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College of science

Department of chemistry

Chemical and biological study of the Dandelion (taraxacum officinale L.) plant

A project submitted to the scientific committee in the chemistry department in partial fulfillment of the requirement for the degree of bacterial science in Chemistry

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بسم الله الرحمن الرحيم

﴿ يَرْفَعِ هاللَّـُ الـهذِينَ آمَنُوا مِنْكُمْ وَالـهذِينَ أُوتوُا الْعِلْمَ دَرَجَاتٍ وَ هاللَّـُ بِمَا تعْـَمَلوُنَ خَبيِرٌ ﴾

صدق الله العظيم

(المجادلة: من الآية11)

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Abstract

Dandelion, scientifically known as Taraxacum officinale, is a herb from the Asteraceae family that is commonly found in the temperate regions of the Northern Hemisphere. It grows up to about 12 inches tall, with spatula-shaped leaves and yellow flowers that bloom throughout the year. Dandelion has a long history of use in traditional and modern herbal medicine systems across Asia, Europe, and North America. It is commercially cultivated in the United States and Europe, with its leaves and roots being utilized in herbal medicine and as a food source. The plant's bitter taste, attributed to sesquiterpene lactones, is most prominent in the leaves and roots, especially when harvested in the spring. Research has shown that dandelion possesses various properties, such as anti-inflammatory, diuretic, digestive stimulant, insulin stimulant, demulcent, prebiotic, immunomodulatory, antiangiogenic, and anti-neoplastic effects. Dandelion root and leaf have been found to offer protection against oxidative stress-related conditions like atherosclerosis and can reduce the atherogenic index. The plant also contains bioactive components that may have anti-diabetic properties. In folk medicine, Taraxacum officinale has been used to treat liver and various diseases, including breast and uterus cancers. Dandelion extract has shown potent inhibitory activity against HIV-1 replication and reverse transcriptase activity. The plant's leaves are a good source of fiber, potassium, iron, calcium, magnesium, phosphorus, vitamins A and C, thiamine, riboflavin, and protein. This review aims to assess the diverse biological activities and properties of dandelion.

Keywords: Dandelion, diuretic, oxidative stress, sesquiterpene, type 2 diabetes

1.Introduction of (Dandelion (taraxacum officinale) plant:

For many years, medicinal plants have played a crucial role in treating and curing various illnesses. There are approximately 500,000 plant species, with 80,000 possessing medicinal properties. Some plants, like the dandelion in Figure (1), grow naturally in different regions and have been used in alternative medicine for a long time. The dandelion, scientifically known as Taraxacum officinale, belongs to the Asteraceae family and is easily identifiable by its serrated leaves. Studies have shown that dandelions contain phenolic compounds, vitamins, minerals, alkaloids, tannins, flavonoids, and proteins. Research has also demonstrated the antioxidant and anti-inflammatory properties of dandelion extracts, making them a promising candidate

for pharmaceutical and biotechnological applications. The leaves can be eaten cooked or raw in various forms, for assembling salads or soup, which is also recommended as a natural source of vitamin C in the early spring. Dandelion water extract has anti-tumor activity attributed to polysaccharides.

Figure (1). Taraxacum officinale plant morphological structure

The most important biologically active components are sesquiterpenic lactones, biotin, inositol, and vitamins B, D, E, and phosphorous (P). The leaves possess a higher content of β-Carotene than carrot and more Fe and Ca levels than spinach, along with macro- and micro-elements. Flavonoids and coumaric acid derivatives were identified from dandelion flowers. Its roots have been used to make a coffee-like drink and the plant has been used by Native Americans as a food and medicine.

However, its use has mainly been based on empirical findings. This contribution provides a comprehensive review of the pharmacologically relevant compounds of Taraxacum officinale characterized so far and of the studies supporting its use as a medicinal plant.(Martinez et al., 2015)

1.1History and distribution of dandelion

The dandelion was first classified by Linnaeus in 1753 as Leontodon taraxacum, with subsequent refinements by Wiggers and Georg Heinrich Weber. It is believed to have originated in Greece or the Northern Himalayas and spread to Europe and Asia Minor. The plant has a fossil record dating back to glacial and interglacial periods in Europe and is thought to have reached the Americas post-Pleistocene through Beringia. Its introduction to North America is uncertain, with conflicting claims suggesting arrival with the Vikings, on the Mayflower, or by later settlers for medicinal or garden purposes. The earliest recorded sighting in North America was in New England in 1672, where indigenous

Figure (2). distribution of dandelion

tribes like the Cree, Digger, Apache, and Mohican Indians recognized its medicinal properties.in Figure (2) The dandelion likely had multiple introductions from various sources and spread to the West Coast with loggers and settlers. The first Canadian collection was in Montréal in 1821, where it was noted as a common species. Today,

dandelions are widespread across Europe, Asia, and America, blooming almost year-round in various habitats from sea level to two thousand meters. Farmers often consider it a troublesome weed due to its abundance. (Escudero et al.,2003)

1.2Common Types of Dandelion Plants

Here are some of the more common varieties of dandelion plants:

- **Common dandelion** (*Taraxacum officinale*) is the familiar, bright yellow dandelion that pops up along roadsides, in meadows, along riverbanks, and of course, in lawns. Although it's considered to be an invasive weed, these dandelions have value as a medicinal and culinary herb.
- **Red-seeded dandelion** (*Taraxacum erythrospermum*) is similar to and often mistaken for the common dandelion, but red-seeded dandelion has reddish stems. It is native to Europe but is also found in the more northern regions of North America. Red-seeded dandelion is thought to be a variety of *Taraxacum*
- *laevigatum* (rock dandelion).

Figure(3). Red-seeded dandelion

- **Russian dandelion** (*Taraxacum kok-saghyz*) The Russian dandelion, also called Kazakh dandelion or rubber root, is originally from the mountainous areas of Uzbekistan and Kazakhstan. It is similar in appearance to the common dandelion but has thicker leaves with a grayish hue. The roots of the Russian dandelion contain a significant amount of rubber and could serve as a promising alternative source of high-grade rubber.

- **Japanese white dandelion** (*Taraxacum albidum*) The plant is originally from southern Japan, where it can be found growing in roadside areas and meadows. While it may look similar to the common dandelion, it is not as invasive or troublesome. Its beautiful white flowers are appealing to butterflies and other pollinating insects.

