Article published on 2025-7-9

Golden Flaxseed (*Linum Usitatissimum*): Unveiling Its Botanical Marvels, Therapeutic Potentials, and Nanoscale Applications

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Chinese Journal of Applied Physiology, 2025: e20250017

Abstract Flax seeds, scientifically known as *Linum usitatissimum*, are nutrient-rich seeds with omega-3 fatty acids, lignans, and fiber. They offer diverse health benefits including cholesterol reduction, cardiovascular support, anti-inflammatory properties, and potential in combating chronic diseases like diabetes and cancer. Additionally, their anti-arrhythmic and anti-atherogenic properties benefit vascular health. Studying their botanical features, phytochemical composition, and pharmacological activities could lead to innovative medical treatments. Flax seeds, with their nutritional versatility, present a valuable addition to a balanced diet, potentially contributing to improved well-being and disease prevention. studies have demonstrated its effectiveness in the production of nanoparticles with enhanced pharmacological effects and potential applications in various biomedical fields. Therefore, the main purpose of this review is to explore the importantrole of *L. usitatissimum* as an important medicinal weed and to study its various pharmacological activities as well as the required chemical components.

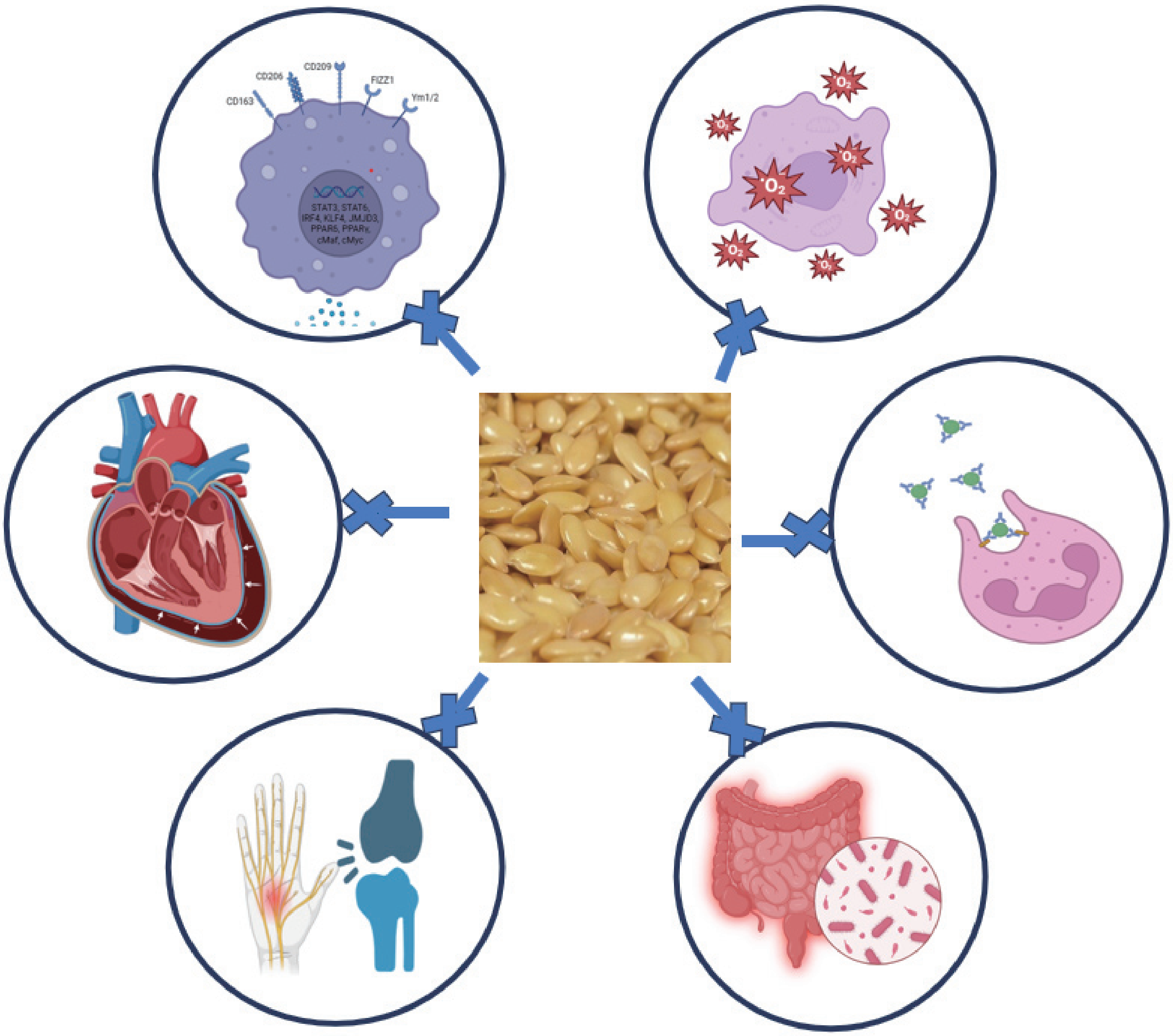
Keywords *Linum usitatissimum*, Linaceae, morphology, phytochemistry, ethanomedical uses, Pharmacology,nanoparticles

1. Introduction

There is currently a growing interest worldwide in medicinal plants and their natural healing abilities. In the modern world, these plants are increasingly viewed as alternatives to traditional medicines. This trend reflects the growing recognition of the therapeutic benefits of naturopathic medicine for human health and well-being [1]s.In recent years, scientists around the world have paid increasing attention to research on herbal medicines to reveal their biological functions and safety. India and in some parts of the world has in the past used herbs and shrubs as remedies for human diseases. In light of the decline in the discovery of new synthetic drugs, traditional medicines of natural origin

DOI: 10.62958/j.cjap.2025.017
www.cjap.ac.cn

Published by CJAP editorial office and Asian BioMed Innovation Press



Graphical Abstract

have become an attractive avenue for the development of new, safe and effective medicines, sparking renewed interest in harnessing the potential of these ancient therapies to meet modern healthcare needs [2].

Herbal medicine involves the study and use of the healing qualities of plants. Interestingly, plants are in a position to develop a variety of chemicals of importance in various physiological processes. It is assessed that roughly 80% of people in emerging nations rely on traditional medicine as their main healthcare source and this depends on its natural origin and fewer side effects. Medicinal plants occupy a central place in almost all traditional medical systems and are an essential component of healthcare practice. These plants are valuable resources that have been exploited for their therapeutic potential and used to all eviate various health problems in all cultures around the world [3]. In recent years, researchers have become increasingly interested in herbal treatments because of evidence supporting their safety and benefits. This has also given rise to the new scientific phrases such as phytotherapy, phytomedicine, phytoneering and nutraceuticals. Flaxseed is a plant-based remedy that is used in both nutrition and medicine. Flaxseed has several health-promoting properties that health experts and nutritionists find attractive for preparing nutritious meals and promoting healthy eating[4]. Certainly! Flax seeds have been in use since ancient times, such as Egypt's Nefertiti era. They were called "Tisi" or "Alsi" in India and were used as an additive to the food consumed by hardworking villagers. Flaxseed is the most important oilseed crop for the present days, which is used in production of food, fodder and fiber. It was highly regarded due to its flexibility and wide-reaching uses [5]. The large number of potential active ingredients and its multifunctional properties make *L. usitatissimum* a foolproof candidate for the production of health-promoting drugs and nutritional supplements[6].

Flaxseed contains different phyto chemicals, including tri terpenoids, steroids, glycosides, flavonoids, free amino acids, tannins, saponins, alkaloids, carbohydrates, and L-ascorbic acid. Apart linolenic and linoleic acids, lignans, cyclic peptides, polysaccharides, cyanogenic glycosides, proteins, and cadmium are among the various physiologically dynamic substances and components that amass in flaxseed. These mixtures add to the nourishing and medical advantages of flaxseed [7]. The growing popularity of flax is due to its potentiality in reducing - cardiovascular diseases, hazard of malignant growth, especially of the mammary and prostate organ disease, mitigating action, purgative impact, and lightening of menopausal side effects and osteoporosis [8]. flaxseed is renowned for its rich composition of various chemical compounds that offer specific biological activities and functional properties. These incorporate PUFA from the, dissolvable dietary filaments, omega3 family, carbohydrates, lignin, proteins and. Also, flaxseed has properties like solvency, warm solidness, emulsifying abilities, electrostatic charge thickness, water maintenance, and the ability to assimilate fats. These qualities make flaxseed a significant fixing in different food items and dietary decisions [9].

2. Botanical Description

2.1 Introduction

2.1.1 Taxonomic Classification

Botanical Name: *Linum Usitatissimum Linn*.

Taxonomical classification of *Linum usitatissimumis* discussed in Table no. 1.

2.1.2 Vernacular Names

Vernacular names are given in Table no. 2.

Table 1: Taxonomical classification of *Linum usitatissimum* [10].

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Rosidae
Order: Linales
Family: Linaceae
Genus: *Linum*
Species: *Usitatissimum*

Table 2: Common names of *Linum usitatissimum*[10]

Language	Synonyms
Sanskrit	Uma, Ksuma
Hindi	Alsi
Gujarati	Alahi , Atasi
Bengali	Masina, Atasi
Kannada	Agasebeeja, Semeagare, Agasi
Kashmiri	Alsi
Malayalam	Agastha, Agasi, Cheri, Charm
Marathi	Atasi
Punjabi	Ali Tamil – Ali, Virai
Telugu	Avisa
Urdu	Alsi, Katan

2.2 Plant Overview

Figure 1: Plant of linum usitatissium

Figure 2: Close up view of plant

2.3 Habitat

A. habitat
B. habit
C. phyllotaxis
D. leaf adaxial surface
E. leaf abaxial surface
F. inflorescence
G. flower front view
H. flower side view
I. sepal
J. petal
K. stamen inner surface
L. stamen outer surface
M. pistil
N. fruit
O. seed

2.4 Description of plant

It is a small semi prostate annua lweed. The stems of the plant usually grow to a height of 30-120 cm. The stems have a simple cylindrical shape and are upright. Their under sides become hard and woody, and the higher the trunk, the more they split into smaller branches, which are arranged in clusters or umbels. It is available annually or year-round. It is an herbaceous creeper with leaves that are short in height and have a hairy, blade-like appearance. The leaves are glassy, green, slender and lanceolate, 20-40 mm long and 3 mm wide. The flowers are 15-25 mm in diameter and have five petals, which, depending on the variety, may be white, blue, yellow and red. The fruit is a round, dry capsule 5-9 mm in diameter containing several shiny, brown seeds in the shape of an apple core and 4-7 mm long. This plant is a growing plant. Morphology of *Linum usitatissimum* is further explain in table no 3 [14,15].

Currently, *L. usitatissimum* occurs in the eastern Mediterranean, India, western Asia, the Middle East, and ancient sites in Israel and Syria [11]. It was reported that it was first cultivated in Egypt, but it is grown all over the world. It is a native species and a well-known cultural weed. It is widespread in theregion, particularly in Turkey, Iran, Jordan and Syria, Canada, China, India and the United States. Linseed is currently cultivated in approximately 50 countries, mainly in the northern hemisphere[12]. In India, flax is mainly grown in the states of Chhattisgarh, Bihar, Jharkhand, Karnataka and West Bengal. Three states - Uttar Pradesh, Madhya Pradesh and Maharashtra - account for about 74% of India's flaxseed production. It is an important weed that spreads widely and produces many seeds[13].

