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Pharmacognosy, phytochemistry, pharmacology and clinical applications of *Taraxacum officinale*

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Abstract
Taraxacum officinale (Dandelion), family Asteraceae is widely distributed in the warmer temperate zones of the Northern Hemisphere. It is known for its variety of curative properties and is anciently used in the treatment of various diseases such as dyspepsia, heartburn, spleen and liver complaints, hepatitis, anorexia, etc. Phytochemically, the plant contains artemetin, quercetin, luteolin, luteolin-7-O-beta-D-glucopyranoside, caffeic acid, esculetin, stigmasterol, lutein epoxide and taraxasteryl acetate. The present article briefs about Pharmacognosy, Phytochemistry, Pharmacology, and Clinical Applications of *Taraxacum officinale.*

Keywords: *Taraxacum officinale*, phytochemistry; pharmacological activity; anti-carcinogenic

Introduction
Taraxacum officinale, commonly called dandelion, is an edible plant spread worldwide [1]. It was native to Europe however currently is found throughout the northern temperate zones, in cool highlands (1,200-1,500 m of altitude) [2]. Plants come under the genus Taraxacum belongs to the family Asteraceae or Compositae (also referred to as the aster, daisy, or sunflower family), subfamily Cichorioideae, tribe Lactuceae, have long been accepted as a medicinal herb. The primary reference to its application is mirrored in its name, which is derived from the Greek words "taraxis" for inflammation and "akeomai" for curative [3, 4]. Common Dandelion is considered a nontoxic herb that may be probably exploited for its choleretic, diuretic, antirheumatic, and anti-inflammatory properties [5]. Folkrole of dandelion root to improve appetite and treat minor digestive disorders.
Modern naturopathic physicians consider dandelion to have the ability to detoxify the liver and gallbladder, reduce the side effects of medications processed by the liver, and relieve symptoms of diseases in which impaired liver function plays a role [6]. Dandelion is a perennial plant [7]. This herb typically has deeply toothed hairless leaves, 5–30cm long and 1–10cm wide. It grows 3-35cm tall, forming a rosette of leaves at ground level. It's single, golden yellow flowers on straight leafless hollow stems that emerge from the center of the rosette. Every flower consists of a set of florets. This herb has tap roots, tapering from 2 to 3cm wide and a minimum of 15cm long. Roots are fleshy and brittle, and area dark brown color on the outside and white on the inside [2]. It contains 1.5% lipids (total weight) and has higher proportions of unsaturated fatty acids (oleic, palmitoleic, linoleic, and linolenic acids) than either lettuce or spinach [8] and it is the richest green-vegetable sources of β-carotene [9].

Other names of dandelion: Blowball, Cankerwort, Clockflower, Common dandelion, Irish daisy, Lion's tooth, Piss-in-bed, Pissinlit, Priest's Crown, Puffball, Swine's snout, Tell time, Yellow gowan, Bitterwort, Lentodon taraxacum.

Scientific classification of dandelion [10].

Kingdom	Division	Class	Order	Family	Tribe	Genus	Species	Binomial name
Plantae	Magnoliophyta	Magnoliopsida	Asterale	Asteraceae	Cichorieae	Taraxacum	Officinale	*Taraxacum officinale*