Figure(4). Japanese white dandelion

- **California dandelion** (*Taraxacum californicum*) The California dandelion is a wildflower that grows in the meadows of the San Bernadino Mountains in California. It looks similar to a regular dandelion but has lighter green leaves and paler yellow flowers. Unfortunately, this plant is at risk due to factors such as urban development, climate change, off-road vehicles, and deliberate damage.
- **Pink dandelion** (*Taraxacum pseudopodium*) The plant is akin to the typical dandelion, but its flowers are a soft pink hue with a yellow middle, setting it apart as one of the most unique and distinct dandelion varieties. Originally from the high meadows of central Asia, the pink dandelion may spread like a weed but thrives when grown in containers where its vigor can be controlled. (Mary et al.,2007)

Figure(5). Pink dandelion

1.3. Names of dandelion:

Blow ball, Cankerwort, Clock flower, Common dandelion, Irish daisy, Lion's tooth, Pissinlit, Priest's Crown, Puffball, Swine's snout, Tell time, Yellow gowan, Bitterwort, Lentodon taraxacum. (Newall et al.,1996)

Arabic names :Hindiba, Khas berri . (الزبيد.,1916)

پشیله پایزه

figure (6).life cycle of a flower

1.4. Taxonomic Rank of dandelion

Dandelion is an angiosperm, a group whose members produce flowers and seeds (Kingdom Planta, Phylum Magnoliophyta, or Anthophyta). Dandelions are a subclass of the largest families within the angiosperms, the aster/sunflower family (Asteraceae), a group that is usually easy to recognize because the flowers occur in dense clusters (inflorescences) that themselves look like a single flower. The genus Taraxacum is a large and complex group, owing to the complications of apomixes and polyploidy.

Table (1). Taxonomy of plant Taraxacum officinale

Scientific Classification	Name
Botanical Name	Taraxacum officinale
Kingdom	Plantae
Phylum	Tracheophytes
Class	Angiosperms
Subclass	Eudicots
Order	Asterales
Family	Asteraceae
Genus	Taraxacum

The genus is taxonomically complex, with some botanists dividing the group into about 34 macrospecies, and about 2000 microspecies, about 235 apomictic and polyploidy microspecies have been recorded in Great Britain and Ireland. Some botanists take a much narrower view and only accept a total of about 60 species.

(Wirngo.,2016)

1.5. Origin and botany of dandelion

Dandelion, a plant belonging to the Taraxacum genus within the Asteraceae family, has a long history of being utilized as a medicinal herb. The plant is cultivated for medicinal and culinary purposes, with major production hubs in Bulgaria, Romania, Hungary, and Poland. Dandelion thrives in various climates, from tropical regions to cool highlands and temperate zones in the northern hemisphere, showing resilience to drought and frost. The Taraxacum species in Figure (7) is taxonomically intricate, with approximately 2800 known species in the Arctic and Northern temperate regions. Taraxacum officinale WEBER WIGG, originating from Europe, is commonly used for medicinal applications, while Taraxacum platycarpum is employed in Chinese traditional medicine for treating conditions like T2D and hepatic diseases. Dandelion, a perennial weed,

Figure (7). origin of flowers

develops a sturdy taproot averaging 15-30 cm in length, capable of regenerating new plants even if cut below the soil surface. Each plant typically produces 5 to 10 flowers with brown, conical fruits that have a hairy pappus facilitating seed dispersal by wind. Young dandelion plants are typically cultivated in manure soil under glass and transplanted between April and June in northern Europe. In regions like Russia, India, and China, dandelion has been used in traditional folk medicine due to its hepatic and hyperglycemic effects. It is also consumed as a food source, particularly in salads, as it is rich in essential micronutrients like minerals and vitamins. Dandelion is recognized for its various therapeutic benefits, including treating

conditions such as T2D, blisters, spleen and liver complaints, and is a popular traditional remedy in countries like Turkey and Mexico for managing T2D. (. Honek et al ., 2009)

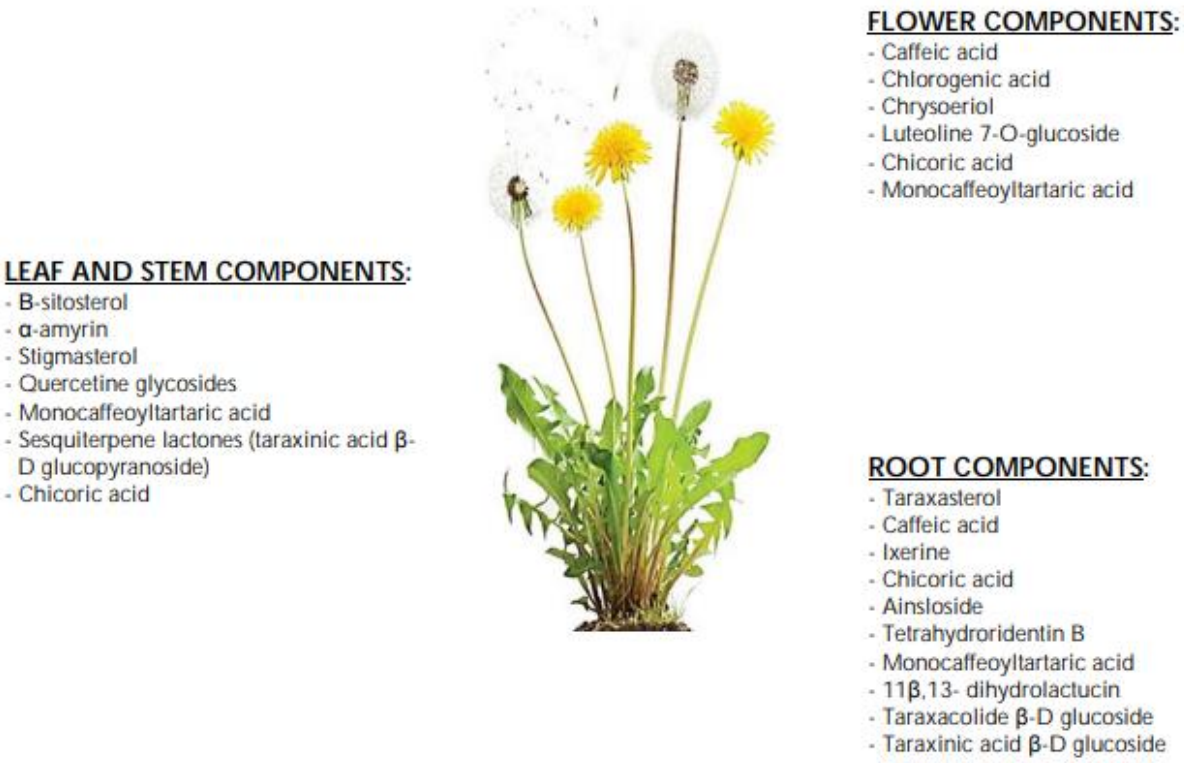


Figure (8). dandelion and some components present at the flowers, root, and leaves