3. Morphology of *Linum Usitatissimum*

Pictorial presentation of morphology

Figure 3: Natural habitat of *Linum usitatissimum*[3,4]

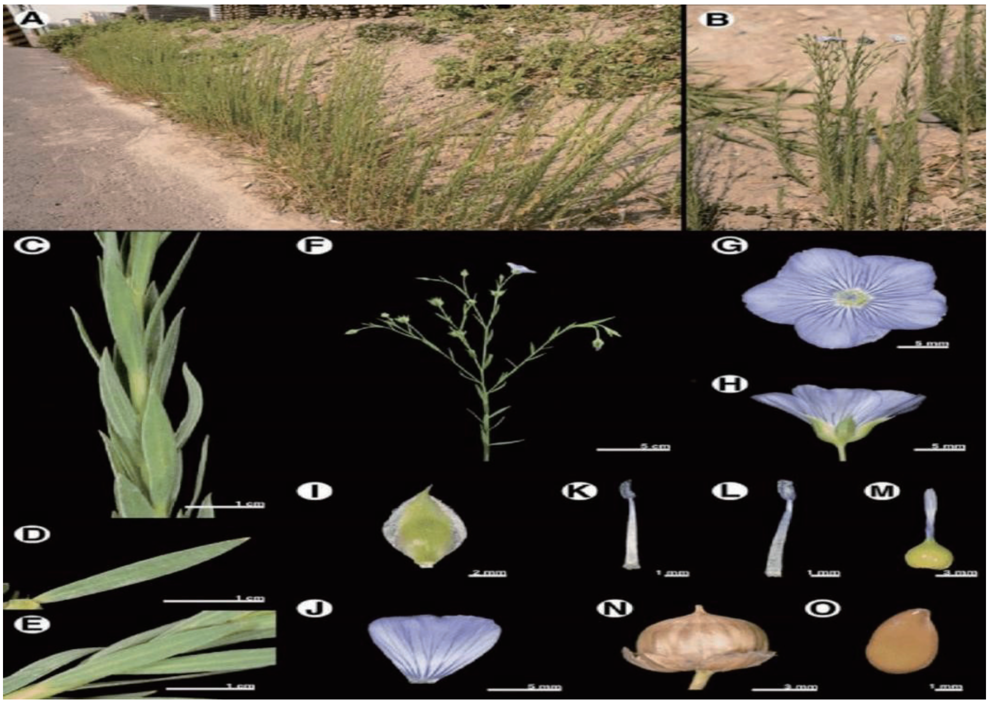


Figure 4: Morphology of *Linum usitatissimum*[5]

Table 3: Morphology of Linum usitatissimum[14-16]

Part	Description	Picture
Leaves	The leaves are arranged in an alternating spiral shape, ranging from almost upright to ascending or spreading. They are simple, sessile, without stipules and usually appear in whorls on the lowest stem. These spear-shaped leaves are ½ to 1.5 inches long andabout 1/8 inch wide. The leaves are elliptic to lanceolate, 1-3 cm long and 3-4 cm wide. They have serrated edges that end in a pointed tip. At their base, the leaves have three distinct veins with parallel orientation and a slightly convex appearance on the underside.	 **Figure 5:** Leaves[6]
Stem	These stems are usually single or multiple, upright, mostly unbranched except for flower clusters, withascendingbranches. Theyhave a leaf-like appearance, rounded cross-section, hairlessandsmoothbody. In addition, they can have a cylindrical shape up to 10 mm in diameter, with a tought exture and slightly speck led green parts (stomata), forming a periderm at the lower base.	 **Figure 6:** Stem[7]

Flower	Flowers are bisexual, radial, about 17-23 mm in diameter. It has 5 overlapping sepals and is firmly attached to the container. The outer 3 sepals are green with narrow colorless margins, while the inner sepals are green with broad colorless margins and conspicuous short cilia and fringes. The petals are fan-shaped, blue, with about 7 veins, purple, white at the base, narrow edges, and raised midrib on the upper side. The stamens are fused at the base to form a short tube, the stamens are erect and narrow and triangular. The pistil is oval, the ovary is green and shiny, with 5 chambers, each chamber contains 2 ovules, 5 styles, only the base is fused, and the stigma is lavender.	 **Figure 8:** Flower[8]
Infloresence	The inflorescence is a loose terminal raceme or cyme, open, multi-flowered, bracted, glabrous, rarely solitary, fixed by a pedicel, 20 cm long. The bracts are arranged in leaf-like sessile stems .During flowering, the pedicel is 9 mm long, but during fruiting, its length increases four fold and becomes some what erect (sub erect) with some grooves.	 **Figure 7:** Inflorescence[9]
Fruit	The fruit resembles a capsule and is divided into five parts, each containing two seeds. When it opens, it cracks along the walls and in the middle. There are ten seeds inside, which are round or oval, about 6 to 7 mm wide and 6.5 to 7.5 mm long. The seeds are pointed at one end and have a smooth, shiny surface with no hair-like structures. Simply put, flaxseeds are usually flat, slightly curved in the middle, oval or elongated oval, with a rounded base and a pointed tip.	 **Figure 9:** Fruit[10]
Seed	The seeds come in a variety of sizes, ranging from less than 4.0 mm to more than 5.25 mm in length. Ripe flax seeds can come in different colors such as yellow, various shades of brown, black, olive, and sometimes you can even find seeds in multiple colors.	 **Figure 10:** Seed[11,12]
Root	Their taproots are relatively short and thin, with smaller fibrous branches. In loose soil, these branches can extend to a depth of about 3 to 4 feet. The main root grows straight down. Lateral roots mainly develop in the upper part of the root system. This lateral root system helps the plant anchor itself and efficiently absorb water.	 **Figure 11:** Root[13]

4. Ethnomedical uses

Various pieces of *L. Usitatissimum* people in Sri Lanka, Pakistan, Canada, china, Ethiopia, India, utilize L. Usitatissimum either by itself or in conjunction with other therapeutic spices to treat a range of illness. Associated with the plant's capacity to generate linseed oil, which is used to treat skin salve (demulcent) and orally for constipation, arthritis, cancer, vaginitis, weight loss, heart disease and benign prostatic hypertrophy [17]. *L. usitatissimumuse* as, malignancy, diabetes, obesity, stomach, renal and bone disorders [18]. Flaxseed was used in Turkey to help with painrelief, wound healing and bronchitis. Cooked Taking flaxseed water on an empty stomach can help treat stomach problems and asthma. Ground flaxseed and spinach have strong laxative properties[19]. In North America, flaxseed is primarily used to produce industrial oils and animal feedmeal. Flax seed oil is a drying oil used in theproduction of paints and varnishes as well as linoleum flooring[20]. Ancient Egypt laid the foundation for the cultivation of flax as a textile fiber plant, especially to produce mourning clothes and mummy strips for the upper classes. Most textiles are also made from coconut fibers of wool, goat hair and flax (*Linum usitatissimum*) plants[21]. *L. usitatissimum* is also found in use in other countries. Rawseeds reportedly treat in digestion in southwestern Algiers [22]. Algerians also use the whole plant to treat obesity[23]. Tribal members in the Kurram region of Pakistan use the seeds to treat flatulence[24].

Tribal people in northern Morocco consume the seeds with honey to treat stomach problems[25]. seed oil on burns and boils and seed poultice has been applied on rheumatic and swellings in western Nepal [26]. Residents of Khyber Pakhtunkhwa regionhavebeenreported to use seeds to treat infectious diseases[27]. It has been accounted for use of seed in infectious diseases among dwellers of Khyber Pakhtunkhwa region. Powder of leaves has been utilized by individuals of Kurdistan district of Iraq to treat blood cholesterol, stiffness, colon issues, antispasmodic, skin consumes, gallstones and thyroid issues [28]. Ayurveda is a very ancient and still active tradition that is broadly practiced in Sri-Lanka, India along diverse nations has a decent philosophical and experimental foundation. Linseed oil is said to help with mental and actual perseverance by fighting weakness and reducing down the ageing process. Hippocrates, the father of medication, instructed linseed for the lightening with respect to stomach torments about 650 BC, about a similar time Theophrastus recommended linseed adhesive for hack cure. Hildegard von Bingen, 15th in the period A.D., utilized linseed feast in warm packs to treatment both internal diseases and exterior [5,29]. Flaxhas many uses. It is used internally to treat problems such as habitual constipation, colon problems caused by laxative abuse, and irritable bowel syndrome. Flax is also used as a soothing agent to relieve gastritis and enteritis. Flaxseed oil has laxative properties, while flax flowers are thought to enhance heart function. Use flaxseed meal or pressed cake topically to relieve inflammation and as an emollient in a poultice to treat condition such as boils, carbuncles, and other skin infections[30]. Flaxseed Unani can be taken internally to treat colds, coughs, bronchial problems, urinary tract infections, and diarrhea due to its sedative properties. Ground flaxseed can be applied topically as a poultice to relieve localized inflammation, ulcers, boils, and carbuncles. Flaxseed compresses are particularly effective as they retain heat well, helping to dilate local blood vessels, relax tissues, and alleviate tension and pain, making them a valuable supportive treatment. In addition, flaxseed dressings can help treat deeper inflammations such as bronchitis and have even been recommended for the treatment of gout and rheumatics welling[31]. In the taluk district of Karnataka, tribal have historically used flaxseed (*L. usitatissimum*) according to traditional practices to relieve constipation and flaxseed oil to treat wounds. Consult modern healthcare for reliable treatments[32]. Tribal people in Odisha take seed oil to treat asthma, intestinal problems and allergies, and roasted seeds to relieve joint pain[33].

In Rewa district of Madhya Pradesh, the seeds have been traditionally used as medicine with soothing properties for the treatment of rheumatism and gonorrhea[34]. Tribal communities in Jammu and Kashmir have traditionally used seed powder as traditional medicine to treat abscesses[35]. And ensure smooth delivery in labour [36]. The seeds have been reported to treat abscesses, arthritis, boils, relieve rheumatic pain, and act as a laxative and purgative among the ethnic groups of Jammu, Kashmir and Ladakh [37]. It has been reported that seed oil can treat heart disease and skin diseases among local tribes in the Firozabad region of the United States[38]. In Lucknow district of Uttar Pradesh, tribals in Bundelkhand district of the same province use seed paste topically to treat infections[39]and crushed seed paste topically to treat inflammation, ulcers and boils[40]. A seed paste for the treatment of hard ulcers has been reported from Uttar Pradesh

[41]. Tribes in Rajasthan use the seeds to treat various ailments such as bile, backpain, leprosy, ulcers, kidney problems, galactagogue and as an aphrodisiac and diuretic[42]. Tribal people in the Mandi region of Himachal Pradesh use the seeds to cure gonorrhea and back pain; and as a laxative[43]. Seed oil from the Gondia region of Maharashtra has been reported to treat tympanitis[44]. The whole plant has been reported to treat coughs and poisonings[45]. In the Stragrachi district of West Bengal, they have been found to provide relief from gastrointestinal problems, coughs and colds [46]. The local community of Udham Singh Nagar in Uttarakhand district uses a paste made from the whole plant to cure wounds[47].he seeds and their hot compresses have been reported to treat conditions such as boils, rheumatism, insufficient milk production, burns, eczema, gonorrhea, pneumonia and bronchitis (hot compresses) [48,42].

5. Phytochemical study

Phytochemical primer screening helps identify secondary metabolites present in plant parts. Secondary metabolites such as flavonoids, alkaloids, steroids, saponins, Terpenoids, tannins and so on. The ethanolic extract of various *L. Usitatissimum* parts was analyzed using a conventional phytochemical screening method that was previously reported elsewhere. The phytochemicals screening id mention in table 4 and 5[49,50].

Table 4: Phytochemical study of crude extracts of leaf, seed and stem of L. Usitatissimum[51]

Phytochemical	Leaf	Seed	Stem
Alkaloids	+	+	-
Flavonoids	+	+	+
Tannins	+	+	-
Saponins	-	+	-
Terpens / Steroids	-	+	-
Cardiac glycosides	-	-	-
Balsam	+	+	+
Carbohydrates	+	+	+
Phenol	+	+	+
Resins	-	+	-

Table 5: Phytochemical analysis of L. usitatissimum extracts with various solvents [52,53]

Photochemical	Methanol	Ethanol	Chloroform	Pet ether	Aqueous
Alkaloids	+	+	-	-	+
Steroids	++	+	+++	-	-
Terpenoids	+++	+++	+++	++	-
Flavonoids	++	+	-	-	++
Saponins	+	+	+	-	+
Phenols	+	++	-	-	+
Tannins	+++	++	-	-	+++
Cardiac glycosides	++	++	+	+	++
Proteins	+++	+++	++	++	+++
Amino acids	+++	+++	++	++	+++
Carbohydrates	-	-	-	+	-

+++: Strongly indicated, ++: Moderately indicated, +: Present, −: Absent

6. Phytochemical constituents

Flaxseed, also known as flaxseed, contains many important ingredients. They contain approximately 6.6% water, 20.3% protein, 37.1% fatty oils, 28.8% carbohydrates, 4.8% fiber, and 2.4% minerals. The specific nutrients are: 0.17% calcium, 0.37% phosphorus, 2.7 mg iron per 100 grams. It is also rich in vitamins and other compounds, including carotene, thiamine, riboflavin, niacin, pantothenic acid, choline and vitamins E. A distinctive feature of flaxseed is its fatty oil content of between 30% and 40%. This oil contains beneficial unsaturated fatty acids such as 35 to 77 percent α-linolenic acid (a type of ω-3 fatty acid), 12 to 30 percent oleic acid, and 8 percent linoleic acid. to 29%. In seeds are rich in omega-3 fatty acids. Additionally, flaxseed contains about 3-10% mucilage, which is found in the outer layer of the seed. This mucus is composed of polysaccharides including arabino xylan, galactan, and rhamno galacturonans, Essentially in the form of calcium salts. In terms of protein, flaxseed contains 16 to 31 percent. The major proteins in flaxseed are globulin, of which Linin and Colinin are two isolated globulin proteins. They also containg luten but seem to lack albumin. About 21.7% of thetotal nitrogen in seeds comes from non-protein nitrogen compounds. The essential amino acids contemporary in linseed proteins (per 16 grams of nitrogen) are histidine, lysine, phenylalanine, methionine, threonine, leucine, tryptophan, isoleucine, and valine, arginine, in varying amounts. These components make flaxseed a valuable nutritional source, especially since it containsω -3 fatty acids and other essential nutrients.

The carbohydrates in flaxseeds are made up of sugars like sucrose and raffinose, cellulose, and mucilage. Ripe flaxseed contains neither reducing sugar nor starch, but it does contain small amounts before ripening. The total ashcontent of linseed is about 6.846%, of which acid-insoluble ashaccounts for about 3.76% and water-soluble as haccounts for about 0.413%. The ash contains sulfates and chlorides of potassium, calcium and magnesium. In addition to linla statin and neolin statin, flaxseed contains small amounts of a cyanogenic glucoside called linamarin. In addition, there are two other glycosides, one crystalline and the other non-crystalline. Linamarin is not only found in seeds, butalso in the leaves, stems, flowers and roots of plants. Other components in flaxseed are calcium phytate, lecithin, waxes, resins, pigments, malic acid, acetic acid and enzymes such as lipase, protease and amylase. They also contain beta-carotene. Some phytochemicals are present such as phenolic acids, cinnamic acids, flavonoids, and lignin. Flaxseed contains both soluble and insoluble fiber, with mucilage being the main soluble fiber.A distinguishing feature of flaxseed is its high lignan content, making it a rich source of antioxidants and phytoestrogens. Secoisolariciresinol diglucoside is the predominant lignan, butother lignans are also present, such as isolariciresinol, pinoresinol, matarresinol, and various derivatives of ferulic acid. These lignans have potential health benefits wheni ncluded in the diet[54].

