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Phytochemistry, biological properties, economic and ecological importance of *Taraxacum officinale*, A review

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Abstract
Taraxacum officinale (dandelion), a flowering perennial herb of the family "Asteraceae," native to Eurasia, shows the cosmopolitan distribution. Titled "King of weeds" in literature, the plant has been used as a traditional botanical remedy to treat various bacterial infections and hepatobiliary problems. *Taraxacum officinale* is used as food, beverages, desserts, and a biomonitoring agent. Phytochemistry of the plant shows diverse compounds like flavonoids, terpenoids, triterpenoids, sesquiterpene lactones, sesquiterpenoid phytoalexin, phenols, free sterols, coumarins, saponins, flavones, steroids, and amino acids. The plant possesses diverse pharmacological activities, including anti-oxidant, anti-inflammatory, chemotherapeutic, hepatoprotective, hypolipidemic, anti-atherogenic, hypoglycemic, immuno-modulation, anti-bacterial, anti-viral, diuretic, and gastrointestinal. This review will describe the phytochemistry, properties, and pharmacology of *Taraxacum officinale.*

Keywords: Phytochemistry, biological properties, *Taraxacum officinale*

Introduction
Taraxacum officinale is a herbaceous plant included in the family Asteraceae. The word "*Taraxacum*" originates from the Arabic word "tarakhshaqun" or from "talkh chakok" which means unpleasant herb. The word *officinale* "actually means belonging to an "Officina" which in the past means storeroom of a religious house where medicines and other essentials were kept. *Taraxacum officinale* is commonly called Dudal, Radam, Bathur and Haend in the Indian Himalayan area. It is acquired from the French word "dent de lion," meaning tooth of the lion because of the serrated border of its leaves. The plant is native to Europe and Asia, also distributed to North America and the moderate area of the Arctic hemisphere. It is found all over the Himalayan mountains on nordic pastures and hills in India. The plant is generally a perennial herb up to 40cm altitude having spatula-like leave and yellow blossoms flourishing throughout the year. The leaves arise directly from the taproot in a rosette, and every sixth leaf overlaps in a basal rosette. Taproot is thick and branched up to 2-3cm in diameter and 1-2 m in length. The basal rosette gives rise to peduncles, 5-50cm high, reducing in width along their length from bottom to top. Every peduncle bears an extreme head of 2-5 cm wide, subtended by an involucre with herbaceous leaflets in two chains. The capitulum comprises 250 ligulate, perfect, bisexual and yellow florets, with each flower consisting of 5 fused petals and 5 fused stamens. There is no difference between a ray and disc floret, both morphologically and functionally. The fruit is a cypsela (Grieve, 1931) [19].
Taraxacum officinale is also recognized as the "King of Weeds" due to its limitless uses. It is also used in traditional and ayurvedic medicinal systems. It also has numerous anti-diabetic, anti-cancer anti-oxidant, anti-inflammatory, anti-microbial properties (Gonzalez-Castejon *et al*, 2012) [18]. It is also used to treat various bacterial infections and is a traditional botanical remedy. These properties are because of bioactive compounds, including terpenes, flavonoids, and phenolic compounds obtained from various parts (Chadwick *et al*, 2013; Mir *et al*, 2013) [8, 33]. It also contains sesquiterpene lactones, and most of the sesquiterpene occur as glycosides. Other important constituents include pectin, taraxasterol, polysaccharides (Fructosans and Inulin), taraxerol, free sterols (Sitosterin, Stigmasterin, and Phytosterin), mucilage, beta-amyrin, resin, Chicoric-acid, monocaffeyl-tartaric acid, flavonoids, hydroxycinnamic acids, and chlorogenic acid (Phenyl propanoids). Lactupicrine, linolenic acid, iron, choline, magnesium, inulin, niacin, calcium, PABA, gluten, gum, phosphorus, potash, proteins, resin, inositol, sulphur, vitamins, fats and zinc are also found in it. It is also a hepatoprotective agent used to treat hepatobiliary problems (Okaiyeto *et al*, 2018) [36]. The fruits of *Taraxacum officinale* possess free radicle scavenging property and defensive effects abutting oxidation of brain cells of rats; this property is because of ethanol extracted from its fruits. It also contains huge fibres, minerals, vitamins, and essential fatty acids, making it a favourite food source.
It is also used as a Salad green. It acts as a nice index of pollution in the environment and is used as a "Biomonitor" as its roots and leaves accumulate various metals such as As, Br, Cd, Co, Cu, Cr, Hg, Mn, Pb, Se, and Zn (Asadi-Samani *et al*, 2015) [3]

