Azhar Int J Pharm Med Sci 2024; Vol 4 (2): 14-26
(Review Article)

Open Acces

Print ISSN: 2735-4598
Online ISSN: 2735-4601

Approach to Pharmacological Properties and Chemical Constituents of Selected Apiaceous Plant Species

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Article history: Received 2023-01-25 Revised 2023-04-06 Accepted 2023-08-07

Abstract: Umbelliferae family represents the broadest plant families. It is mainly distributed in the Mediterranean countries. Coriander, cumin, fennel, and anise are the Apiaceous plant species that are traditionally used most frequently. The Apiaceae family is thought to have the potential to bioactive metabolites as terpenoids, polyacetylenes, polyphenols compounds, and essential oils. The Apiaceae family's ability to exhibit hepatoprotective, antifungal, antimicrobial, antioxidant, antiaging has been convincingly demonstrated in a myriad of pharmacological investigations using both *in vivo* and *in vitro* models, supporting the rationale behind several of its therapeutic uses. The current review highlights the inconsistent information provided in the literature regarding the chemical makeup and pharmacological properties of various extracts and volatile oils from selected Apiaceae plants. It also reveals their potential for usage in other industrial applications, such as the development of medicines and cosmetics. This review will provide backing for additional research on the pharmacological effects of species of medicinal plants in the Apiaceae family.

Keywords: Phytoconstituents; Pharmacological effects; Apiaceae; Fennel; Anise; Coriander and Cumin.

1. INTRODUCTION

One of the largest plant families, the Umbelliferae Apiaceae family contains more than 400 genera and more than 3700 species.; it is mainly distributed in the Mediterranean countries [1]. Due to a diversity of bioactive components and phytochemical components, members of Apiaceae family are well known for their use in herbal medicine, cuisines, drinks, and cosmetics [2]. The Apiaceous species that are most frequently utilized today include coriander, cumin, fennel and anise [3]. They have been the subject of numerous studies that have focused on their health advantages in addition to their use as spices, including their anti-tumor, antibacterial, anti-inflammatory, digestive, antispasmodic, estrogenic, hypoglycemic, radical scavenging, and hypolipidemic actions [2]. As a supplier of bioactive metabolites for volatile oils, the Umbelliferae family is regarded as being particularly important, phenolic compounds, polyacetylenes and terpenoids [1]. The essential oils of the apiaceous fruit have anticancer, to treat spasm, antibacterial, antioxidant, anti-inflammatory, antiulcer, antiseptic, and antiaging properties [1]. As they function to clear the pores and prevent clogging, consumers think that the skin is thoroughly cleaned by the essential oils from the aforementioned plant species. Additionally, the essential oils remove the skin's surface pollutants and hyperpigmented spots. and therefore, the oils are purported to whiten the skin. Due to their fragrant properties, several terpenoids, particularly monoterpenes and sesquiterpenes, such as trans-anethole in anise and fennel, are added to common foods as supplements to improve their flavour, smell, and biological values [4]. Pharmaceutical companies frequently employ

Cite this article: Manaa E. G., Osama N., Salem M. A., Hamdan D. I., Ibrahim M. T. Approach to Pharmacological Properties and Chemical Constituents of Selected Apiaceous Plant Species. Azhar International Journal of Pharmaceutical and Medical Sciences, 2024; 4(2): 14-26. doi: 10.21608/AIJPMS.2024.189374.1188

DOI: 10.21608/AIJPMS.2024.189374.1188

apiaceae seed oils and extracts as flavouring components in toothpastes, and as fragrance components in mouthwash, candies cleanser, lotion, and fragrances [1]. Furthermore, apiaceae extracts frequently contain phenolic components as flavonoids, and organic acids [1]. The effects and causes of skin ageing, skin diseases, and skin injuries like wounds and scars can be lessened by using beauty preparations containing phenolic compounds topically [5]. Additionally, phenolic compounds have been found to have anti-inflammatory characteristics by preventing the production or action of pro-inflammatory moderators, making them an effective substitute for anti-inflammatory medications [6]. From Apiaceae plants, polyacetylenes were isolated and/or identified and demonstrated antifungal, antimicrobial, anti-inflammatory, and antitumor effects [4] . Additionally, they exhibit antidiabetic properties and may be used to treat endotoxemia [4]. Fennel, cumin, anise, and coriander are four plants of the Apiaceae family that have not yet been thoroughly studied in terms of metabolite composition and antioxidant activities. Additionally, this is the first time that a comparative examination of the anti-inflammatory and anti-aging properties of apiaceous volatile oils and extracts has been done.

