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Review Article

Pharmacological, ethnobotanical, and phytochemical studies of *Ginkgo biloba:* An updated review

Pritesh Ranjan Dash[1*], Benjir Ahammad Rumi[1], Neser Uddin[1], Firoz Ahmmed[1], Jannatul Ferdous Samia[1], Md. Sohel Rana[2] and Deepanwita Nath[3*]

[1]*Department of Pharmacy, Primeasia University, Banani, Dhaka, Bangladesh*
[2]*Department of Pharmacy, Jahangirnagar University, Savar, Dhaka, Bangladesh*
[3]*Faculty of Medicine, University of Science and Technology Chittagong (USTC), Chittagong, Bangladesh*

***Correspondence E-mail:** pritesh@primeasia.edu.bd, nathdeepanwita92@gmail.com

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Abstract: *Ginkgo biloba L.* has been a revered source of auspicious food and traditional herbal medicine for thousands of years. Extensive research in advanced phytochemistry has highlighted that polysaccharides are key biologically active components of *Ginkgo biloba*. The fruits and leaves of this remarkable plant offer significant medicinal benefits, rich in Ginkgolide A, flavonoids, terpene, Tri lactones, and phenolic compounds. However, consumers should be cautious, as the seed contains certain allergenic and toxic alkylphenols, underscoring importance of using this powerful natural remedy responsibly. *Ginkgo biloba* demonstrates powerful biological activities, such as potent antioxidant, antiviral, anti-tumor, and anti-inflammatory effects. They are highly effective in cancer treatment, dementia care, liver protection, and are essential in addressing cardiovascular, metabolic, and neurodegenerative diseases. This review is dedicated to delivering comprehensive and up-to-date insights into the isolation methods, structural characteristics, and pharmacological properties of *G. biloba.* By highlighting their potential, we aim to promote the effective application of these compounds as therapeutic agents and functional foods, thus enhancing their value in health and wellness.

Keywords: *Ginkgo biloba L,* ginkgolide, polysaccharides, anti-cancer activity, EGb 761.

1.Introduction

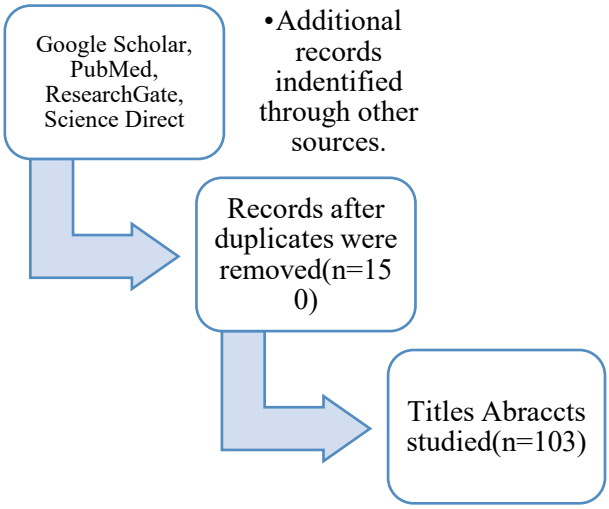
Ginkgo biloba L., is also known as Yinhsing to the Chinese and ginkgo to the Japanese, is a remarkable plant which is perennial in the *Ginkgoaceae* family. This Chinese herb is traditional and has been utilized for centuries and stands out as a true "living fossil." With a history spanning approximately 250 million years, this plant is one of the most ancient medicinal trees, primarily found in Korea, Japan, and China. Today, it is extensively cultivated worldwide, and its leaves and seeds are actively employed in various food products, health solutions, and dietary supplements.[1, 2]. The *Ginkgo biloba* tree stands out as an ideal choice for roadside planting in urban areas of Japan, Europe, and North America due to its remarkable resistance to air pollution. Its vertical growth slows significantly upon reaching sexual maturity at around 25 years of age. Moreover, the Ginkgo thrives even in low-light conditions and nutrient-poor environments, showcasing its exceptional resilience against bacteria, fungi, and viruses [3] . The main pharmacologically active components identified were flavonols (tamarixetin, kaempferol, myricetin, quercetin, apigenin, luteolin and isorhamnetin) and terpenes, tri-lactones (ginkgolide A, ginkgolide B, ginkgolide C, ginkgolide J, ginkgolide K, ginkgolide L, ginkgolide M, and bilobalide)[4, 5] and The main bioactive components identified in ginkgo are bioflavonoids, which have been used in various treatments (1 amentoflavone, 2 sequoiaflavone,3 bilobetin, 4podocarpusflavone A,5ginkgetin,6 isoginkgetin, 7 5'-methoxybilobetin, sciadopitysin) [6]. *Ginkgo biloba* seeds are not only rich in

