Taraxacum officinale: The Esculent Dandelion as Herbal Medicine

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Insha Qadir, Sheeba Nazir, Mohammad Asif Sheikh, Farha Naaz, Saika Bashir, Syed Ovais, Nisar A. Khan, and Mubashir Hussain Masoodi

Abstract

Taraxacum officinale Weber is a perennial herb, which belongs to Family Asteraceae and grows wild in hotter zones of the Northern Hemisphere. The plant is commonly called Dandelion. It is native to Eurasia but also reported in Himalayan region (India), including Alpine meadows. Although, the nature of the plant is weedy, the plant has a great potential to treat a number of ailments. The herb has been utilized as a medicinal herb since ancient times. Dandelion is supposed to be loaded with significant number of bioactive constituents including triterpenes, sesquiterpene lactones, fatty acids, carotenoids, volatile oils, tannins, carbohydrates, phenolic acids, flavonoids, phytosterols, sugars, proteins, calcium, and minerals. Due to the presence of these potent phytoconstituents, it has been traditionally used as a folklore medicine for a vast majority of locals in different parts of the world. Reported literature of the plant available from primary and secondary search engines unveil a number of pharmacological activities of the plant, including hepatoprotective potential, diuretic activity, anti-inflammatory activity, antidepressant activity, hypolipidemic activity, anticancer activity, etc. The aim of this chapter is to provide a detailed review of various therapeutic activities of the plant and phytochemical moieties responsible for the medicinal status of *T. officinale.*

I. Qadir · S. Nazir · M. A. Sheikh · F. Naaz · S. Bashir · N. A. Khan · M. H. Masoodi (✉)
Department of Pharmaceutical Sciences, School of Applied Sciences and Technology, University of Kashmir, Hazratbal, Srinagar, Jammu and Kashmir, India
e-mail: mubashir@kashmiruniversity.ac.in

S. Ovais
Department of Chemistry, S. P. College, Srinagar, Jammu and Kashmir, India

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9.1 Introduction

Taraxacum officinale Weber, having a place with family Asteraceae (Compositae), is a perpetual herbaceous enduring plant, regularly called "Dandelion." The plant is considered as a weedy animal type (Chen 1955). It has numerous English regular names including Blowball, Lion's-tooth, Cankerwort, Swine's nose, and so forth (Cho and Lee 2010). Its Arabic names include Hindiba and Khasberri (Clare et al. 2009). The species name may be from the Arabic word "Tharakhchakon" (Chen 1955) or from the Greek word "Tarraxos." The plant is local to Eurasia. Its appropriation reaches out to Asia, Europe, North America to calm zone of Northern Hemisphere (Grieve 1931). In India, it is accounted for all through the Himalayas on Alpine knolls and slants. It is broadly and barely dispersed at an altitudinal ranges between 1000 and 4000 m (Hajra et al. 1995). In the Indian Himalayan districts, it is regularly known Dudal, Radam, Bathur, and Haend (Hajra et al. 1995). Dandelion herb has significantly toothed smooth leaves, 5–30 cm long and 1–10 cm wide. It is 3–35 cm in stature, surrounding a rosette of leaves at ground level (Wichtl 1994). It has single, splendid yellow blooms on straight leafless void stems, which ascend out of the point of convergence of the rosette. Each sprout includes a get-together of florets. Blossoms are conveyed from pre-Spring until late gather time. Right when the florets created, they produce fleece seeds, which are viably dissipated by the breeze. Dandelion plants have tap roots, diminishing from 2 to 3 cm wide, and no under 15 cm long. Roots are stout and delicate, and are a dull darker shading apparently and white inside (Ali 1989).

The important intelligent portrayal of *T. officinale* was given by Linnaeus in 1753 as *Leontodon taraxacum* (Jaeger and Charles 1955). Wiggers portrayed the assortment *Taraxacum*, and Georg Heinrich Weber made the present plan in 1780 (Britton and Brown 1970).

T. officinale leaves are rich in fiber, potassium, iron, calcium, magnesium, phosphorus, nutrient A, B, C, thiamine and riboflavin, and protein as mulled over (Jackson 1982; Schmidt 1979). Sesquiterpene lactones concede a brutal taste to the plant, which is especially noteworthy in the leaf yet furthermore in the root particularly when spring accumulated (Kuusi et al. 1985). *T. officinale* is suggested as sustenance source because of the high substance of minerals, fiber, supplements, and fundamental unsaturated fats (Hu and Kitts 2005).

The phytochemical examination showed that TO has a wealth of terpenoid and sterol (essentially taraxacin and taraxacerin), likewise passed on in the roots, leaves, and blossoms. Other terpene/sterol blends consolidate beta-amyrin, taraxasterol, and taraxerol, similarly as free sterols (sitosterin, stigmasterin, and phytosterin) fundamentally related to bile (Koo et al. 2004; Schütz et al. 2006).

