



A SYSTEMATIC REVIEW ON THE TRADITIONAL USES, PHYTOCHEMICAL COMPOSITION AND PHARMACOLOGICAL PROPERTIES OF BLACK PEPPER (*P. NIGRUM* L.)

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Abstract

Black pepper (*Piper nigrum* L.) is an important healthy food owing to its antioxidant, antimicrobial potential and gastro-protective modules. Black pepper, with piperine as an active ingredient, holds rich phytochemistry that also includes volatile oil, oleoresins, and alkaloids. It has also been extensively explored for its biological properties and its bioactive phyto-compounds. In addition to its culinary uses, pepper has important medicinal and preservative properties, and, more recently, piperine has been shown to have fundamental effects on p-glycoprotein and many enzyme systems, leading to biotransformative effects including chemoprevention, detoxification, and enhancement of the absorption and bioavailability of herbal and conventional drugs. The alkaloid piperine improves the therapeutic value of several drugs, vaccines and nutrients by enhancing bioavailability through inhibiting numerous digestive enzymes. Piperine also aids in digestion through stimulating pancreatic and intestinal enzymes, and enriches cognitive skills and fertility. Furthermore, piperine is recognized as delivering several therapeutic activities distinct from other chemical components. This study endeavors to systematically review précised data on the traditional uses and pharmacological properties of black pepper. Besides, this review presents a summary of the data on the chemical composition of black pepper, including minerals, vitamins, carotenoids and flavonoids, and various therapeutic benefits. Up to date existing information, various metabolites have been isolated from *P. nigrum*. Among them, biologically active alkaloid piperine and the main essential oils constituents including β -caryophyllene, limonene, sabinene, α -pinene, β -bisabolene and α -copaene can serve as a new natural source for use in food, aroma, cosmetics and pharmaceutical industries.

Keywords

Natural bioactives, Oleoresins, Piperine.

INTRODUCTION

Black pepper, (*Piper nigrum* L.), is a widely used spice, known for its pungent odour. *Piper nigrum* is a perennial shrub native to southern India, and has been extensively cultivated there and in other tropical regions. Due to its strong pungency, it has valuable medicinal potency. It is one of the world most common kitchen spices and well known for its pungent chemical constituent piperine (1-peperoyl piperidine, which has diverse pharmacological activities. It is

commonly known as Kali mirch in Urdu and Hindi, Marich in Nepali, Pippali in Sanskrit, Milagu in Tamil, and Black Pepper, Peppercorn, Green pepper, White pepper, Madagascar pepper in English. *P. nigrum* is a woody climbing vine growing to 30 ft and the grayish stem may reach 1.2 cm diameter. Numerous rootlets grow from swollen stem nodes. [1-2] Leaves dark green above and pale green beneath, glossy, ovate and acutely tipped, and range in size from 13–25cm in length. Elongated, slender spikes or catkins (1.6–2cm in

length) bear minute, white flowers. The flower spikes, each producing from 50–60 single-seeded dark red berries, ~5mm in diameter, always appear on stems opposite the leaves. Different parts of the plant are used for medicinal purposes; however, the part commonly used as the spice black pepper is the cooked and dried unripe berry. Due to some religious value of black pepper, its being popular from ancient time to modern generation. This review is aimed to provide a literature review on recent advancement of chemistry, pharmacognosy, pharmacological activities other general use of *Piper nigrum*. It is widely accepted and most used in different traditional systems of medicine, like the Unani and Ayurvedic systems. Recent scientific researchers have established the presence of many active compounds in this spice that are known to possess specific pharmacological properties.