nutrients but also in riboflavin, vitamin C, carbohydrates, and proteins (Son and Ki, 1998). Currently, we known about the Phytomedicine is rising in popularity as an effective approach to healing, with numerous plant-derived phytotherapeutics now playing an important role in addressing a wide range of diseases, particularly those associated with aging including Alzheimer's disease and also immunity booster, cardio-protective, neuro-protective, memory impairment and cognitive decline by the leaf extract of *Ginkgo biloba* [7, 8]. *Ginkgo biloba* is widely included in energy drinks that appeal to teenagers and young adults, but this can lead to potential health risks. On the other hand, many elderly individuals are turning to *Ginkgo biloba* for its promising benefits in preventing or postponing the onset of dementia, making it an important supplement for cognitive health [9]. Cervical cancer stands out as one of the most prevalent malignant tumors affecting women, ranking as the second most common cancer, eclipsed only by breast cancer. Its significance in women's health cannot be underestimated. More than 50,000 such cases have been identified worldwide to date, and this number is expected to continue increasing in the future. Cervical cancer is caused by human papillomavirus. In addition, the main signs are vaginal bleeding and irregular leucorrhea. The treatment of cervical cancer is usually by surgery, which is expensive and long-term painful, and radiotherapy and chemotherapy are also used to treat this disease. This method kills infected cells as well as damages healthy tissues; however, the latest research has found that Ginkgo biloba may reduce the risk of cervical cancer. The main chemical constituents derived from *Ginkgo biloba* are flavonoids and terpenoids, which have demonstrated significant antitumor activity along with ginkgolic acids [10]. Amino acids, carbohydrates, vitamins, and polyphenolic organic acids are found in *Ginkgo biloba* kernel extract. Numerous of these have been demonstrated to be helpful in the treatment of mood and cognitive disorders, cancer, cardiovascular illness, neurodegenerative diseases, and stress reactions [11]. One of the primary defenses against dangerous stimuli, such as wounds and infections, is inflammation. By decreasing exudate, granuloma formation, and inflammatory indicators, GKB significantly reduces inflammation. This is probably due to its inhibition of inflammatory cytokines and adhesion molecules. These findings make GKB a powerful contender for the treatment of inflammatory illnesses [7]. It has outstanding health benefits, including liver and skin protection, DNA repair, and potent antioxidant and anti-inflammatory effects. A main component, bilobalide, a unique sesquiterpene lactone, boosts its anti-inflammatory properties by blocking the TLR4/NF-κB signaling pathway, decreasing inflammatory cytokine production. *Ginkgo biloba* truly stands out as a valuable natural cure. [52]

2. Materials and Methods

This review paper on *Ginkgo biloba* was compiled using various literature sources from nine databases-SciFinder, PubChem, PubMed, ScienceDirect, Scopus, Google Scholar, CrossRef, and Web of Science. The article was prepared by analyzing over 150 articles and ultimately selecting information from 103 of them. The articles included in this review must be published in English and prior to March 2025, ensuring the inclusion of high-quality and relevant information. The focus is on the numerous phytochemicals isolated from various parts of Ginkgo biloba, as well as the primary pharmacological activities of the extracts, their therapeutic applications, and the pharmacological properties, phytochemistry, and traditional medicinal uses.

Figure 1: Flow chart of Data extraction



3. Botanical descriptions

These plans are used in traditional medicine in East Asia and also in Europe. Ginkgos are large trees reaching a normal height of 20–35 m (66–115 ft). *Ginkgo biloba* is dioecious, meaning it has distinct male and female trees. Small pollen cones are produced by male trees that contain sporophylls; each sporophyll has two microsporangia arranged in a spiral around an axis. Additionally, sex conversion has been observed in some trees, where certain branches change from one sex to the other [97]. Cones are not produced by female plants; instead, two ovules at the end of a stalk are formed. Wind pollination is necessary to convert these ovules into seeds, thereby ensuring plant reproduction [13]. "Ginkgo folium" Vegetative reproduction is achieved through the formation of embedded buds known as lignotubers, which develop at the base of the main stem [14]. A draft genome of Ginkgo biloba has been published by Chinese scientists, comprising 10.6 billion DNA nucleobases and approximately 41,840 predicted genes. These genes support various antibacterial and chemical defense mechanisms, with 76.58% of the sequence being monotonous [15, 16].