2. PHYTOCHEMISTRY

There are many different types of secondary metabolites, such as phenolic and organic acids, as well as their derivatives, flavonoids, coumarins, and fatty acids, have been reported to be isolated and/or identified in the selected Apiaceous plant species fennel, anise, coriander and cumin under investigations.

2.1. Essential oils

Different plant parts can be used to produce essential oil. which abundant in the apiaceous plant species under investigation, Furthermore, their fruits, where it is found in the glands vittae present in the mericarp, contain the highest concentration. Because of its chemical components, namely the presence of aldehydes, this oil is what gives seeds their distinctive odor **[1]**. According to reports, myrecene, fenchone, estragol methyl chavicol, linalool, sabinene, 1,8-Cineole, and -Pinene are the major constituents of apiaceous plant species seed essential oil, their molecular configurations are displayed in Figure 1[7-11] .

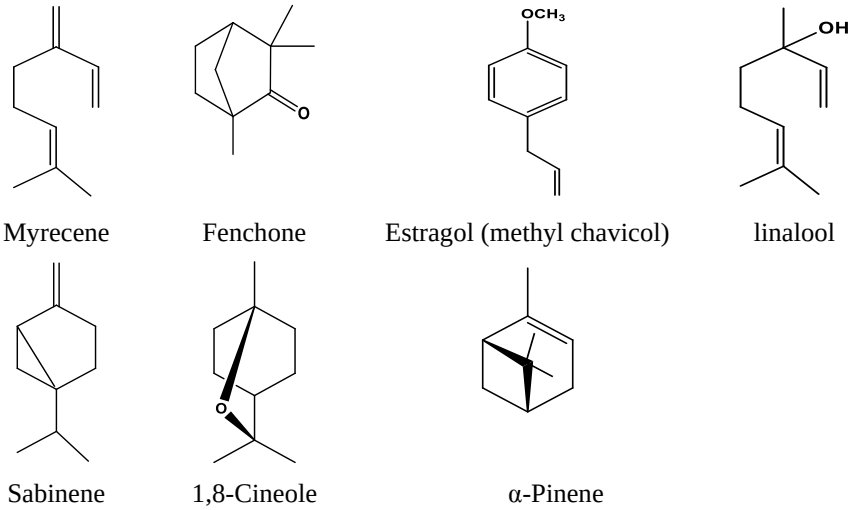

Figure 1. The structures of the major bioactive volatile oil components of Apiaceous plant species under investigations.

2.2. Phenolic and organic acids and their derivatives

Apiaceous plant species under investigations are rich sources for phenolic acids. The aromatic acids are either benzoic, syringic , or cinnamic acids derivatives, benzoic acid derivatives as hydroxybenzoic acid ,gallic, vanillic and protocatechuic acid while hydroxycinnamic acid derivatives as caffeic. *P*-coumaric, and feruolic acids[2, 12, 13] .These phenolic acid and their derivatives and their molecular structures are are shown in Figure 2.

