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Ocimum basilicum L.: A Systematic Review on Pharmacological Actions and Molecular Docking Studies for Anticancer Properties

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Abstract

Basil (*Ocimum basilicum L*) is a plant that belongs to the Lamiaceae family and is known for its pharmacological and therapeutic properties, as it is rich in active biological substances, which endow it with antioxidant and anti-inflammatory activities. Many people from all over the world use basil in traditional medicine, including North African countries, especially Algeria, which they use to treat many organic and infectious diseases. On the other hand, according to scientific reports, the *O. basilicum* plant contains most of the major and biologically active molecules such as flavonoids, phenols, tannins, steroids, glycosides, and reduced sugars. Pharmacological studies also indicate that the plant has antioxidant, anti-inflammatory, analgesic and antibacterial activities. In silico tools, a compound's ability to block a receptor can be successfully studied by combining many in silico approaches. There have been reports of natural chemicals of O. basilicum having anticancer action. In conclusion, *O. basilicum* may be one of the best sources of plant medicines that can be used to treat many acute and chronic diseases.

Keywords: Basil, Systematic review, Phytochemistry, Botany, Pharmacological activities, Molecular docking study

Introduction

Research on herbal medicines has grown to be one of the most pressing scientific issues in the previous two decades (Chetehouna *et al*., 2020). A variety of ailments has historically been prevented or treated using medicinal herbs. More than 1200 plants are utilized in traditional medicine across the globe, according to ethnopharmacological investigations (Derouiche, 2020). The use of medical and food plants is a major part of the medication management of so-called chronic diseases in some traditional non-industrialized civilizations (China, and several African and Latin American nations), according to Chetehouna *et al*. (2023). Bioactive compounds found in medicinal plants represent a variety of interests used in various fields. The secondary metabolites of these compounds are those that are most clearly demonstrated in the therapeutic sector (Tungmunnithum *et al*., 2018).

The public's historical usage of plants as medicine and confirmation of their pharmaceutical effectiveness encouraged their medical use. While their active compounds might treat illnesses and alleviate symptoms, However, the development of study into the elements in such plants demonstrates that their use extends beyond its use in folk medicine (Kalamartzis *et al*., 2020). *Ocimum basilicum*, sometimes known as sweet basil, is one of the therapeutic plants. Many plants of the genus *Ocimum* have been utilized throughout history to cure a variety of illnesses and ailments. *O. basilicum* plays a significant role in this genus because of its many therapeutic characteristics (Purushothaman *et al*., 2018).

In light of these data, this review aimed to identify the phytochemical contents and pharmacological effect of *Ocimum basilicum L*.

Materials and Methods

For this review, the literature on the biological properties, secondary metabolites, and botanical description of basil was collected, examined, and summarized. All articles that have been published concerning this species have been collected using scientific search engines including Springer Link, Scopus, Science Direct, Wiley Online, Web of Science, PubMed, Scinder, and Google Scholar (e.g., WIPO, CIPO, USPTO). These search engines, as well as numerous patient offices, used to use Scopus, Wiley Online, Scifnder, and PubMed. It's common to hear the phrase "*Ocimum basilicum*," either by itself or in conjunction with the phrases "chemical substances" and "pharmacological activity." There were no restrictions on languages. The obtained data were identified and modified using their titles, abstracts, and contents. To discover if any other papers were pertinent, the reference lists of the papers that were retrieved were also examined.

Results and Discussion

Generalities and Geographic Distribution of Ocimum +L

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Ocimum basilicum L., also called sweet basil (Ahmed *et al*., 2019), is among the aromatic plants **(Figure 1)** as it belongs to the *Lamiaceae* family. As it is characterized by its richness in chemicals (Rumengan *et al*., 2019), it is known to be a plant used in medicine and food (Taha *et al*., 2020). *Ocimum basilicum L*. is grown in soil and clearings Basil (*Ocimum basilicum L.*), is an herb that has been cultivated since ancient times, making it very well-known (Georgiadou *et al*., 2018). It is also a plant that grows in warm regions, Africa, tropical regions, and some regions in Asia and South America, and it is very perennial (Choi *et al*., 2019).

