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An overview on Dandelion Plant Leaf Extract

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Abstract

Dandelion (Taraxacum officinale) is used in many traditional and modern herbal medical systems, as particularly has been documented in Asia, Europe, and North America. The root is primarily considered a gastrointestinal remedy supporting digestion and liver function, while the leaf is used as a diuretic and bitter digestive stimulant. Preclinical research on dandelion has revealed numerous properties, including its actions as an inflammation modulator, diuretic, digestive stimulant, insulin stimulant, demulcent, prebiotic, immunomodulator, antiangiogenic, and antineoplastic, although not all studies agree. There are very limited numbers of clinical trials involving dandelion. So, this reiew aimed to declare the active consttuents , mechanisms of action, applications, side effects and toxicity of dandelion. Overall, dandelion is very safe. Further research is warranted on this widely-used, intriguing herbal medicine.

Keywords: Dandelion, Taraxacum, Toxicity.

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1. Introduction

Dandelion (Taraxacum genus) is an edible vegetable and medicinal herb. It is a perennial plant belonging to the Asteraceae family [1]. The name "*Taraxacum*" comes from the Greek words "taraxos" (disorder) and "akos" (remedy). The word "*officinale*" denotes a plant having medicinal properties [2]. Its French name, pissenlit, is attributed to the diuretic activity of the plant parts. Dandelion stems from the French word “dent de lion” (“lion’s tooth”) [3-4]. Dandelion is widely distributed in the northern hemisphere. Many botanists consider that dandelion originated in Greece, or perhaps the Northern Himalayas, and spread across temperate areas to Europe and Asia Minor. Dandelion has a fossil record that goes back to glacial and interglacial times in Europe. Indians soon became aware of its properties and used it as a medicinal herb [4]. It blossoms almost the whole year. It starts growing in the autumn and is seen in parks, pastures, meadows, fields, lawns gardens, wildlands on disturbed banks, shores of waterways, waste ground, and by the roadsides. It is so abundant that farmers everywhere find it a troublesome weed [5]. The root is a substitute for cereal coffee, the leaves are eaten raw in salads, and syrups are made from the flowers [6]. Dandelion has long been utilized in traditional medicine, folk remedies, and substitution therapies in many countries to treat diverse diseases. It was used by Arabs in the 10th and 11th centuries to treat liver- and spleen-related conditions [7]. It has been used as a common drug for detoxification, swelling, and lactation since the 16th century in China [8]. The plant has been utilized in the treatment against various ailments such as cholera, cancer, rheumatism, scurvy, acidosis, headache, collagen buildup, jaundice, uric acid disorders, kidney diseases, diabetes, bacterial infections, diuretic, liver and spleen disorders, and as an anti-inflammatory factor [6-9].

1.1. Plant description and active constituents

Dandelion is a perennial weed producing from a sturdy taproot. Its root is fleshy and is dark brown on the outside, white and milky inside. The roots can produce new plants even when the plant is cut at or below the soil surface. The long and light to dark green leaves are gathered in a rosette deeply serrated at ground level. Leaves grow from the highest end of the root at ground level. Their flower heads open during the daytime and close at night, and have colors ranging from yellow to orange. The fruits are brown and crowned by a white, hairy pappus, which allows the seeds to be distributed by wind. The fruit is cotton-like with many seeds [10]. Dandelion has many medicinal properties, due to phytochemicals found in flower, leaves, stem and roots of the plant. The main phytochemicals are: carotenoids; flavonoids; phenolic acids; polysaccharides; sesquiterpene lactones; sterols and triterpenes [2]. Sesquiterpene lactones have anti-inflammatory and anti-bacterial activities. Phenolic acids and sesquiterpene lactones are responsible for its antidiabetic potential [6]. Sterols and triterpenes can alleviate cardiovascular diseases; while coumarins possess anti-inflammatory, bacteriostatic, anti-coagulant, and anti-cancer effects [4]. Research studies show that dandelion leaves contain high concentrations of fiber, minerals, vitamins and essential fatty acids [2]. Dandelion leaves are a rich source of potassium, which may be related to the plant’s diuretic activity [6]. This plant is also an important source of vitamins

(A, C, E, K, and B) and minerals for example, iron, silicium, sodium, copper, zinc, magnesium, and manganese [11].

2. Mechanisms of action and Applications

Dandelion has been reported to have multiple pharmacological actions, including anti-oxidant, anti-inflammatory, neuro-protective, anti-cancer immunostimulatory, anti-bacterial, anti-rheumatic, etc. [12].