Figure 2: (a)Ginkgo leaves in clusters [17] (b) Fan-shaped leaf of the ginkgo plant [17]

3.1. Scientific classification [101]

Kingdom: Plantae*;* Clade: Tracheophytes*;* Clade: Gymnospermae*;* Division: Ginkgophyta*;* Class: Ginkgoopsida*;* Order: Ginkgoales*;* Family: Ginkgoaceae*;* Genus: Ginkgo*;* Species: *Ginkgo biloba.*

3.1.2. Synonyms[101]

- *Ginkgo macrophylla* K.Koch
- *Pterophyllus salisburiensis* J.Nelson, nom. illeg.
- *Salisburia adiantifolia* Sm., nom. illeg.
- *Salisburia biloba* (L.) Hoffmanns.
- *Salisburia ginkgo* Rich., nom. illeg.
- *Salisburia macrophylla* Reyn.

3.1.3. Traditional uses

From the 11th century CE, Ginkgo has been used in traditional Chinese medicine [98]. It is valued for its potential to address health issues like asthma, bronchitis, dementia, and kidney in addition to bladder disorders. Nevertheless, scientific research has not confirmed its effectiveness for these conditions [99,100]. Ginkgo leaf effectively treats mild dementia, which is age-related and mid-peripheral vascular disease in adults after ruling out serious conditions [103]. Extensive clinical trials have compellingly demonstrated the remarkable benefits of EGb 761, a particular standardized extract, in addressing senile dementia of various origins—whether primary degenerative, vascular, or mixed. Furthermore, this anomalous extract has also shown promising effects on peripheral arterial occlusive disease and many neurosensory disturbances, highlighting its potential to increase

overall well-being [18]. It has been observed in the case of people who were mentally disturbed that when they used the ginkgo biloba extract, their dementia gradually started to decrease [17].

4. Pharmacological Activity

Ginkgo biloba has been an effective medicine in addition to traditional herbs and herbal dietary supplements. The latest research has proven that many bioactive components in *G. biloba* exhibit various pharmacological activities, including anti-inflammatory, anti-tumor, antidepressant, hepatoprotective, antiviral, antifungal, anticancer, and antioxidant effects.

4.1 Anti-oxidant activities

The antioxidant effect is linked to increased amounts of superoxide dismutase, glutathione, cytochrome P-450, and catalase activity. Stefanovits-Bányai et al. (2006). Both male and female *Ginkgo biloba* leaf extracts exhibit antioxidant activity. The male extract showed greater free radical-scavenging ability, while the female extract contained more beneficial ions (Mg^{2+}, Ca^{2+}, K^{+}, Na^{+}, and Zn^{2+}) that positively affected degenerative brain diseases. At concentrations of about 10–500 µg/mL, the *Ginkgo biloba* extract helped protect human lymphocyte DNA and cell membranes from damage caused by free radicals. Its antioxidant activity is similar to that of α-tocopherol. Polyphenols are important antioxidants found in plants. They help protect the plant by neutralizing harmful free radicals, reducing certain substances, or binding to metals. The maximum classes of plant phenolics, flavonoids, and phenolic acids have shown significant antioxidant activity in various studies [19]. Most compounds in GBL significantly decreased during intestinal digestion, except for vanillic acid and bioflavonoids. There were notable reductions in total flavonoid and phenolic content after in vitro digestion. While DPPH and ABTS scavenging capacities dropped post-gastric digestion, they were enhanced during intestinal digestion. The FRAP assay, however, showed a different trend [20]. Polysaccharides derived from *Ginkgo biloba* are recognized as a highly effective and rising source of antioxidants, making them an excellent choice for those seeking natural ways to enhance their health [21]. Biflavonoids possess a less potent antioxidant capacity when contrasted with the other remarkable compounds found in ginkgo. Notably, the biflavonoids amentoflavone, bilobetin, ginkgetin, and sciadopitysin have been evaluated alongside 25 other ginkgo-derived compounds for their effectiveness in combating oxidative stress in HL-60 (promyeloblast) cells. In addition to amentoflavone, derived from various plants, it demonstrates powerful antioxidant activity [6]. *Ginkgo* extract is a powerhouse of flavonoids, celebrated for its potential as a natural antioxidant. It works by skillfully scavenging free radicals, superoxide anions, and nitric oxide, while also inhibiting harmful free radical reactions and lipid peroxidation. By harnessing the remarkable protective properties of *Ginkgo*, we can embrace a vibrant, healthier future [22].