Plant Profile

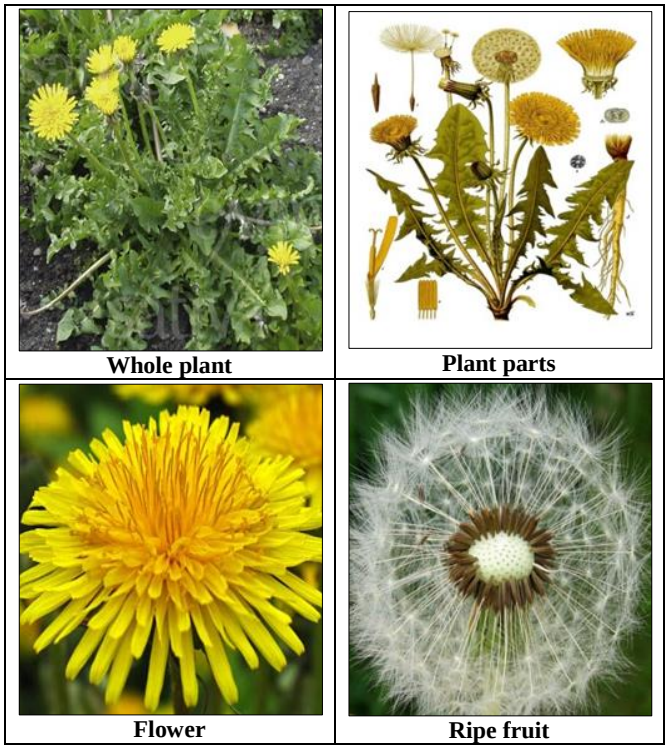


Fig 1: Various plant parts of *Taraxacum officinale*

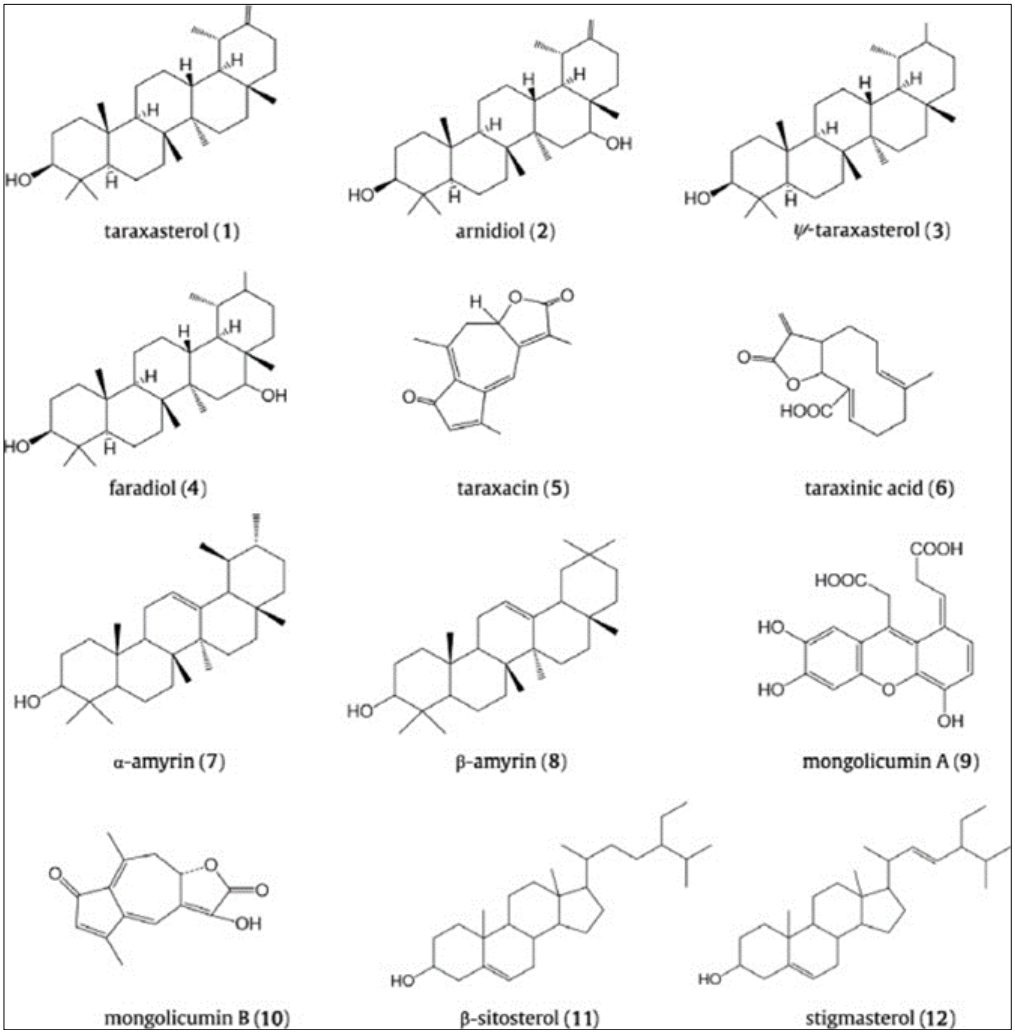
Photochemistry [11].
Carotenoids: Lutein and violaxanthin.
Coumarins: Esculin and scopoletin.
Flavonoids: Apigenin-7-glucoside, luteolin-7-glucoside, isorhamnetin 3-glucoside, luteolin-7-diglucoside, quercetin-7-glucoside, quercetin, luteolin, Phenolic acids: Caffeic, chlorogenic, chicoric (dicaffeoyltartaric acid) and y-hydroxyphenylacetic acids.
Polysaccharides: Glucans and mannans and inulin.
Sesquiterpene lactones: is the rich source in plant or bitter principles: rutin and chrysoeriol. Taraxacin or taraxinic acid or lactucopicrin, lactucin and cichorin are chief bitter principles and belong to the guaianolide class. The plant contains a crystalline substance, taraxacerine ortaraxaceron, which is reported to be bitter resin. Taraxacoside, a type of acylated gamma-butyrolactone glycoside has been reported from the plant. Other sesquiterpene lactones are of the germacranolide type including 11Z, 13-dihydrolactucin, ixerin D, ainslioside taraxinic acid Z-glucopyranosyl, taraxinic acid 1 '-Taraxacinortaraxinic acid or lactucopicrin, lactucin and cichorinare chief bitter principles and belong to the guaianolide class. Eudesmanolides including tetrahydroridentin-B and taraxacolide-O-Z-glucopyranoside are reported. Recently, a cyanogenic glycoside, prunasin has been reported from an extract of the plant. Phenylpropanoid glycosides: dihydroconiferin, syringin, and dihydrosyringin have been reported. Sterols: Taraxasterol, z-taraxasterol, homotaraxasterol (Chopra, 1956), Z-sitosterol, stigmatsterol, campesterol.
Triterpenes: Y-amyrin, Z-amyrin, lupeol, taraxol, taraxaserol, and cycloartenol are present in the roots. 3Z-hydroxylup-18(19)-ene-21-one has been reported from fresh roots of the plant. Arnidiol and faradiol have been reported.
Other: Lettucenin A, a serine proteinase: taraxalisin, amino acids, choline, mucilage, and pectin.