9.2 Morphology

The genus *Taraxacum*, family Asteraceae, subfamily Cichorioideae, clan Lactuceae, typically known as dandelion, fuses generally 30–57 collections with various microspecies, divided into nine segments (Vašut and Majeský 2015).

Taraxacum is methodically puzzling in subarctic and northern quiet areas, there are around 2800 known species (Kirschner et al. 2014). *T. officinale* is a basically stemless, lactiferous, enduring herb. The stems are acaulescent, just 1–2.5 cm long, with staggeringly short internodes at or underneath the soil surface (Gier and Burress 1942; Holm et al. 1997). The leaves structure a basal, extended rosette in which each sixth leaf covers (Holm et al. 1997). The basal rosette offers rise to one to different glabrous, unfilled, tube-molded scapes (peduncles), 5–50 cm tall, reducing in width along their length from base to tip. Each scape bears a terminal capitulum (inflorescence) of 2–5 cm expansiveness (Gier and Burress 1942; Gleason 1963; Holm et al. 1997). Each capitulum is subtended by an oval-barrel-molded involucre with lanceolate, brutal, green to tannish, herbaceous bracts, in two sections of phyllaries, with the outer phyllaries shorter and more broad than the internal phyllaries (Holm et al. 1997). The unquestionable midrib of the leaves stretches out in shading from light yellow-green to dull darker red (L. L. Collins, unpublished data, University of Western Ontario, London, ON).

Phenotypic variability in *T. officinale* fabricates its ability to colonize a wide extent of common environment. In cool or dry atmosphere, or in solidly mown greenhouses, the leaves spread largely against the ground to form a prostrate rosette (Longyear 1918; Lovell and Rowan 1991). In more sultry atmosphere or in regions where it is swarmed by taller vegetation, the leaves stay in essentially erect tufts (Longyear 1918). The responsibility for leaves, which resemble those of thistles, and the brutal white latex, are acceptable to changes in accordance with anticipation of brushing animals (Richardson 1985). *T. officinale* demonstrates a wide extent of leaf shapes, from a smooth balanced (youthful) structure to a significantly etched runcinate (grown-up) structure (Sanchez 1971). The length–breadth extent decreases as the leaf number grows (Sanchez 1971) and the extent and significance of section focuses in the runcinate structure are influenced by light, mediated by the phytochrome framework (Wassink 1965; Sánchez 1967). Light power and quality can manage the shape of the leaves with balanced sharp edges, and high power runcinate front lines (Sánchez 1967; Slabnik 1981).

9.3 Ancient Background

History of using herbs to treat diseases and prosperity has been ordinary in human social orders. Vast amounts of drugs are being segregated and isolated from herbs. The remedial plants and herbs are the wellsprings of discretionary metabolites and essential oils of accommodating criticalness. The basic ideal conditions against the helpful usage of remedial plants in various sicknesses and messes are their prosperity other than being traditionalist, reasonable, and adequately available (Damylo and

Frank 1984). Asia and Europe have a crucial unquestionable establishment as for the standard occupations of *Taraxacum*, basically *T. officinale*, *Taraxacum mongolicum*, and *Taraxacum coreanum*. This ordinary data has been the chief clarification behind pondering the potential uses and reap necessities of *Taraxacum*; considerations in America remain uncommon (Martinez et al. 2015).

In Russia, India, and China, dandelion has been used in as a regular society sedate in perspective on its hepatic and hyperglycemic impacts (Kemper 1999). The concerned plant is eaten in the Kashmir valley from times degenerate as a vegetable, by the lactating mothers, as a wellspring of minerals especially calcium. The general public solutions of China, India, and Russia have seen dandelion's effect as a liver tonic. Regular Chinese medication unites dandelion with various herbs to treat hepatitis (Modaresi and Resalatpour 2012). Plants of the genus *Taraxacum* have a long history of usage in standard medication (Martinez et al. 2015; Schuetz et al. 2006). Customary dandelion (*T. officinale*) (Fig. 9.1) is an archaic and popular society cure, considered as an "answer of life" (Hojimatov 1989).

Theophrastus, an ancient Greek scientist, recommended dandelion against spots and liver spots on the skin. In Chinese customary medication, the dried establishments of *T. officinale* have been used as a drug to fix edema (Saeki et al. 2013). As demonstrated by Abu Ali Sino (Avicenna), the smooth juice of dandelion reduces the reality of glaucoma and the squeezed juice is uncommonly useful for liver affirmation and against hydrops, similarly as a solution for scorpion bite.