4.2 Anti-tumor Activity

Polysaccharides extracted from *G. biloba* leaves, in addition to the exocarp, have demonstrated a remarkable ability to block human endometrial cancer cell HEC-1B, in addition to the proliferation of 4T1 breast cancer cells, showing a clear dose-dependent effect [21]. Ginkgolide B, isolated from *G. biloba*, inhibits the proliferation of tumor cells [23]. GBSP, a highly purified polysaccharide derived from *G. biloba* seeds, powerfully induces apoptosis in the SMMC-7721 hepatoma cell line and significantly inhibits its cell division [24]. Endophytic fungi, ingeniously extracted from *Ginkgo biloba* leaves, encompass the remarkable strains J-1, J-2, and J-3, all of which exhibit the fascinating ability to produce podophyllotoxin. These three strains were meticulously identified through advanced molecular biology techniques. The secondary metabolites derived from J-1, J-2, and J-3 display a striking potency, significantly inhibiting the proliferation of HeLa cells, increasing their apoptosis, and effectively halting their migration. Furthermore, these remarkable compounds have been shown to profoundly diminish the growth of HeLa tumors, highlighting their potential as powerful allies in the fight against cancer [10].

4.3 Anti-inflammatory activity

The extracts and their commercial procedure, including ginkgolides (A or B), bilobalide, water-soluble polysaccharides also amentoflavone, and have shown positive anti-inflammatory effects. Studies indicate significant reductions in interferon, nitric oxide, prostaglandin E2, TNF-α, IL-4, IL-6, IL-1β in inflamed tissues and IL-12, IL-1. There were also alternatives in the MAPK and NF-κB signaling routes, linked to decreased translocation of NF-κB, alongside enhanced activation of AMPK protein kinase, as well as heme oxygenase and Natural polysaccharides, such as those from G. biloba leaves (PGBL), have notable anti-inflammatory effects. They reduce monocytes' sensitivity to lipopolysaccharide (LPS) and inhibit inflammatory factor expression in RAW 264.7 cells [25-29]. GBSP3a (a water-soluble polysaccharide from *Ginkgo biloba* sarcotesta) has

significant effects on LPS-induced RAW264.7 macrophages. It effectively reduces the release of key inflammatory intermediaries, including nitric oxide (NO), tumor necrosis factor-alpha (TNF-α), and interleukin-1 beta (IL-1β). Additionally, GBSP3a inhibits the disclosure of inducible nitric oxide synthase (iNOS) as well as cyclooxygenase-2 (COX-2) in a dose-dependent fashion. Its anti-inflammatory effect primarily stems from the prevention of nuclear factor-κB (NF-κB) and MAPK signaling routes [30]. EGb 761 alleviates inflammation in the hippocampus of mouse brains after 8 minutes of extended ischemia by examining the activation of microglia and astrocytes, key markers of inflammation. Microglia activation results in an "amoeboid" cell shape, with a larger soma and retracted, thicker processes and enhanced expression of the integrin CD11b. Similarly, activated astrocytes have larger soma and increased GFAP expression. The vehicle-treated group had a significantly increased number of GFAP-positive cells and activated microglia in the hippocampus after seven days compared to the sham group's baseline values. EGb 761 pretreatment revealed a decrease in GFAP-positive and activated microglia, indicating the anti-inflammatory function of EGb 761 [31].