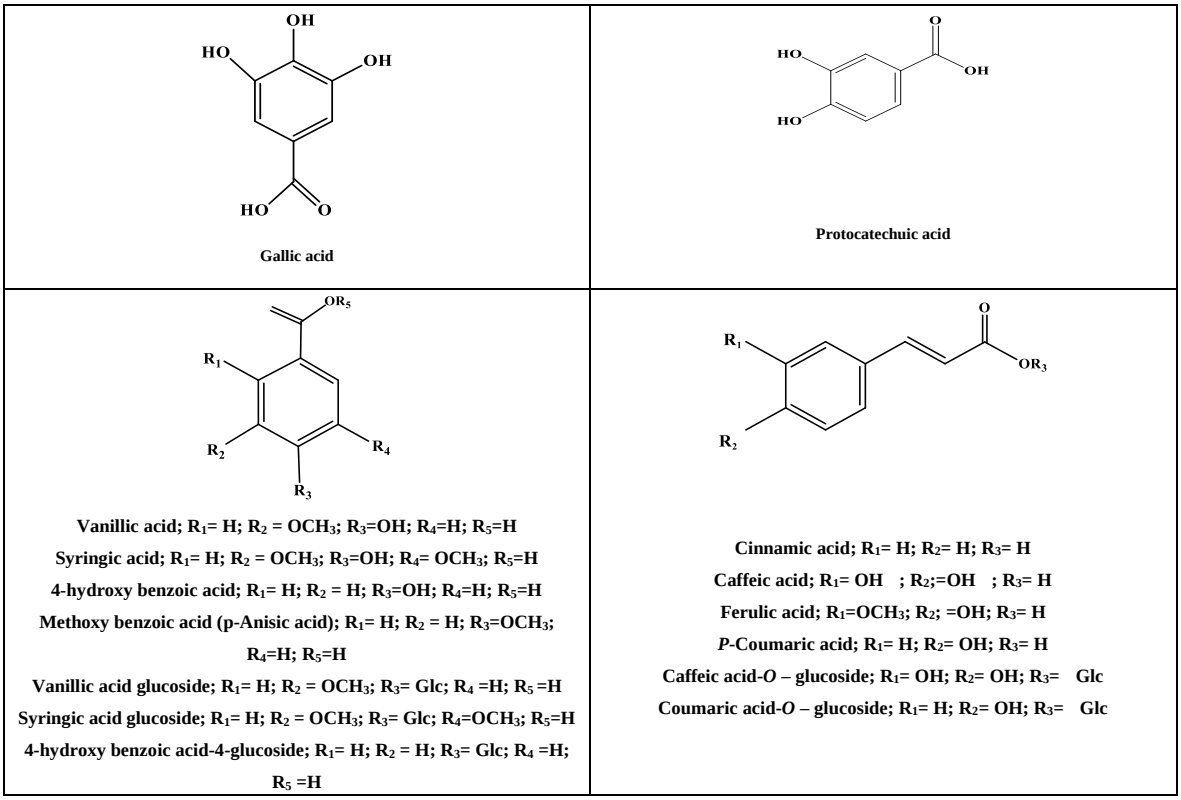

Figure 2. The molecular structures of phenolic and organic acids and their derivatives components of Apiaceous plant species under investigations.

2.3. Flavonoids

Apiaceous plant species under investigations contain a wide variety of flavonoids as flavones, flavonols, flavanones, isoflavone and flavan-3-ols[2]. A structure and isolation By using chromatography to identify flavonoid constituents from fennel, anise, coriander, and cumin, quercetin, rutin, kaempferol, isorhamnetin were isolated [14-16]. In other studies reported that chrysin, acacetin, luteolin, apigenin, chrysoeriol, luteolin-7-glucoside and luteolin 7-rhamnoside were isolated from selected Apiaceous plant species [2, 13, 17]. Their molecular structures are shown in Figure 3.

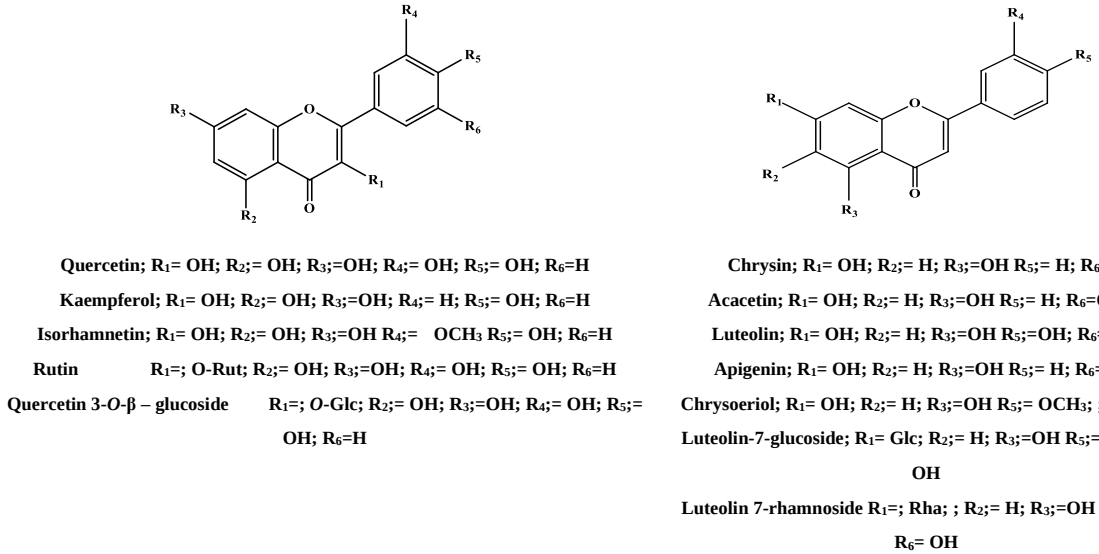

Figure 3. The molecular structures of flavonoids components of Apiaceous plant species under investigations.