Various botanists believe that *T. officinale* in Greece, or possibly the northern Himalayas, and spread across over gentle zones to Europe and Asia Minor (Richards 1973; Schmidt 1979; Gail 1994). It is thought to have colonized the Americas post-Pleistocene through Beringia (Richards 1973). Later introductions of *T. officinale* to North America are obfuscated in conflicting cases (Gail 1994). The earliest record is that it was found on the east coast by the Vikings in around 1000 AD; others state it was carried on the *Mayflower*; while others believe the introduction was by later pioneers, who brought it as a nursery plant or a pot herb for helpful purposes (Schmidt 1979; Jackson 1982).

9.3.1 Ethnomedicinal Importance

Dandelion (*T. officinale*) is a wild plant that has been used for an extensive time span as a standard drug in the and treatment of a couple of afflictions. This use is a direct result of the sesquiterpenes, saponins, phenolic blends, flavonoids, and sugars, among others, found in the parts of the plant. The leaves can be eaten cooked or used rough in the of blended greens, soups, and tea, which are recommended as a trademark wellspring of supplements in the late winter (Hudec et al. 2007). *T. officinale*, has been used in legends medicine in the treatment of hepatic issue, irritation, and a couple of women's illnesses, for instance, chest and uterus sicknesses.

The principal referenced use of dandelion as a medicine is in advancement of the Arabian specialists of tenth and eleventh, who talk about it as a sort of wild endive,

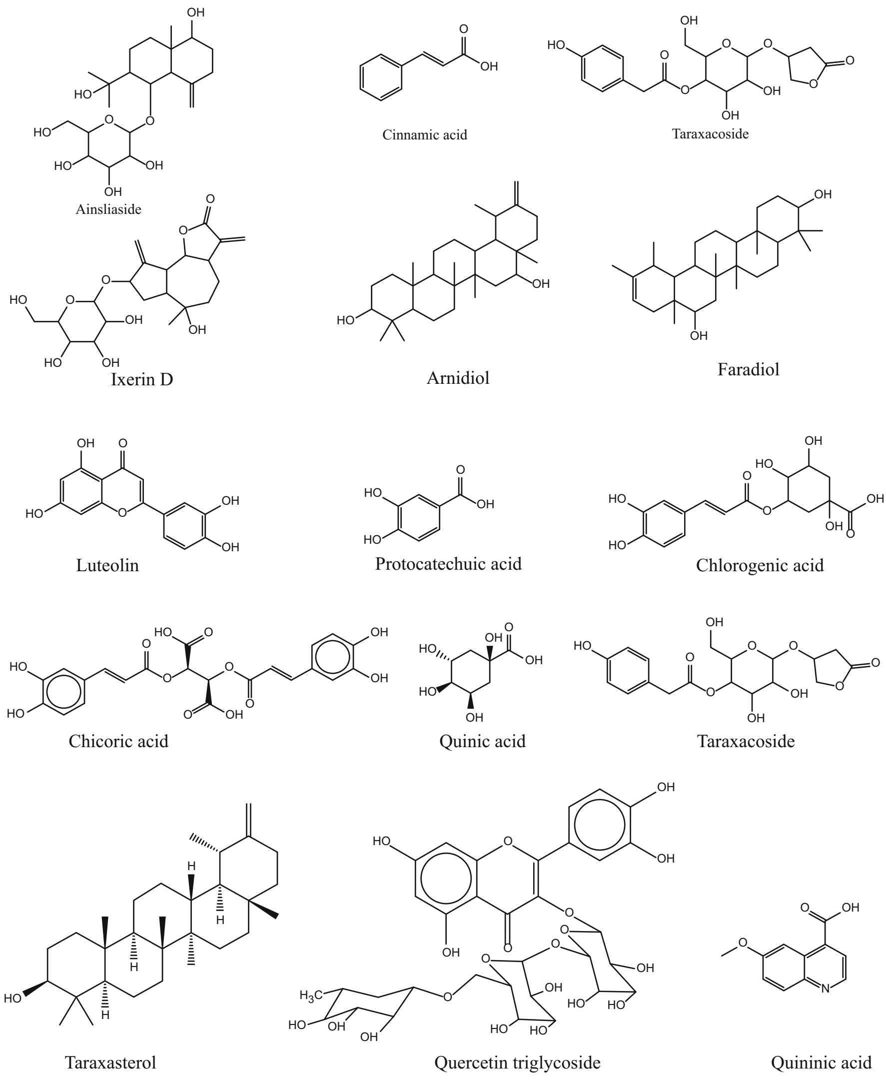

Fig. 9.1 Some bioactive compounds from *Taraxacum officinale*

under the name of Taraxcacon. Dandelion roots and leaves were used to treat liver issues (Grieve 1931). Nearby Americans used gurgled dandelion to treat kidney sickness, swelling, skin issues, indigestion, and irritated stomach (Bensky et al. 1984). In customary Chinese solution, it is moreover acclaimed as a nontoxic herb with exceptional characteristics for its choleretic, diuretic, antagonistic, to rheumatic and quieting properties (Williams et al. 1996). In French writing, dandelion is known for its diuretic activity. In India, dandelion is used in the entire Himalayan belt. In Kashmir, in the Himalaya, paste of gurgled leaves with little measure of salt and turmeric (haldi) is utilized to treat bone splits (Malik et al. 2011). It is in like manner used as a vegetable in Kashmir (locals experience). In Himachal Pradesh, the roots are used in kidney and liver complaints. The whole plant is pounded into paste and given orally in snakebites and paste is in remotely on wound.