Phytochemistry

The phytonutrient constituents of 'dandelion' rely upon the time it is obtained, the season of gathering, and other environmentally friendly causes and differ significantly between the roots, flowers and leaves. *Taraxacum officinalis* contains many Sesquiterpene lactones (Gonzalez-Castejon *et al*, 2014) [7], also called sharp constituents. Most Sesquiterpene lactones normally occur as glycosides (sugars) (Taraxacin and Taraxacerin). Roots also possess these sharp glycosides, namely inulin, taraxacin, sterols, taraxacerin, tannins, choline, triterpenes, volatile oil and asparagine. However, taraxacin is the important constituent that is bitter. These Sesquiterpene lactones convey a sharp flavour to the plant and are found in both root and leaf, particularly when harvested in spring. It also contains sesquiterpenoid phytoalexin free sterols (Sitosterin, Stigmasterol, and Phytosterin). The further connected constituents are taraxerol, beta-amyrin and taraxasterol. Some flavonoids like free aglycons and flavonoid glycosides have been detected in both flowers and leaf takeouts such as apigenin, flavones luteolin, chrysoeriol and numerous flavonols such as rutinoside, quercetin and their O-glycosides glucoside. Polyphenols are also present but are abundant in aerial parts, and the major generous phenolic constituents present in *Taraxacum* roots or aerial parts are hydroxycinnamic acid derivatives (HCAs), such as cafteric (monocaffeoyl tartaric), chlorogenic acids and chicoric(dicaffeoyltartaric) acids (Jedrejek *et al*, 2019; Xue *et al*, 2017) [23, 49]. There are also reports of triterpenoids, steroids, saponins, coumarins, terpenoids, flavonoids, flavones, phenols chalcones, phlobatannins and cardaic glycosides in anti-microbial takeouts (Abdul *et al*, 2012; Lateef and Issah, 2012; Ghaima *et al*, 2013; Kenny *et al*, 2014) [2, 27, 15, 26]. Numerous flavonoid glycosides such as luteolin-7-O-rutinoside, luteolin-7-O-glucoside, isorhamnetin-3-O-glucoside, quercetin-7-O-glucoside are also reported from its leaves. Other constituents present are polysaccharides, mainly inulin and fructosans, less quantity of mucilage, pectin and resin. Protein, biotin, calcium, niacin, choline, crude fibre, gluten, gum, phosphorus, inositol, inulin, iron, linolenic acid, magnesium, fats, lactupicrine, PABA, potash, pesin, tocopherols, L-ascorbic acid, riboflavin, thiamine, vitamins (A, B1, B2, B5, B6, B9, B12, C, E and P), sulphur, zinc, silicon, sodium, manganese have also been reported (Gonzalez- Castejon *et al*, 2012) [18]. These compounds lead to an enhancement in producing bile in the case of cattle. There are also reports of beta-carotene, carotenoids, xanthophylls, chlorophyll, in addition to vitamins and minerals in the leaves of dandelions. Caffeic acids, P-hydroxyphenyl acetic acid, rutin, synergic acid, vanillic acid are the compounds isolated from Dandelion roots (Colitti and Stefanon, 2016; Xue *et al*, 2017) [10, 49].

Table 1

Secondary Metabolites	Phytoconstituents
Sesquiterpenoids	Tetrahydroridentin β, Taraxacolide-o-β-glucopyranoside, Taraxinic acid -β-glucopyranosyl ester, 11,13- dihydrotaraxinic acid -β-glucopyranosyl ester, 11-β, 13-dihydrolactucin, Ixerin D, Ainslioside
Flavonoids	Luteolin, Crysoeriol, Lutiolin-7-O-rutinoside, Luteolin-7-O-glucoside, Luteolin-4-O-glucoside, Apigenin-7-O-glucoside (Grauso *et al*, 2019).
Steroids & Triterpenoids	Sitosterol, Stigmasterol, Campestrol, lanosterol, β-amyrin, 3β-hydroxylup-18, 19-ene-21-one, taraxerol, taraxasterylacetate etc.
Carbohydrates	Glucose-1-Phosphate, Fructose, Mannose, Inositol, Glucose, Rhamnose, Sucrose
Fatty acids	Hexadecanoic acid, Heptadecanoic acid, Octadecanoic acid, 9,12-Octadecanoic acid, Linolenic acid etc.
Caffeoylquinic acids	Monocaffeoyl tartaric acid, Quinic acid, 5-O- Caffeoylquinic acid, 4-O-Caffeoylquinic acid, Chicoric acid, Chlorogenic acid, 3, 4-di-O-Caffeoylquinic acid.
Organic acids	Malic acid, Acetic acid, Citric acid, Succinic acid, Formic acid, Tartaric acid.
Amino acids	Alanine, Arginine, GABA, Glutamine, Carnitine, Asparagine, Isoleucine, Phenylalanine, Proline, Threonine, Valine.
Other compounds	Choline, o-phosphocholine, Tocopherol, Lutein epoxide, Benzyl-o-β-glucopyranoside, Dihydroconiferin, Dihydrosyringin, Syringin.