2.4. Coumarins

Apiaceous plant species under investigations are rich of coumarins such as esculetin, xanthotoxin , 4-hydroxycoumarin and umbelliferone[2, 18]. A coumarin glycoside with a variety of medicinal effects, such as antiinflammatories, anticoagulant and anti-cancer effects. is esculin [2]. These coumarins and their molecular structures are shown in Figure 4.

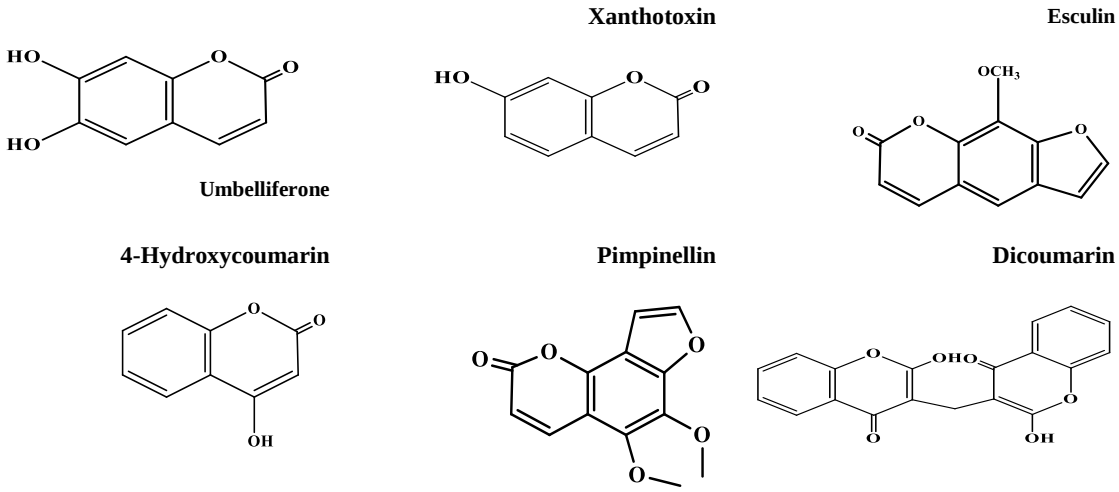

Figure 4. The structures of coumarins components of Apiaceous plant species under investigations.

2.5. Nitrogen containing compounds

Apiaceous plant species under investigations have been reported to contain nitrogen containing compounds as N-rhamnosyl proline, fructosyl-*O*-valine, tryptophan, fructosyl-*O*-phenylalanine, amino-methyl-heptadecanetriol and eicosenamide[2]. These Nitrogen containing compounds and their molecular models are shown in Figure 5.