2.Diverse biological activities of dandelion

Dandelion, scientifically known as Taraxacum officinale Weber, belongs to the Asteraceae (Compositae) family and is originally from Europe but is now found in many warmer temperate regions of the Northern Hemisphere. It is commonly consumed as a plant food in various parts of the world and is also used in herbal

medicine. Dandelion contains a variety of phytochemicals that are currently being studied for their potential health benefits, including antioxidant and anti-inflammatory properties. Recent research suggests that dandelion and its components have diverse effects on human health. This review offers a detailed examination of dandelion's components, its pharmacological properties, and relevant studies supporting its medicinal use. (Marta González-Castejón., 2012)

2.1. Dandelion as Food

Dandelion is a highly nutritious plant that can be used in various food products due to its leaves, roots, and flowers.in Figure (9) It contains a rich array of minerals, proteins, fiber, and vitamins, as well as a good balance of trace elements, making it a valuable source of micronutrients. When compared to lettuce and spinach, dandelion stands out for its higher levels of dietary fiber, proteins, amino acids, vitamins, and minerals. It also has a higher lipid content with a greater proportion of unsaturated fatty acids.

Figure (9).dandelion as food

Dandelion is particularly rich in beta-carotene and is commonly consumed fresh in salads or cooked in soups and other dishes. The dried leaves are used in beverages like dandelion wine, while the roasted roots can be used as a coffee substitute. Dandelion flowers are used in making wines, desserts, and flavor extracts for various food products.

2.2.What parts of the Dandelion are used?

The entire dandelion plant can be eaten cooked or raw, but we get different benefits from each part:

- **Dandelion Root -** The root in Figure (10) extract holds a lot of nutritional value and herbalists have used it in traditional medicine to help with liver detox.

Figure (10). dandelion root

- **Dandelion Flowers -** The flowers in Figure (11) contain antioxidant properties and may boost your immune system.

Figure (11). dandelion flower

Dandelion Leaves - The dandelion leaf in Figure (12) can assist with digestion and support blood sugar levels. Like spinach, you can sauté dandelion leaves and add to any dish.

Figure (12). dandelion leave

3.The Complete Health Advantages of Dandelion

1. May reduce cholesterol levels

High levels of triglycerides and cholesterol are significant factors for heart disease.

Studies on animals have indicated that dandelion leaf and root extract might decrease blood lipids, such as triglycerides and cholesterol. Nevertheless, further research is required to determine the impact on humans.

2. May aid blood pressure

The dandelion plant has been historically utilized in traditional medicine for its potential to assist with blood pressure.in Figure (13) It is believed to act as a diuretic, promoting the release of sodium by the kidneys through urine, which can help reduce excess fluid in the body and subsequently lower blood pressure. Additionally, dandelion contains potassium, a mineral that is recognized for its ability to relax blood vessels and potentially decrease blood pressure.

Figure (13).effect plant in blood pressure

3. Potentially has an anti-inflammatory effect

Further research is required to fully understand this effect, but animal studies indicate that the compounds found in dandelion may possess anti-inflammatory properties. In response to injury, our immune system triggers inflammation to safeguard our cells; however, prolonged inflammation can lead to additional harm. The research demonstrated that dandelion has the potential to decrease inflammation, which could subsequently alleviate pain.

4. May aid a healthy digestion

Studies on dandelion suggest that it can enhance the flow of bile, which is important for digesting food and absorbing fats. Additionally, dandelion has been utilized as a natural solution for constipation by serving as a laxative to help empty the bowels. It contains prebiotic fiber that has been proven to alleviate constipation and support regular bowel movements.

5. May assist in weight loss

Several studies indicate that dandelion can enhance the way our bodies process carbohydrates and control the absorption of fats in Figure (14). It is important to have a well-functioning carbohydrate metabolism so that our bodies can utilize carbohydrates as energy instead of storing them as fat. However, these studies have only been conducted on animals, and further research is required to determine the effects on humans

Figure(14).weight loss

6. May support liver health

Research on animals has demonstrated that dandelion plants can impact the liver in various ways. in figure (15) One study found that dandelion can decrease the accumulation of excess fat in the liver and shield it from oxidative stress, which is known to cause liver damage. Another study indicated that dandelion root might aid in preventing liver disease by enhancing liver function and stimulating bile production.

Figure (15). flowers affect liver health

7. May promote healthy bones

Dandelion leaves are a valuable source of calcium and vitamin K, which promote strong bones. in Figure (16) Research indicates that they can greatly improve bone density and overall bone well-being.

Figure (16). taraxacum officinal affect the healthy bines

8. Antioxidant properties may reduce cell damage

Antioxidants can fight against free radicals formed in the body, which are free molecules that could cause damage to cells if the free radical levels get too high.

Dandelion is a great antioxidant that could regulate free radical levels and reduce the chances of them causing cell damage and chronic disease.

9. May boost the immune system

Some experiments conducted in test tubes indicate that dandelion may have the ability to defend against harmful bacteria and inhibit the replication of virus cells. Strengthening your body's defenses against harmful bacteria can enhance the effectiveness of your immune system. (Katherine et al.,2023)

3.1. The potential dandelion benefits for skin

In the quest for more beautiful skin and to prevent premature aging, dandelion is a popular ingredient to look for in skincare. From moisturizers and serums to cleansers and scrubs, learn why dandelion root extract is so hard to beat.

1. Studies have investigated the anti-inflammatory effects of dandelion

particularly for skin problems. Utilizing dandelion to alleviate redness and inflammation caused by skin conditions such as rosacea, cystic acne, eczema, and psoriasis can help reduce skin irritation.

2. Antibacterial and anti-fungal

Dandelion is an effective skincare ingredient for treating acne due to its ability to prevent microbial infections. With its antibacterial, germicidal, and anti-fungal properties, dandelion helps detoxify the skin, unclog pores, eliminate acne, and reduce the likelihood of future breakouts. It is a versatile solution that benefits not only acne-prone skin but also various other skin types, making it a valuable skincare ingredient.