Biological Activities

Anti-oxidant properties

Anti-oxidants obtained from *Taraxacum officinale* protect from various pathophysiological effects e,g, cancer, ageing, neurodegenerative disorders and atherosclerosis. The anti-oxidant activity of dandelion is demonstrated by *in-vivo* as well as in-vitro. The leaf extracts of *Taraxacum officinale* are productive as hydrogen peroxide, hydrogen donors and reducing agents scavengers. The highest content of phenolic compounds in dandelion flowers makes them a potential source of anti-oxidants. The flavones luteolin and luteolin- 7- O- glucoside, the "caffeic" and" chlorogenic" acids found in the raw takeout of inflorescences, are responsible for inhibition of both ROS- induced (Reactive Oxygen Species) destruction and nitric-oxide induced destruction. The advancement of interior anti-oxidant description in rats is attributed to root and leaf extracts of *Taraxacum officinale*.

The most systematic obstruction of hydroxyl radicle manufacturing has been shown by water extracts and ethyl acetate of *Taraxacum officinale* inflorescences succeeded by aqueous extracts of dandelion stems. The "flavonoids" in the dandelion are responsible for protecting V79-4 cells from the toxicity of free radicals. The

oxidation inhibition of RAW26.7 cells induced by peroxyl-radical within is also attributed to flower extracts. The anti-oxidant action of leaf vegetable mix composed of *Taraxacum officinale* has been observed in the case of C57BL/6J mice that take a high-cholesterol and high-fat diet. Besides, these also show beneficial effects in protecting lymphocyte and hepatocyte DNA from oxidative destruction. The ethanolic takeout of *Taraxacum officinale* inflorescences shows scavenging activity against DPPH (2, 2-diphenyl-1-picryl hydrazyl hydrate) radicals in a concentration-dependent manner, and this DPPH radical scavenging may be ascribed to the capability of its takeout to contribute hydrogens. Anti-oxidants can remove a radical by contributing hydrogen to the radical and then reduce it to an inert species. Polysaccharides obtained from *Taraxacum officinale* possess anti-oxidant function in-vitro (Guo *et al*, 2017; Aabideen *et al*, 2020; Lis *et al*, 2020) [20, 1]

Anti-inflammatory Activities

The methanolic takeout from flowers (95%), roots (51%) and leaves (69%) of *Taraxacum officinale* show significantly higher anti-inflammatory activity and the 86% anti-inflammation was ascribed to two sesquiterpene nucleosides, i.e. 14-O-Beta-D-glucosyl-taraxinic acid and 14-O-Beta-D-glucosyl-11,13-dihydro-taraxinic acid. The leaf takeouts (0.1 and 1.0 micrograms/ml) also show anti-inflammatory action in the central nervous system by defeating both tumour necrosis factor-alpha (TNF-alpha), and interleukin-1 produced by prime cultures of rat astrocytic glial cells and provoked with lipopolysaccharide (LPS) and P (Go *et al*, 2000). The 'Chicoric acid' and 'luteolin' of *Taraxacum officinale* inhibit the swelling reactions through deactivation of Phosphatidylinositol-3-kinase (PI3)/AKt pathways and damage of Nuclear Factor Kappa B (NF-KB) transference in LPS-inspired RAW264.7 cells. The aqueous extracts of *Taraxacum officinale* leaves also show anti-inflammatory action towards severe cholecystokinin octapeptide activated inflammation of the pancreas in rats and defensive and anti-inflammatory outcomes on severe lung damage inspired by LPS in rats. *Taraxacum officinale* obstructs the making of inflammatory cytokines (IL-6 and TNF-alpha) in bronchoalveolar lavage fluid 6 hours, subsequently impairment initiation and diminishing the count of white blood cells and wet mass of lungs after 24 hours. The 'Luteolin' present in 'dandelion' decreases the LPS-inspired myeloperoxidase function and increases the superoxide dismutase function in the lungs (Liu *et al*, 2010) [32]. Patients suffering from "inflammatory bowel disease" show less duodenal blood loss and decreased disease effects by a 7-herb combination, including 'dandelion' in the case of humans. TNF-alpha, an important target for anti-inflammatory molecules, as an inflammatory mediator, is often activated and subsequently facilitates the transcription of several genes involved in inflammation.