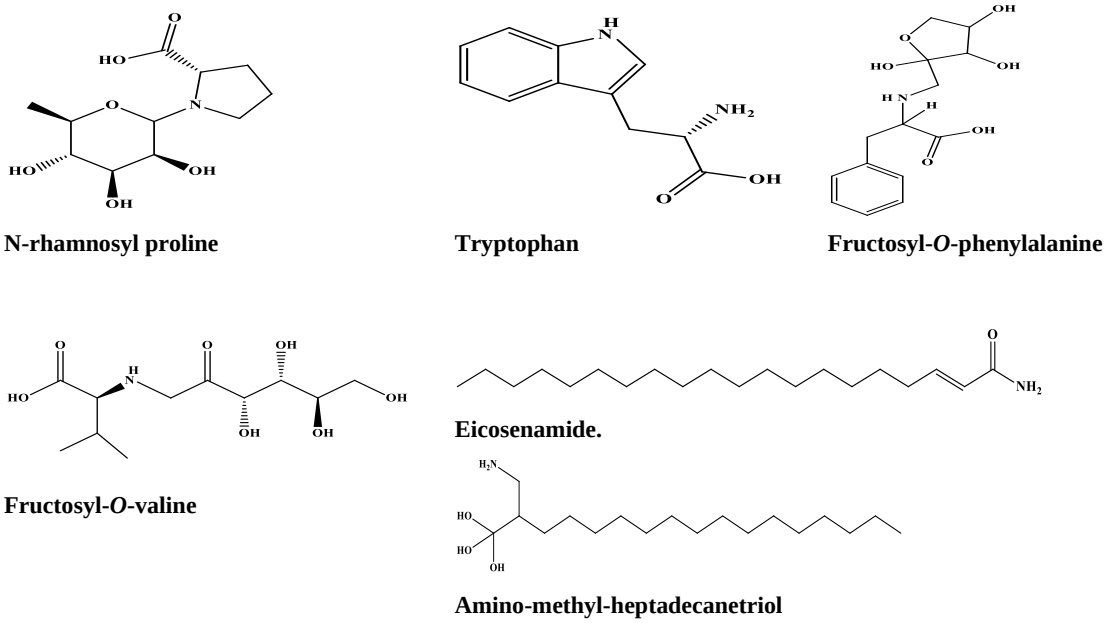

Figure 5. The structures of nitrogen containing compounds of Apiaceous plant species under investigations.

2.6. Fatty acids

Numerous fatty acids were found. in apiaceous fruits under investigation such as arachidic, pentadecanoic, octadecanedioic, lauric acid and Methyl nonadecanoate.[10, 19] Additionally it was reported [2] that some of fatty acid such as linolenic and linoleic acid which possess as anti-inflammatory properties through providing the

building blocks for prostaglandin [2]. These fatty acids and their molecular structures are shown in Figure 6.

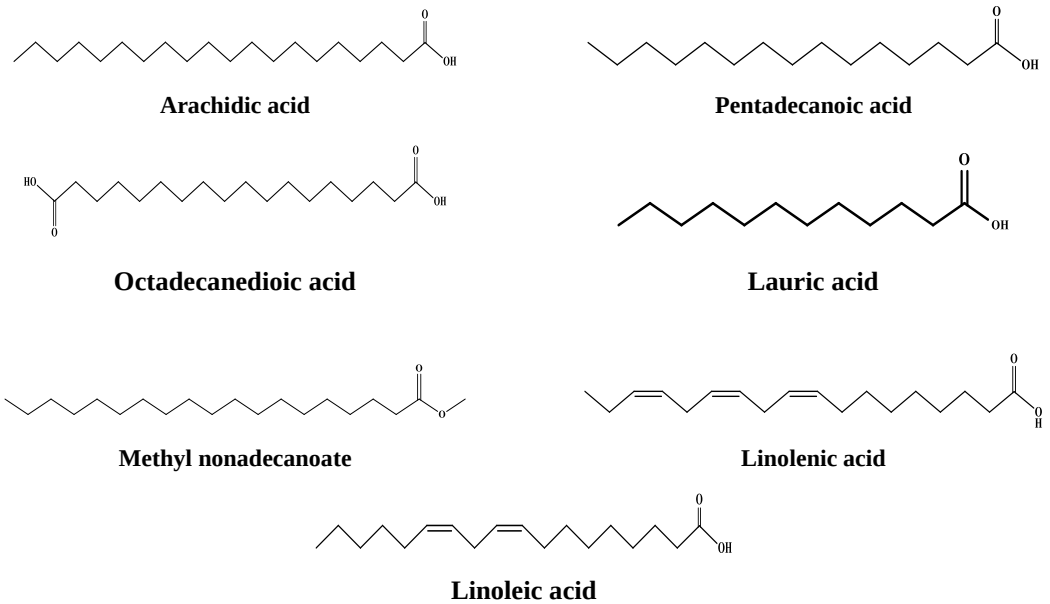

Figure 6. The molecular structures of fatty acids components of Apiaceous plant species under investigations.

3. BIOLOGICAL EFFECTS

Family apiaceae has been reported to have a large variety of biology, including antimicrobial, antioxidant, anti-inflammatory, antitumor, antifungal, anti-diabetic and anti-wrinkles as listed in table 1.