Table 1: Phytochemical Composition of *Taraxacum officinale* and Main Medical Properties of Phytochemical Parts

Dandelion root	Phytochemicals group Biological activity	Phytochemical
Terpenes	**Sesquiterpene lactones** Anti-inflammatory and Antimicrobial activities.	Tetrahydroridentin B Taraxacoside Taraxacolide-O-beta-glucopyranoside Acylated gamma-butyrolactone glycoside 11beta,13-dihydrolactucin Ixerin D Taraxinic acid beta-glucopyranoside Ainslioside, 11,13-dihydro-taraxinic acid b-glucopyranoside
Phenolic compounds	**Phenolic acids** Immunostimulatory activities	Chicoric acid Monocaffeoyltartaric acid 4-caffeoylquinic acid Chlorogenic acid, Caffeic acid Rho-coumaric acid, Ferulic acid Rho-hydroxybenzoic acid Protocatechuic acid Vanillic acid, Syringicaacid Rho-hydroxyphenyl acetic acid
Aerial Dandelion Parts (leaves and stems).		
Terpenes Phenolic compound	**Sesquiterpene lactones**. Anti-inflammatory and antimicrobial Activities **Triterpenes/phytosterols** Promote reduced cholesterol absorption **Phenolic acid** Inmunostimulatory Activities **Flavonoids** Antioxidant Activities **Coumarins** Acts on cardiovascular system	Taraxinic acid beta-D-glucopyranoside 11,13-dihydrotaraxinic-acid b-D-glucopyranoside Arnidiol Beta-sitosterol Beta- amyrin Chicoric acid Monocaffeoyltartaric acid Caffeic acid Chlorogenic acid Rho-hydroxyphenyl acetic acid Luteolin 7-O-rutinoside Luteolin 7-O-glucoside Isorhamnetin 3-O-glucoside Quercetin 7-O-glucoside Apigenin 7-O-glucoside