Chemotherapeutic Activity

The aqueous takeouts of *Taraxacum officinale*' are used in conventional medication all over Europe, North America, and Asia to cure numerous cancers such as leukemia and breast cancer. The 'dandelion' shows anti-cancer results on cell reproduction and spread of cancerous cells in-*vitro,* and these takeouts bring about programmed cell death in human hepatoma cells (Hep G2) and cytotoxic effects in human intestinal cancerous cells. *Taraxacum officinale* at 0.2mg/ml concentration increases the generation of cytokines by Hep G2 cells. An aqueous extract of ' dandelion causes a 26% time-reliant and partly dose-reliant decrease of cell feasibility'. The raw takeouts of *Taraxacum officinale* leaves diminished the expansion of MCF-7/AZ breast carcinogenic cells by 40% after 96 hours of hatching in an ERK-reliable mode. The result on cell reproduction is due to hindrance of ERK (Extra Cellular-Signal Regulated Kinase) action, with ERK being the main factor in the MAPK (Mitogen-activated-protein kinases) path associated with cell differentiation, cell survival and cell growth. The dandelion root extract blocks the encroachment of MCF-7/AZ breast carcinogenic cells, and the leaf takeouts obstruct the encroachment of LNCaP (Lymph node carcinoma of prostate). The obstruction of tumour cell reproduction by *Taraxacum officinale* was ascribed to "triterpenoids" and "sesquiterpenes." Among the triterpenoids, "Taraxerol" and "Taraxasterol" displayed important prohibiting results. The vigorous substance "Lupeol," which is a triterpene (lupane type), has been isolated, obstructing cell growth and introducing melanogenesis of mouse melanoma cell line (B16 2F2). The components of aqueous root extract of 'dandelion' cause the death of cancer cells by introducing signalling complex and by selectively introducing subsequent external programmed cell death in carcinogenic blood cells in case of humans, these root extracts work by primary stimulation of "Caspase-8 "and subsequent stimulation of "Caspase-3". The ethanolic takeouts of *Taraxacum officinale* leaves and flowers have" anti-angiogenic "property, and this property is attributed to 'flavonoid' components such as ' luteolin.' *Taraxacum officinale* extract is used as a potential herbal medication for breast cancer cases in humans. Up to 30% of carcinogenic breast events showed ERBB2 overexpression and has become a significant indicator of chemoresistance and inferior diagnosis of breast carcinoma (Pinto *et al*, 2015). ERBB2 is one of the HER family of receptor tyrosine kinases overexpressed in various cancers. Current work reveals an effective anti-carcinomic action of *Taraxacum officinale* root takeouts (Ovadje *et al*, 2016) [38]. The plant takeouts can obstruct the multiplication and growth of carcinogenic breast cells, managing the phosphatidylinositol 3-kinase (P13K)/Protein kinase B (AKT) pathway (Nassan *et al*, 2018) [34]. *Taraxacum officinale* brings cytotoxicity results on human liver carcinogenic cells (Saratale *et al*, 2018) [45]. The plant takeouts can produce apoptosis in various types of carcinogenic cells such as colorectal, prostate, human leukemia, and pancreatic cancer cells (Nguyen *et al*, 2019; Ovadje *et al*, 2016) [35, 38]. both in-vitro as well as *in-vivo*