3. Reduces the appearance of wrinkles and fine lines

With its anti-aging properties, dandelion extract in skincare will help reduce the appearance of fine lines and wrinkles.in Figure(17) The trifecta of vitamins - A, C, and E -- in the dandelion extract is what can help reduce the appearance of those pesky lines and wrinkles because they encourage healthy skin cell production.

Figure (17). dandelion can effect healthy skin

4. Minimizes dark spots

Dandelion has the potential to diminish hyperpigmentation or age spots, also known as sunspots, which can develop due to unprotected exposure to UVA/UVB rays. By preventing the formation of these spots through reducing oxidative stress in sun-damaged cells, dandelion can help improve skin tone. The vitamin C in

dandelion aids in lightening and brightening the skin, resulting in a more even complexion.

5. Firms the skin

Dandelion can help tighten and improve the firmness of your skin by promoting the production of collagen and elastin. This can prevent sagging and loss of elasticity, as well as enhance the appearance of skin that lacks firmness.

4.The Physiological Effects of Dandelion (Taraxacum Officinale) in Type 2 Diabetes

4.1. Anti-diabetic properties of dandelion and its components

The active compounds found in dandelion have shown various anti-diabetic effects, in Figure (18) attributed to components like sesquiterpene lactones, triterpenes/phytosterols (taraxasterol), phenols, flavonoids, and phenolic acids. The primary issue in Type 2 Diabetes (T2D) is the imbalance in insulin secretion and sensitivity, leading to elevated blood sugar levels (hyperglycemia) and T2D, which can eventually lead to vascular diseases. Given that T2D is a widespread problem with significant economic and social implications, many countries are

Figure (18). taraxacum officinal effect of type 2 diabetes

increasingly relying on anti-diabetic medications. Dandelion root contains inulin, including fructooligosaccharides (FOS), a complex carbohydrate that supports beneficial bifid-bacteria in the gut, aiding in pathogen elimination. FOS also enhances mineral absorption, boosts the immune system, and inhibits abnormal cell growth. This carbohydrate can help regulate blood sugar levels. Plant extracts have been shown to lower hyperglycemia when used in high concentrations of water extract. Chromogenic acid (CGA) is a promising compound for preventing obesity and inflammation, as well as influencing insulin secretion and sensitivity, making it a potential candidate for future anti-diabetic treatments. (Chadwick et al., 2014)

4.2. Action mechanisms of dandelion in Type -2 diabetes (T2D)

T2D impacts many biological systems that influence the proper function of lipid metabolism, glucose metabolism, and insulin regulation. Glucose is the main energy source for most organs of the body and insufficient release of insulin by the cells to control glucose levels leads to metabolic disorders. Therefore, a possible explanation for the effects and mechanisms of dandelion on T2D could be its interaction with factors involved in the metabolic syndrome (lipid metabolism, glucose metabolism, protein metabolism, α- and β-cells dysfunction). in Figure (19) The mechanisms by which plant-derived compounds manifest their anti-diabetic properties are

1. Inhibition of renal glucose reabsorption.

2. Reduction of the activity of carbohydrate enzymes (αamylase with β-galactosidase andα-glucosidase).

3. Reduction of dietary blood sugar (which stimulates hepatic glycolysis and glycogenesis).

4. Inhibition of potassium channel flow. (Prabhakar et al., 2008)

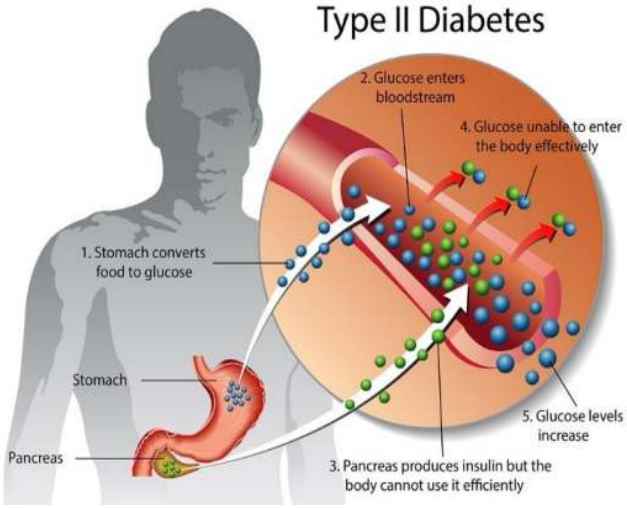


Figure (19). mechanisms of dandelion in Type -2 diabetes

4.3. The Physiological Effects of Dandelion (Taraxacum Officinale) in Type 2 Diabetes

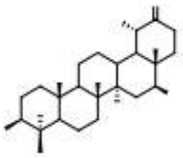
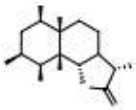
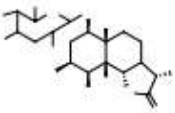
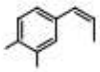
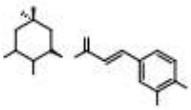
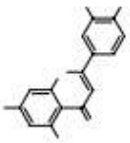
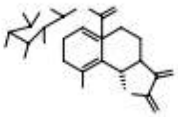
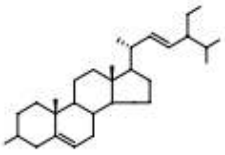
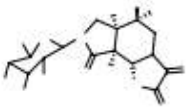
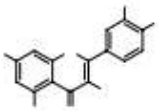
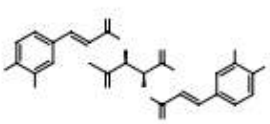
The increasing financial burden associated with type 2 diabetes (T2D) has led to a quest for more affordable treatment options. Dandelion presents a promising array of bioactive elements that may possess anti-diabetic properties. The Taraxacum genus, belonging to the Asteraceae family and primarily found in the temperate regions of the Northern Hemisphere, is widely distributed across various parts of the world. It is utilized as both a food source and a therapeutic agent for managing and treating T2D in different countries.in Figure(20) The anti-diabetic effects of dandelion are linked to its bioactive chemical constituents, such as chicoric acid,

taraxasterol (TS), chlorogenic acid, and sesquiterpene lactones. While previous studies have highlighted the pharmacological benefits of dandelion in

Figure(20).dandelion has anti-diabetic property.

treating various diseases, there has been limited exploration into the impact of its bioactive components on T2D. This review summarizes existing research on dandelion and its potential role in managing and preventing T2D, emphasizing its anti-diabetic properties, the structures of its chemical compounds, and their potential mechanisms of action in T2D. Despite promising initial findings, there is a need for further investigation into the cellular effects of dandelion, necessitating additional studies using clonal β-cell lines (INS-1E), α-cell lines, and human skeletal cell lines to identify active components that could aid in controlling and treating T2D. Extensive in vitro, in vivo, and clinical research is essential to delve deeper into the pharmacological, physiological, and biochemical mechanisms through which dandelion-derived compounds may impact T2D. (Fonyuy et al .,2015)

Table (2). Name and structure of dandelion compound with antidiabetic action.