Figure 1. Basil leaf shape (Nadeem *et al*., 2020)

Taxonomy and Botanical Description

Ocimum basilicum is an aromatic plant that grows all year round, reaching 0.3 to 0.5 meters in length, reaching 1 meter in some cases. 'Dark Garnet' is a cultivar of basil that has dark purple leaves and stems. Its leaves are oval, but its flowers are often wrinkled and white and pink. Its fruits contain small nuts, and when wet they are gummy (Burkil, 1995).

The branched herbaceous plant *Ocimum basilicum* L. has square, glabrous stems and branches that range in color from green to light purple. It typically stands between 0.6 and 0.9 meters tall. Basil leaves are simple, oppositely oriented, and range in length from 2.5 to 5 cm on average. These longer leaves feature an oval form, a sharp apex, and a lobed or serrated edge (Nadeem *et al*., 2020). Basil's taxonomy is regarded as being extensive and complicated **(Table 1)**. According to Chowdhury *et al*. (2017), genetic diversity driven by cross-pollination and several environmental conditions is thought to be the cause of this taxonomic complexity. *Ocimum basilicum L*., sometimes known as Labiatae, is a member of the Lamiaceae family of mints, which is part of the Lamiales order (Azoz *et al*., 2016; Idowu & OzIegbe, 2017). One of the most significant species in the *Ocimum* genus, which has more than 60 species, is basil (Murali & Prabakaran, 2018).

Table 1. Taxonomy of Basil (Romanus *et al*., 2020)

Kingdom	**Plantae**
Clade	Asteroids
Clade	Eudicots
Clade	Tracheophytes
Family	Lamiaceae
Genus	Lamiales
Species	O. basilicum L
Order	Ocimum
Common Name	Sweet basil
Local Names	Ibibio/Efik-Iko
Yoruba	Efinrin wewe
Igbo	Nchu- anwu
Hausa-	Daidoya tagida

Chemical Composition

According to Falowo *et al*. (2019), The basil plant contains variable amounts of nutrients such as glucides, protein, vitamins, fats, and some minerals such as potassium, iron, calcium, and magnesium. In addition, the basil plant contains several secondary metabolites such as saponins, alkaloids, flavonoids, and terpenoids. Terpenoids, alkaloids, flavonoids, and ascorbic acid **(Table 2)** have been identified (Rumengan *et al*., 2019).

Table 2. Major constituents of *O basilicum*

Major constituents	**References**
β-Myrcene, 1,8-cineol, methyl cinnamate, , Myrtenol, α-cubebene, β-ocimene, caryophyllene, eugenol, et α-farnesene.	(Abou El-Soud *et al*., 2015)
carvone and *iso*-pinocamphone.	(De-Martino *et al*., 2009)
Linalool and Methyl chavicol,	(Sajjadi, 2006)
α-cardinole, Linalool, δ-caridnene, α-selinène, α-bergamotène, β-selinene, γ guaiene,α-guaiene	(Kostic *et al*., 2008)
estragole and Linalool	(Martinez-Velazquez *et al*., 2011)

Therapeutic Effect and Economic Value of Sweet Basil

According to Bahcesular *et al*. (2020), The plant (*Ocimum basilicum L*.) can be considered one of the most important aromatic plants that have medicinal importance that can be grown and marketed and culinary relevance in various regions of the world because it includes significant components (Kalamartzis *et al*., 2020). Due to a high level of secondary metabolites (Dörr *et al*., 2020), basil leaves have substantial antioxidant and antibacterial properties that are used in folk medicine to treat a wide range of illnesses (Ahmed *et al*., 2019). According to numerous studies (Akbari *et al*., 2019), basil essential oil possesses fungistatic and insecticidal properties. It can also be utilized as a flavoring agent in cosmetics, medicine, and food (Rezzoug *et al*., 2019). All parts of Basil have historically been used as medication to treat digestive issues, kidney dysfunction, warts, worms, diarrhea, and migraines (Falowo *et al*., 2019). Several studies conducted by various researchers have also demonstrated that the essential oils isolated from *Oryza basilicum* exhibit outstanding antibacterial action against a variety of microbes, including fungi, bacteria, and Gram-positive and Gram-negative bacteria (Matasyoh *et al*., 2008).