Detoxifying and hepatoprotective effects

Taraxacum officinale is used in folk medication to maintain hepatic health and treat abundant systemic and dermatologic diseases due to its capability to detoxicate the blood. The aqueous takeouts of *Taraxacum officinale* roots show increased anti-oxidant potential and decreased peroxidation of fats, thus giving protection contrary to the alcoholic hepatic destruction in HepG2/2E1 cells. The hepatoprotective potential of ethyl alcohol takeouts and sesquiterpene-lactone-rich portions of *Taraxacum officinale* roots were measured in contrast with CCl_4 prompted hepatotoxicity in rats. The ethyl alcohol takeouts and sesquiterpene-lactones decreased the frequency of hepatic injury prompted by CCl_4. Thus, the sesquiterpene-lactones present in *Taraxacum officinale* produces defensive results contrary to severe hepatotoxicity prompted by CCl_4 operation in the rats. The hepatoprotective effect of 2 polysaccharides (operated at 304.92mg/kg bodyweight for 7 days) separated from *Taraxacum officinale* through the rectification of inflammatory reactions and improvement of oxidative pressure attenuated the CCl_4-prompted liver destruction in Sprague-Dawley rats by the administration of NF-KB and its moderators such as IL-1, TNF-alpha, iNOS (Inducible nitric oxide synthase) and COX-2 (Cyclooxygenase). These polysaccharides decrease the ALT, AST activities, and hepatic holes, increase the free radical scavenging activity and reverse the other hepatitis-associated symptoms. *Taraxacum officinale* takeouts manifest hepatoprotective results against CCl4-prompted liver fibrosis by decreasing the GFAP and alpha-SMA and introducing the MT1/2 expression. Upregulation of MT1/2 expression had protective effects against liver injury. Dandelion is also used as an antifibrotic agent. The herbal formula plays a role in hormone detoxification. *Taraxacum officinale* takeouts also overexpress the progesterone, estrogen, and follicle, provoking hormone receptors in rats. The fat-rich diet and their addition by the leaf takeouts seriously decreased the fat accumulation in the liver (Davaatseren *et al*, 2013) [11]. *Taraxacum officinale* is one component of "Kimchi," and "Taemyeongcheong" applied for hepatic disorders. Dandelion root takeouts decreased the collagen precipitation in the necrotic area and turnover the fibrosis of the liver, which was connected with a decrease in alpha-SMA and GFAP and enhancement in the Cu/Zn SOD action, explaining its hepatoprotective effect. The two polysaccharides present in this plant are important for protecting acetaminophen (APAP)-induced hepatic lung injury (AILI) (Cail *et al*, 2017) [6].

Gastrointestinal effects

Dandelion is widely used to stimulate digestion and causes gallbladder contractions to promote bile flow supporting the conventional usage of *Taraxacum officinale* as appetite and digestive anti-depressant. The liver produces the bile into the gallbladder to intermix fats, which is vital for absorbing fat-soluble minerals and digestion of fatty acids. *Taraxacum officinale* containing herbal mixtures improved diarrhea, intestinal cramping, and constipation in 96% of patients in a group of 24 adults determined with chronic colitis. In animals, hyperplasia, gastric ulcers, and gastric metaplasia can also be treated with the help of dandelion, and oligo-fructans like bifido bifidum, bifido adolesentis, bifido longum and bifido catenulation cause the increased growth of 6 useful intestinal bacterial strains. The kinetogenic results of serum including *Taraxacum officinale* accomplished on rat colonic muscle cells accelerated their shrinkage. The "inulin" present in the roots of dandelion acts as demulcent and prebiotic, increasing the resistance activities enormously (Gonzalez-Castejon *et al*, 2012) [18]. Pains in large intestines disappear with dandelion root and other herbs by the 15th day of treatment.

Hypolipidemic and anti-atherogenic effects

The hypolipidemic results of leaf takeouts were noticed in mice treated with a cholesterol-rich food and in diabetic mice by the care of *Taraxacum officinale* water takeouts. Mice treated with leaf and root takeouts of dandelion limit the levels of atherosclerosis and decrease the triglycerides oxidative stress, LDL (Low-density lipoprotein) cholesterol, serum levels of total cholesterol, and the increased serum quantities of HDL (High-density lipoprotein) cholesterol. *Taraxacum officinale* also diminishes the chance of atherosclerosis via a decrease in inflammatory and oxidative activities (Choi *et al*, 2010) [9]. Both alcohol takeouts (3%) and water takeouts (1.5%) on inflammation, lipid profiles, and oxidative stress of C57BL/6 rats treated with atherogenic foods showed a remarkable reduction in liver triglycerides and total cholesterol quantity following the treatment of 6 weeks. 'Pancreatic lipase' (key enzyme for fat digestion) inhibition can alter the fat absorption, and this obstructive function of *Taraxacum officinale* on pancreatic lipase' has been checked both by *in-vivo* and *in-vitro* for determining its ability as an anti-obesity agent with fewer reactions. In-*vitro*, the inhibiting property of *Taraxacum officinale* against pancreatic lipase at a quantity of 250 micrograms/ml is 90.2% that of gastrointestinal lipase inhibitor, with the *Taraxacum officinale* being having dose reliant results resulting in an IC50 (Half-maximal inhibitory concentration) of 78.2 micrograms/ml versus an IC50 of 0.14 micrograms/ ml seen with a pancreatic lipase inhibitor, gastrointestinal lipase inhibitor and an anti-obesity remedy with several reactions. The pancreatic lipase activity is also inhibited by *Taraxacum officinale* leaves containing flavonoids such as ' luteolin.' The hypolipidemic results and operation of luteolin, an essential flavonoid in *Taraxacum officinale*, was expressed in HepG2 cells. The hypolipidemic results of plant takeouts rich in flavonoids may be resolved by decreasing cholesterol absorption (Li *et al*, 2021) [29].