Almost all spices have aromatic features, regular grindings of spices lead to loss of important aroma compounds and accordingly resulted to considerable loss of aroma and flavor components and deterioration of quality. The dried black pepper fruit is rich in bioactive phytochemical compounds. Piperine is one of the most abundant chemical alkaloids in the black pepper. Other similar alkaloids are also isolated from black pepper such as piperanine, piperettine, piperylin A, piperolein B, and pipericine. However, the pungency of these piperine's analogs are less than the Piperine. Black pepper

was also found to have a good quantity of polyphenols. The interesting findings are that, black pepper contains more polyphenols compared with white pepper (White pepper is made from fully ripe pepper berries. They are soaked in water for about 10 days, leading to fermentation. Then their skins are removed, which also removes some of the hot piperine compound, as well as volatile oils and compounds that give black pepper its aroma. As a result, white pepper has a different flavor and heat component than black pepper. The process used and handling of white pepper can introduce different flavor notes as well.). [3-5] Moreover, it is believed that, after eating Black pepper, it hydrolyzed in the gut and liberating these bound polyphenols. Even some studies stated that the Black pepper contains aromatic compounds, flavonoids, alkaloids, amides and lignans. The volatile oils of the Black pepper fruits were analyzed using column chromatography, high resolution gas chromatography and gas chromatography mass spectrometry (GC-MS); up to 46 compounds were identified including δ -cadinol, δ guaiene, (Z) (E)- farnesol, (E)- β -ocimene and guaiol. In another study, five phenolic amides were isolated from the black pepper, which revealed high antioxidant activity more effective than some naturally occurring antioxidants of the black pepper in bioactive phytochemical components of promising medicinal importance. The therapeutic efficacy of this individual spice for specific pharmacological actions has also been established by experimental and clinical studies. [6-9]

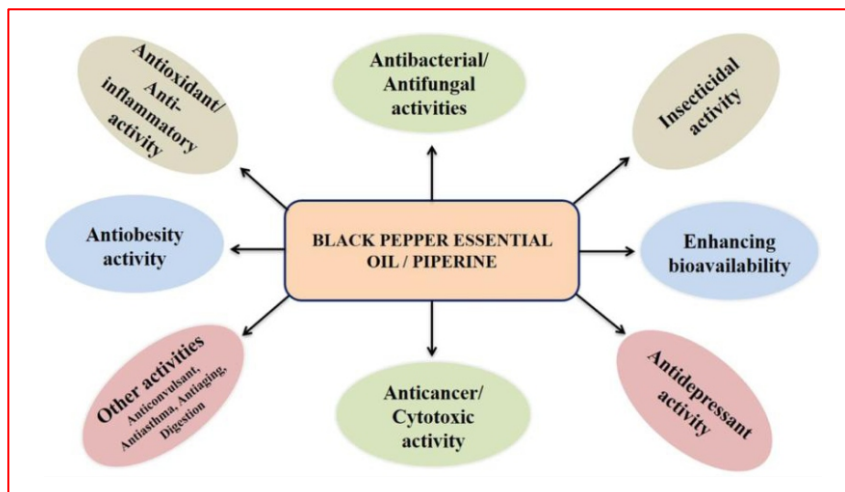


Fig. 1: Some reported bioactivities of black pepper.



Fig. 2: Green and Pink black pepper seeds on vine.