2.1. Anti-inflammatory activity

Inflammation is a complex pathophysiological process mediated by a variety of signaling molecules generated by leukocytes, macrophages, and mast cells. Inflammation is a tissue response to injury characterized by enhanced blood flow to the tissue causing raised temperature, redness, swelling, and pain. Macrophages perform an important role in the inflammatory condition through the release of inflammatory mediators such as nitric oxide (NO), prostaglandin (PG) E2, and pro-inflammatory cytokines including TNF-α, IL-1β, and IL-6 [4]. The anti-inflammatory effects of extracts of dandelion or its single components have been reported in both in vitro and animal models. Dandelion extracts were demonstrated to inhibit lipopolysaccharide (LPS)-induced TNF-α production in rat astrocytes by inhibiting interleukin-1 (IL-1) production. Luteolin and luteolin-7-O-glucoside, two active components from dandelion flower extracts, significantly suppressed the production of both inducible nitric oxide synthase and COX-2 in LPS activated mouse macrophage cells [13]. Medicinal dandelion has anti-angiogenic, anti-inflammatory, and anti-nociceptive properties by inhibiting NO production and COX-2 expression and/or its anti-oxidant activity [14]. Mouse macrophages were used to study the anti-inflammatory effects and mechanism of the methanolic extract of dandelion leaves on LPS induction. The methanolic extract and its components inhibited LPS-induced production of NO, proinflammatory cytokines, and prostaglandin (PG) E2. However, the chloroform soluble fraction significantly inhibited the production of NO, PGE2, and two pro-inflammatory cytokines (TNF- α and IL-1 β) [1].

2.2. Anti-oxidant activity

Aerobic mammals utilize oxygen to maintain normal physiological functions, and up to 2% of oxygen consumption ends in the form of reactive oxygen species (ROS). ROS are oxygen derivatives with unpaired orbital electrons, unstable and highly reactive. ROS includes hydroxyl radical, superoxide radical, peroxyl radical, and singlet oxygen. Natural plant extracts have been investigated extensively for their anti- oxidant potential [4]. Dandelion polyphenols have the ability to protect dietary lipids, proteins and vitamins from oxidation. Additionally, they prevent damage to the building elements of the body (DNA, lipids and proteins) [15]. The most abundant phenolic compounds found in either Taraxacum root or aerial parts are hydroxycinnamic acid derivatives (HCAs), such as Chicoric (dicaffeoyltartaric), caftaric (monocaffeoyltartaric), and chlorogenic acids [16]. Additionally, many flavonoids, such as free aglycones and flavonoid glycosides, have been identified in both flower and leaf extracts, with the most commonly-reported examples being the flavones luteolin, chrysoeriol and apigenin [17]. Ceramella et al. [18] studied the toxic effects of prenatal exposure to lead acetate on brain tissues of newborn rats and potent protective effects of dandelion added to rat diet were tested in female rats. Lead acetate was administered to one-half of these rats through drinking water. Lead poisoning of mothers caused lead deposition in the brain and cerebellum of newborns and cerebellum tissue damages. Furthermore, a significant decrease in weight and protein content of these tissues was found. Oxidative stress and changes in anti-oxidant enzymes activity in brain tissues were also recorded. Conversely, no such damages or biochemical changes were found in neonates from plant fed lead poisoned mothers. These results strongly suggest that beneficial effects of the dandelion-added diet on lead-intoxicated rats proceeded through the reduction of the lead induced OS and related damages.

2.3. Neuro-protective activity

As, dandelion possesses bioactive compounds such as polyphenols, vitamins, and terpenes, which exhibit antioxidant properties. These natural antioxidants play a crucial role in safeguarding organisms from oxidative stress, a significant contributor to the ageing process and the development of neurodegenerative conditions [19]. The neuro-protective effects of extracts of dandelion on glutamate-induced oxidative stress in HT22 cells (neuronal cell line derived from the mouse hippocampus) were tested. Both cell viability and ROS assays confirmed that extract effectively attenuated glutamate-induced cytotoxicity and ROS generation. Moreover, extract increased the expression of heme oxygenase 1 (HO-1: a dynamic sensor of cellular oxidative stress and likely arbiters of tissue redox homeostasis) and promoted the nuclear translocation of nuclear factor erythroid 2-related factor-2 (Nrf2: a crucial transcription factor that serves as a central regulator of endogenous defense mechanisms against oxidative stress) [4]. In another study, just the extract of the aerial parts showed cyto-protective effects on glutamate-induced neurotoxicity and induced the expression of HO-1 in the mouse hippocampal HT22 cells, while roots extract did not show neuro-protective effect. So, the extract of aerial parts could be an effective candidate for the treatment of ROS related neurological diseases [20].