Hypoglycemic effects

Both the roots and leaves of *Taraxacum officinale* show properties of hypoglycemia. The activities of 'insulin' present in *Taraxacum officinale* takeouts at 40 micrograms/ml have been present in INS-1 cells, proposing the

ability of these takeouts as anti-diabetic representatives and decreasing the concentration of glucose in serum. Diabetes mellitus can also be treated by the inhibition of alpha-glucosidase. Water mixture from unquantified parts of dandelion inhibits 3 kinds of alpha-glucosidase from rabbit liver, rabbit intestine, and baker's yeast-IC50(mg plant/ml): 3.5,1.83 and 2.3 respectively. *In-vivo*, reduction in liver malondialdehyde (MDA) concentrations and serum glucose concentrations were observed in mice with streptozotocin-prompted diabetes mellitus after the conduction of an aqueous takeout of dandelion leaves. Dehydrated ethanolic takeouts remarkably decrease the fructosamine and glucose amounts in alloxan-induced non-obese diabetic (NOD) rats at a dose of 20mg/kg. The results of takeouts of dandelion on hepatic quantities of MDA and glutathione S-transferase (GSTs) are the markers of oxidative stress in first diabetes mellitus in the case of diabetic NOD (Non-obese diabetic) mice. A remarkable enhancement in the catalytic quantities of GSTs and a non-remarkable reduction in MDA quantities noticed is an anti-diabetic effect of dandelion. Diabetes is a long-term non-infectious disorder produced by unusual production or unusual action of insulin, and hyperglycemia is a common property of diabetes (Park *et al*, 2020) [39]. So it is essential to get hypoglycemic medicines on time to manage the amount of blood sugar, to reduce and manage the events of problems. Many bioactive constituents such as saponins and polysaccharides have proved the hypoglycemic properties of these plants (Liang *et al*, 2017; Su *et al*, 2020; Zhao *et al*, 2020) [30, 47, 52]. The experiments have assessed the hypoglycemic effects of DRE in-vitro according to the obstructing results of alpha-glucosidase and alpha-amylase. Obstructers of these two enzymes can be considered successful medicines to protect postprandial hyperglycemic effects in T2DM (Type 2 diabetes) victims (Gong *et al*, 2020). DRE (Digital rectal exam) could obstruct the function of alpha-glucosidase, and alpha-amylase, particularly the hampering rate of DRE-w on these enzymes almost to precose; DRE may also utilize the hypoglycemic results by obstructing the function of these two enzymes and also repressing the enhancement of postprandial blood sugar. The hypoglycemic results of phenolic compounds and polysaccharides have been extensively approved (Sasikala *et al*, 2019) [46]. DRE-w possesses phenolic compounds and polysaccharides and can more successfully obstruct the function of these two enzymes. A combination of both RAE (Reactive angioendotheliomatosis) and DRE-w can increase the hypoglycemic property.

Immuno-modulation

The immunomodulatory activities have been reported from polysaccharides present in the dandelion. The recovery of repressed immune activities (humoral, non-specific, and cell-mediated immunity) was observed in short-chain aldehyde reductase (Scald) rats with the help of dandelion. The takeouts of dandelion inhibit the stimulation of cachectin. The higher quantities of different cytokines, e,g IL-12, and IL-6, are produced when thioglycolate-claimed phagocytes are added with either cold or hot water takeouts of *Taraxacum officinale* showing that dandelion cause the rectification of the intrinsic immune reaction. More immunoglobulins (G1, G2a, G2b) are produced when animals are immunized *in-vivo* with Ova/FIA (Freund's Incomplete Adjuvant). The higher amounts of both cytokines (IL-4, IL-6, IL-10) and OVA-specific Th1- type (IFN-gamma) cells are produced when splenocytes of rats are mediated with FIA and OVA and hot water takeouts of *Taraxacum officinale*. The immunomodulatory effect of *Taraxacum officinale* is because of active substances known as flavonoids present in flowers (Jassim *et al*, 2012) [22]. Anti-microbial activity and immuno-stimulatory activities are perhaps the two major techniques by which phytobiotics apply their beneficial influence on animals' commercial growth and fitness (Fallah *et al*, 2013) [13]. *Taraxacum officinale* used in products for animal nutrition resulted in the highest total leucocyte and thymocyte amplification in the plunking eggs. Dandelion takeouts enhance the immune system by improving rats' cytokines and nitric oxide creation (Lee *et al*, 2012) [28]. The Bax/Bcl-2 non-apoptotic signaling path is activated by "Taraxasterol," which is suppressed in autoimmune diseases (Sang *et al*, 2019) [44]. Dandelion takeouts improve the immunity reactions *in-vivo* (Tan *et al*, 2017) [48].