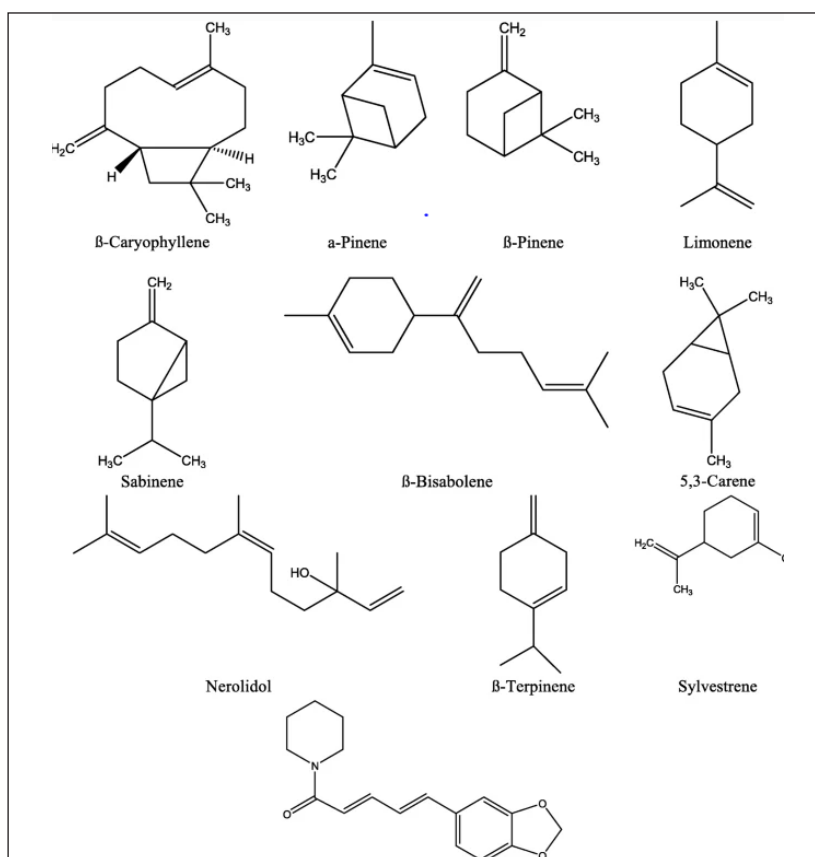
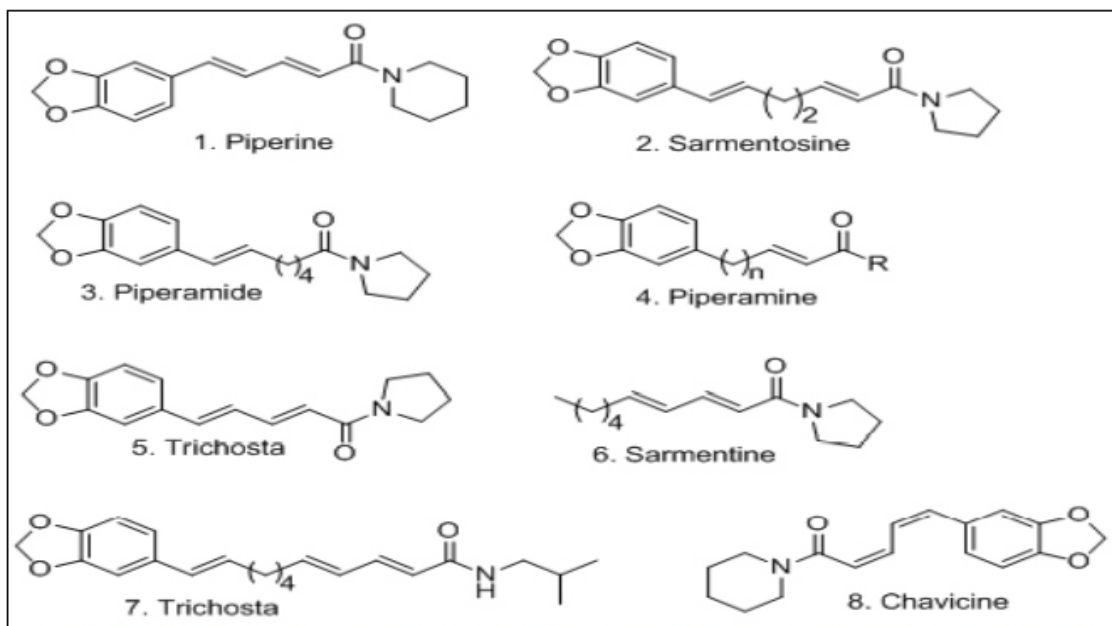
Bioactive chemical compounds of the black pepper