		Cichoriin Aesculin
Dandelion Flowers		
Phenolic compounds	Flavonoid and Phenolic acid	As given above

Chemical structures of the most representative phytochemicals in Dandelion



Pharmacological properties of dandelion

Dandelion leaf and root have each been studied for their effects on digestion, largely as bitter biological process stimulants. Its root has been investigated for demulcent, prebiotic, hypoglycemic, and immune-modulating effects. Blowball leaf has additional been investigated as a water pill and inflammation modulator. Whereas most of the possibly bioactive parts of the dandelion are isolated and known the pharmacological activity of many of those parts remains undiscovered. Some phytochemicals, together with bitter substances, phenols, and phytosterols, possess antioxidant and anti-inflammatory activities (Table 1).

Diuretic activity

An aqueous extract of dandelion roots (*Taraxaci radix*) or dandelion herb (*Taraxaci folium*) was administered through a gastric tube to male rats at a dose of 50 mL/kg body weight. The results showed that the diuretic action of extracts obtained from the dandelion herb was consistently stronger than that from the root extracts, reaching the highest diuretic and saluretic indices corresponding to 8 g dried herb/kg body weight. The high potassium content of the leaf compensated for the potassium eliminated in the urine. Thus, *Taraxacum* is devoid of furosemide side effects due to potassium loss such as hepatic coma and circulatory collapse [12]. Petrol ether fraction and two methanol fractions in a concentration of 50 mL/kg body weight slightly increased the final urine volume [13].

Anti-inflammatory activities

Very recent animal studies additionally rumored protecting anti-inflammatory effects of dandelion on acute lung injury induced by LPS in mice. Dandelion inhibits the assembly of inflammatory cytokines (TNF-a and IL-6) in bronchoalveolar lavage fluid six hours after injury induction and reduces the number of neutrophils and also the wet weight of lungs after twenty-four hours [15]. Additionally, dandelion reduces LPS-induced myeloperoxidase activity and increased superoxide dismutase activity within the lungs [16]. This impact was attributed to luteolin [13], That blocks mitogen-activated protein kinase (MAPK), extracellular signal-regulated kinase (ERK), and protein kinase B (Akt)-related signaling cascades and attenuates neutrophil chemotaxis and respiratory burst, therefore being useful in acute lung injury [17].

In vivo, the preventive administration of dandelion ameliorates the severity of induced pancreatitis and reduces IL-6 and TNF-a production during the illness. The anti-inflammatory effects of aqueous extracts of dandelion leaves

toward acute cholecystokinin-octa peptide-induced pancreatitis were evaluated in rats. Protective effects were shown in terms of a significant reduction in pancreatic wet weight and secretion of cytokines (IL-6 and TNF-a), and accumulated expression of heat-shock proteins (HSP60, HSP72) in the pancreas [18].

Anti-oxidative activity

Liver microsomes are highly sensitive to lipid peroxidation when incubated in the presence of NADPH and ADP-Fe2+. Both leaf and root extracts diminished enzymatically induced lipid peroxidation and reduced cytochrome *c* with and without NADPH in a concentration-dependent manner indicating anti-oxidant activity [18]. Dandelion leaf and root extract are proved as effective hydrogen donor, reducing agent, and hydrogen peroxide scavenger. In another study, the most efficient inhibition of hydroxyl radical production could be achieved with ethyl acetate and water extracts of dandelion flowers and aqueous dandelion stem extract. The marked anti-oxidative activity of a dandelion flower crude extract was confirmed in various chemical model systems [19].