In the present review, we indicate that the *Ocimum basilicum* is richer in secondary metabolites like flavonoids, steroids, Phenols, Catechic Tannin, Saponoside, Carbohydrates, and Alkaloids. This is in the same line with the study of Tariq *et al*. (2016), *O. basilicum* is considered a plant rich in active substances such as phenolic compounds, glycosides, terpenes, saponins, flavonoids, and many other substances, makeup flavonoids **(Figure 2)**. Numerous advantageous physiological activities are exhibited by flavan-3-ols, flavonoids, and other derivatives (Panche *et al*., 2016). Several flavonoid characteristics, such as antioxidant, anti-inflammatory, antiplatelet activity, and cardio-protective effects (Corti *et al*., 2009).

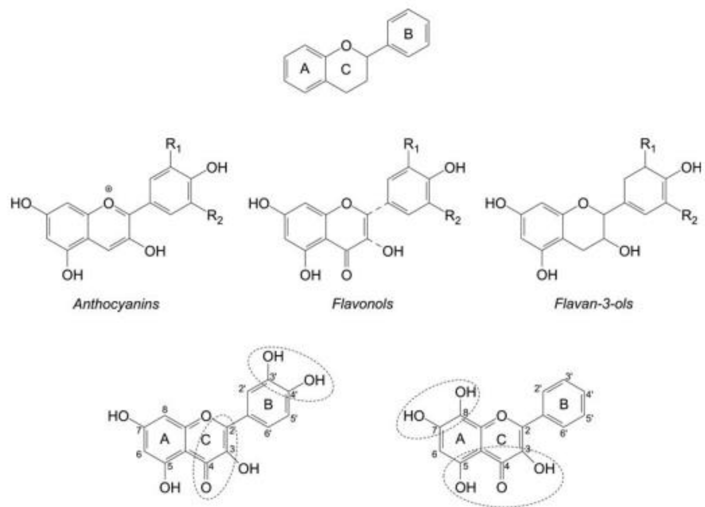


Figure 2. Some flavonoid basic skeletons with hydroxyl groups (Katz *et al*., 2011)

It has been proven that secondary metabolites have effective anti-inflammatory activity, such as terpenes, and antioxidant activity, such as flavonoids **(Figure 3)**, which qualifies them to be a treatment for many cancers and osteoporosis, and the effects of coronary diseases can also be reduced by using phenols. (Derouiche *et al*., 2020). Regarding the antioxidant activity, several studies by El-Dakar *et al.* (2015) show that Basil has a high-power antioxidant. A study by Harnafi *et al*. (2009) suggested that phenolic compounds are predominant in *O basilicum* such as tannins and flavonoids. On the other hand, Due to its phenolic and aromatic components, *O. basilicum* has demonstrated antioxidant activity (Gebrehiwot *et al*., 2016). The aqueous extracts of Basil had a very high level of free radical scavenging antioxidant activity. Basil is a plant that is frequently used as medicine (Constantinescu & Adriana, 2019). In 2020, Pistelli *et al*. conducted another study and discovered that basil has phenolic antioxidant chemicals. Flavonoids have antioxidant properties that prevent oxidative damage through a variety of processes (Rameshrad *et al*., 2015).