Black pepper is rich in minerals, vitamins and nutrients. The chemical composition of 100 g of black pepper seeds includes carbohydrate 66.5 g, protein 10 g, and fat 10.2 g, as well as a relatively high concentration of minerals such as calcium (400 mg), magnesium (235.8-249.8 mg), potassium (1200 mg), phosphorus (160 mg), and the lower concentration of sodium, iron and zinc. These minerals are essential elements for day-to-day activities of humans. Besides, black pepper also has a significant concentration of vitamins such as Vitamin C, B1, B2 and B3. Nine accessions of Nigeria grown black pepper had a concentration of tannin ranging from 2.11 to 2.80 mg/100 g. In a recent study on black pepper, catechin,

Quercetin, myricetin, and carotenoids, namely lutein and β -carotene have also been detected in significant concentration. Several researchers evaluated essential oils (EO), oleoresin and piperine in various parts of black pepper. The EO yield of black pepper berries and leaves have varied from 1.24 to 5.06 %, and 0.15–0.35 %, respectively. It has been observed that variability of volatile oil and oleoresin content in 14 black pepper accessions ranged from 2.7 – 5.1 % and 7.6 – 9.4 %, respectively. The oleoresin content of black pepper ranged between 4.27 and 12.73 % and the characteristic natural alkaloid of black pepper “piperine” ranged from 2.13 – 5.80 % and 0.12 – 20.86 %, in seeds and leaves correspondingly. [10-34]

Table 1: Nutritional composition of Black Pepper [Nutrient concentration/100g].

| Chemical composition | Concentration |
|------------------------------|---------------|
| Proximate | |
| Water (g) | 8.0 |
| Energy (Kcal) | 400.0 |
| Carbohydrate (g) | 66.5 |
| Protein (g) | 10.0 |
| Fat (g) | 10.2 |
| Total Ash (%) | 3.43–5.09 |
| Crude fibre (%) | 10.79–18.60 |
| Minerals | |
| Calcium (mg) | 400.0 |
| Magnesium (mg) | 235.8–249.8 |
| Phosphorus (mg) | 160.0 |
| Sodium (mg) | 10.0 |
| Potassium (mg) | 1200.0 |
| Iron (mg) | 17.0[36] |
| Zinc (mg) | 1.45–1.72 |
| Vitamins | |
| Vitamin C (mg) | 27.46–32.53 |
| Vitamin B1 (mg) | 0.74–0.91 |
| Vitamin B2 (mg) | 0.48–0.61 |
| Vitamin B3 (mg) | 0.63–0.78 |
| Metabolites | |
| Tannin (mg) | 2.11–2.80 |
| <i>Flavonoids</i> | |
| Catechin (μ g) | 410.0 |
| Myricetin (μ g) | 56.0 |
| Quercetin (μ g) | 13.0 |
| <i>Carotenoids</i> | |
| Lutein (μ g) | 260.0 |
| β -carotene (μ g) | 150.0 |

Table 1: Nutritional composition of Black Pepper [Nutrient concentration/100g].**Figure 3: Major chemical constituents of Black pepper seed and essential oil. [15-18].**