Anti-carcinogenic activity

An aqueous root extract of *Taraxacum japonicum* inhibited both the initiation and promotion in two-stage carcinogenesis of mouse skin tumors induced by different types of initiators [20]. Based on these findings, 11 triterpenoids isolated from *Taraxacum japonicum* were investigated in a preliminary *in vitro* screening. In the following *in vivo* two-stage test, taraxasterol and taraxerol exhibited strong inhibitory effects in the carcinogenesis of mouse skin tumors. Furthermore, oral administration of taraxasterol showed remarkable inhibitory effects on spontaneous mammary carcinogenesis applied at a concentration of 2.5 mg in 100mL drinking water [20]. Dried aqueous dandelion (*Taraxacum officinale*) herb extracts show the effect on the cytotoxicity and production of cytokines in human hepatoma cell lines (Hep G2) [21]. The dandelion extract caused a time-dependent and partially dose-dependent reduction of cell viability by 26%. Furthermore, in cells treated with 0.2 mg/mL extract for 48 h, maximum secretion of TNF- α (186±2.0 pg/mL) and IL- 1 (66±1.7 pg/mL) was observed. The increased amounts of TNF-α and IL-1 contributed to dandelion extract-induced apoptosis, which was almost completely neutralized by the addition of anti-TNF- α and IL-1α antibodies. These results suggest that the extract induced cytotoxicity through TNF-α and IL-1 secretion in Hep G2 cells. As a consequence of the induced secretion of TNF-α, increased nitric oxide production from recombinant interferon-ϒ primed mouse peritoneal macrophages was observed [22]. Nitric oxide has received increasing attention as a potent macrophage-derived effector molecule against tumors [23]. Taraxinic acid, the compound resulting from hydrolysis of the sesquiterpene lactone glycoside taraxacinic acid-1-*O*-β-D glucopyranoside, isolated from *Taraxacum coreanum* NAKAI was investigated for its activity against cancer cells and showed significant cytotoxicity against human leukemia-derived HL- 60 cells, with IC50 at concentrations of 34.5–135.9μM. Its glycoside showed no effect at levels up to 200 μM. Moreover, cell growth was inhibited in a concentration and time-dependent manner (15–30 μM taraxinic acid). Apart from its anti-proliferative activity, taraxinic acid induced the differentiation of human leukemia cells to monocyte/macrophage lineage in various test systems [24]. In contrast, no effects on cellular growth of human gastric cancer cell lines AGS were detected using lyophilized ethanolic extracts of *Taraxacum mongolicum* [25].

Anti-allergic activity

Desacetylmatricarin, a guaianolide sesquiterpene isolated from *Taraxacum platycarpum* DAHLST, was investigated for its anti-allergic activity by measuring the release of β-hexosaminidase from rat basophilic leukemia (RBL-2H3) cells, which occurs concomitantly with the release of histamin when mast cells are immunologically activated. Desacetyl matricarin exerted a significant inhibition of the β-hexosaminidase release from RBL-2H3 cells in a dose-dependent manner. Its IC50 value of 7.5 μM is considerably lower than that of disodium cromoglycate (IC50 value is estimated over 100 μM).

Anti-hyperglycemic activity

The root of dandelion contains inulin which incorporates fructooligosaccharides (FOS). FOS is a complex carbohydrate; its intake benefits bifidobacteria that eliminate pathogens within the gastrointestinal tract. As a result of mineral absorption, FOS stimulates the system and thereby suppresses abnormal cell growth. This complex carbohydrate will facilitate normalize blood sugar levels.

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

T2D impacts several biological systems that influence the correct function of lipid metabolism, glucose metabolism, and insulin regulation. Glucose is the main energy supply for many organs of the body and insufficient release of insulin by the β-cells to manage glucose levels ends up in metabolic disorders.

Therefore, an attainable clarification for the consequences and mechanisms of dandelion on T2D could be its interaction with factors concerned within the metabolic syndrome (lipid metabolism, glucose metabolism, protein metabolism, α- and β-cells dysfunction) [27]. The mechanisms by that the plant-derived compounds manifest their anti-diabetic properties are [28].

1. Inhibition of renal glucose reabsorption.
2. Decrease in the activity of carbohydrate enzymes (α-amylase with β-galactosidase andα-glucosidase).
3. Decrease of dietary blood sugar (which stimulates hepatic glycolysis and glycogenesis).
4. Inhibition of potassium channel flow.