Phytochemical names	Antidiabetic actions/plant part	Structure
Taraxasterol (phytosterol)	Antihyperglycemic and anti- inflammatory properties (roots)	
Tetrahydroridentin B (sesquiterpene lactone)	Anti-inflammatory and anti-microbial properties (roots)	
Taraxacolide-β-D-glucoside (sesquiterpene lactone)	Antihyperglycemic, anti-inflammatory, antimicrobial and hypolipidemic properties (leaves and stem)	
Caffeic acid (phenolic acid)	Anti-oxidative and immunostimulatory properties (flower, stems ,leaves and roots)	
Chlorogenic acids (phenolic acid)	Anti-oxidative and immunostimulatory properties (flowers, stems, leaves and roots). Strongest anti-oxidant	
Luteolin 7-O-glucoside (flavonoid)	Anti-oxidant properties (flower)	
Taraxinic acid-β-D-glucopyranoside (sesquiterpene lactone)	Anti-inflammatory, anti- hyperglycemic and antimicrobial properties. (roots, leaves and stems)	
Stigma sterol (phytosterols)	Anti-inflammatory, anti- hyperglycemic, antimicrobial properties (roots)	
Ixerin D (sesquiterpene lactone)	Anti-inflammatory and antimicrobial properties (roots)	
Quercetin glycosides (flavonoid)	Anti-oxidant properties (leaves and stems)	
Chicoric acid (phenolic acid)	Immunostimulatory and anti-hyperglycemic (most abundant compound found in roots leaves and stem)	

5.Diverse biological activities of dandelion

5.1. Phytochemistry of dandelion

Dandelion in Figure (21) is rich in various phytochemicals that are spread throughout the plant and have potential health benefits. The plant's bitterness comes from sesquiterpene lactones, mainly of the eudesmanolide and germa crinoline types, which are unique to dandelion. These sesquiterpene lactones, such as taraxacolides, dihydro-lactucin, ixerin, taraxinic acids, and ainslioside, are major components of dandelion and are believed to have anti-inflammatory and anticancer effects. In addition to sesquiterpene lactones, in Table (3) dandelion also contains phenyl propanoids, terpenoids, polysaccharides, and inulin, which have various health benefits such as immune regulation, antiaggregation activity, hepatoprotective effects, and antitumoral activity. Dandelion is also a good

Figure (21). Phytochemistry of dandelion

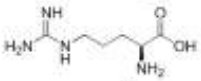
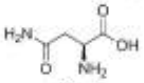
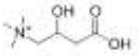
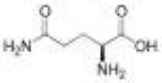
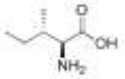
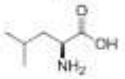
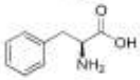
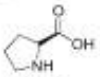
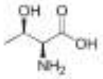
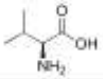
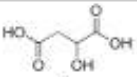
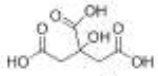
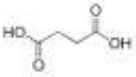
source of vitamins (A, C, D, E, and B), choline, inositol, lecithin, minerals, and oligo-elements. The composition of phytochemicals in dandelion varies depending on factors like the season, time of harvesting, and ecological conditions, and differs among the flowers, leaves, and roots of the plant. Sesquiterpene lactones give dandelion its bitter taste, especially in the leaves and roots. The plant also contains various sterols, with sitosterol being the most abundant in the leaves, followed by stigmasterol and campesterol. Levels of free methyl sterols are highest in winter, while sitosterol and cycloartenol esters are highest during sunny periods. (Schütz et al ., 2006)

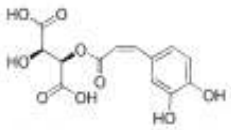
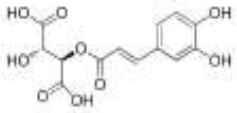
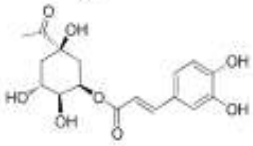
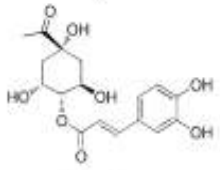
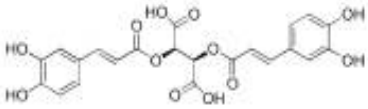
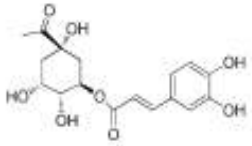
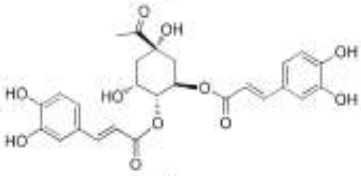
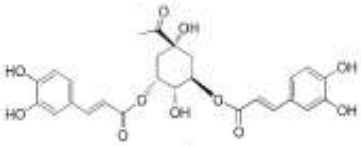
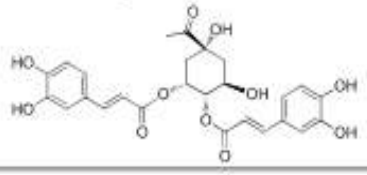
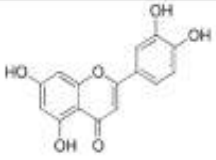
Table (3). Phytochemical composition of dandelion

Table 1 **Phytochemical composition of dandelion. Main purported pharmacological properties of phytochemical components are shown in italics.**