Traditional Medicinal uses

Traditionally, black pepper has been used in a variety of different remedies and for different purposes. According to Ayurveda, the pungency and heating properties of black pepper work to help metabolize food as it is digested in our system. Its heat works as a stimulant like lighting a fire might. Like many aromatic kitchen herbs, black pepper is considered a carminative in Western herbalism, and in Ayurveda black pepper is known to enkindle *agni*, the digestive fire. These actions are likely due to the taste of black pepper on the tongue triggering the stomach to release hydrochloric acid, which is needed to digest protein, and pepper's ability to stimulate digestive enzymes in the pancreas. This stimulating quality is also used to clear congestion in the respiratory system as well as other processes. In the classical literature, many Unani scholars have mentioned various medicinal uses of black pepper. It has been described for its efficacy in cholera, dyspepsia, flatulence, diarrhea, and other gastrointestinal ailments. It is also a useful ingredient in tooth powders. In "Ilaj-ul-Ghurba" a pill is recommended for syphilis, which is prepared by taking black pepper (*P. nigrum*), *Calotropis gigantea*, and jaggery. Externally, it is applied to boils. It is also used in case of sore throat, alopecia, skin disorders, and piles etc. Finely powdered black pepper and sesame oil well mixed and heated, when applied over the paralytic area, is proved to be very effective. A preparation made with black pepper and leaves of *Cassia occidentalis* is even good for night blindness. It is also used in the treatment of gonorrhea. The drug is used as an antidote for scorpion sting. plant *Cissampelos pareira*, in combination with black pepper, has been claimed to be useful in birth control when given immediately after delivery. In Cambodia, it is also used as cure for dysentery. In reference with Dioscorides,. It is beneficial for the treatment of cough and chest pain when given in the form of sharbat (Syrup) or lauq (Paste). Along with honey, it is good for diphtheria. The combination of black pepper, onion, and salt, when applied on the bald area, is effective for curing alopecia. When used along with vinegar, it is also good for teethache. [10-14}]

Health Benefits of Black Pepper

Just a pinch of black pepper when added to any food preparation can enhance its flavor. It is a spice that is known to offer many health benefits. It helps to promote weight loss and even aids in digestion. It is believed that this amazing spice prevents cancer as black pepper detoxifies the body, cleanse the intestine and stomach. Black pepper releases hydrochloric acid in stomach which helps in cleaning the intestines. It prevents constipation and helps to combat occurrence of common cold. Black pepper is used for combating skin exfoliation, skin deformation and helps to keep wrinkles at bay. It is used to combat dandruff, helps in restoring hair growth and makes the hair shiny. Mentioned below are the best health benefits of Black Pepper. Black pepper helps to prevent the occurrence of cancer. Black pepper is credited with piperline and this when combined with [turmeric](#) can help in preventing cancer. Black pepper is also loaded with antioxidants, and presence of vitamins like [Vitamin A](#),

flavonoids and carotenes helps in combating cancer causing free radicals. Black pepper aids in digestion problem, and when a person consumes raw black pepper, hydrochloric acid is released by the stomach, and this helps in breaking down of proteins. The release of hydrochloric acid in black pepper also helps in cleaning the intestines and helps in combating gastrointestinal diseases. Stomach disorders such as constipation, [colon cancer](#), [diarrhoea](#) and other bacterial diseases are prevented when black pepper is consumed daily. Cold and [cough](#) can be cured by adding this spice to [herbal tea](#) and consumed two or three times a day. Having dishes prepared with black pepper are useful in winter and facilitate removal of phlegm from the body. Black pepper with honey prevents chest congestion. One can add crushed black pepper to warm water along with [eucalyptus oil](#) drops and inhale the steam to get rid of chest congestion. Black pepper prevents a skin pigmentation disease called [vitiligo](#). This condition makes the skin turn white. There are many chemical rich medicines available in the market to [restore](#) skin color. However, one should know that black pepper is loaded with piperline that helps in restoring the natural color of the skin. This also ensures that the chances of occurrence of [skin cancer](#) due to overexposure to chemicals are reduced. Black pepper used for skin rash and skin allergy, you also uses black pepper as scrub to remove dead skin. Skin deformation, like wrinkles, is kept at bay if one adds black pepper to their [diet](#) since young age. The occurrence of premature ageing, dark spots are also kept in control if one eats black pepper in raw or cooked form. Eating black pepper makes sure that blood circulation to different parts of the body is improved. This also ensures that skin is rejuvenated. [Skin disorders](#) like acne are controlled if one adds black pepper to their diet. The skin exfoliation can be done by crushing some black pepper and applying it over skin. Black pepper is used in the treatment of dandruff in hair. Add curd with black pepper for hair loss problem, one of the effective home remedy. Even black pepper oil used to prevent hair loss and hair regrowth. Black pepper aids in [weight loss](#). The reason is that black pepper is rich in phytonutrients and this helps in breaking down excess fat and improves the metabolism of the body. Black pepper is used in the treatment of [depression](#). When one chews raw black pepper, a mood-inducing chemical is released from the brain, and this fills the mind with a soothing, calm mood. Black pepper is good for prevention of arthritis and joint pains. Black pepper has medicinal properties that help to combat gout. It is useful for people suffering from joint and spinal pain. This wonder spice helps to promote [sweating](#) and urination. Thus help to get rid of toxins in the body. Black pepper is good for prevention of arthritis and joint pains. Black pepper has medicinal properties that help to combat gout. It is useful for people suffering from joint and spinal pain. Black pepper is used in many cuisines as a spice globally. It is used extensively during cold and winter seasons and helps to combat respiratory problems. It is used as an aphrodisiac and also in the treatment of [erectile dysfunction](#). Black pepper is found to cause stomach [burns](#) when taken in large quantities. When large quantities of black pepper enter the lungs, it may cause death. Black pepper is known to cause burning sensation inside the