3.1. Antibacterial activity

Apiaceous plant species under investigations exhibit a strong antibacterial activity against different strains of microorganism [10, 20]. where *Coriandrum sativum* coriander essential oil EO obtained from fruits and leaves using various assays, including disc diffusion, agar or broth dilution, to be efficient against a variety of bacteria [21]. Additionally Seed EO is discovered to prevent the growth of 25 bacterial strains [1]. Coriander seed EO was shown by Silva and Domingues to be effective against *Campylobacter jejuni, methicillin -sensitive Staphylococcus aureus, K. pneumoniae*, *Shiga toxin generating Escherichia coli*, and *Acinetobacter baumannii*. [21]. Linalool, -pinene, p-cymene, -terpinene, limonene, and linalyl acetate are some of the coriander EO constituents that have been shown to act well against a variety of microorganisms. As phenolic chemicals include the hydroxyl -OH group, they have the highest antibacterial properties. [21].

Numerous studies demonstrate the potency of *Cuminum cyminum* cumin against various bacterial species. Due to cumin aldehyde in volatile oils, this activity has occurred [22]. Likewise, cumin seeds' ethanolic extract contains antibacterial qualities that are effective against *Helicobacter pylori* [23]. Additionally, EO derived from the fruits of *Foeniculum vulgare* fennel has an antibacterial impact on microorganisms that cause foodborne illness, including *Escherichia coli*, *Bacillus megaterium*, and *Listeria monocytogenes* [24]. The growth of *Agrobacterium radiobacter pvtumefaciens*, *Pseudomonas fluorescens*, and *Pseudomonas glycinea* can all be suppressed by aerial parts fennel extract [1]. A phenyl propanoid derivative, dillapional, and scopoletin, among other chemical components derived from fennel, have been discovered as potent antibacterial principles [24]. Methanolic and aqueous extracts 50% v/v and anise oil showed a strong bacterial resistance against *Staphylococcus aureus*, *Proteus vulgaris, Escherchia coli, and Klebsiella pneumoniae* [1]. Polyphenolic compounds, which function as antimicrobial agents via a number of procedures provides a breakup of microbial membranes, are likely responsible for the previous activity [25].

3.2. Antifungal activity

The hydrodistillation of coriander EO shown considerable antifungal efficacy against various Candida species 26. Because it consists of phenolic, aldehydic, and alcoholic components that significantly inhibit filamentous and yeast fungi,

cumin EO also shown considerable antifungal activity [26].

Essential oils of fennel and anise shown antifungal properties towards ,*Penicillium citrinum*, *Aureobasidium pullulans* and *Debaryomyces hansenii* since there is anethole which represents the core element of anise and fennel essential oils [27].

Table 1. Biological activities that reported selected Apiaceous plant species.

No	Biological activity	Plant source	Plant part (extract)	References
1	Antibacterial	*F. vulgare* *C. cyminum*	Fruit extract	(10)
		P. anisum *C. sativum*	Fruit Essential oil	(60) (20)
2	Antifungal	*F. vulgare* *C. sativum* *C. cyminum*	Fruit Essential oil	(10) (61) (62)
		P. anisum	Fruit extract	(63)
3	Anticancer	*F. vulgare*	Aerial parts Essential oil	(64)
		P. anisum	Fruit extract	(36)
		C. sativum	Leaves extract	(65)
		C. cyminum	Fruit extract	(66)
4	Hepatoprotective	*F. vulgare* *P. anisum* *C. sativum*	Fruit (Essential oil)	(67) (51) (68)
		C. cyminum	Fruit extract	(69)
5	Antioxidant	*F. vulgare* *P. anisum*	Fruit extract	(24) (70)
		C. sativum	Fruit extract	(71)
		C. cyminum	Fruit (Essential oil)	(72)
6	Anti- inflammatory	*F. vulgare*	Fruit extract	(24)
		P. anisum	Fruit (Essential oil)	(51)
		C. sativum	Fruit (Essential oil)	(73)
		C. cyminum	Leaves (Essential oil)	(74)
7	Anti-diabetic	*F. vulgare* *C. cyminum*	Seed extract	(10) (75)
		P. anisum	Fruit essential oil	(76)
		C. sativum	Fruit extract	(77)
8	Anti-aging	*F. vulgare*	Fruit extract	(59)
		C. sativum	Fruit essential oil	(13)