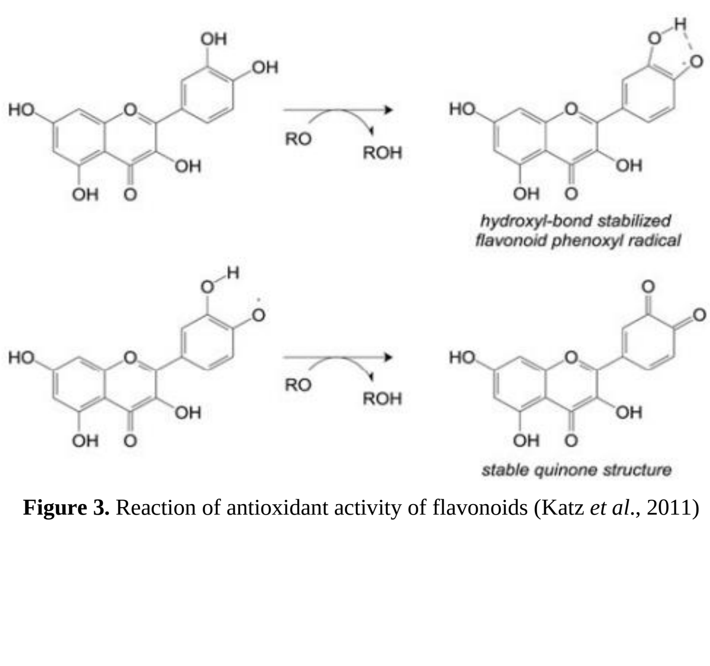


Figure 3. Reaction of antioxidant activity of flavonoids (Katz *et al*., 2011)

Basil was additionally widely mentioned as a typical anti-inflammatory. We conducted several studies on human erythrocytes exposed to a pro-inflammatory substance to confirm this activity and assess the mechanism at play. The study highlights the significance of *O. basilicum* leaves' anti-inflammatory properties (Ahmad *et al*., 2015). Pro-inflammatory cytokines play essential roles in the inflammatory response like IL-1 antagonist receptor, IL-6, IL-10, and IL-112 are antiinflammatory cytokines (Güez *et al*., 2017). The main mechanism of anti-inflammatory action is the inhibition of prostaglandin formation resulting from the inactivation of cyclooxygenase, the enzymes of arachidonic acid metabolism, and lipoxygenase (Barbalho *et al*., 2011).

Sweet basil showed strong antibacterial resistance to a variety of pathogens. Moderate antibacterial activity was displayed by *O. basilicum*. In contrast, Gebrehiwod *et al*. (2015) revealed that the Basil and its oil essential primary component, linalool, have antifungal properties and that Gram-positive bacterial strains were more sensitive to them than their counterparts.

In silico tools, a compound's ability to block a receptor can be successfully studied by combining many in-silico approaches. There have been reports of natural chemicals having anticancer capabilities, but it's still unclear how they work. To shed light on potential mechanisms of the anticarcinogenic interaction between receptor proteins and enzymes, theoretical docking studies targeting lipoxygenase-5 (LOX) and cyclooxygenase-2 (COX-2) have been conducted. In the production of prostaglandin E2, the primary enzyme is COX-2 (Bourzikat *et al*., 2022). Given the clear association between inflammation and carcinogenesis, prospective COX-2 inhibitors may also qualify as chemopreventive medicines for cancer (Gurpinar *et al*., 2013). According to docking research, isoeugenol (PDB ID: 4COX) sits in the active site of COX-2 with an orientation comparable to that of indomethacin **(Figure 4)**. The pocket is composed of some amino acids. The terminal carbon atom is traveling in the direction of Leu384 (Redzicka *et al*., 2023).