7. Study of Gas chromatogram and Mass spectrometry (GC-MS) analysis carried out to assess the various phytochemical compositions

7.1 Leaf phytochemicals

The major components found in L. Usitatissimum. Leaf methanolic extract of Linum usitatissimum include Silane (2.22%), Trimethyl-2-Propyne (2.44%) (1),Cyano Methyl-Triiron Disulfide Octacarbonyl (2.44%) (2), Cyclohexanecarboxylic Acid, Cyclohexyl Ester (Cas) Cyclohexyl Cyclohexanecarboxylate (2.64%) (3), Guanidino-L-proline (3.76%) (4), 5, 6-Dichlorohexene (3.99%) (5), 2(3H)-Furanone, 5-methyl- (7.17%) (6), 1- Chloro-1-fluoroethane (7.98%)(7), and Hexadecanoic acid (Palmitic acid)(22.84%)(8). Other than this it possess a wide range of phytochemicals such as 1,2-Propadiene (3.55%)(9), 2-methylene-7-oxabicyclo-heptane (4.09%) (10), 3-Pyrazolidinone, 1,2,4,5-tetramethyl- (6.61%) (11) , N,N'-Bis(4-cyclohexylphenyl)benzene-2,5-diamine(4.13%) (12), 2,2-Dimethyl-3-cyclohexen-1-ol (3.27%) (13),Cyclohexanol, 3,3,5-trimethyl- (3.37%) (14) 3-Methyl-2-pentadecylthiophene (2.71%) , (15), 4-Amino-6-methyl-piperidin-2-one(3.90%) (16) , Acetic acid,2-cyano-, ethyl ester (4.77%)(17), 2-t-Butyl-5-(dimethoxy-phosphoryl)-3- methyl-4-oxoimidazolidine-1-carboxylic acid, t-butyl ester (4.23%) (18) , 1,3,5-Triazine-2,4,6(1H,3H,5H)-trione (2.23%) (19) , 4-Amino-2-hydroxypyrimidine (3.90%) (20) [55].

7.2 Stem phytochemicals

The methanolic extract of stem Linum usitatissimum, also known as flaxseed, contains several major components 3-Thioxo-3,4-dihydro-2H-[1,2,4]triazin-5-one (3.22%)(21), Isoamyl laurate (3.43%)(22), Furfuryl glycidyl ether (4.12%)(23), Nerinine (4.17%)(24), Carbonochloridic acid, ethyl ester (CAS) Cathyl chloride (4.94%)(25),2-Oxazolidinethi on, 5-ethenyl-, (S) (6.16%)(26), 4-Amino-6-methyl-piperidin-2-one (7.00%) (27). Its diverse range of phytochemicals also contain Tridecanoic acid (CAS) Tridecylic acid (8.26%) (28),4-Cyclohexene-1,2-diol (4.77%) (29), Tetrahydrolinalool(3.78%)(30), Cyclohexane, 1,1'-(1,3- propanediyl)bis- (10.43%)(31), 2,6-Dihydroxypyridine(4.20%)(32) , Cyclohexanol, 2-(2-ethyl-1- hydroxy-1-hexyl)- (4.11%) (33), 1-Cyclohexanone, 3-butyl-3- methyl- (4.62%) (34), 3-methylbutyl decanoate(3.80%)(35), 1H-Pyrrole (CAS) Pyrrole Azole PyrrolImidole MonopyrroleDivinylenimine 1-Aza-2,4-cyclopentadiene (4.40%) (36), 1,3,5-Triazine- 2,4,6(1H,3H,5H)-trione(3.89%) (37), 1- oxacyclooctan-3-one(4.95%) (38), 2,6-pyridinediol (4.20%) (39), 2(1H)-Pyrimidinone, 4-amino- (3.98%) (40) 2,4-dimethyl-4,5-dihydro-1H-imidazole (5.76%) (41) [55].

7.3 Root phytochemicals

The primary components found in the methanolic extract of *Linum usitatissimum* (common flax) roots are Form amidinium acetate (6.86%) (42), Beta-ionone epoxide (5.75%)(43), Furfural (4.53%)(44), Nonane, 4-methylene- 1-Heptene, 2 (11.33%)(45), Cis 3 Hexenyl Lactate (6.98%)(46), Hexanenitrile (also known as Capronitrile or Tricapronile) (5.04%)(47), and 8-Pentadecanol (4.09%) (48). It also containphytochemicals like(2S,3S)-2,3-Epoxy-1-hexanol (3.29%) (49) , Propane, 2-methoxy-2-methyl- (CAS) (3.42%) (50) , 1H-Cyclopropan [b] naphthalene-2,7-dione(3.32%) (51) , Tetraethylsuccinic acid dinitrile Butanedinitrile(3.03%) (52) , Furfural(5.53%) (53), 5-(1-Methoxy-vinyl)-3,5-dimethyl-4,5-dihydro-isoxazole (3.08%) (54), tricyclo[4.1.0.0(2, 4-bromo-5-(phenylthio)] (3.10%) (55), 2(3H)-Furanone, dihydro-5-methyl- (3.93%) (56), Cyclohexanone, 2,2,6-trimethyl(5.21%) (57) Dodecanoic acid, 2-hexen-1-yl ester, (4.89%) (58) , (2H)Pyrrole-2-carbonitrile, 5-amino-3,4-dihydro (6.15%) (59) , Hexanenitrile (CAS) CapronitrileTricapronile (5.04%) (60) , 8-Pentadecanol(4.09%) (61) n-Hexyl acrylate 2-Propenoic acid, hexyl (62) [55].

7.4 Seed phytochemicals

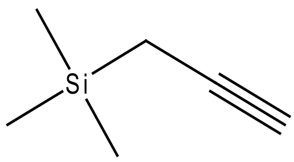
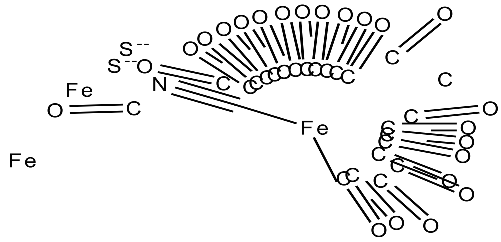
The ethanol extract of flaxseed revealed the presence of major compounds like squalene (45.27%) (63), 9, 12, 15, octadecatrienoic acid, (z,z,z)-(24.6%)(64), Pyrolidine,1-(1-oxo-7,10-hexadecadienyl)-(17.60%)(65), oleic acid (10.16%)(66) and sucrose (9.80 %)(67). Besides this it contain phytoconstituents such as Butane, 1, 1-diethoxy -2-methyl- (0.45%) (68), Hexanoic acid, ethyl ester (0.25%) (69) Propane, 1, 1, 3-triethoxy- (0.17%) (70) 2-Furancarboxaldehyde, 5-(hydroxymethyl) - (2.72%) (71), 2-methoxy-4-vinylphenol (0.32%) (72), Cyclohexane, 1, 2, 4 -trimethoxy- (0.49%) (73) 8-Acetyl-8-azabicyclo [3.2.1] octane (2.18%) (74), n-Hexadecanoic acid (7.44%) (75), Hexadecanoic acid, ethyl ester (0.85%) (76), Palmitoylethanolamide(8.94%) (77), Hexadecanal, 2-Methyl-(1.69%) (78), 1-Monooleoylglycerol trimethylsilyl ether(4.56%) (79),[56] trimethylsilyl 3-trimethylsilyloxypyridine-2-carboxylate (10.42%)(80), 1, 3, 5-Tris (trimethylsiloxybenzene) (11.87%) (81), 1, 3, 5-Tris (trimethylsiloxy) benzene (12.96 %) (82), Trifluoroacetic acid, 2-tetrahydrofurylmethyl ester (16.61%) (83), 1, 2-Benzenediol o-(2, 2, 3, 3,4,4,4 heptafluorobutyryl-o-(4 nitrobenzyl) - (19.73%) (84), 9,12-Octadecadienoyl chloride (Z, Z)- (20.10 %)(85), Estra-1,3,5 (10)-trien-17-one-3,4-bis trimethylsilyl (oxy)- (23.40%)(86), Octasiloxane, 1,1,3,3,5,5,7, 7,9,9,11,11,1 3,13,15,15 hexadecamethyl-(24.40 %)(87), 2,4-Dimethyl-3-[(trimethylsilyl) oxy]-5-([(trimethylsilyl) oxymethyl) pyridine (25.27%)(88), Citrazinic tri-TMS (28.14%) (89) [53].

7.5 Flaxseed oil phytochemicals

Major constituents of the oil are 9-Octadecenoic acid (Z)-, hexadecyl ester (27.58%) (90), 9, 12-Octadecadienoic acid (Z, Z)-, methyl ester(25.44%) (91), 9, 12, 15-Octadecatrienoic acid, methyl ester, (Z, Z, Z) - (19.73%) (92), Hexadecanoic acid, methyl ester (14.12%) (93), Methyl stearate (11.20%) (94). Along with this above phytochemicals it also contain Methyl tetradecanoate (0.07) (95), Pentadecanoic acid, methyl ester(0.03%) (96), 7-Hexadecenoic acid, methyl ester, (Z) - (0.04 %) (97), 9-Hexadecenoic acid, methyl ester, (Z) - (0.19%) (98), cis-10-Heptadecenoic acid, methyl ester (0.11%) (99), cis-11-Eicosenoic acid, methyl ester(0.53 %) (100), Eicosanoic acid, methyl ester (0.27%) (101), Docosanoic acid, methyl ester (0.32%) (102), Tetracosanoic acid, methyl ester (0.17%) (103), Heptadecanoic acid, methyl ester (0.20 %) (104) [57].