3.3. Anticancer and cytotoxic activity

According to studies, coriander seed EO exhibits antiproliferative effects on a number of cancer cell lines, including hepatocarcinoma. HepG-2, leukaemia,breastcancer MCF7,lung adenocarcinoma NSCLC , epidermoid carcinoma SCCs and prostate cancer due to linalool which revealed an *in vitro* cytotoxic impact that was dose-dependent and reduced the size and weight of the tumor [28, 29]. Rutin, catechins, and polyphenolic acids are all present in the coriander fruit extract's polyphenol-rich portion. [28]. The anticancer activity of coriander fruit extract may be attributed to polyphenolic-rich fraction containing mainly catechins,where they showed direct antioxidant properties, as well as targeting lipid and the endoplasmic reticulum [30]. In addition, polyphenolic acids, such as chlorogenic acid, have anticancer action against the cancer cell lines of the human breast MCF7, lung adenocarcinoma NSCLC, colon HCA-7, bone, and kidney HEK [31]. Vanillic acid also prevented cell division by stopping the G1 phase and suppressing angiogenesis [32].The anticancer activity of rutin was demonstrated against glioblastoma GBM , leukemia LL-100, breast MCF7, prostate, lung adenocarcinoma NSCLC, stomach, liver HepG-2, and colon by inhibiting cancer initiation and development via regulating many dysregulated signalling pathways related to apoptosis, autophagy, inflammation, and angiogenesis [32, 33].

Additionally, cumin EO was shown to stimulate pro-apoptotic proteins, change the integrity of mitochondria, and prevent the malignancy. This is why it was reported to have anticancer action against colorectal cancer [34]. Cumin dietary supplements reduce the activity of the enzymes -glucuronidase and mucinase as well as the development of colon cancer in rats exposed to a colon-specific carcinogen. [35].

Finally, Prostate cancerPC-3 cell line is significantly reduced by an ethanolic anise seed extract. [36] and gastric adenocarcinoma AGS [37] compared to normal cell line L6 .

3.4. Hepatoprotective Activity

The hepatoprotective activity of coriander, cumin, fennel and anise seeds against carbon tetrachloride CCl_4 was evaluated *in vitro* & *in vivo* with estimation of several markers such as serum glutamyl oxaloacetic acid transaminase SGOT, alkaine phosphatase ALP and bilirubin [38-40].

Hepatocytes are damaged by CCl4, which also alters the integrity of the membrane. As a result, enzymes in the hepatocytes leak out [41]. Therefore, the abnormal elevations of ALT, ALP, and AST were dramatically reduced following therapy with coriander, cumin, fennel, and anise seed [39, 40].

3.5. Antioxidant activity

Different plant parts of the Apiaceae family's essential oils and solvent extracts were tested for their antioxidant activity via different techniques, such as free radical scavenging, metal chelating activity, and hydrogen peroxide scavenging [1].

Coriander leaves exhibit stronger antioxidant activity in ethanolic, methanolic, and aqueous extracts than in seeds extracts, which may be a result of the high carotenoid concentration [1]. The higher linalool concentration in coriander seeds EO may explain why they exhibit greater radical scavenging action than the leaves EO [1]. [21] reveal that coriander's total antioxidant capacity was increasingly reliant on the amount of tannins and flavonoids than it was on the total amount of polyphenolic components. While flavan-3-ols, which are catechins found in coriander seed extract, operate as pro-oxidants inside of cells. [42] . Their indirect antioxidant activities include stimulating antioxidant enzymes, blocking pro-oxidant enzymes, and creating phase II detoxification and antioxidant enzymes. They are metal ion chelators and ROS scavengers [43] .

Cumin EO has a higher DPPH radical scavenging activity as opposed to butylated hydroxytoluene BHT and butylated hydroxyanisole BHA. This may be because cumin contains significant amounts of antioxidant compounds like pinocarveol, linalool ,cuminal, terpinene, and carotol [44]. Additionally, it has been claimed that cumin seed extracts and their fractions have antioxidant effects [44]. Whereas the extract of ethyl acetate exhibited the greatest capacity to neutralise superoxide radicals. Methanolic extract had the highest percentage of inhibition.

Finally, The high amount of phenolic compounds such as kaempferol ,rosmarinic acid, 3-caffeoylquinic acid, eriodictyol -7 rutinoside, 4-caffeoylquinic acid, , ,quercetin -3-O galactoside, and 1,5-O-di caffeoylquinic acid may be the reason for the strong antioxidant activity of fennel and anise seeds extracts [45, 46].