Dandelion root	Phytochemicals group Biological activities	Phytochemicals
Terpenes	Sesquiterpene lactones *Anti-inflammatory and antimicrobial properties*	Tetrahydroridentin B Taraxacolide-O-β-glucopyranoside Taraxacoside Acylated γ-butyrolactone glycoside 11β,13-dihydrolactucin Ixerin D Taraxinic acid β-glucopyranoside Ainslioside 11,13-dihydro-taraxinic acid β-glucopyranoside
	Triterpenes/phytosterols *Promote reduced cholesterol absorption*	Taraxasterol Ψ-taraxasterol Arnidiol Faradiol α- amyrin β- amyrin β-sitosterol β-sitosterol-β-D-glucopyranoside Stigmasterol
Phenolic compounds	Phenolic acids *Inmunostimulatory properties*	Chicoric acid Monocaffeoyltartaric acid 4-caffeoylquinic acid Chlorogenic acid Caffeic acid ρ-coumaric acid Ferulic acid ρ-hydroxybenzoic acid Protocatechuic acid Vanillic acid Syringic acid ρ-hydroxyphenylacetic acid
	Coumarins *Act on cardiovascular system*	Umbelliferone Esculetin Scopoletin
Storage carbohydrate	Inulin *Prebiotic activity*	
Aerial dandelion parts (leaves and stems)		
Terpenes	Sesquiterpene lactones *Anti-inflammatory and antimicrobial properties*	Taraxinic acid β-D-glucopyranoside 11,13-dihydrotaraxinic-acid β-D-glucopyranoside
	Triterpenes/phytosterols *Promote reduced cholesterol absorption*	Arnidiol β-sitosterol β- amyrin
Phenolic compounds	Phenolic acids *Inmunostimulatory properties*	Chicoric acid Monocaffeoyltartaric acid Caffeic acid Chlorogenic acid ρ-hydroxyphenylacetic acid
	Flavonoids *Antioxidant properties*	Luteolin 7-*O*-glucoside Luteolin 7-*O*-rutinoside Isorhamnetin 3-*O*-glucoside Quercetin 7-*O*-glucoside Apigenin 7-*O*-glucoside
	Coumarins *Acts on cardiovascular system*	Cichoriin Aesculin
Dandelion flowers		
Phenolic compounds	Phenolic acids *Inmunostimulatory properties*	Caffeic acid Chlorogenic acid Monocaffeoyltartaric acid
	Flavonoids *Antioxidant properties*	Luteolin 7-*O*-glucoside Luteolin 7-diglucoside Free luteolin Free chrysoeriol

Table (4,5). Its major organic and inorganic compounds isolated from the dandelion plant

Alanine		Whole plant Leaves	796.29 µM 9.4 µg/g	GC-MS, NMR NMR	Jung et al. (2011) Grauso et al. (2019)
4-Aminobutyrate (GABA)		Whole plant Leaves	959.75 µM 11.3 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Arginine		Whole plant	417.44 µM	NMR	Jung et al. (2011)
Asparagine		Whole plant	4905.54 µM	NMR	Jung et al. (2011)
Carnitine		Whole plant	n.q.	GC-MS	Jung et al. (2011)
Glutamine		Whole plant	4904.95 µM	NMR	Jung et al. (2011)
Isoleucine		Whole plant Leaves	703.96 µM 6.2 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Leucine		Whole plant Leaves	707.34 µM 15.6 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Phenylalanine		Whole plant Leaves	676.49 µM 20.1 µg/g	GC-MS, NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Proline		Whole plant Leaves	14472.28 µM 80.9 µg/g	GC-MS, NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Threonine		Whole plant	914.4 µM	NMR	Jung et al. (2011)
Valine		Whole plant Leaves	1407.16 µM 15.6 µg/g	GC-MS, NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Organic acids					
Malic acid		Whole plant Leaves	20542.27 µM 163.6 µg/g	GC-MS, NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Acetic acid		Whole plant Leaves	738.94 µM 6.2 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Citric acid		Whole plant Leaves	1404.03 µM 32.5 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Succinic acid		Whole plant Leaves	296.48 µM 10.2 µg/g	NMR NMR	Jung et al. (2011) Grauso et al. (2019)
Formic acid		Leaves	3.5 µg/g	NMR	Grauso et al. (2019)

cis-Caftaric acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
trans-Coutaric acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
5-O-Caffeoylquinic acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
		Leaves	n.q.	NMR	Grauso et al. (2019)
4-O-Caffeoylquinic acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
Chicoric acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
		Roots	0.6 mg/g	HPLC-UV/VIS	Williams et al. (1996)
		Leaves	10.4 mg/g		
		Leaves	n.q.	NMR	Grauso et al. (2019)
Chlorogenic acid		Flowers, roots, leaves, bracts	n.q.	HPLC-UV/VIS	Williams et al. (1996)
		Leaves	n.q.	NMR	Grauso et al. (2019)
3,4-di-O-caffeoylquinic acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
3,5-di-O-Caffeoylquinic acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
4,5-di-O-Caffeoylquinic acid		Roots, herb juice	n.q.	HPLC-ESI(-)-MS	Schutz et al. (2005)
Flavonoids					
Luteolin		Flowers	n.q.	HPLC/UV-VIS	Williams et al. (1996)

6.Identification of Dandelion Taraxacum officinale Leaves Components and Study Its Extracts' Effect on Different Microorganisms.

chemical composition of Dandelion Taraxacum officinale leaves was analyzed in both watery and alcoholic extracts. The findings revealed that the watery extract was alkaline due to the presence of alkaloids, while the alcoholic extract was acidic and contained glycosides, alkaloids, phenolic compounds, tannins, flavonoids, and proteins, with no saponins or resins detected. in Table (6) The leaves were also found to have high concentrations of trace elements such as potassium, calcium, sodium, and iron, and low concentrations of zinc, cadmium, and copper. The extracts were tested for their effects on various microorganisms, with a concentration of 0.5 mg/ml proving effective in inhibiting the growth of bacteria, particularly Staphylococcus aureus for both extracts, and E.coli more effectively by the alcoholic extract. Concentrations lower than 0.1 mg/ml did not inhibit any microorganisms. in table (7) High-Performance Liquid Chromatography (HPLC) was utilized to identify flavonoids, revealing the absence of kaempferol and morin in the extracts compared to the standard. (Jassim el at.,2005)

The concentration trace elements content of Taraxacum officinale leaves.