4.4 Anti-cancer activity

Ginkgo leaves have been shown to exhibit remarkable anticancer and antiproliferative effects in numerous in vitro studies targeting diverse cell lines [32]. Bilobetin, isoginkgetin, in addition to sciadopitysin, are less studied compounds with a significant role in the anticancer treatments of ginkgo extracts [33]. Amentoflavone contributes to anti-cancer action by regulating key signaling routes like ERK, NF-κB, and PI3K/Akt [34]. Ginkgetin, extracted from *Ginkgo biloba*, effectively stops cancer progression by blocking the cell cycle and stimulating autophagy and apoptosis. It targets key disrupted signaling pathways, including JAK/STAT and MAPKs, and is a powerful Hsp90 inhibitor. Ginkgetin, isolated from Ginkgo leaves, also increases the anticancer effects of cisplatin by disrupting the Nrf2/HO-1 axis through ferroptosis, which is especially monumental in non-small-cell lung cancer that has an EGFR wild-type. This suggests its potential as a valuable adjunct in cancer treatment [6]. We clearly established that *Ginkgo Biloba* extract (GBE) exhibits significant anti-cancer effects on human gastric cancer cells (SGC-7901 & MGC-803), effectively inhibiting metastasis in a dose-dependent manner. Furthermore, ginkgolic acid from *ginkgo biloba* powerfully impedes the growth of pancreatic tumor cells by downregulating essential adipogenesis enzymes, including acetyl-CoA carboxylase, in addition to fatty acid synthesis [35, 36]. We began our investigation into the effects of EGb 761 on cancer cell invasion and migration. As expected*, Ginkgo biloba* extract 761 significantly reduced the migration of HT29 and HCT116 cells after 48 hours, demonstrating a strong dose-dependent response, particularly between the 500 mg/L and 250 mg/L groups [37]. The *Ginkgo biloba* extract not only boosts the rate of DNA mending following oxidative stress but also demonstrates a remarkable enhancement of the DNA repair mechanisms. Additionally, it provides robust protection against the damaging effects of oxidative stress on DNA {Marques, 2011 #2}.

4.5 Anti-bacterial and anti-fungal activity

The extract of *Ginkgo biloba* shows activity against various Gram-negative bacteria in addition to Gram-positive bacteria [38]. Biflavonoids are derived from *Ginkgo biloba* and exhibit antibacterial activity [39]. The biflavonoids of ginkgo are also protected from antifungal agents (Krauze-Baranowska, 2003). Amentoflavone exhibits antimicrobial activity against *Pseudomonas aeruginosa*, *Streptococcus mutans*, *Escherichia coli* O-157, *Escherichia coli*, *Staphylococcus aureus*, and *Enterococcus faecium*. It shows significant antibacterial effects and synergistic interactions with antibiotics against a range of strains, excluding *S. mutans*. Amentoflavone also demonstrated effectiveness against food-borne pathogens like S. aureus and Escherichia coli in food models, including apple juice and chicken [6, 40, 41][14]. The protein extracted from *Ginkgo biloba* seeds in this study, named ginkbilobin, is a novel antifungal protein determined based on its N-terminal sequence. A notable feature of ginkbilobin is its strong antifungal activity against various fungal species, including *Coprinus comatus, Mycosphaerella arachidicola, Fusarium oxysporum, Rhizoctonia solani,* and *Botrytis cinerea*. It's important to note that specific antifungal proteins are ineffective against bacteria. Both the antimicrobial protein from garlic, *Allium cepa* (ACE-mp1), and ginkbilobin share antifungal and antibacterial properties [42]. The bioactive compounds are tannins, alkaloids, and saponins obtained from *ginkgo biloba* leaf extract. These plants are activated against *the S. cerevisiae organism, while the organism is inactivated by* fluconazole [43]. *Ginkgo biloba* exhibits the most antibacterial properties, as it not only has 94% antibacterial activity against Bacillus cereus but also prevents 96% of Escherichia coli (E. coli) [44].

4.6 Anti-viral activity

Ginkgetin's antiviral activity was tested against two influenza virus sialidases: A/PR/8/34 (H1N1) with a 50% inhibitory concentration of 55.00 μg/mL, and A/Guizhou/54/89 (H3N2) at 9.78 μg/mL. Amentoflavone can intercept herpes simplex virus 1 (HSV-1), including Acyclovir-resistant strains. Ginkgetin, from ginkgo leaves,

exhibits anti-influenza properties and protects against various viruses. Biflavonoids have shown potential as antiviral agents, demonstrating inhibitory effects against viruses like influenza A, influenza B, and respiratory syncytial virus [6, 45-47].