8. Phytoconstituents structures

8.1 Leaf phytochemicals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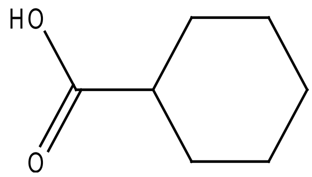	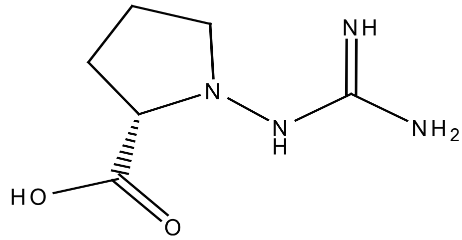
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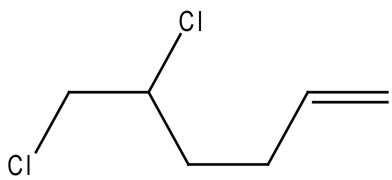	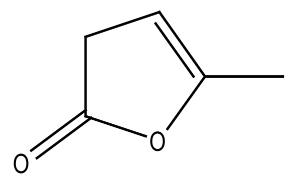
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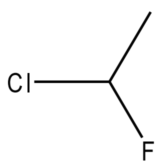	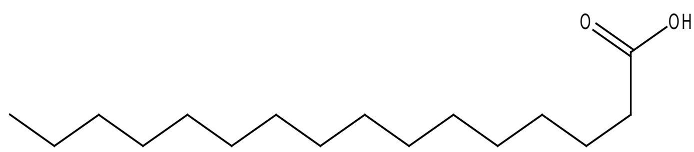
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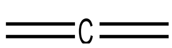	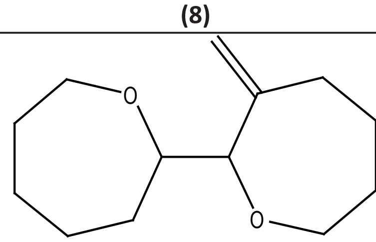
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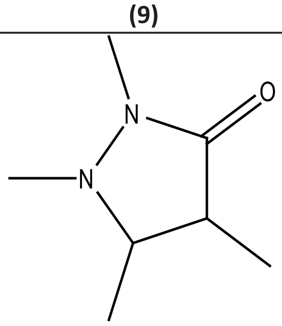	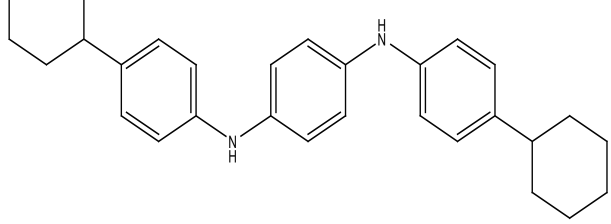
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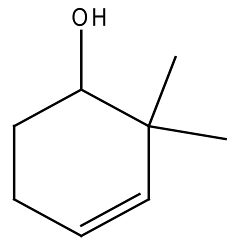	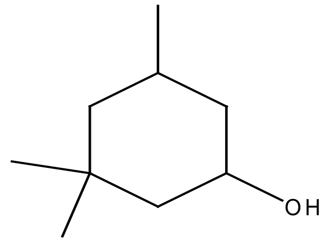
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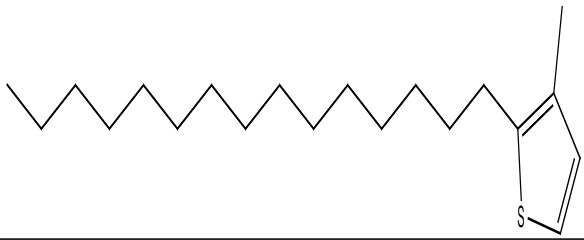	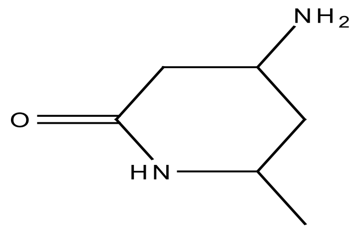
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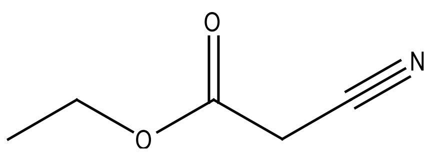	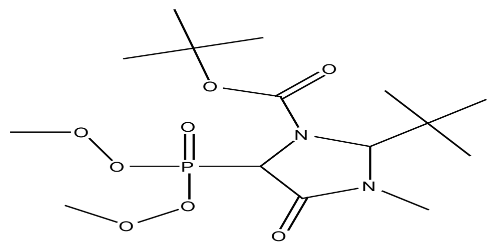
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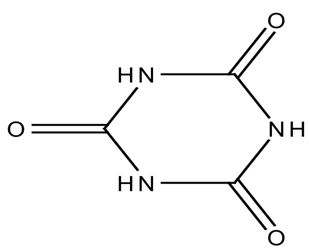	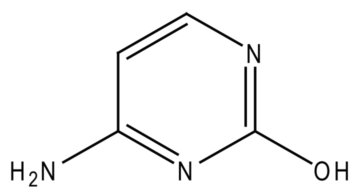
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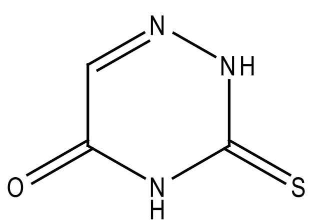	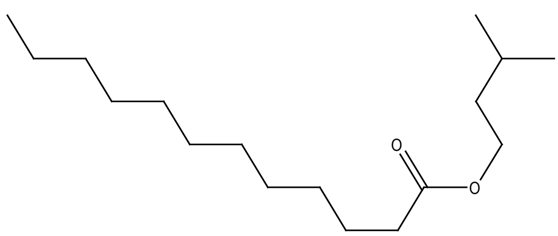
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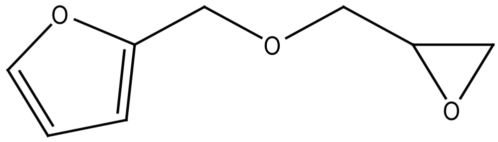	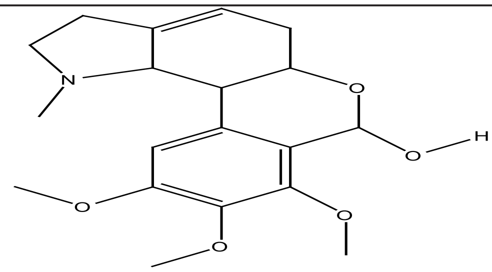
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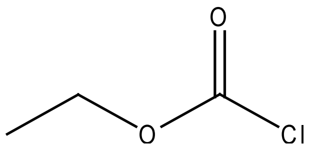	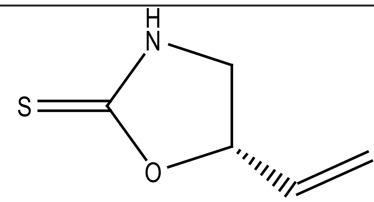
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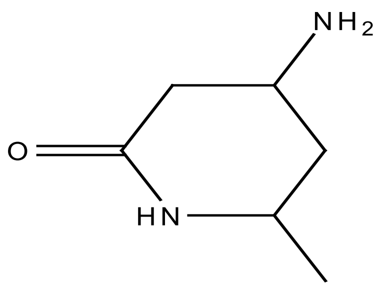	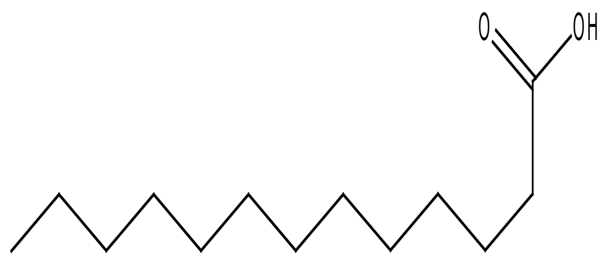
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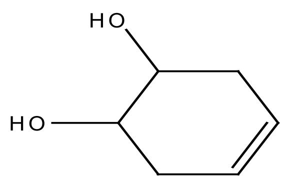	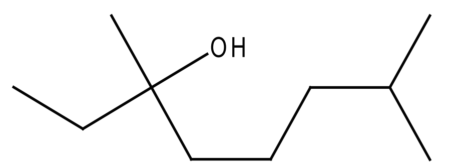
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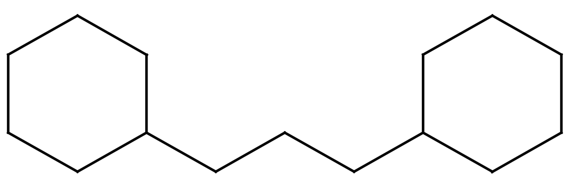	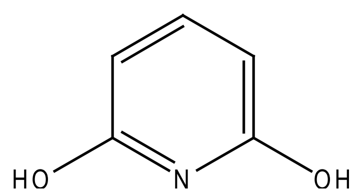
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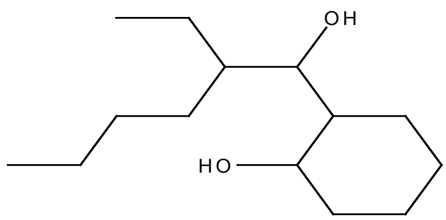	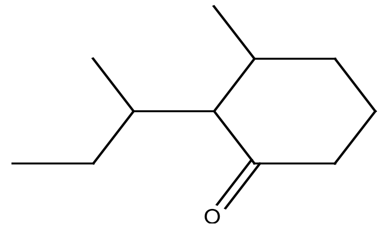
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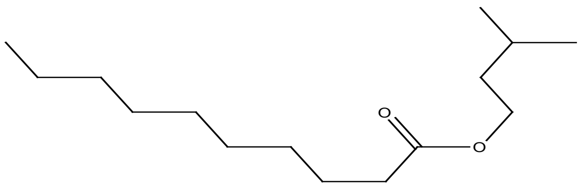	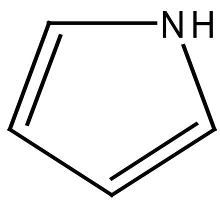
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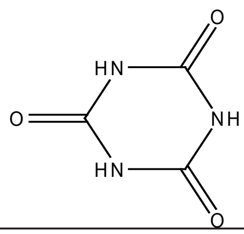	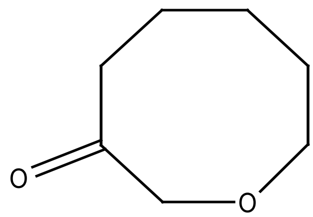
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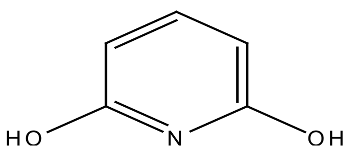	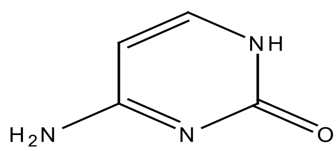
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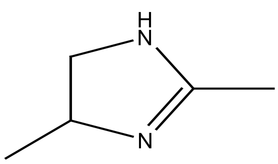	
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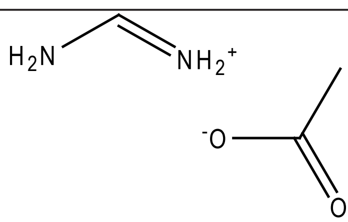
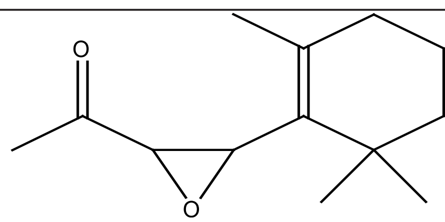
8.3 Root phytochemicals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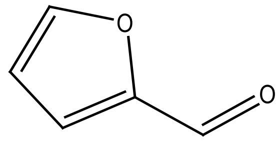	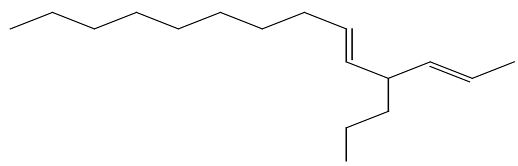
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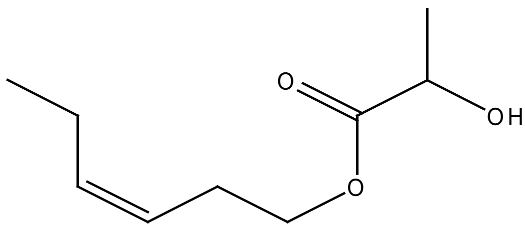	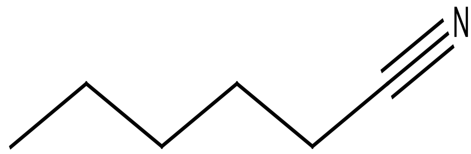
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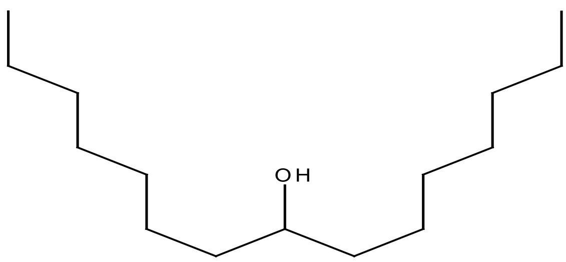	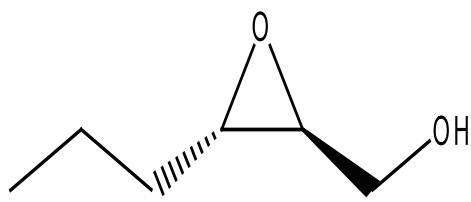
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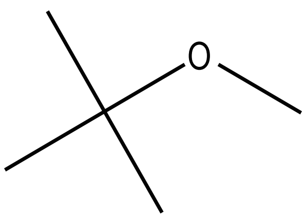	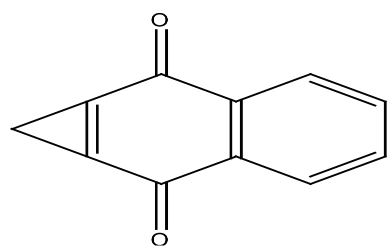
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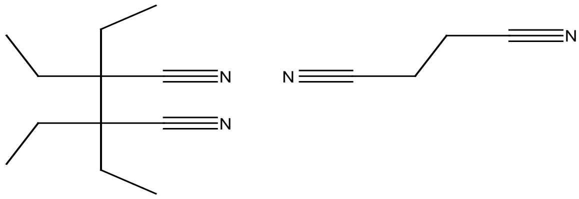	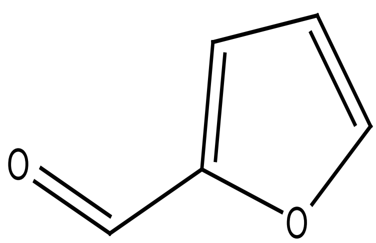
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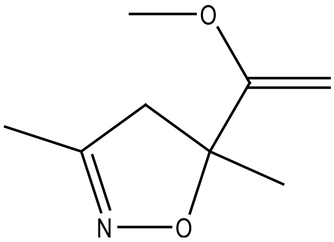	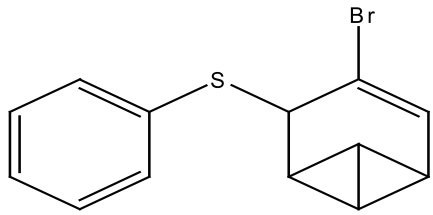
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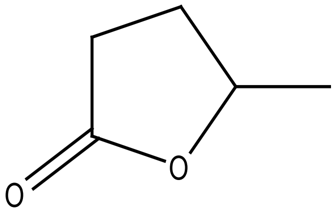	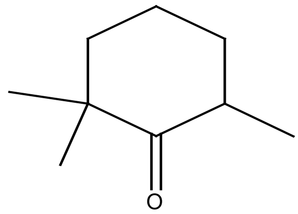
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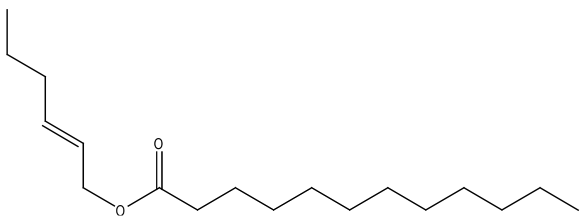	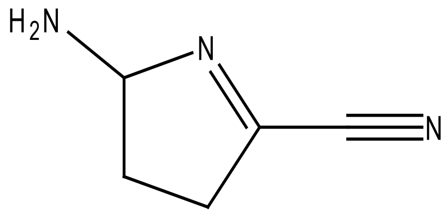
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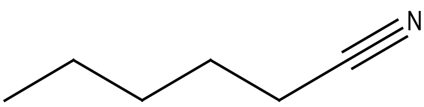	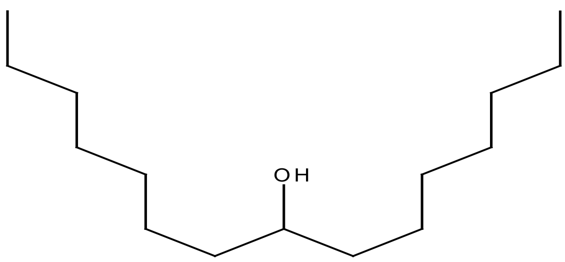
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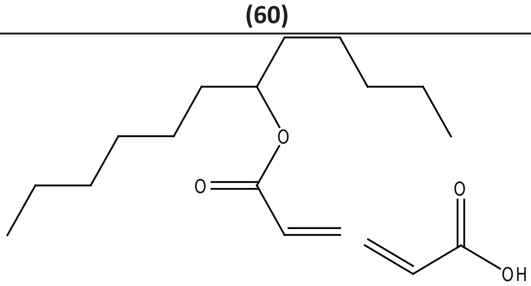	
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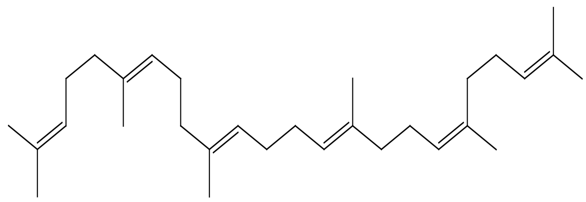
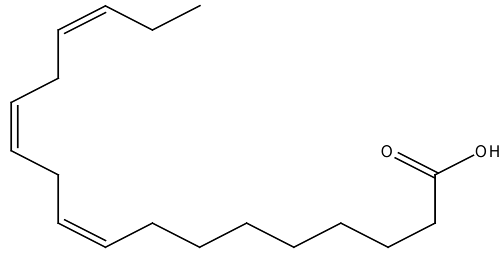
8.4 Seed phytochemicals	
	