2.4. Anti-cancer activity

In 1981, for the first time, it was shown that the hot water extract of dandelion possessed anti-tumor activity [21]. Then in vitro and some in vivo studies demonstrated that dandelion possesses anti carcinogenic activity in a large variety of tumors, such as liver, colon and gastric cancers probably due to its bioactive compounds, such as terpenoids, sesquiterpene lactones, phenylpropanoids and flavonoids [22]. The methanolic extract of dandelion root down-regulated antiapoptotic factor Bcl-2 and up-regulated the pro-apoptotic factor Bax, thereby decreasing the Bcl-2/Bax ratio and exposing cells to apoptosis [23]. Proteins of the Bcl-2 family control the intrinsic apoptosis pathway, for example, the pro-apoptotic Bcl-2 proteins Bax and Bcl-2 antagonist killer (Bak) can commit a cell to its programmed death by permeating the outer mitochondrial membrane and subsequently initiating the caspase cascade [24]. Besides its cytotoxic effect, it also reduces the invasion of cancer cells by lowering the phosphorylation levels of focal adhesion kinase. It was shown that dandelion increased the retinoic acid receptor ß2 gene which limits growth of many cell types by regulating gene expression. Dandelion also increase

protein expression in cancer stem cells which play a significant role in the initiation and progress of tumorigenesis, so control apoptosis in cancer [4]. In 2018 Menke et al., [25] presented preclinical data for general cytotoxicity of dandelion on a panel of pediatric tumor cell lines whose results revealed a dose-dependent decrease in cell viability, with different sensitivities for each tumor entity. Burkitt´s lymphoma and acute myeloid leukemia showed the highest sensitivity, medulloblastoma and neuroblastoma cells appeared to be moderately sensitive, and osteosarcoma cell line showed the lowest sensitivity. In neuroblastoma cell lines dandelion induced apoptosis and loss of mitochondrial integrity as well as an inhibition of invasion and migration.

2.5. Immunostimulatory activity

Dandelion leaves can influence the anti-inflammatory response through the inhibition of synthesis of NO and inhibition of COX-2 expression. Accordingly, they can be considered as immunostimulatory for combination with chemotherapy (co-chemotherapy). Ethanol extract of dandelion increases the number of leukocytes, lymphocytes, neutrophils and cytotoxic CD8 + T cells [4].

2.6. Anti-microbial and anti-viral activity

Aqueous and organic extracts of different plant parts exhibit promising *in vitro* antimicrobial activity relevant for controlling fungi, Gram-positive and Gram-negative bacteria related to respiratory, intestinal and oral disorders, meningitis, and other ailments. Therefore, dandelion represents a potential source of bioactive phytochemicals with broad-spectrum antimicrobial activity. It also has good anti-microbial activity against dental pathogens and can be suggested as a useful herb to control dental caries and endodontic infections [26]. Díaz et al. [27] isolated diverse chemical compounds from dandelion leaves, mainly triterpenoids and other unknown compounds. Subsequently, the leaves' extract could markedly inhibit Gram-positive bacteria with a minimum inhibitory concentration, thus suggesting dandelion had promising anti-bacterial potential. Different dandelion extracts have strong anti-viral activity against Human immuno- deficiency virus 1, Influenza virus type A, H1N1, Hepatitis C virus and Dengue virus serotype 2 (DENV2) [4].

2.7. Diuretic and kidney protective activity

The root of dandelion is a registered drug in Canada, sold principally as a diuretic. Also, the German Standard License for dandelion tea includes stimulation of diuresis, and the German Commission E approves the use of dandelion for diuresis. Also, the Leaves of dandelion were better diuretic and saluretic than the roots [4]. Dandelion contains three times the amount of potassium in other botanical diuretics and provides more potassium than that lost from diuresis induced by ingesting dandelion [20]. Regular intake of dandelion along with conventional medicine can be beneficial in treating kidney injury and would improve the working efficiency of the kidney while preventing any damage and side effects. This protective effect is possible by increasing the anti-oxidant defense system by dandelion extract [28].

2.8. Anti-diabetic activity

Dandelion products, due to the presence of polyphenols and flavonoids in their composition, can regulate the expression of several genes whose dysfunctions contribute to lipid deposition, oxidative stress, and insulin resistance. Dandelion components also show activity in regulating the pathways responsible for insulin release, most likely by inhibiting certain enzymes involved directly and indirectly in carbohydrate breakdown in Krebs cycle and glycolytic cycle [6].