3.6. Anti-inflammatory activity

Because of the occurrence of fatty acids such as, petroselinic, oleic acid, palmitic and linoleic acid ,it considerably boosted the synthesis of an anti-inflammatory precursor and has the ability to decrease arachidonic acid production in rats, coriander EO fruit demonstrated significant anti-inflammatory activity [47]. Additionally, it has been discovered where cumin EO considerably lowers IL-1 and IL-6 mRNA levels [48].

The weight of the edoema caused by carrageenan in the rat paw was greatly reduced by ethanolic and methanolic extracts of the aerial portions of fennel, demonstrating significant anti-inflammatory efficacy [49]. Additionally, studies using a hot plate revealed analgesic action 56. The alpha-pinene and fenchone compounds in fennel EO may have antinociceptive properties because they significantly lowered the nociceptive threshold [50].

Anise EO is typically anethole, a component of which, is known to have anti-inflammatory qualities, which prevents platelet aggregation and the production of thromboxane B2 in plasma in response to adenosine diphosphate, adrenaline, and arachidonic acid [51]. Prostaglandins and NO levels in the inflammatory exudate were also decreased by the use of anethole as a therapy [57]. EO anise demonstrated a strong analgesic effect comparable to morphine and aspirin [52].

3.7. Antidiabetic activity

Investigations on Apiaceous plant species revealed strong hypoglycemic activity as seen by the decrease in blood sugar levels in rats [10, 53]. In streptozotocin- deficient mice, coriander extract demonstrated a potent hypoglycemic effect by stimulating insulin production, improving glucose uptake and metabolism by muscle, and regulating blood sugar and dyslipidemia in individuals at usual conventional doses [47]. Becouse of the presence of large amounts of polyphenols components, which reduce the hyperglycemic effect and result in a decrease in glucose absorption in normal rats, cumin seeds' ethanolic extract also demonstrated strong antidiabetic activity [53]. Due to the presence of cuminaldehyde and cuminol, which significantly increase intracellular Ca2+ amounts, cumin seed EO also demonstrated strong insulinotropic effects [54]. Trans-anethole, found in fennel and anise seed EO, increases insulin levels [55, 56].

3.8. Anti-aging activity

Consumers believe that Apiaceous plant species coriander, cumin, fennel and anise EO provide the necessary deep cleaning for the skin, which helps to clear the pores and prevent clogging and lightens the skin [57]. The skin surfaces are also cleaned of hyperpigmented patches and other irritants by the essential oils [57] . Due to linalool, which was discovered to have substantial antioxidant capacity, coriander seed EO was revealed to have antiaging action [58]. This might be explained by decrease the overexpression of MMP in skin cells and preventing the excess expression caused by UVB of various inflammatory cytokines such as COX-2,TNF- and IL-6 [58]. Furethmore, essential oils of cumin and anise displayed an antiaging effect owing to the high proportion of *trans*-anethole and cuminaldehyde [13]. The antiaging activity of fennel extract may be attributed to polyphenolic-rich fraction which act as a potent antioxidant compounds that scavenge free radicals [59].

5. CONCLUSIONS

This review highlights the therapeutic action and active ingredients of Umbelliferae family plants. It reveals that Apiaceae family plants a significant supply of naturally occurring bioactive components, this may prove valuable for applications in diet, medicine, and cosmetics. Subsequently, the composition of chemicals of these plants, along with the antioxidant and antibacterial efficiency demonstrated by their crude extracts and essential oils, offer experimental and scientific substantiation supporting their numerous traditional usages as prospective herbal drugs due to their safety and potency. Further investigations of the Apiaceous plant species fennel ,coriander, anise and cumin are essential for a thorough knowledge of the underlying pathways behind their action *in vivo* and *in vitro* as well as for ensuring the safety of plant extracts for human consumption.

Funding: The authors indicate that this work did not receive funds from funding agencies in the public and private sectors.

Acknowledgments: Grateful acknowledgment is expressed to all staff of Pharmacognosy Department, at Menofia University for their useful cooperation and help all the time throughout the entire work.

Conflicts of Interest: We certify that there is no conflict of interest of any type regarding the publishing of the current study.

Author Contribution: All authors have reviewed the literatures; participated in writing and revising the manuscript to be ready for publication.

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