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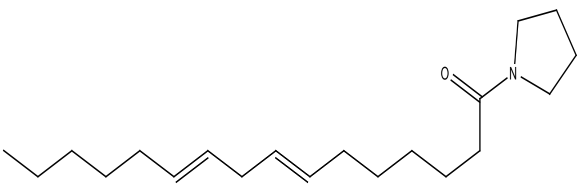	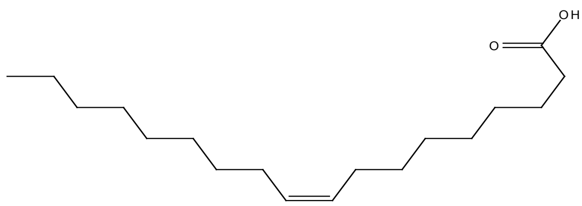
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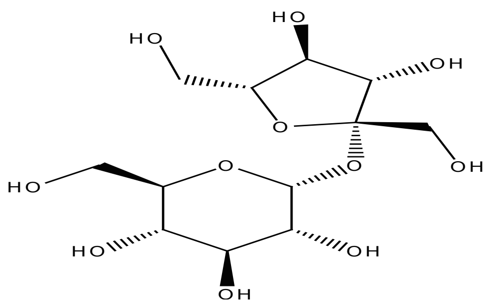	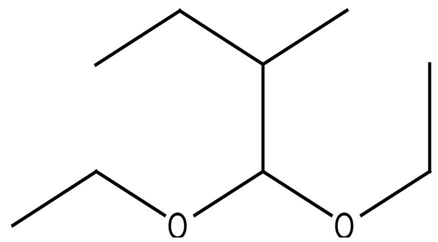
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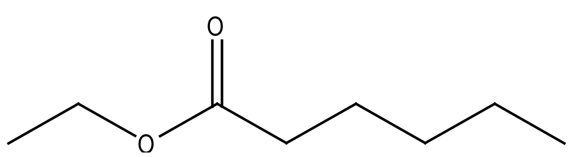	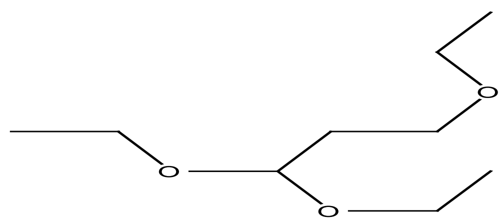
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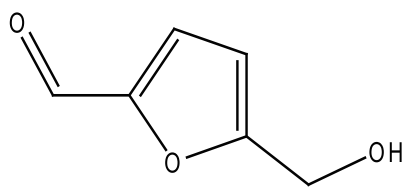	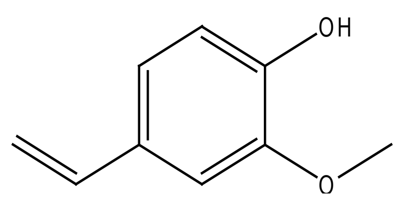
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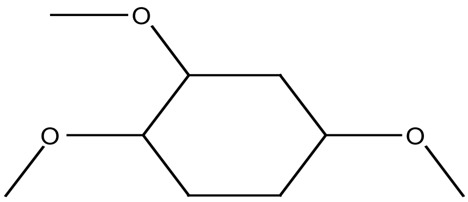	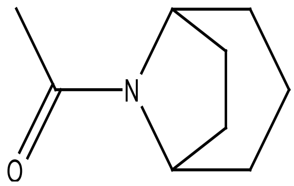
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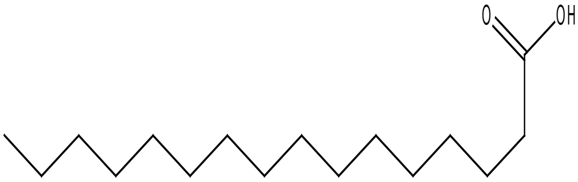	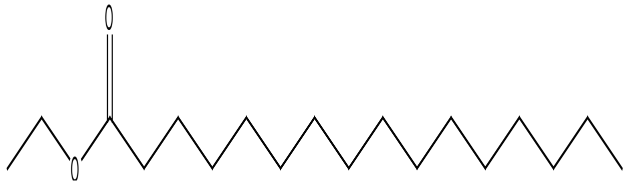
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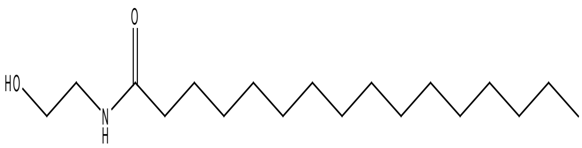	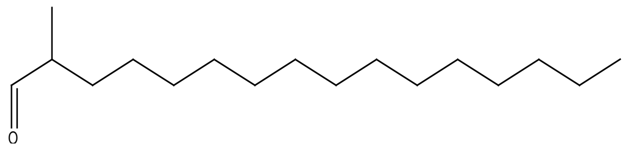
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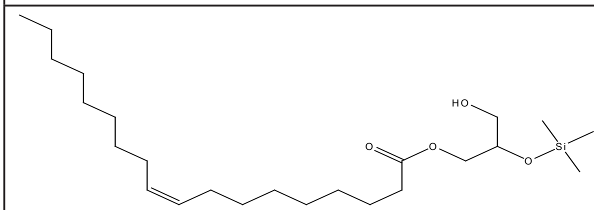	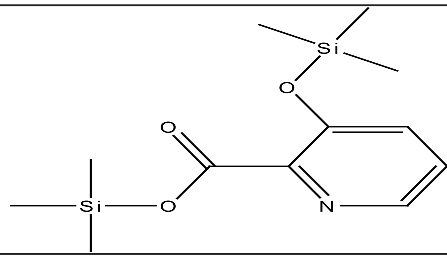
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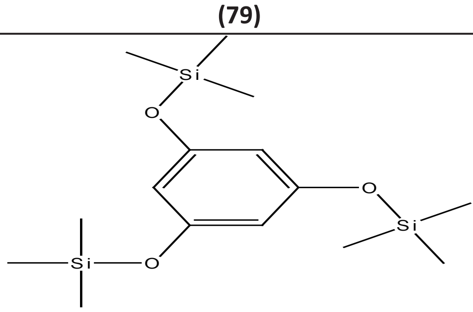	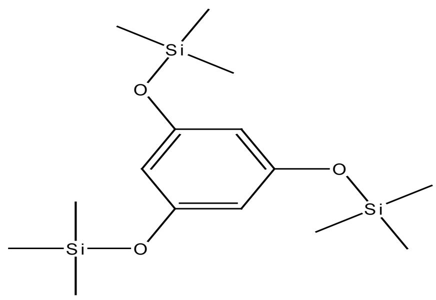
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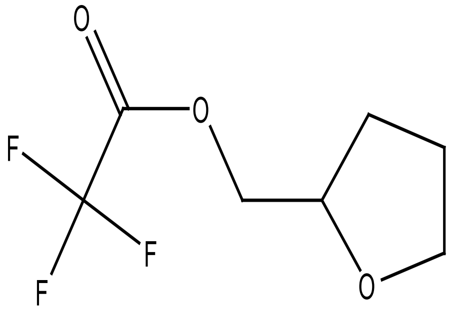	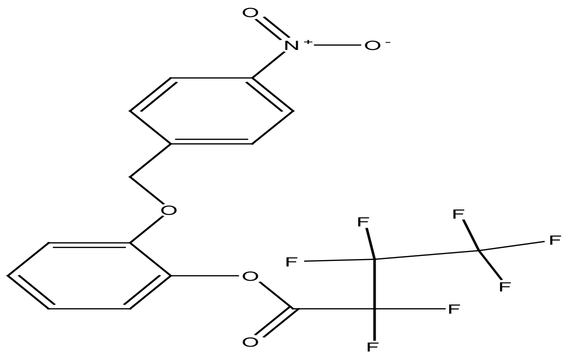
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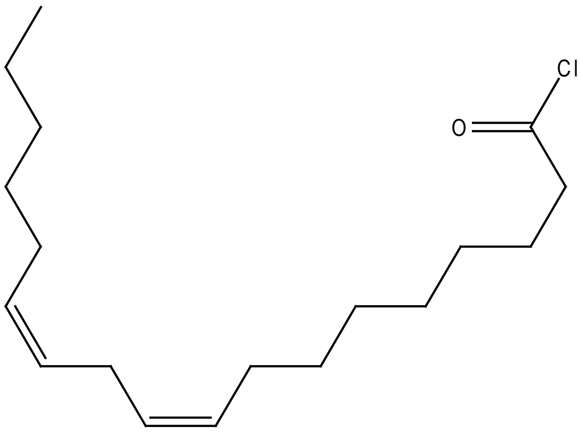	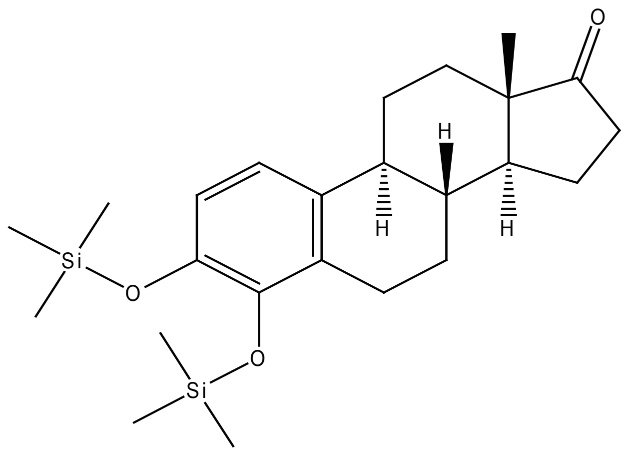
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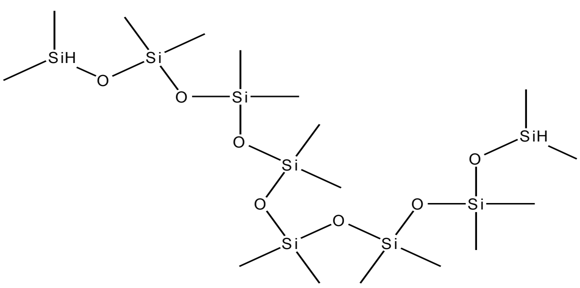	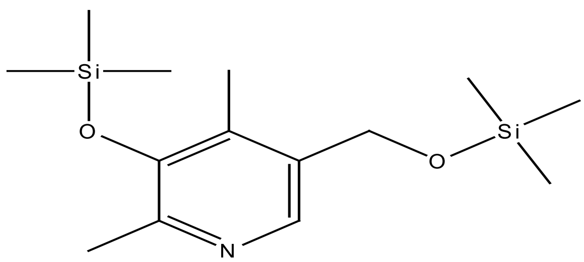
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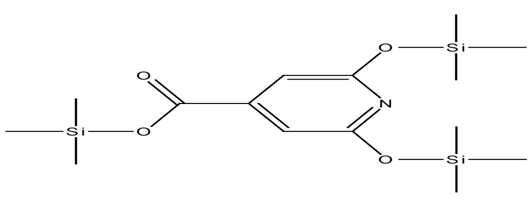	
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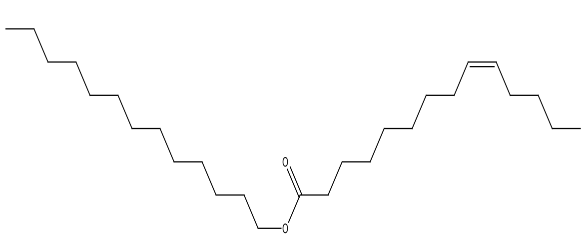	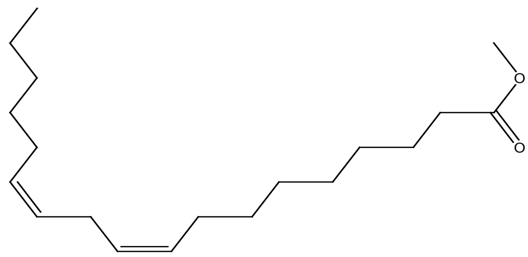
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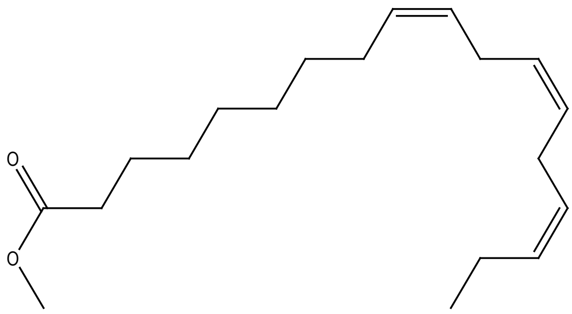	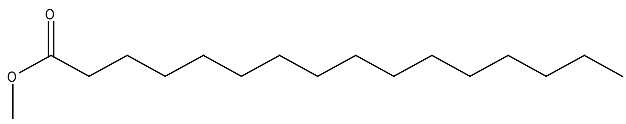
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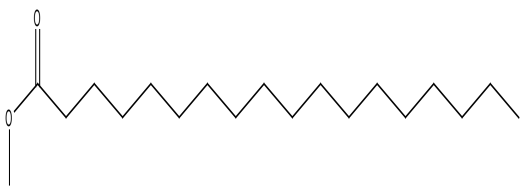	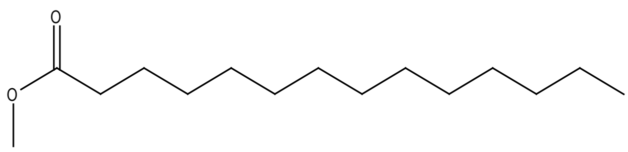
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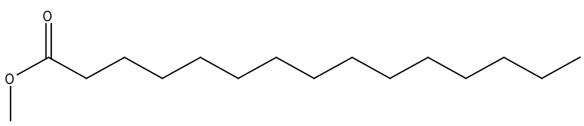	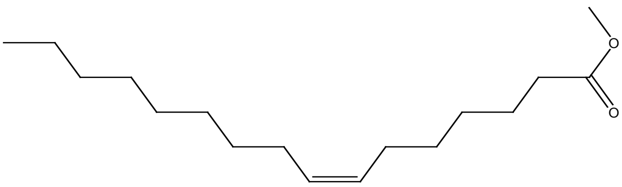
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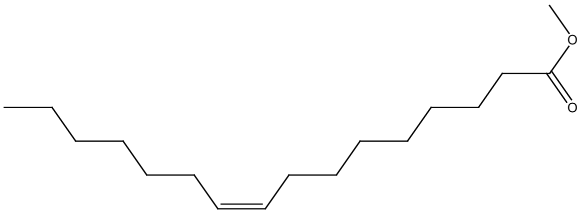	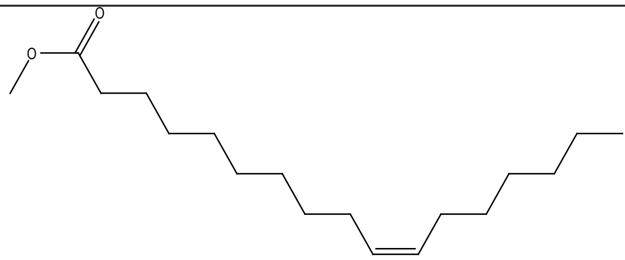
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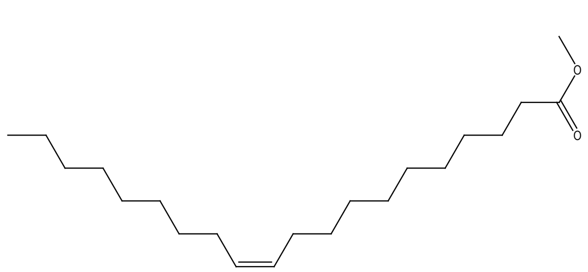	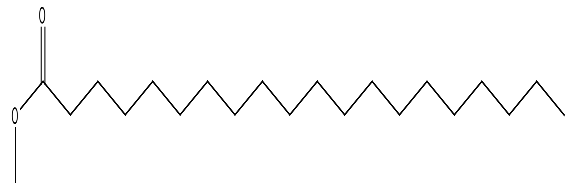
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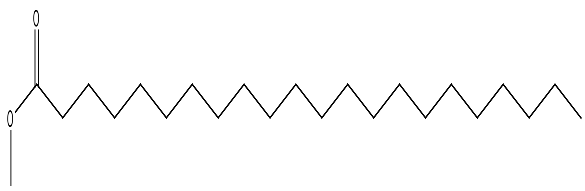	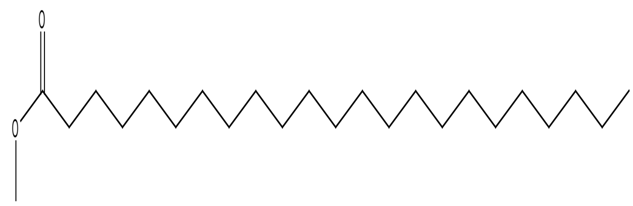
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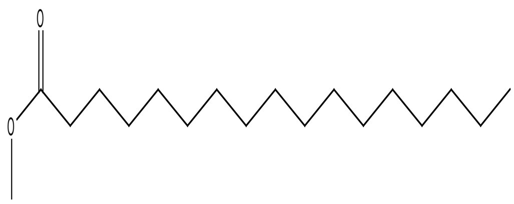	
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9. Pharmacological Activities