4.7 Alzheimer's and dementia

Ginkgo biloba L. is a potent herbal remedy for Alzheimer's disease. The extract EGb 761 has demonstrated referable efficacy in alleviating cognitive dysfunction in gerbil models of vascular dementia, showcasing its promise in the realm of cognitive health [48]. GbE with cholinesterase inhibitors, which act to treat dementia [49]. The study found that when used to treat patients with dementia who also had neuropsychiatric signs, EGb 761, 240 mg once a day, was markedly more effective than a placebo. EGb 761 is highly beneficial in treating patients with cognitive impairment and enhancing cognitive function, according to another study involving 188 middle-aged volunteers [4]. *Ginkgo biloba* leaf extract has accumulated observations for its remarkable effects on increasing learning and memory, along with its potential anti-aging benefits in humans. A daily oral dose of 240 mg of EGb 761 has demonstrated important promise in alleviating both presenile and senile major degenerative dementia of the Alzheimer type, as well as multi-infarct dementia, as classified by the DSM-III-R [35,50]. Research indicates that EGb 761 positively affects individuals with mild to moderate Alzheimer's disease. In a study on diabetic rats, *Ginkgo biloba* Extracts (GBEs) led to a reduction in neuronal populations in the jejunum and the myenteric plexus of the ileum. Conversely, the cell body area increased significantly in the myenteric and submucosal plexuses. Furthermore, GBEs enliven the left temporal and prefrontal cortex, enhancing cognitive performance. Randomized regular trials with a 240 mg daily dosage in patients with mild to moderate dementia showed a notable reduction in behavioral, in addition to neuropsychiatric signs [51].

4.8 Other pharmacological activities.

Ginkgo biloba is a medicinal tree with strong antioxidant characteristics. It has been shown to benefit degenerative conditions, inclusive of neurodegenerative retinal diseases. Antioxidants help address health issues caused of oxidative tension by regulating anxiety levels and reducing redox homeostasis [95]. The extract of Ginkgo biloba contains the biologically active compound *Ginkgo biloba* extract 761, which offers a defensive effect against impairment to both neurons and blood vessels, and is also used to treat vascular dementia (VaD) [96]. *Ginkgo biloba* contains polysaccharides that have been shown to exhibit various biological activities. It regulates cardiovascular activity and also reduces liver disease. *G. biloba* polysaccharide promotes insulin secretion, controls obesity, and regulates blood glucose levels [21]. GBE has demonstrated its remarkable ability to enhance cerebral blood flow. However, it's worth noting that individual lobar regions do not exhibit any significant changes following GBE consumption [4].

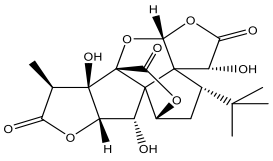
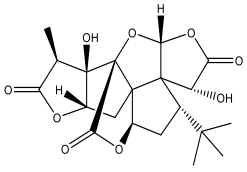
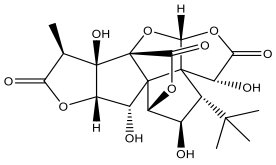
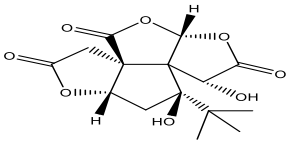
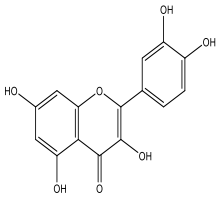
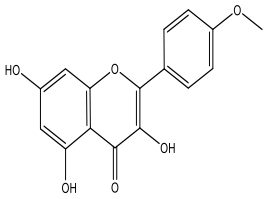
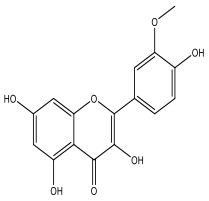
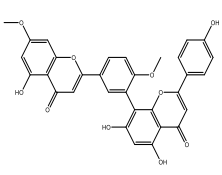
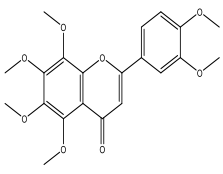
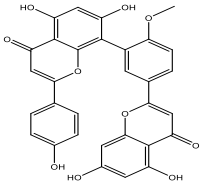
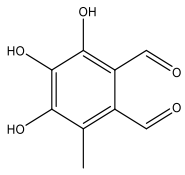
Table 1. The pharmacologically active compounds are obtained from *Ginkgo biloba* extracts.