2.9. Hepatoprotective effect

Dandelion leaves or roots are used for liver complaints in Himalaya region. Oral administration of dandelion roots increases the bile flow and is known as cholagogue. Dandelion is one ingredient of "Taemyeongcheong" and "kimchi" that is used for liver complaints, and also eaten as food and salad by Germans, French and Italian for its hepatoprotective effects. Dandelion leaves infusions are used in Mexico for hepatic, biliary, kidney and spleen ailments. Moreover, dandelion roots eliminate the toxins from liver and kidneys, dissolve the gallstones, increase the appetite and stimulate bile flow [29]. Dandelion has anti-obesity effects via inhibition of digestive enzymes, lipid metabolism and adipogenesis. The lipogenesis effects of dandelion are associated with reduction of inflammation in the body and liver and improvement of insulin resistance and anti-oxidant condition. Dandelion reduced the carbon tetra chloride induced hepatic lesions in mice, which was associated with reduction in NF-κB, NO, COX-2, TNF-α, and IL-1β (regulatory inflammatory mediators) and up-regulation of antioxidant enzymes and GSH level [30].

2.10. Effect on stomach motility

Dandelion has long been used for the treatment of abdominal distension, dyspepsia, nausea, and vomiting. Dandelion roots and leaves are used widely in Europe for gastrointestinal ailments. The German Commission E and European Scientific Cooperative for Phytotherapy recommend dandelion root to treat stomach upset, dyspepsia, and loss of appetite. Also, it has been shown that dandelion causes notable contraction of colonic smooth muscle cells in rats [29].

2.11. Effect on hematological profile

Dandelion, especially its aboveground parts containing hydroxycinnamic acid, which has antioxidant and antithrombotic effects of the hemostatic system; that is, they may be promising preparations in the prevention of cardiovascular diseases, especially those related to changes in hemostasis and oxidative stress [31]. A study about the effect of hydro-alcoholic extract of dandelion on blood cells in mice showed that the number of red blood cells (RBCs), white blood cells (WBCs), lymphocyte, and the rate of hemoglobin (Hb) were increased. The rate of platelet was decreased. So, the study indicated the efficacy of dandelion extract on RBC, Hb and on WBC to achieve normal body balance [32].

3. Side effects and toxicity

Fresh dandelion leaves and other parts are consumed as food in many countries. Also, dandelion has been used as herbal medicine for centuries, and the side effects of its consumption are rather rare. Dandelion root and dandelion extracts have "generally recognized as safe" status approved by the FDA for use in dietary supplements. [6]. Many studies on animals have been conducted regarding the potential toxicity of this plant. Toxicological studies have been

conducted, and lethal dose 50 (LD50) at per os administration to mice was determined to be greater than 20 g/kg body weight. In sub chronic toxicity studies (4 months), no toxic effect noted in rats fed with dandelion leaves (33% in the diet). No acute toxicity was observed in rabbits after the oral administration of dehydrated dandelion plant at a dose of 3–6 g/kg body weight. The LD50 (intraperitoneal injection) of the liquid extract of the herb and root for mice was 28.8 g/kg and 36.6 g/kg, respectively. It was only discovered that taraxacum acid esters could cause contact dermatitis [33]. *In vitro* studies have noted that dandelion infusions can inhibit cytochrome 3A4 (IC50 = 140.6 µg/mL), which may lead to interactions with the metabolism of, for example, immunosuppressive drugs. In studies with rats, it shown that doses up to 1000 mg/kg body weight did not cause mortality when administered by oral route, as did doses of 1600, 2900, and 5000 mg/kg body weight [6]. Dandelion intake is generally considered safe and well-tolerated in adults if taken in moderation, but some side effects exist, such as diarrhea, upset stomach, or irritated skin. Due to its bitter content, dandelion should be consumed with caution by people with diagnosed acute gastroenteritis or reflux esophagitis, acute inflammation, or obstruction of gastrointestinal tract. Allergies to dandelion may also occur. No information on dandelion toxicity or serious adverse effects in humans has been encountered in scientific literature [34].

Conclusion:

Dandelion is emerging as a valuable nutraceutical, known for its potential to combine nutritional benefits with healing properties. Its ability to act as a dietary antioxidant may help prevent various oxidative stress-related disorders, including cardiovascular diseases, cancer, and inflammation. The healing effects are likely linked to its diverse nutrient profile, which includes vitamins, minerals, fatty acids, and other bioactive compounds found in its leaves, roots, flowers, and stems. While animal studies have demonstrated a variety of biological activities associated with these compounds, the specific relationship between their chemical content and health benefits in humans remains unclear. This highlights the need for further research to establish effective prophylactic and therapeutic doses for clinical applications. The accessibility of dandelion as a raw material opens up exciting avenues for future studies and the exploration of its potential in developing natural pharmaceuticals, particularly in today's context of seeking alternative medicine solutions.

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