9.1 Antioxidant properties

Various studies have shown that flaxseed oil supplementation reduces oxidative stress, potentially reducing inflammation[58]. Lignans canact as antagonists of platelet receptors, preventing neutrophils fromforming anaerobic proteins[59][60]. SDG is a plant lignan found in linseed andfound to have cell-strengthening properties [60]. Pattanaik et al. Studies have shown that cardiovascular celldamage is reduced when dogsreceive endotoxin containing flaxseed compared to endotoxin alone[61]. Hypothetically, linseed (not linseed oil) mayrise lipid peroxidation and subsequent oxidative damage. Consumingless defatted flaxseed is associated with reduced accumulation of protein thiols, indicating increased oxidative stress[62].

The cells strengthening effect of *L. usitatissimum* methanol concentrate was considered compared to thecaustic peroxidation of linoleic acid using caustic 1,3-diethyl-2-thiobarbituric acid as reagent. Additionally, the phenolic content of the concentrates was estimated using the Folin-Ciocalteu reagent to assess their promise in promoting cancer prevention. Reported concentrate yield (% of dryweight) is 3.26, cell strengthening effect (IC_{50}) in contradiction of peroxidation of linoleic acid (2 mg/ml) is (IC_{50} (μg/ml)) = 53.52 ± 1.56, phenol content (mg/100 g dry) is 21.76 ± 0.12 [63]. Alternative focus is on cancer prevention, flavonoid campaigns and seed concentrates of *L. usitatissimum*, was shown to exhibit extreme is search actionvia DPPH-free revolutionary search action and provide strong protection against liberal extremists with an IC_{50} (concentrated focus gives half thed isability) of 1.21 mg.ml[64].

A review was conducted to evaluate the cell-enhancing effects of SDG, a plant lignan isolated from linseed. Platelet-initiating receptor antagonists will preven the development of oxygen extremists by polymorphicatomic leukocytes [62]. The antioxidant activity of flax (*Linum usitatissimum* EE-LU) ethanol concentrates (100, 200, 300, 400 and 500 μg/ml) was evaluated in an in vitro model. The results show that EE-LU and α-tocopherol have significant inhibitory effects on DPPH extremism, energy reduction, revolutionary superoxide anion search, hydroxyl search, metal chelation and hydrogen peroxide search [65].

9.2 Anti-Inflammatory and Immunomodulatory Effects

Flaxseed and flaxseed oil may have mitigating properties due to the presence of ALA, which can inhibit the intense response of human neutrophils when ALA is completely converted to EPA and DHA [66]. These abilities may also be due to the inactivation of LTA epoxide hydrolase, there by reducing the assembly of leukotriene B4 and hindering the formation of leukotriene B4 by reducing the formation of [3H]-inositol triphosphate. Chemotactic ALA stimulated by triene B4 and platelet initiating factor was also found to reduce the formation of arachidonic acid, there by reducing inflammation[67]. ALA inhibits intracellular resistance/lymphocyte competence without affecting humoral resistance/B cell competence (shown in immune compromised patients)[68].

The ability of flaxseed oil to control weight-related stimulation and insulin blockade was examined through a study on a group of light-skinned Swiss mice. Mice were fed 4.8 or 16 mg/kg (bodyweight) of flaxseed oil for approximately one month or fed a high-fat diet supplemented with 4.8 or 16 mg/kg (bodyweight) of linseed oil. Improvement in insulin potentiation (4, 8 and 16 mg/kg bodyweight) and reductions in blood glucose levels, fatty oils (8 and 16 mg/kg body weight) and adiposity levels were observed in FXO-enhanced HFD-treated mice. Small Rats were studied. Likewise, in immunomodulatory studies, partial elevation of serum in response to oocyte IgG1, Ig Elevelsand antigen-dominant IL-4 cytokine levels was observed. IgG2b, oocyte-hostile IgG2a, IgG3, and antigen-dominant TH1 cytokines such as TNF-α and IFN-g were essentially suppressed in immunomodulatory assays when measured at 16 mg/kg bodyweight. Furthermore, a decrease in supportive and provocative TNF-α and a partially minor change in cytokines toward a sedative (IL-4) state was observed in co-culture tests. In addition, FXO also has a positive effect on the cellular structure of there sistant organs (spleen, thymus and bone marrow) as well as increasing the total body weight, the weight of the insensitive organs and their cellular structure.

Therefore, the attenuating immune modulatory effects of *L. usitatissimum* and its beneficial effects on alleviating symptoms of insulin obstruction associated with obesity are not expected to be confirmed [69].

It has also been suggested that hydroalcoholic removal of flaxseed significantly all eviates the exacerbation of intense and long-term inflammation[70].

Another review evaluated the joint and immune modulatory movements of *L. usitatissimum* fixed oil (LUFO) in experiment all models. Since it is already closed, LUFO can have beneficial effects in treating stubborn provocative problems like RA. It is trusted that this mitigating capability is because of Alpha-linolenic corrosive (ALA), alongside its digestion item eicosapentaenoic corrosive (EPA)[71].

9.3 Antimicrobial Activity

A preliminary report was prepared measuring the antimicrobial activity of ethanol and chloroform concentrates from flaxseed compared to five for example *Salmonella typhii*, *Enterococcus*, *Escherichiacoli*, *Bacillus subtilis* and *Staphylococcus aureus*. The results showed that chloroform separation was more effective against microorganisms than ethanol separation. Chloroform extract showed antibacterial activity against five microorganisms. Ethanol alone has no antibacterial activity against E. coli [72].

In a review, *L. usitatissimum* has been reported to e.g., *Staphylococcus aureus, Streptococcus agalactiae, Enterococcus faecalis, Micrococcus luteus, Bacillus subtilis, Bacillus pumilus, Staphylococcus epidermidis, Escherichia coli, Lactobacillus sporogenes, Bacillus brevis, Bacillus cereus, Pseudomonas aeruginosa* and *Candida albicans* was evaluated by plate dispersion technique and MIC assurance in nine mastitis-impacted cows. As recent reviews have progressed, California mastitis tests cores and physical cells have been radically reduced, as well as damage to milk. The approximate presence is the explanation for the antibacterial effect of the top seed oil[73].

Close to antimicrobial action of *L. usitatissimum*, different bacterial strains might have retting potential for flax to deliver fiber, which has significance in industry. As it has referenced that among strains having retting capacity, Bacillus lichen form is and B. subtilis were mathematically predominant from 10 to 40 h and were prevailed in strength by *Clostridium acetobutylicurn* and *Cl. felsineum* in view of unadulterated culture and protein studies[74].

9.4 Antiprotozoal Activity

Antiprotozoal exercises of *L. usitatissimum* not set in stone against clonal societies of *Histomonasmeleagridis*, Tetratrichomonasgallinarum and *Blastocystis sp*. Results showed that for Ethanol concentrate of flaxseed Percent parasite decrease in contrast with the control was 93.88 (24h, 10 mg/ml, *H. meleagridis*), 84.64 (24hrs, 10mg/ml *T. gallinarum*), 100 (24hrs, 10 mg/ml *Blastocystis sp.*). For Water extricate, it was 8.67, 44.28, and 25.45, separately[75].