stomach in certain people, and they should check the quantity of black pepper being consumed before discarding it fully. There are certain cases in which black pepper reacts with medicines. Black pepper may cause some irritation to pregnant women, and may cause some allergies to breast feeding mothers. [31-34]

DISCUSSION AND CONCLUSIONS

For millennia, spices have been an integral part of human diets and commerce. Recently, the widespread recognition of diet-health linkages bolsters their dietary importance. The bioactive components present in them are of considerable significance owing to their therapeutic potential against various ailments. They provide physiological benefits or prevent chronic ailment in addition to the fundamental nutrition and often included in the category of functional foods. Black pepper (*Piper nigrum*) is one of the most widely used among spices. It is valued for its distinct biting quality attributed to the alkaloid, piperine. Black pepper is used not only in human dietaries but also for a variety of other purposes such as medicinal, as a preservative, and in perfumery. Many physiological effects of black pepper, its extracts, or its major active principle, piperine, have been reported in recent decades. Dietary piperine, by favorably stimulating the digestive enzymes of pancreas, enhances the digestive capacity and significantly reduces the gastrointestinal food transit time. Black pepper essential oil constitutes approximately 0.4–7 % of the berry dry weight and is beneficial for the management of rheumatism, cold, tiredness, muscular pains and infection. It was also used as a nerve stimulant to enhance blood circulation. Both white pepper and black pepper contained 2–7 % piperine. The volatile oil constituent piperamides and nerolidol exhibited insecticidal activities. β -caryophyllene displayed anaesthetic effects, and piperine was used in perfumes. Black pepper has been used for millennia, including plant breeding activities for the development of superior varieties with improved organoleptic and nutritional properties. It has been used in traditional as well as modern medicine. Based on the reviewed literature, *Piper nigrum* (L.) has many favourable chemical properties and beneficial effects. Besides, this review presents a summary of the data on the chemical composition of black pepper, including minerals, vitamins, carotenoids and flavonoids, and various therapeutic benefits. Up to date existing information, > 80 metabolites have been isolated from *P. nigrum*. Among them, biologically active alkaloid piperine and the main essential oils constituents including β -caryophyllene, limonene, sabinene, α -pinene, β -bisabolene and α -copaene can serve as a new natural source for use in food, aroma, cosmetics and pharmaceutical industries. Piperine also has a broad spectrum of therapeutic potential and potential for improving the bioavailability of therapeutic drugs and nutrients. BPEO and piperine have many biological effects such as antioxidant, antiobesity, antitumor, antipyretic, anticonvulsant, anti-thyroid, antifungal, antibacterial, insecticidal, hepatoprotective, anti-asthmatic, larvicidal, antihypertensive, anti-inflammatory, antidiabetic, antidiarrheal, bioavailability enhancer, immunomodulator,