Mitochondria play another essential role within the onset of insulin resistance as they are the positioning at that the citric acid cycle and fatty acid oxidation turn up. Their dysfunction might cause the buildup of fat in muscle tissue and later the decrease of adenosine triphosphate (ATP) in membrane transport. Bioactive parts in dandelion could also be able to regulate these pathways, probably via inhibition of certain enzymes that digest carbohydrates [29]. The pathways involved are the glycolytic cycle and citric acid cycle, additionally to different pathways involved in the release of insulin from β-cells. Chlorogenic acid and chicory acid (CRA) might activate glucokinase in glycolysis, which catalyzes the phosphorylation of glucose to glucose-6-phosphate (G6P) [30]. Glycolysis is a metabolic pathway in that a 6-carbon glucose molecule is oxidized that results in the formation of two pyruvic acid molecules. This glycolytic pathway principally produces energy in tissues that stay in a low-oxygen state, e.g. those with low-oxygenated red blood cells. The catalytic

reactions involve the actions of many enzymes, as well as phosphofructokinase, hexokinase, and pyruvate kinase. Bioactive parts from medicinal plants like dandelion are known to regulate enzymes such as hexokinase, glucokinase, and phosphofructokinase. These enzymes are involved in the processes of glycolysis and the citric acid cycle. Studies have shown that plants rich in CGA will improve the useful activities of those crucial enzymes (phosphofructokinase, hexokinase, and pyruvate kinase).

As mentioned, the proof is building to support the notion that dandelion decreases the danger of developing atherosclerosis via attenuation of oxidative and inflammatory processes [31]. Additionally, studies in animals according to the consequences of various dandelion extracts on various risk factors of disorder like cardiovascular disease such as obesity, hyperlipidemia, hypertriglyceridemia, and hypercholesterolemia [32].

As an example, hypolipidemic effects of leaf extracts were discovered in rats fed a high-cholesterol diet [33] and in diabetic rats below treatment with dandelion water extracts. In rats, treatment with dandelion root and leaf extracts restricted the extent of atherosclerosis and decrease oxidative stress, serum levels of total cholesterol, triglycerides, and LDL cholesterol, and concomitantly elevated serum levels of HDL cholesterol [34].

Hypoglycemic effects

Dandelion has been studied in experiments designed to clarify the mechanism of action of its hypoglycemic properties. Arguable results recommend mechanisms that involve insulin resistance and contribute to β-cell burnout in patients with diabetes. It seems that certain dandelion extracts stimulate the discharge of insulin by pancreatic β - cell that successively decreases blood glucose levels. In diabetes mellitus, hyperglycemia is responsible for the development of oxidative stress (via glucose auto-oxidation and protein glycation), which is characterized by increased lipid peroxide production and/or decreased antioxidative defense [35]. Insulin secretagogue activities of dandelion extracts at 40 mg/mL were found in INS-1 cells [36]. The antihyperglycemic effect of an anti-diabetes herbal preparation containing 9.7% dandelion root was incontestable by important changes within the antioxidant defense in an experimental model of short-term diabetes mellitus [37]. Administered to alloxan-induced non-obese diabetic (NOD) mice at a dosage of 20 mg/kg, a dried ethanol extract considerably diminished glucose and fructosamine levels [38].

Gastrointestinal effects

Bile is secreted by the liver into the gall bladder to emulsify fats and thus is important for the digestion of fatty acids and also the absorption of fat-soluble nutrients. Early studies of dandelion as a cholagogue date from 1931, when researchers reported that dandelion causes contractions of the gallbladder by promoting bile flow in dogs [38]. A rise in bile production was conjointly discovered in different animal studies [39-41] that support the conventional use of dandelion as a digestive and appetite stimulant [42]. Treatment with completely different dandelion-containing herbal mixtures appeared to improve constipation, diarrhea, and intestinal cramping in 96% of patients in a cohort of 24 adults diagnosed with chronic inflammation [43-44]. Different studies conjointly reported improvement in animals with gastric ulcers, gastric metaplasia, and hyperplasia [45].