9.5 Anti-Mosquito Activity

The adequacy of linseed extricates, against Anopheles stephensi and Aedes aegypti, was assessed under research facility conditions, in light of WHO suggested bioassay technique for grown-up mosquitoes. Outcomes showed that oils from linseed have the LC50 of 12.90 and LC90 of 27.60 after 24hrs of openness. Percent mortality of Ae. aegypti hatchlings after 24 hrs and 48hrs were 57.50% and 72.75%, while it was 24% and 35% for An. stephensi following 24 and 48 hours, individually[76].

9.6 Analgesic Effects

The analgesic effect of pure methanol concentrate of *L. usitatissimum* was studied with tail movement restand compared with a contrast agent and a standard drug (acetylsalicylic acid (300 mg/kg)) using a tail soaking strategy. Different doses (300, 500 and 1000 mg/kg) were administered orally, and 0.9% saline was adjusted as the baseline group. The results showed that *L. Usitatissimum* has an unusually significant an algesic effect[77].

9.7 Effects on GI Disorders and Diet

One study showed that three groups of pig s consuming different amounts of flax in their diet (0, 50 and 100 g/kg) provided sufficient n-3 polyunsaturated fattyacids, eicosapentaenoic acid for human nutrition. Dodecahexaenoicacid. The oil content in each of the three components was constant (60 g/kg). After slaughter, the results showed an increase in alpha-linolenic acid in all tissues and an increase in eicosapentaenoicacid in the liver and kidneys, expansion in Docosapentaenoic corrosive in muscle, liver and kidney and diminished n-6: n-3 proportions, as Linum in the eating routine increment. It was accounted for that expansion of Linum up to 100 g/kg in pigs diet, didn't show adverse consequences on the corpse, meat quality and oxidative dependability of the meat[78].

The effects of flaxseed on fetal development were studied in three breeds of pregnant female rats: a controldiet (18% protein plus 7% soybean oil, normal alpha-linolenic corrosive), two treatment seating less carbohydrate, Protein content was negligible at 12%; one was grown using 7% soybean oil (Treatment I, typical alpha-linolenic acidcaustic) and the other used 3% linseed oiland 4% soybean oil (Treatment II), various normal α-linolenic acidcaustic bases). Results showed a decrease in litter size and weight at birth, as well as a decrease in arachidonic acid in the blood at treatment II collection. Therefore, the results how that the use of flaxseed oil with a negligible protein content has no benefit but also improves the responsiveness of infant sand puppies to high levels[79].

The diuretic effect of flaxseed concentrates in different serving sizes (12.5, 25 mg/kg) was studied in Wister rodents. Purgative motility and gastrointestinal motility were considered separately based on the severity of stool and the charcoal dinner strategy over the 8- to 16-hour time interval. An expansion of both limits was observed at a dose of 25 mg/kg flax seed [80].

One study examined the effects of flax seed oil on a group of light-skinned rodents after they developed esophagitis. The anti-secretory, cell-enhancing, lipoxygenase inhibitory and anti-receptor effects of oil were demonstrated by measuring gastric pH, gastric volume, total corrosiveness and esophagitis disease in putrefactive rodents [81].

In a study aimed at investigating the pharmacological principles of flaxseed regeneration in continuous uninterrupted defecation, a crude methanol concentrate of flax seed was examined concentrated on utilizing the in vivo castor oil-prompted the runs, stomach motility and enter pooling measures on a gathering of mice. Subsequently, flaxseed extract was able to reduce diarrhearates by 68.34%, gastrointestinal output by 38.8%, and digestive motility by 56.20% in mice, all at 500 mg/kg concentrate. In studies on intestinal irresistible permeability, flaxseed extract showed a strong bactericidal effect against all previously mentioned microorganisms (except E. coli K1) at a concentration tried at 10 mg/ml. In this way, *L. usitatissimum* has antispasmodic and antidiarrheal effects on both infectiousand non-infectious diarrhea[82].

Since a study was completed in 2010, *L. usitatissimum* essential oil is considered to have surprising anti-ulcer effect sand is used to treat conditions related to the secretory effects of flax seed oil, including headaches, indomethacin, ethanol, reserpine, serotonin, and stress. Receptor-induced gastric ulcers in rodents and gastric ulcers in guinea pigs. It is accepted that the antiulcer capability of flaxseed oil might be expected to the lipoxygenase inhibitory, receptor opposing and against secretory (anticholinergic) effects[83].

9.8 Effects on Cardiovascular Disease/ Hyperlipidemia

Derived from the omega-3 unsaturated fatty acids found in flaxseed, eicosanoids can significantly improve heart function by lowering blood cholesterol levels. The effects of flaxseed on blood cholesterol and LDL levels are associated with greater concentrations of flax seed in weight control regimens, resulting in more significant reductions in LDL, serum, and liver cholesterol[84,85].

The suspected lipid-lowering properties of flax seed (not flaxseed oil) are attributed to the fiber content, which consists of D-xylose, L-galactose, L-rhamnose, D-galacturonic acid, and galactose[62].

It has been reported that defatted flaxseed (such as flaxseed due to its fiber content) can significantly reduce absolute cholesterol, low-density lipoprotein (LDL) and fattyoil levels[62,86].

It is predicted that the fiber content of flax seed may exert lipid-lowering effects by increasing gastric emptying time, altering travel time, hindering the distribution of bulk fat, and increasing bile acid excretion Its felt that flax seed might apply an ultimate impact on atherosclerotic plaque growth because of the cell reinforcement properties of lignans[86].

Results from a study in rodents suggest that the lipid-lowering effects of flax do not occur through the liver and may be related to cholesterol absorption or potentially damaging reabsorption of bile.[87].

In a study on a group of Wistar rodents (hypertension was induced in rodents by the 2K1C method, which was actually due to RAAS), flax lignan concentrate essentially restored elevated serum levels of liver, kidney and Cardiac Marker Catalyst. Additionally, organ burden (kidney and heart), serum electrolyte levels, and histological irregularities were restored. The antihypertensive and anticancer effects of flax lignan concentrate were partially minor, with the highest proportions (e.g., 800 mg/kg), as in rodents receiving captopril (30 mg/kg). Flax lignan concentrate is believed to reduce pulses by reducing renal angiotensin II levels, inhibiting plasma endothelin-1 formation, and receiving, nitric oxide synthase and in vivo cell reinforcement safeguard system[88].

In a related study designed to evaluate the ability of *L. usitatissimum* to alleviate dyslipidemia, control and test groups of patient swere divided into 50 different subjects with dyslipidemia. After three months of flax seed (30 g of roasted flaxseed), anthropometric limits, blood lipids and circulatory strain values were estimated in the exploratory group at the end of the study. Surprisingly, flax seed was found to affect circulatory blood pressure, lipid profiles, total lipid cholesterol, low-lipoprotein cholesterol, low-lipoprotein cholesterol, high-lipoprotein cholesterol, bodyweight, and weight history (BMI) in individuals with dyslipidemia). It was concluded that flax seed reduces the risk of CVD infection by providing the body with soluble filaments and ALA [89].

In a related study designed to evaluate the ability of *L. usitatissimum* to alleviate dyslipidemia, control and test groups of patients were divided into 50 different subjects with dyslipidemia. After three months of flax seed (30 g of roasted flax seed), anthropometric limits, blood lipids and circulatory strain values were estimated in the exploratory group at the end of the study. Surprisingly, flax seed was found to affect circulatory blood pressure, lipid profiles, total lipid cholesterol, low-lipoprotein cholesterol, low-lipoprotein cholesterol, high-lipoprotein cholesterol, body weight, and weight history (BMI) in individuals with dyslipidemia). It was concluded that flax seed reduces the risk of CVD infection by providing the body with soluble filaments and ALA[90].

The inhibitory activity of lipase is important in the treatment of metabolic disorders and obesity. Therefore, ethanol concentrates from 144 plants pecies we rexamined for pancreatic lipase motility using methyl resorufin and triolein as substrates. *L. usitatissimum* (linseed oil) showed thes trongest effect among 144 plant species with an ID50 upper limit of 1:370, indicating that seeds with a high fat conten tprotect their lipid composition from lipids by forming lipase inhibitory substances[91].

The lipid-hostile effects of flaxseed were focused on hyperlipidemia-induced hyperlipidemia in 24 New Zealand malerabbits. The sequelae of concentrate in rabbitsfed 7.5 g/kg body weight per day of ground flaxseed and the baseline group showed a decrease in serum TC by 34% and 37% ($p<0.001$) and a decrease in LDL-C by 35% and 38.5% ($p<0.001$), and MDA (36.3 and 38.5% ($P<0.05$)) at theend of the first and second months. However, HDL.C and TG foci did not show striking contrast ($p>0.05$)[92].

The cholesterol and cancer preventive effects of linseed methylol and the anti-cholesterol and antioxidant effects of *L. usitatissimum* were studied using cholesterol enzyme end point technology and DPPH-free revolutionary search. conducted a comprehensive investigation. Cancer prevention. The cholesterol-suppressing effect of flaxseed should be comparable to that of the hyperlipidemia drug simvastatin (95.1%). The effect of flaxseed on cholesterol is delayed for up to 20 minutes, and the highest inhibitory effect is 93.04%. Research shows that flaxseed has excellent cholesterol and cell-strengthening activities[93].

Another study was completed by examining a group of nephrectomies rodents to evaluate the rationale for the antihypertensive effects of flaxseed on the preservation of Reno protective element sand natural oxidation catalysts in rodents. EELU (ethanol concentrate of *L. usitatissimum*) possibly diminished the degrees of growth rot factor and myeloperoxidase action. It could amazingly reestablish the degrees of renal endogenous cancer prevention agent compounds and film bound proteins and the degrees of blood urea nitrogen and serum creatinine. A stream cytometry concentrate on affirmed a huge decline in cell putrefaction and expansion in reasonability after RIR (renal ischemia-reperfusion) in EELU-treated rodents. The counter apoptotic job of EELU was evident[94].

9.9 Effects on Urogenital Tract

L. usitatissimum seeds named Telba (Amh.) are used privately for oralplacenta collection by the Zay people of Ethiopia[95].

Another paper looked at the use of flaxseed to treat regeneration in cattle and bison, through interviews with 217 traditional veterinarians. The results showed that they used flaxseed to maintain fetal membranes (mix 250g of seeds in 2 liters of milk and regulate orally for 3 days), to stop estrus/delay puberty (feed 150g of seeds directly for 5 days), and for anesthesia (Mix 500 g of rose flowers with 125 g of flaxseed and take orally for 5 days) and hormone exercise[96].

A study examining the effects of some Iranian natural medicines on human platelet cAMP and cGMP phosphodiesterase inhibition, which are key in the treatment of erectile dysfunction, *L. usitatissimum* ethanol concentrate was showed critical portion relied upon cAMP and cGMP phosphodiesterase inhibitory movement (most action at 0.1 mg/ml), in this way it is reasoned that L. usitatissimum could uncover more effectiveness in erectile dysfunction[97].

A single randomized clinical trial in visual impairment focusing on the suitability of an immune modulator containing the phytoestrogen lignans and omega-3 essential fats as an anti-inflammatory agent in the treatment of lupus nephritis and glomerulonephritis (a complication of SLE). Twenty-six prednisone-treated patients were treated for 1 year with 30 grams of flaxseed per day, chronically taken, followed by a mixture for up to a year without any improvement. The results showed that kidney function improved in those who received the treatment. The decrease in serum creatinine (from 0.97 ± 0.31 mg/dL to a mean of 0.94 ± 0.30 mg/dL) was attributed to patient consistency. Microalbumin reduction after consuming flaxseed[98,99].

9.10 Effects on Liver and Lung Disease

In a study of a group of Wistar rodents (hypertension in rodents was induced by the 2K1C method, as was actually the case with RAAS administration), flax-5ignin concentrate essentially explained the increase in liver, kidney, and heart Restoration of circulating marker proteins in serum electrolyte level and histological anomalies [88].

While one more review done in 2016 presumed that, linseed doesn't influence hare's liver or kidney capability boundaries and it affects their histology. In this manner delayed linseed ingestion in hares is safe[65].

Another study in 2016 showed that flaxseed had no effect on thelimits of liver or kidney function in rabbits, buthad an effect on their histology. Thus, delayed ingestion of flaxseed in rabbits is safe [103]. In a study of a group of Wistar rodents with bleomycin-induced pulmonary fibrosis, flaxseed oilwasable to significantly reduce damage because flaxseed oil is rich in unsaturated fatsand omega-3 and omega-6 has a sedative effect. This study provides evidence that flaxseed oilcan be targeted as a potential lung defense therapy[100].

9.11 Anti-Hyperglycemic Effect

In a study focusing on the hyperglycemic properties of flaxseed, pancreatic cell-enhancing catalysts were analyzed following treatment of alloxan-induced diabetic male Wistar rodents with flaxseed ethanol concentrate (EELU) serum glucose level was altogether diminished. There sults showed that 200 and 400 mg of EELU may reduce blood glucose levels, but the activity began at the 4th hour in the tissue and the peak of the blood sugar-lowering ability occurred at the 6th hour in the tissue. Furthermore, EELU (400 mg/kg) treatment resulted in profound changes in pancreatic GSH ($p<0.01$) and Turf ($p<0.05$), which are known to be partially responsible for the cell-enhancing effects of *L. usitatissimum*. Considering the ability of ROS to affect this plant, it can be considered a powerful enemy of hyperglycemia in pancreatic tissue[101].