antiepileptic, antifertility, GI stimulant, lipid metabolism accelerator, anticancer, CNS stimulant, diuretic, aphrodisiac, blood purifier and antiplatelet activities, etc. For centuries, black pepper has been used for traditional medicines to cure cuts and wound injuries. Piperine stimulates a dose-dependent increase in the secretion of gastric acid and interruption of gastrointestinal motility. The oral administration of piperine activates the liver, pancreas and digestive enzymes in the small intestinal mucosa. Furthermore, the addition of piperine in food materials as food flavours may increase the protease, lipase, and pancreatic amylase activities.

REFERENCES

1. **Parthasarathy VA, Sasikumar B, Nair RR, George KJ.** Black Pepper: *Botany and Horticulture*. In; Hort Rev. 2007;33:173–266.
2. **Acharya SG, Momin AH, Gajjar AV.** Review of Piperine as A Bio- Enhancer. *Am J Pharm Tech Res*. 2012; 2:32-44-48.
3. **Agbor GA, Vinson JA, Oben JE, et al.** Comparative analysis of the in vitro antioxidant activity of white and black pepper. *Nut Res*. 2005; 26(12):659–663.
4. **Ahmad N, Fazal H, Abbasi BH, Farooq S, Ali M, et al.** Biological role of *Piper nigrum* L. (Black pepper): A review. *Asian Pacific J Trop Biomed*: 2012;S1945-S1953.
5. **Damanhoury ZA, Ahmad A.** A review on therapeutic potential of *Piper nigrum* L. (Black Pepper): The King of Spices. *Medicinal and Aromat Plants*. 2014; 3(3): 1-6.
6. **Elizabeth TJ, Gassara F, Kouassi AP, et al.** Spice use in food: Properties and benefits. *Crit Rev Food Sci Nutr*. 2015; 57(6):1078–1088.
7. **Gorgani L, Mohammadi M, Najafpour GD, et al.** Piperine-The bioactive compound of black pepper: From isolation to medicinal formulations. *Comprehensive Review in Food and Food Safety*; 2017;16:124–140.
8. **Khan M, Siddiqui M.** Antimicrobial activity of Piper fruits. *Nat prod Rad* 2007;6:111-113.
9. **Liu Q, Meng X, Li Y, et al.** Antibacterial and Antifungal Activities of Spices. *Int J Mol Sci*. 2017;18(6):1283.
10. **Meghwal M, Goswami TK.** *Piper nigrum* and piperine: An Update. *Phytother Res*. 2013;27:1121-1130.
11. **Murthy CT, Bhattacharya S.** Cryogenic grinding of black pepper. *J Food Eng*. 2008; 85(1):18–28.
12. **Nakatani N, Inatani R, Ohta H, et al.** Chemical constituents of peppers (*Piper* spp.) and application to food preservation: Naturally occurring antioxidative compounds. *Env Health Persp*. 1986; 67:135–142.
13. **Pino J, Feo GR, Borges P, et al.** Chemical and sensory properties of black pepper oil (*Piper nigrum* L.). *Mol Nut Food Res*. 1990;34(6):555–560.
14. **Sabina EP, Nasreen A, Vedi M, Rasool M.** Analgesic, antipyretic and ulcerogenic effects of piperine: An active