Trace elements	*symbol*	*Concentration (ppm)*
Potassium	K	185.1
Calcium	Ca	22
Sodium	Na	19.5
Iron	Fe	11.2
Zinc	Zn	6.3
Cadmium	Cd	1.3
Cupper	Cu	0.2
Chrome	Cr	Nil
Lead	Pb	Nil

Table (6). concentration trance element content of dandelion

Table (7). chemical components analysis (qualitative methods) for watery and alcoholic extracts of taraxacum officinale leaves

Chemical components analysis (qualitative methods) for watery and alcoholic extracts of Taraxacum officinale leaves.

Components	*Reagents*	*Note*	*Result Watery extract*	*Result Alcoholic extract*
Glycosides	Iodine test Molish test Benedict test	Brown ppt. Violet ring Orange ppt.	Ve+ Ve+ Ve+	Ve- Ve+ +Ve
Alkaloids	Mayer's reagent Wagner reagent Picric acid	No white ppt. Brown ppt. Yellow ppt.	Ve- Ve- Ve-	Ve- Ve- Ve-
Saponins	Fast stirring Mercuric Chloride	No dense foam for long time No White ppt.	Ve - Ve -	Ve- Ve-
Phenolic compounds	Aqueous%1 Ferric chloride	Green ppt.	Ve+	Ve+
Tannins	Aqueous%1 Ferric chloride Lead acetate%1	Green ppt. Preface yellow ppt.	Ve+ Ve+	Ve+ Ve+
Resins	Ethanol + Boiling + Distilled Water	No turbidity	Ve-	Ve-
Flavonoids	aqueous%1 Ferric chloride Ethanol hydroxide alcohol	Green ppt. Yellow ppt.	Ve+ Ve+	Ve+ Ve+
Proteins	Folin-Ciocalteau reagent	Blue color	Ve+	Ve+

7.Chemical Composition, Antioxidant and Antiproliferative Activities of Taraxacum officinale Essential Oil

The hydrodistillation process of the plant material produced essential oil (EO) with a light yellow color and a mild scent. The average yield of the oil obtained was 0.071 ± 0.003% (w/w). Analysis of the EO's chemical composition revealed 34 compounds, with 7 main compounds identified based on peak intensity in the gas

chromatography-mass spectrometry (GC-MS) results.in Table (8) These major compounds include n-hexadecanoic acid, 9,12-octadecadienoic acid, octadecadienoic acid, linoelaidic acid, pentadecanoic acid, n-nonadecanol-1, and tetradecanoic acid.

Table (8). chemical composition of dandelion essential oil

Table 1. Chemical composition of *Taraxacum officinale* essential oil.

Name	[a] RI	[b] RI	% Area
Pentadecanoic acid	1762	1777	2.28
Tetradecanoic acid	1774	1774	0.99
n-Hexadecanoic acid	1987	1980	26.11
Thunbergol	2051	2047	0.66
Heptadecanoic acid	2081	2080	0.81
Heptadecanolide	2094	2051	0.95
9,12-Octadecadienoic acid	2105	2152	34.19
n-Nonadecanol-1	2157	2153	1.36
Octadecanoic acid	2205	2165	1.11
Linoelaidic acid	2206	-	2.57

[a] RI: retention index measured relative to **n**-alkanes (C6–C30) on the non-polar 123 DB11 column. [b] Linear retention index taken from the NIST 05 library.

7.1. Essential oil composition of Taraxacum officinale

The gas chromatography–mass spectrometry (GC–MS) analysis of essential oil obtained by hydrodistillation from the flower of Taraxacum officinale L. in Table (9) revealed the presence of 25 compounds with 1,3-dimethylbenzene, 1,2-dimethylbenzene, 1-ethyl-3-methylbenzene, heneicosane and tricosane as the main components. (Fatima et al .,2022) **Table (9).** compound identified by using GC-MS

No.	Retention time (min:s)	Name	Match factor
1	3:15	1,3-Dimethylbenzene	948
2	3:28	1,2-Dimethylbenzene	929
3	4:25	1-Ethyl-3-methylbenzene	943
4	4:57	Octanal	869
5	5:40	Phenylacetaldehyde	911
6	6:06	2-Methylbenzaldehyde	934
7	6:31	Nonanal	838
8	7:06	1-Hydroxymethyl-4-methylbenzene	789
9	10:57	2,5,5-Trimethylheptane	816
10	11:48	6-Ethyl-2-methyloctane	830
11	12:32	2-Nonen-1-ol	790
12	13:49	1,9-Nonanediol	702
13	15:03	Pentadecanal	826
14	15:53	Benzyl benzoate	863
15	16:31	5-Methyl-2-hexanone	720
16	16:56	1-Tridecanol	872
17	17:03	Nonadecane	887
18	17:48	Hexadecanoic acid	845
19	18:06	Hexadecane	884
20	19:08	Heneicosane	926
21	19:34	1-Tridecyne	798
22	19:39	10-Undecenal	737
23	20:03	Pentadecane	869
24	20:59	Tricosane	870
25	22:44	Eicosane	861

Figure (22). essential oil of taraxacum officinale

7.2. Pharmacological Effects

Recent research in Table (10) has shown that dandelion possesses various pharmacological benefits such as antibacterial, antioxidant, anticancer, and anti-rheumatic properties. This part examines the recent discoveries regarding the pharmacological effects of Taraxacum. (Min et al.,2023)

Table(10). Pharmacological Effects

Table 3. The bioactivity of extracts from different species of *Taraxacum*.