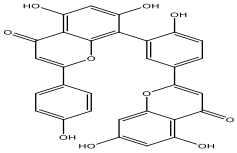
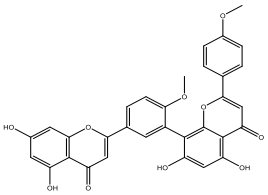
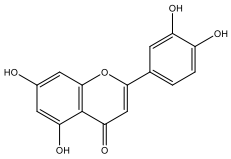
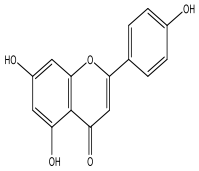
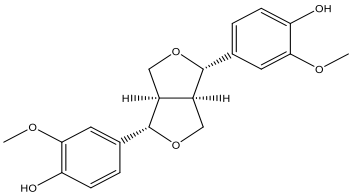
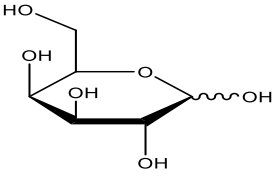
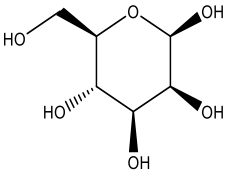
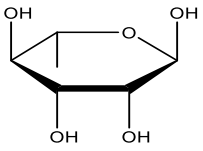
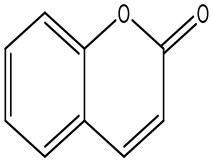
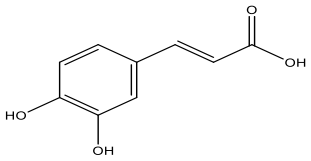
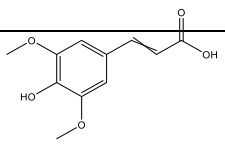
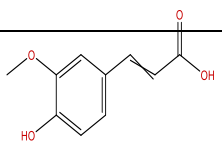
Sl. No.	Bioactive compounds	Source	Pharmacological activities	Ref.
1.	Ginkgolide B,	Leaves	• Anti-diabetic effects. • Anti-obesity Effects.	[12, 52-54]
	Bilobalide.		• Produce vasodilatation action. • Neuro-protective action. • Cardioprotective actions.	[55, 56]
	Ginkgo flavonoids (quercetin, kaempferol, isorhamnetin)			
2.	Flavonol glycosides & terpenic lactones,		• Antidepressant and	[57],

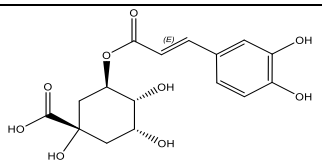
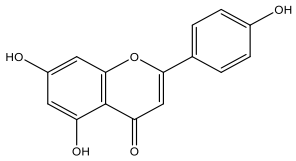
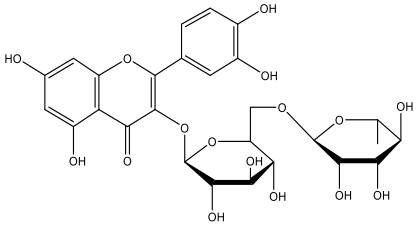
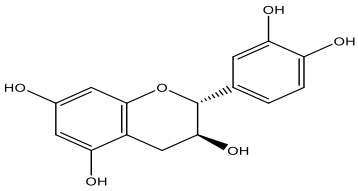
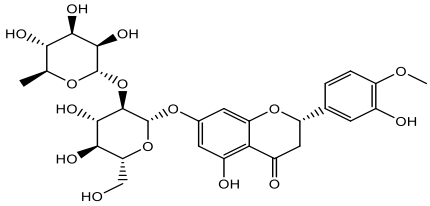
	Ginkgo flavonoids, ginkgolides A, B, and C.	Leaves	Anti-Stress Activity. • This compound is regulated to dementia and Alzheimer's disease (AD). • Memory effect.	[43, 48, 49, 58, 59] [8]
3.	Flavonoids (Chrysin 7-gentiobioside, Typhaneoside) and terpenoids (Blinin, Ginkgolide B, C), phenolic acids, Ginkbilobin. Biflavones (amentoflavone, sciadopitysin). Triterpenes, alkaloids, tannins. Naringin, Rosmarinic acid.	Leaves	• Anti-bacterial and cytotoxic activity, anticancer activity, and antimicrobial activity. • Anti-fungal activity. • Anti-bacterial & anti-fungal effect. • Anti-viral activity. • Anti-bacterial activity.	[60-62] [63] [40, 42] [64, 65] [66]
4.	Ginkgolide B, Biflavonoids (ginkgetin, amentoflavone, and bilobetin (9.4%).	Leaves	• Anti-inflammatory effect & protects skin from inflammation. • Anti-aging, Ear edema.	[4, 9, 35, 40, 43, 67-69]
5.	Bilobalide, β-D-glucopyranoside, ginkgolide A, C, lariciresinol	Bark	• Anti-inflammatory and metabolic disease. • Protect against neuronal injury and inflammation.	[50, 70] [64]
6.	Flavonoids, terpenoids, and ginkgolic acid. Flavonoid glycosides. Gallic acid, Rutin, Isorhamnetin, Ginkgotoxin. Bilobetin, Isoginkgetin. Quercentin, Naringin, Taxifolin, and Rosomarinic acid.	Leaves	• Anti-cancer activity. • Anti-cancer (pancreatic and gastric cancer) • Anti-cancer, anti-ulcer. • Cytotoxic activity. • Anti-cancer activity. • Anti-tumor activity.	[10] [37, 71] [72] [73] [36] [33] [66]
7.	Phenolics, Ginkgolides, Flavonol glycosides, Flavonol aglycones, biflavonoids. Polysaccharides (Galactose, mannose, rhamnose). Flavipin, Phenolic acids, Flavonoids.	Leaves	• Antioxidant activity. • Antioxidant activity. • Antioxidant activity. • Antioxidant activity. • Antioxidant activity.	[20, 74, 75] [65] [19, 63, 76, 77] [38]