Antimicrobial/antiviral effects

Revealed knowledge demonstrates *in vitro* antiviral effects against the human herpesvirus type 1 [46]. Crude extracts of dandelion have conjointly been screened for their *in vitro* antioxidant and antimicrobial properties. The results show that blowball has antimicrobial properties [47], that have been attributed to its flavones. This antimicrobial activity might be mediated by the antioxidant activity of the flavones, however, this hypothesis needs confirmation

Anticoagulant/antithrombotic effects

Ethanolic extracts of dandelion roots exert inhibitory effects on human platelet aggregation, at least *in vitro*. Such extracts can dose-dependently inhibit ADP (adenosine 5′-diphosphate)-induced platelet aggregation, with a top inhibition of 85% at a concentration corresponding to 40 mg of dried root per milliliter of human platelet-rich plasma. Low-molecular-weight polysaccharides caused a 91% inhibition, whereas a fraction enriched in triterpenes and steroids showed an 80% inhibition of platelet aggregation, conjointly at a concentration equivalent to 40 mg crude material per milliliter of platelet-rich plasma [48].

Immunomodulation

The polysaccharides of dandelion are typically projected to possess immunomodulatory activities. As an example, the results of blowball on the restoration of suppressed immune functions (cell-mediated, humoral, and nonspecific immunity) are tested in short-chain aldehyde reductase (scald) mice, and a dose-dependent result was reported [49]. Some observations report inhibition of TNF, whereas others claim stimulation [50, 51]. For example, the results of hot-water (100 °C) and cold-water (4 °C) extracts of blowball roots on the innate and adaptive immune responses in mice were assessed. Neither hot- nor cold-water extracts affected the viability of macrophages at concentrations below 18 mg/mL and 8 mg/mL, respectively [52].

Prebiotic activity

Aqueous root extracts of *Taraxacum officinale* WEBER were tested for their growth-stimulating activity of 14 different strains of bifidobacteria. The growth of six strains (*B. adolescentis*1 and 2, *B. bifidum*1, *B. catenulatum*, *B. longum*2) was significantly enhanced in the medium containing dandelion root extract, while only two strains developed slightly less intensive in this medium compared to the control. The remaining six strains exhibited equivalent growth in both media. Determination of carbohydrates before and after incubation in all bifidobacterial cultures revealed 1–48% utilization of dandelion oligo fructans [53].

Hepatoprotective activity

Dandelion aqueous leaves extract show hepatoprotective activity in CCl_4 induce hepatocyte injury [54]. Leaves extract of dandelion also protect from hepatic stenosis by suppressing triglycerides, cholesterol, and insulin [55]. Taxacum is a good detoxifier for liver and removes dermatological problems.

Dosage and Toxicology

A survey of the literature shows that the most widely used daily dose of crude dried dandelion roots or leaves is within the range of 4–10 g, while that of fresh roots or leaves, routinely consumed as plant foods, is approximately 50 g/day or more, varying with totally different culinary habits. The British Herbal Pharmacopoeia suggests 0.5–2 g of root or 4–8

mL of root tincture, thrice per day [56]. The German Commission E Monographs suggest doses of 3–4 g of a root, two times per day, or 10–15 drops of a tincture, thrice per day [57]. The British Herbal Pharmacopoeia suggests 3–5 g of leaves or 5–10 mL of leaf tincture, two times per day [56]. The Commission E recommends 4–10 g of leaves or 2–5 mL of leaf tincture, thrice per day [58].

Conclusion

Dietary phytochemicals represent a relevant analysis area of nutrition and health. The long run of this area depends on the identification of active molecules in the food and plants and on an enhanced understanding of however the utilization of such molecules would possibly play a task in illness bar and medical care. As reviewed here, rising proof suggests that dandelion and its constituents have antioxidant and anti-inflammatory activities that translate into various biological effects. Blowball (dandelion) includes a vital antioxidant capacity because the leaves are rich in vitamin C, flavonoids, and carotenoids. It can be a readily available source of minerals and antioxidants in the human diet.

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Authors' contributions

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