Extracts/Compounds	Species	Formulation/Dosage	Results	References
		Anti-bacteria		
Ethanol extracts	*T. mongolicum*	In vitro; 1 g·mL^{-1}	*T. mongolicum* has a higher nutritional value, better antimicrobial effects and is an edible plant.	[78]
Ethanol extracts from flowers	*T. mongolicum*	In vitro; Gram-negative bacteria (125 to 250 μg·mL^{-1}) and Gram-positive bacteria (62.5 to 250 μg·mL^{-1})	The anti-bacterial test results showed that this fraction strongly inhibited the growth of all of the microorganisms, especially *P. aeruginosa* and *B. subtilis* (with MIC values of 125 μg·mL^{-1} and 62.5 μg·mL^{-1}, respectively)	[79]
Aqueous and ethanol extracts	*T. mongolicum*	In vitro; 0.125, 0.25, 0.5 g·mL^{-1}	It could inhibit these bacteria at different level in which ethanolic extracts of *P. oleracea* L. generally had higher anti-bacterial activities than aqueous extracts.	[66]
Water extracts	*T. mongolicum*	In vivo; 20 mg·kg^{-1}	The possibility of a multifactorial drug–drug interaction existed between extracts and ciprofloxacin. Thus, the implications of concomitant dosing of the two agents should not be overlooked.	[80]
Extracts from leaves	*T. officinale*	In vitro	It was found to be effective against all the tested Bacterial pathogens *P. aeruginosa*, *E. coli*, *S. aureus*, *B. Subtilis* and *M. luteus*.	[81]
Extracts from roots	*T. officinale*	In vitro	It exhibited considerable α-amylase and α-glucosidase inhibitory activities.	[82]
Extracts from leaves	*T. officinale*	In vitro	It displayed excellent antimicrobial activity against *S. aureus* and *E. coli*.	[83]
Peptides	*T. officinale*	In vitro	It displayed high antimicrobial activity both against fungal and bacterial pathogens.	[84]
Ethanol extracts from leaves	*T. officinale*	In vitro	It had shown an antimicrobial activity against the bacterial strains of *E. coli* and *S. abony*, but had not shown any antimicrobial activity against *S. aureus*.	[85]
Endophytic fungi	*T. coreanum*	In vitro	The results indicated that the endophytic fungis had the ability to antifungal.	[86]
		Anti-oxidant		
Methanol extracts	*T. coreanum*	In vitro	Its anti-oxidant activity was presented in a dose-dependent pattern.	[87]
Extracts	*T. officinale*	In vitro	It inhibited oxidative stress through elevated de novo synthesis of anti-oxidative enzymes and suppression of iNOS expression by NF-B inactivation.	[88]
Methanol extracts	*T. mongolicum*	In vitro	The anti-oxidant activity of *T. mongolicum* was presented in a dose-dependent pattern.	[89]
Extracts	*T. officinale*	In vitro	Dandelion root was a valuable source of dietary fibers and natural anti-oxidants.	[90]

8. Toxicity of dandelion

Due to the lack of toxins and alkaloids in its composition, dandelion has a low level of toxicity. Research conducted on rabbits, mice, and rats, including studies where rabbits were given dried dandelion plants orally and mice were treated with dandelion ethanoic extracts, did not show any significant signs of toxicity. However, it is important to note that allergic reactions may occur in sensitive individuals. The main components in dandelion, such as taraxinic acid and sesquiterpene lactone, can lead to allergic contact dermatitis and reactions in those who are sensitive. In a study examining the effectiveness of dandelion root extract on drug-resistant human melanoma cells, it was found that the extract was non-toxic to normal human cells but toxic to the melanoma cells. Various reputable sources, including renowned physicians, the European Commission, and the British Herbal Pharmacopoeia, have recommended specific dosage ranges for dandelion.

Fresh leaves 4-10 g daily

- Dried leaves 4-10 g daily
- 2-5 ml of leaf tincture, three times a day
- Fresh leaf juice, 1 teaspoon twice daily
- Fluid extract 1-2 teaspoon daily
- Fresh roots 2-8 g daily
- Dried powder extract 250-1000 mg four times a day

While these basic dosage suggestions are simple, they offer populations the ability to access alternative and cost-effective treatments when traditional medicine is not available. Despite this, compounds derived from dandelions hold significant potential for treating Type 2 Diabetes. More research is needed, particularly in

isolating the active ingredients, studying and standardizing the pharmacokinetic and pharmacodynamic properties of dandelion-derived compounds for pharmaceutical and alternative medicine use, and thoroughly examining their effects through laboratory, animal, and clinical studies. (Seo et al .,2005)

8.1. possible side effects of dandelion

As with all herbs, vitamins and minerals, different side effects may affect different people:(Omudhome et al .,2022)

- Allergic reactions
- Diarrhea
- Heartburn
- Dermatitis in those with sensitive skin

9.Dandelion

9.1. Impact

Dandelion poses a significant challenge as a weed for those managing turf and ornamental plants. In turf areas, it forms clumps that can create unsafe conditions for athletic fields and golf courses. The distinct texture and color of dandelion compared to regular turfgrass, along with its yellow flowers, diminish the visual appeal of the turf. When dandelion takes over turfgrass and ornamental plantings, it creates dense circular mats of leaves that outcompete desirable species and weaken the surviving plants. Removing dandelion by hand or hoeing is often ineffective due to its deep root system, making control efforts more successful in home lawns and

gardens. Once dandelion establishes itself in an area, its seeds can easily spread through wind or equipment. This weed is also problematic in non-tilled orchards where mowing is used for weed management, especially during the spring

Figure (23). impact of flowers

bloom season when it attracts bees. Dandelion seeds can cause issues by clogging tractor radiators, and its roots are appealing to gophers. In irrigated pastures and alfalfa fields, dandelion is a significant concern in California's intermountain regions where it can persist for long periods due to its challenging root system.

(Letchamo et al .,1996)

10.conclusion

Research has shown that dandelion, scientifically known as Taraxacum officinale, is commonly used in traditional and natural medicine practices around the world. Dandelion is rich in antioxidants such as vitamin C, flavonoids, and carotenoids, making it a valuable source of minerals and antioxidants in the human diet. The leaves of dandelion can be used in fresh salads, while its flowers and roots can be incorporated into acidic dairy or cheese products to enhance their nutritional value and appearance. Studies have explored the potential health benefits of dandelion, including its anti-diabetic, hepatoprotective, antisteatotic, antilipidemic, and anticancer effects. Dandelion is considered safe for consumption with Generally Recognized as Safe (GRAS) status, but further research through in vitro, in vivo, and clinical studies is needed to fully understand its therapeutic potential and mechanisms for promoting health**.**

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حوکومەتی هەرێمی کوردستان-عێراق

وەزارەتی خوێندنی باڵا & توێژینەوەی زانستی

زانکۆی سەلاحەدین- هەولێر

کۆلێژی زانست

بەشی کیمیا

لێکۆڵینەوەی کیمیایی و بایۆلۆجی لە ڕووەکی پشیلە پایزە

(پرۆژەی دەرچوونە

پێشکەش بە بەشی کیمیا کراوە، وەك بەشێك لەپێداویستەکانی

بەدەستهێنانی بڕوانامەی بەکالۆریۆس لە، زانستی کیمیا)

ئامادەکراوە لەلایەن:

خەڵات علی اسماعیل

بەسەرپەرشتی:

م. ژاڵە بەهجەت زێوەر

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