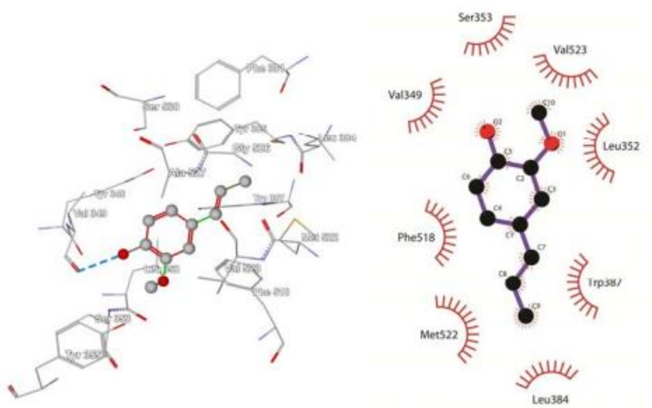
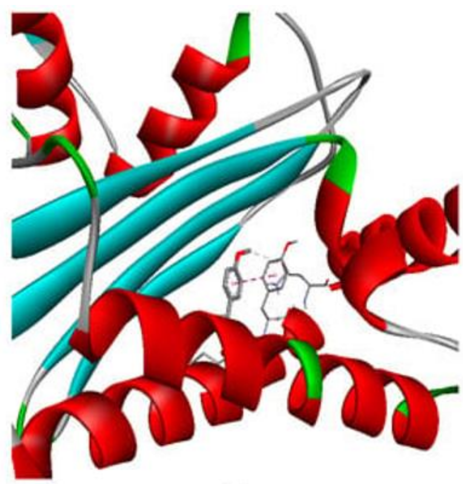
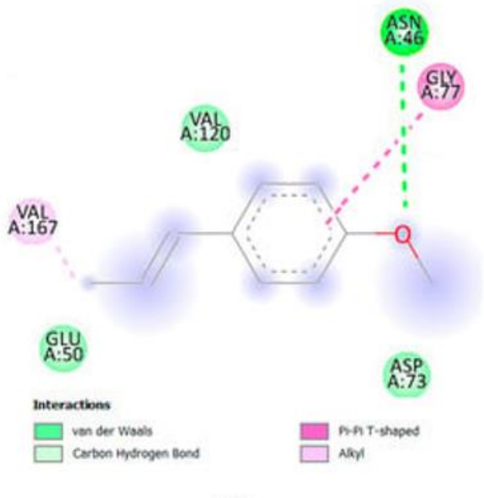


Figure 4. Interaction between the active site of COX-2 and Isoeugenol (Zarlaha *et al*., 2014).

According to a different study, the molecular docking method was used to evaluate the compounds' propensity for binding to DNA gyrase B's active site. The photos of the 2D and 3D ligand-AA interactions for the two compounds under study are displayed in **Figure 5**. When the residues interacting with these compounds are compared to those in the active site. This supports the theory that these chemicals have the solidest inhibitory influence on E. coli (Eswaramoorthy *et al*., 2021). Van der Waals connections from the AAs Glu50 and Val120 surround the trans-anethole, while the compound's benzene ring interacts with an alkyl bond from Val 71 through a pi-pi cationic link formed by Gly77. The lone hydrogen bond in the molecule is formed by Asn46 with the oxygen atom; Asp73 forms the electron-accepting carbon bond with a carbon-hydrogen. Furthermore, there are notable interactions between methyl chavicol and trans-anethole. The hydrophobic chains comprising the amino acids, as well as the alkyl bonds with Val167 and Ile94, envelop this molecule. By completing a hydrogen bonding contact with the crucial AAs Thr165, the molecule is expanded into the active site outwards (Kiessling & Diehl, 2021).



a)



b)

Figure 5. Representation by 3D and 2D of the docking pose of DNA gyrase B and *trans*-anethol (Qasem *et al*., 2023).

Isoeugenol's significant cytotoxic action can be partially explained by its ability to inhibit the COX and LOX enzymes, as well as by trans-anetholes at the active site of DNA gyrase B of E. Coli, according to a study of (Das Chagas Pereira and Mendes, 2020). In tests on cell lines, caffeine performs on par with or better than cisplatin (Teng *et al*., 2020).

Conclusion

The fact that the plant's aqueous extract contains a large number of bioactive molecules, as well as anti-inflammatory, anti-oxidants, and anticancer compounds, shows that basil has a strong biological impact on lowering several diseases associated with these mechanisms.

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Conflict of interest: None

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Ethics statement: This study was approved by the Faculty of natural and life Sciences, El-Oued University.

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