Anti-bacterial and Anti-viral effects

Dandelion possesses anti-viral properties against the Human herpesvirus type-1. *In-vitro*, the dandelion showed anti-microbial properties attributed to its flavones. *Taraxacum officinale* shows anti-bacterial activity in opposition to *S. typhi, A. hydrophila, S. aureus, E. coli*, and *B. cereus*, and the section of inhibitors ranges from 14.18mm. These effects shown by plant takeouts are because of secondary metabolites (tannins, alkaloids, and flavonoids. *Taraxacum officinale* also shows anti-bacterial activities in opposition to *E. coli*, *Proteus mirabilis*, and *Staphylococcus aureus*, and the area of obstruction ranges between 4-10mm (Abdul *et al*, 2012) [2]. The dandelion takeouts are quantity reliant, and the most vital and suitable bacteriocidal property has been shown by ethanolic extract (Oseni and Yussif, 2012) [37]. The disinfectant property of hydro-alcoholic takeouts of *Taraxacum officinale* is also determined (Ionescu *et al*, 2013) [21], and the *Taraxacum officinale* leaves gathered at 2 and 5 months of their growth were tested for anti-viral activity against the "flavivirus". Recently the opposing HCV role of *Taraxacum officinale* was also aimed to be clarified (Rehman *et al*, 2016) [43]. The aqueous extract of *Taraxacum officinale* possesses anti-viral properties, obstructing replication, reverse transcription of human immunodeficiency virus type1 (HIV-1). These extracts also protect influenzal infections by obstructing the reproduction of viruses. The plant extracts also possess anti-viral properties in opposition to the dengue virus serotype 2(DENV2) (Flores-Ocelott *et al*, 2018) and the hepatic-C virus (HCV) (Rehman *et al*, 2016) [43]. Dandelion takeouts possess ant-viral properties against hepatitis B virus (HBV) because of the bioactive compound "Taraxasterol" (Yang *et al*, 2020) [50]. Dandelion reveals anti-bacterial results in opposition to *Bacillus subtilis, Staphylococcus aureus*, and *Escherichia coli*, and this property is because of polysaccharides

and oligosaccharides extracted from dandelion (Qian *et al*, 2014). The root extract of *Taraxacum officinale* possesses anti-bacterial activity against *Bacillus cereus* and *S.aureus* (Kenny *et al*, 2015) [25]. The dandelion leaf takeouts possess powerful anti-bacterial activities against *S. aureus* and modest anti-bacterial properties against *Proteus mirabilis, E. coli,* and Klebsiella pneumoniae (Diaz *et al*, 2018).

Diuretic Activity

For over 2000 years, the species of *Taraxacum* have been selected as a diuretic drug in both conventional Chinese medication and Ayurvedic medicine. Dandelion leaves acquire diuretic results in rats and mice, which is as influential as frusemide. Dandelion has been used to protect and cure renal calculi in the case of female waster rats. The newly harvested leaf hydroethanolic takeouts of *Taraxacum officinale* were given to human patients for assessing the urine capacity and urination frequentness. However, additional study is required to ascertain the role of dandelion in the initiation of diuretic effects in human patients. The German Commission E approved the utility of dandelion for diuresis. The dandelion contains potassium three times more than in other herbal diuretic cases, producing greater potassium than that disappeared from diuresis by taking the *Taraxacum officinale.* It also demonstrated a diuretic result at a human equivalent dose (HED) of 640mg/kg. The USDA database of Duke shows that dandelion possesses 9 diuretic compounds, and the diuretic compounds can be a result of the presence of elemental class of secondary metabolites such as phenolics and alkaloids terpenes. The ultimate efficient medicinal water pills function through a single direction known as "loop diuresis," influencing the resorption of sodium in the nephron loop. The root of dandelion is also regarded as a diuretic, and the hepatoprotective effect has been reported in mice because of these root extracts. The ethanolic leaf takeouts enhance urine frequentness and fluid removal in normal persons. The dandelion takeouts display the positive result for the cure and protection of renal problems e,g" Nephrolithiasis"(Ghale-Salimietal *et al*, 2018; Karakus *et al*, 2017)

Agricultural, Economic and Ecological uses of *Taraxacum officinale*

Like other leafy green vegetables, *Taraxacum officinale* is also regarded as the nutritiously essential diet due to high minerals, proteins, vitamins, fiber constituents, and essential fatty acids. *Taraxacum officinale* leaves are used as an ordinary vegetable, taken as salad or prepared in soups and sauces by Nigerians. It is also used in beverages, and desserts e,g, wine, beer, and tea, also used as a coffee alternate. The flowers are also considered the great beginning of nectar for honey, and apiarists mostly use the nectar in the brood nest to build up the spring colony. Dandelion flower jam is another recipe formed from it, and in Silesia and other parts of Poland, dandelion flowers are used to make a honey substitute syrup with lemons (May-honey).

