurement ran at the Laboratory temperature and the wavelength detected was 310nm. TLC was performed for isolating ferulic acidfrom ascorbic acid using the solvent system of Chloroform: methanol: formic acid (85:15:1) and the R_f value of ferulic acid detected was 0.70±0.01 (P. Tee-ngam, *et.al.* 2013).

Conclusions

Phenols present in plants play a key role as defense compounds against environmental stresses, pathogen infection, herbivores and nutrient deficiency. Ferulic acid being a phenol can provide its impact on the plants by protecting them and recoveringfrom nutrient deficiency. It has potential applications in the field of medicine, food and cosmetics industries.Itsbioconversion leads to commercially valuable molecules, especially vanillin. This phenol has already produced vanillin through bio conversation, so in future also by doing some or the other changes it can lead to the production of more compounds. This compound is not yet fully exploited and additional studies on its application can help in the development of new industrial products. Its pure form costs around Rs 7000 per 100gm package. We can increase the quantity of ferulic acid in plants by improving their nutritional health and employing better cultural practices.

References

1. A. J. Fernandes, U. Gupta, D. Sharma, A. U. Mankad and H. A. Solanki (2015). Antioxidant potentials in leaves of Kigelia, Thespesia, Eucalyptus, Peltophorum, and Azadirachta. International Journal Of Advances In Pharmacy, Biology And Chemistry, 4(3):620-627.
2. L. V. Mabinya, T. Mafunga and J. M. Brand (2006). Determination of ferulic acid and related compounds by thin layer chromatography. African Journal of Biotechnology, 5(13):1271-1273.
3. N. Kumar and V. Pruthi (2014). Potential application of ferulic acid from natural sources. Biotechnology reports, 86-93.
4. P. Jankovska, J. Copikova and A. Sinitsya (2001). The Determination of Ferulic Acid in Sugar Beet Pulp. Czech J. Food Sci, 19(4): 143-147.
5. P. Tee-negam, N. Nunant, P. Rattanarat, W. Siangproh and O. Chailapakul (2013). Simple and Rapid Determination of Ferulic Acid Levels in Food and Cosmetic Samples Using Paper-Based Platforms. Sensors, 13:13039-13053.
6. S. B. Badgujar, V. V. Patel and A. H. Bandivdekar (2014). Foeniculum vulgare Mill: A Review of Its Botany, Phytochemistry, Pharmacology, Contemporary Application, and Toxicology. BioMed Research International, 1-32.
7. V.A. Parthasarathy, B. Chempakam and T. J. Zachariah (2008). Chemistry of spices. ©CAB International, 1-455.