	Phenolic acid(Luteolin, p-Coumaric acid, caffeic acid, syringic acid)	[78]
	Terpenoids.	

Table 2. The structure of phytochemical compounds in *Ginkgo biloba* extract.

SL. No.	Chemical Compound	Structure	Ref.
	Ginkgolide A Ginkgolide B Ginkgolide C	 Ginkgolide A  Ginkgolide B  Ginkgolide C	[40, 79, 80] [81, 82]
	Bilobalide	 Bilobalide	[83]
	Quercetin Kaempferol Isorhamnetin	 Quercetin  Kaempferol  Isorhamnetin	[63, 84, 85]
	Flavonoid Bilobetin Ginkgetin Flavipin	 Flavonoid  Bilobetin  Ginkgetin  Flavipin	[20, 74, 76, 85-88]

Amentoflavone Isoginkgetin	 Amentoflavone	 Isoginkgetin	[6]
Luteolin Apigenin	 Luteolin	 Apigenin	[38, 72, 89]
Pinoresinol	 Pinoresinol		[90]
Galactose Mannose Rhamnose	 Galactose	 Mannose	 Rhamnose	[29, 65]
Coumaric acid Caffeic acid.	 Coumaric acid	 Caffeic acid.	[91]
Sinapic acid			[92,

Ferulic acid	Sinapic acid	Ferulic acid	93]
Chlorogenic acid	 Chlorogenic acid		[94]
Apigenin	 Apigenin		[4]
Rutin	 Rutin		[72]
Catechin	 Catechin		[72]
Neohsperidin	 Neohesperidin		[72]

5. Conclusions

Ginkgo biloba, one of the oldest living tree species, has fascinated humans for over a hundred years due to its valuable applications in health food and medicine. The latest phytochemical studies have isolated key bioactive compounds from its leaves, seeds, and sarcotesta, including polysaccharides, biflavonoids, amentoflavone, ginkgetin, and phenolic acids, which are proven active ingredients with significant health benefits. G. biloba has diverse pharmacological activities, including antioxidants, anti-inflammatory, antiviral, immunostimulatory, anticancer, hepato-protective, anti-fungal, and anti-depressant in addition to anti-tumor properties, and can help reduce blood glucose levels, and so on. *Ginkgo biloba* is widely recognized for its safety,

demonstrating a low incidence of adverse reactions. To maximize its therapeutic potential, it is essential to conduct more rigorously controlled clinical studies in the future. These studies will help pinpoint the groups of individuals who stand to gain the most from treatments involving *Ginkgo biloba.*

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