Dandelion invades earthly environments universally, growing in hey fields, pastures, lawns, roadsides, orchards, and further regions of hardly disrupted flora. It has been used for medicinal purposes for the treatment of various conditions. Matol Botanical International LTD manufactures and delivers an energy booster and puts it up for sale by the trademark name of "MATOL" in Canada containing 14 pharmaceutical plant takeouts e,g, a root takeout of *Taraxacum officinale*. Dandelion is also used as a soft drink popular in the United Kingdom. The newly harvested upper parts of *Taraxacum officinale* lower the demography of communicable, second phase immatures of the nematode *Meloidogyne hapla Chitwood* and thus enhances the carrot harvest in greenhouses. Natural dyes of yellow and green colors are extracted from flowers of dandelion, latex from dandelion stem acts as a mosquito repellent.

Dandelion is also an excellent marker of ecological contamination. Leaves and roots of *Taraxacum officinale* contain minerals including Pb, As, Zn, Br, Se, Cd, Co, Hg, Cu, Cr, Mn, and Sb, but the accumulation of larger quantities of Fe, Zn, and Mn occur in aboveground parts compared to underground parts while Cu accumulates more in underground parts than in aboveground parts (Bini *et al*, 2012). The larger advantage of transference factors (TF) in contrast to bioconcentration factor (BCF) for Fe, Mn, and Zn proposes that the plants efficiently displace these minerals from underground to aboveground parts. Due to the lesser advantages of transference factor in contrast to bioconcentration factor, Cu is still less prone to displace from underground parts to aerial parts, and some soil characteristics decide the absorption of minerals by plants, i.e., soil reaction the constituents of organic matter. The opportunity of some minerals for plants, e.g., Zn, Fe, Cu, rises with an increment of soil acidity, but it also relies on oxidoreduction circumstances in the case of Mn. Characters such as weight and length of seeds decrease, but the count of seeds rises as an adjustment to live unfavorable situations when pollution increases (Bini *et al*, 2012).

Veterinary uses

The *Taraxacum officinale* is also consumed by cattle instead of grass because of its high protein and mineral content. The dietary supplementation of dandelion leaves is supposed to possess beneficial results given enhancing the activities of broiler chicken (Raziq *et al*, 2012) and the supplementation of enzymes in poultry diets increase the performance (Yousuf *et al*, 2012) by the degradation of non-amyloid polysaccharides, improving the digestion and absorption of nutritive substances and the morphology of their intestines (Ayoola *et al*, 2015). Enzyme supplementation also improves the villus height and villus height/crypt depth ratio in poultry (Ayoola *et al*, 2015). The addition of herbaceous goods in the nourishment of broiler chicken improves the surface area and intestinal villus height leading to superior intestinal fitness. In a hot plate test of anesthesia, 100mg/kg body mass of a dehydrated ethanol takeout given to mice intra-peritoneally enhances the reaction time

by about 38% after 3 hours. However, a similar dosage diminishes the folding reaction phenylalanine in rata by approximately 24%. The *Taraxacum officinale* takeouts overexpressed follicle-stimulating hormone receptors, progesterone receptors, and estrogen receptors (ER-alpha, ER-beta) in rats' reproductive organs and fatty tissues followed by treatment through the mouth with extract for about 6 weeks, proposing its possible use to treat the reproductive hormone associated problems.

Conclusion

Taraxacum officinale is present in both temperate and semitropical zones of the world, and this is because of its tolerance over a wide range of climatic conditions. The phytochemistry of *Taraxacum officinale* is diverse. The plant is also regarded as a wealthy origin of sesquiterpene lactones, which impart a sharp taste. The other phytochemicals present in this plant are flavonoids, steroids, triterpenoids, carbohydrates, fatty acids, caffeoylquinic acids, amino acids, organic acids, phenols, and saponins. The plant is also known as the "king of weeds" in literature due to its limitless uses. Nearly every part of the plant has medicinal importance. The *Taraxacum officinale* is also a good index of ecological contaminations.

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