9.12 Skin and Wound Healing Properties

A meeting of experts in Brazil focused on the half-strength definition of skin lesions from linseed oil (made from commercial linseed oil obtained from cold-pressed seeds) in 72 Wistar rodents. The neck areas of these creatures are hand-trimmed and sterilized using metallic gold casting and careful feathering. After the animals were divided into six groups, they received 1% SSFLO, 5% SSFLO, 10% SSFLO flaxseed oil, ESO (positive control) or gasoline jam (negative control) for 14 consecutive days. In experimental excisional wounds, progression of re epithelialization was observed in 100% of animals treated with effective tissue SSFLO (1% or 5%). This ability of flaxseed oil is thought to be due to the presence of PUFA and MUFA in its fraction (by promoting the formation of growth factors, fibro plasia and neo vascularization[102].

Available information on flaxseed (selective for vegetable oils). Because it contains up to twenty kinds of omega-6 unsaturated fats, and the omega-3 unsaturated fats must be converted into omega-3 fatty acids (EPA) and docosa hexaenoic acid (DHA), it has a negative impact on platelet function. The impact is contradictory. Two examinations contrasting linseed oil with a linoleic corrosive control (one concentrate in solid workers (N=11) and one concentrate in patients with atrophic joint pain (N=22)) revealed that linseed oil diminished collagen-animated platelet collection and draining time[103].

9.13 Anti-Tumor Effects

In a concentrate on antitumor properties of *L. usitatissimum*, Cell thickness/cell multiplication was assessed with the sulforhodamine B (SRB)-colorimetric examine. The emulsions from flaxseed oil fundamentally diminished in vitro expansion of the tried human growth cell lines (counting A549 (pneumonic basal cell alveolar adenocarcinoma), A431 (epidermoid carcinoma), MCF7 (bosom disease) CCRF/CEM (Lymphocyte lymphoblastoid intense leukemia), LOVO (colon adenocarcinoma[58].

In one more examination with respect to antitumor properties of *L. usitatissimum*, Secoisolariciresinoldi glucoside rich concentrate of *Linum usitatissimum L.* showed a huge chemo preventive impact in colon cancer (by restraining the action of the bacterial beta-glucuronidase protein, which, in any case expands the gamble of colon malignant growth). It was seen that Secoisolariciresinoldi glucoside rich concentrate of Flax is equipped for decreasing malignant growth biomarker levels, serum biomarkers, proliferative file and controlling hyperglycemia and hyper insulinemia. It is likewise accepted that SDG rich concentrate of flaxseeds is a strong chemo protective in skin malignant growth by repressing CDK4 and up-controlling p53 [104].

An examination concerning the motivation behind involving flaxseed in bosom carcinoma was finished by German scientists in 2012. In this exploration, MCF-7 and BT20 mamma carcinoma cells were presented to ethanol concentrate of *L. usitatissimum*, in vitro. In the wake of estimating the cell lethality, the cell essentialness and the identification of cell multiplication, separately by the LDH-test, the MTT-test and the BrdU-test, it was presumed that the concentrate caused different enemy of cancerogenic and cytotoxic consequences for both MCF-7 and BT20 cells in undeniably utilized test. There have been likewise a few examinations done in vivo to show the impact of flaxseeds on the development of various hetero-relocated bosom tumors in mice. Thusly, it isn't is business as usual to announce that flaxseed supplementation dietary could likewise control and diminishing the metastasis and growth angiogenesis too [105].

9.14 Anaphylaxis to Linseed

A review proposes that *L. usitatissimum* seeds may be a wellspring of unfavorably susceptible refinement, for example a 39-year-elderly person showed hypersensitivity instigated by linseed ingestion. Positive skin prick tests and receptor discharge tests led utilizing linseed remove proposed type I touchiness. In addition, resistant CAP measure affirmed the presence of Linum-explicit IgE in her serum [106].

9.15 Linseed in Drug Formulation

L. usitatissimum glue, which is an extraordinary source of polysaccharides, has been used to prepare midazolam nasal gels due to its properties, which include: high water-holding capacity, high consistency of the liquid system, large thickness, high gripping force and bonding strength, Increased bulk edibility, high permeability coefficients, biodegradability and biocompatibility, having a pH in the pH range of nasal depression and exceptionally mucoadhesive properties extending the home season of midazolam in the nasal cavity. It was accounted for that 100 % midazolam hydrochloride was let in 5 h out of gel ready with Linum with no enhancer. Aftereffects of this study affirm the vast majority of Linum in this definition in contrast with HPMC and carbopol 934, as manufactured polymers [107].

Consequences of one more affirm the viability of Linum adhesive as a disintegrate for getting ready dispersible tablet of diltiazem hydrochloride, in contrast with starch[108].

9.16 Effects on Carpal Tunnel Syndrome

A pilot randomized, sham-controlled clinical trial in dual visual impairment was conducted in 2014 on 100 patients; the effect of *L. usitatissimum* on carpal tunnel conditions was considered. One group of patients was treated with flaxseed, the majority of whom received skin implants. After 4 weeks of treatment, the nerve conduction velocity of the patient's median nerve was examined. Patients in the case group had a significant increase in median nerve conduction velocity of 2.38 m/s ($p<0.05$). However, patients showed slight improvement during the combined rest phase compared to the other group ($p < 0.05$). Therefore, flaxseed shows extraordinary possibilities in treating mild and immediate carpal tunnel disorders, controlling the severity of side effects and having practical applications. It also shows a dramatic impact on electro diagnostic limits (rarely on NCV[109]).

9.17 Feticidal Effects

A review focusing on the estrogenic and progestogenic effects of ethanol concentrate of *L. usitatissimum* in juvenile rodents and pregnancy in adult rodents found that oral administration of LU-EE to pregnant female rodents from days 1 to 7 of gestation resulted in fetal termination and termination of pregnancy (at doses of 500 and 1000 mg /kg bodyweight). This effect on the fetusmay possibly be due to the presence of estrogen in *L. usitatissimum*[110].

9.18 Anti-arrhythmic effect

Restricted human review and logical surveys recommend a potential enemy of arrhythmic impact of ALA and omega-3 greasy acids[111,112] Nonetheless, another investigation discovered that enemy of arrhythmic impacts were focus conditionally improved by DHA and EPA, yet not by ALA[113]. Higher admission of dietary omega-6-unsaturated fat could be connected with a diminished gamble of strangely drawn out re-polarization in men and ladies[114].

9.19 Antidiabetic effects

The effect of flax on blood glucose levels has been analyzed, but reports are uncertain. In a series of cases, postprandial glucose levels were reduced by 27% after dinners containing flaxseed [115]. Nestel et al. conducted a caseseries of 15 obese patients. demonstrated in detail that a four-week diet rich in omega-3 unsaturated fats (ALA) (20 g of margarine containing linseed oil) reduced insulin sensitivity In men with type 2 diabetes, consumption of omega-3 unsaturated fats resulted in an increase in fasting glucose levels and a 22% increase in mixed lunch glucose levels[116].

10. Applications of *Linum usitatissimum* as nanoparticles

Hydroalcoholic extracts of *Linum usitatissimum* were prepared via maceration and tested for antimicrobial activity alongside CuS nanoparticles. Minimal inhibitory concentration and bactericidal concentration were determined, highlighting their effectiveness against pathogens. The combination of metal nanoparticles with Linum extracts proved effective in eradicating bacterial infections, offering a promising antibiotic alternative[117].

Linum usitatissimum and *Euphorbia microsciadia*, prominent plant species in Iran, possess medicinal properties across different regions. Nanoparticles, particularly $ZnO/Zn(OH)_2$, are potent antibacterial agents, enhancing the effectiveness of these medicinal plants against severe bacterial infections. Hydroalcoholic extracts obtained via maceration method were combined with $ZnO/Zn(OH)_2$ nanoparticles and tested for antimicrobial activity. Minimal inhibitory concentration and minimum bactericidal concentration were determined, showcasing the efficacy of the developed antibacterial materials. This retrospective study explored the impact of plant extract and $ZnO/Zn(OH)_2$ nanoparticles on bacteria, while also assessing the antioxidant content of the extracts[118].

Green synthesis of silver nanoparticles (AgNPs) using plant extracts is a promising approach in nanobiotechnology, offering chemical-free AgNPs for various biomedical applications. In this study, AgNPs were successfully synthesized using whole plant extract (WPE) and thidiazuron-induced callus extract (CE) of *Linum usitatissimum*. Phytochemical analysis showed a higher content of phenols and flavonoids in CE compared to WPE. Ultraviolet-visible spectroscopy showed characteristic surface plasmon bands at 410–426 nm for the synthesized AgNPs. CE-mediated AgNPs were smaller (19–24 nm) and more dispersed than WPE-mediated AgNPs (49–54 nm). Both types showed a face-centered cubic crystal structure. Fourier transform infrared spectroscopy demonstrated the role of polyphenols and flavonoids in reducing and blocking AgNPs. Energy dispersive X-ray analysis confirmed successful synthesis. CE-mediated AgNPs exhibited better bactericidal activity against drug-resistant human pathogens compared to WPE-mediated AgNPs, showcasing the potential of thidiazuron-induced cultures for enhanced biosynthesis of AgNPs for nano-medicine applications.[119]

Linum usitatissimum serves as a reducing agent for the biological synthesis of barium oxide nanoparticles, leveraging its antioxidant, anti-inflammatory, and antidiabetic properties. These nanoparticles exhibit enhanced pharmacological effects due to the plant's characteristics. With low cost, low toxicity, and high magnetic properties, they find utility in biomedical applications. The environmentally friendly and cost-effective synthesis method further underscores the advantages of using biological materials for nanoparticle production[120]

Iron oxide nanoparticles (Fe_2O_3NPs) are valued for their ecofriendly and biocompatible nature, finding wide application. This study investigated the influence of biosynthesized Fe_2O_3NPs on flax (*Linum usitatissimum L.*) plants. The nanoparticles exhibited a cubic phase as confirmed by XRD analysis, with FTIR analysis verifying functional groups characteristic of iron oxide. Elemental analysis confirmed their composition. Scanning and transmission electron microscopy revealed an average particle size of approximately 56 nm. Fe_2O_3NPs positively impacted seed germination and biochemical parameters. Seedling length, number of seedlings with leaves, and root length increased significantly with nanoparticle treatment compared to the control. A dose-dependent correlation was observed, potentially attributed to enhanced metabolic activity[121].

The study demonstrated the uptake of AuNPs and AgNPs by calli cells and regenerants without affecting viability. Nanoparticles localized primarily in the cytoplasm. Their presence potentially influences flax calli regeneration frequency and type. The method could facilitate metal nanoparticle delivery to plant cells, offering numerous possibilities in plant science, breeding, and agronomy. This research highlights the potential of AuNPs and AgNPs in diverse plant-related applications[122].

11. Conclusion

Plants have been extensively utilized in traditional medicine across cultures worldwide for centuries, offering a vast array of therapeutic compounds. The phytochemical diversity of plant species provides a rich source of bioactive compounds, serving as the foundation for various medicinal applications.

Flax seeds, scientifically known as *Linum usitatissimum*, are nutrient-rich powerhouses containing omega-3 fatty acids, lignans, and fiber, offering a myriad of health benefits. Their consumption has been linked to cholesterol reduction, cardiovascular support, anti-inflammatory effects, and potential in combating chronic diseases like diabetes and cancer. Notably, their anti-arrhythmic and anti-atherogenic properties contribute to vascular health. Understanding their botanical features, phytochemical composition, and pharmacological activities could pave the way for innovative medical treatments.

Studies have highlighted the effectiveness of flax seeds in nanoparticle synthesis, resulting in particles with enhanced pharmacological effects suitable for various biomedical applications. This review aims to explore the pivotal role of *Linum usitatissimum* as a medicinal plant, delving into its diverse pharmacological activities and essential chemical components. By elucidating its multifaceted contributions to health and disease prevention, this comprehensive investigation underscores the significance of integrating flax seeds into a balanced diet for improved well-being.

In conclusion, *Linum usitatissimum* emerges as a potent medicinal weed, offering a treasure trove of pharmacological benefits and serving as a vital resource for the development of novel therapeutic interventions.

List of abbreviations

ω-3 fatty acid = omega-3 fatty acids
SDG = Secoisolariciresinoldiglucoside
ALA = Alpha-Linolenic Acid
LTA = leukotriene epoxide hydrolase
DHA = Docosahexaenoic acid

Consent to participant

Not applicable

Consent for publication

Not applicable

Author contribution

Nikita sahane: Research idea, undertook the analyses and wrote the draft manuscript.
Nirmala V. Shinde: had overall responsibility for the work that provided the basis for the study.
Sachin K. Bhosale, Nikita T. Kannor: collection of data.
Vrushali P. Patole and Ashwini S.Satalkar edited the manuscript. All authors read and approved the final manuscript.

Funding

None.

Competing interests

The authors declare that they have no competing interests deriving from the subject matter of this work.

Availability of data and material

The data sets and methodology supporting the results of this article are included within the article, the supplementary material, and in the cited work.

Conflict of interest

The authors declare no conflict of interest financial or otherwise.

Acknowledgements

SMBT College of pharmacy , Dhamangaon , Nashik , MS-422403 for providing review facility.

Ethics Approval & Consent to participate

Not Applicable.

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