- ingredient of pepper. *J pharm Sci Res.* 2013;5(10): 203-206.
15. **Sapam R, Kalita PP, Sarma MP, Talukdar N and Das H.** Screening of phytochemicals and determination of total phenolic content, anti-oxidant, and antimicrobial activity of methanolic extract of *Piper nigrum* leaves. *Indo Am J Pharmaceut Res.* 2018;8(2): 1354-1360.
 16. **Shamkuwar PB, Shahi SR, Jadhav ST.** Evaluation of anti-diarrheal effect of Black pepper (*P. nigrum* L.). *Asian J Plant Sci Res.* 2012;2: 48-53.
 17. **Srinivasan K.** Black pepper and its pungent principle-piperine: a review of diverse physiological effects. *Crit Rev Food Sci Nutr.* 2007;47: 735- 748.
 18. **Sunila ES, Kuttan G.** Immunomodulatory and antitumor activity of *Piper longum* Linn. and piperine. *J Ethnopharmacol.* 2004;90: 339-346. 9819-9998.
 19. **Butt MS, Imran Pasha, Sultan MT, Randhawa AR, Saeed F. Waqas Ahmed.** Black pepper and health claims: a comprehensive treatise *Crit Rev Food Sci Nutr.* 2013;53(9):875-86. doi: 10.1080/ 10408398.2011.571799.
 20. **Meghwal M, Goswami TK.** *Piper nigrum* and piperine: an update. *Phytother Res.* 2013;27(8):1121-1130. doi: 10.1002/ptr.4972.
 21. **Srinivasan K.** Black pepper and its pungent principle-piperine: a review of diverse physiological effects. *Crit Rev Food Sci Nutr.* 2007;47(8):735-48. doi: 10.1080/10408390601062054.
 22. **Savina.** A review on bioactive chemical compounds, traditional medicinal uses and pharmacological activities of *Piper nigrum* L. seeds: Demand of the time. 2021;8(6):b847-b857.
 23. **Ashokkumar K, Murugan M, Dhanya MK.** et al. Phytochemistry and therapeutic potential of black pepper [*Piper nigrum* (L.)] essential oil and piperine: a review. *Clin Phytosci.* 2021;7: 52-54. (<https://doi.org/10.1186/s40816-021-00292-2>).
 24. **Nair KP.** Agronomy and economy of black pepper and cardamom. *The King and Queen of Spices: Elsevier press;* 2011. p.380.
 25. **Damanhoury ZA, Ahmad A.** A review on therapeutic potential of *Piper nigrum* L. (Black Pepper): the king of spices. *Med Aromat Plants.* 2014;3:161-164. doi:<https://doi.org/10.4172/2167-0412.1000161>.
 26. **Wong CM, Ling JJ.** In Vitro Study of Wound Healing Potential in Black Pepper (*Piper nigrum* L.). *UK J Pharmaceut Biosci.* 2014;2:05–9.
 27. **Gülçin İ.** The antioxidant and radical scavenging activities of black pepper (*Piper nigrum*) seeds. *Int J Food Sci Nutr.* 2005;56:491–499.
 28. **Szallasi A.** Piperine. Researchers discover new flavor in an ancient spice. *Trends Pharmacol Sci.* 2005;26:437–439.
 29. **Srinivasan K.** Black pepper and its pungent principle-piperine: a review of diverse physiological effects. *Crit Rev Food Sci Nutr.* 2007;47:735–748.
 30. **Taqvi SI, Shah AJ, Gilani AH.** Blood pressure lowering and vasomodulator effects of piperine. *J Cardiovasc Pharmacol.* 2008;52:452–458.
 31. **Joshi DR, Shrestha AC, N. Adhikari N.** A Review on diversified use of the king of spices: : *Piper nigrum* (Black pepper). *J Pharmaceut Sci Res.* 9(10): 4089-4101 doi: 10.13040/IJPSR.0975-8232.9(10).4089-4001.
 32. **Takooree H, Aumeeruddy MZ, Rengasamy KRR, Katharigatta N Venugopala, Jeewon R, Zengin G, Mahomoodally MF.** A systematic review on black pepper (*Piper nigrum* L.): from folk uses to pharmacological applications *Crit Rev Food Sci Nutr.* 2019;59(sup 1):S210-S243. doi: 10.1080/10408398.2019.1565489.