Dandelion has been comprehensively used in regular individuals prescription and in current phytotherapy as a diuretic (the saluretic sway being displayed probably) and a cholagogue. In Chinese, Arabian and Native American traditional prescription it is used to treat a grouping of diseases including harmful development (Clare et al. 2009). In standard drug the plant *T. officinale* has been used for poor assimilation, water upkeep, and against liver illnesses including hepatitis and cirrhosis (as a result of its hepatoprotective effect). Dandelion has been associated in home-developed remedy as a smooth diuretic, for appetite, and for improving osmosis. Its smooth latex has been used as a mosquito repellent (Sohail et al. 2014). *T. officinale* serves fundamentally as a diuretic and as a compound for blood and liver. Dynamic substances of dandelion decline serum cholesterol and triglycerides since they fortify bile discharge. Dandelion improves the limit of liver, pancreas, and stomach. It is moreover used to treat iron inadequacy and affliction; have moderating, against coagulator, unfriendly to oxidative, threatening to malignant growth causing, torment calming, antihyperglycemic, and prebiotic impacts (Abdul et al. 2012; Petkova et al. 2015). *T. officinale* has for a long while been used in normal medication for its choloretic, insect rheumatic, and diuretic properties. In the traditional individuals drug, blends and decoctions from dandelion roots and leaves were moreover used to treat dyspepsia, bronchitis, heartburn, and particular skin defilements. The herb is furthermore used to update the insusceptible response (Onal et al. 2005; Schutz et al. 2006).

9.4 Pharmacological Activities Reported for *T. officinale*

9.4.1 Antioxidant Activity

The production of reactive oxygen species (ROS), which is the outcome of aerobic metabolism and reactive intermediates, occurs in several physiological and pathophysiological states (Jeon et al. 2008). In normal conditions, ROS production is maintained by endogenous antioxidant systems present within the body that sets up a balance between ROS and antioxidants. The excess generation of ROS or inappropriate antioxidant content results in oxidative stress (Kaur et al. 2006). ROS stimulates lipid peroxidation, destroy biomolecules such as DNA and proteins, and has an effect on cellular viability (Jeon et al. 2008).

Oxidative stress is considered to be an essential factor in various neurodegenerative diseases (Beal 1996). The brain is more vulnerable to free radical damage due to the high usage of oxygen by the brain and the presence of quite low concentrations of antioxidant enzymes and free radical scavengers (Muralidhara 2008).

With the aim to gain protection against ROS and to avoid the progression of neurodegenerative diseases, exclusive studies are being done to search new therapies using antioxidant substances with scavenging ability (Wang et al. 2008). Such antioxidant activities observed in plant extracts had been attributed to polyphenols (Peschel et al. 2006). Polyphenols act as antioxidant via numerous mechanisms such as free radical scavenging, metallic ion chelation, hydrogen donation, and as a substrate for radicals, inclusive of superoxide anion and hydroxyl (Barreira et al. 2008). Flavonoids and phenolic compounds like luteolin, caffeic acid, and chlorogenic acid are determined in extracts of *T. officinale* (Hu and Kitts 2003; Koh et al. 2010). These compounds shield cells from oxidative stress by means of inhibiting the formation of free radicals or by detoxifying free radicals, thus resulting in the prevention of a number of pathophysiological processes (Mates and Sanchez-Jimenez 2000).

Oxidants cause a wide array of DNA damage that includes strand breakage, sister chromatid exchange, and DNA–DNA and DNA–protein cross links in addition to base modifications (Davies et al. 1995). The net result of these modifications can lead to carcinogenesis and mutagenesis (Wei et al. 1998). In both hydroxyl radical and peroxyl radical-induced DNA supercoiled breakage, dandelion fractions exhibited distinct stages of protection toward free radical-induced DNA damage. Flavone glycoside of dandelion flower, namely, luteolin 7-glucoside, provided a protective effect against hydroxyl radical-precipitated DNA scission. Luteolin 7-glucoside also successfully retarded the peroxyl radical-triggered liposome peroxidation, demonstrating that luteolin 7-glucoside specially is an essential antioxidant agent of dandelion flower.

The protective activity of *T. officinale* fruit extract has been investigated against sodium nitroprusside (SNP)-induced decreased cell viability and increased lipid peroxidation in the cortex, hippocampus, and striatum of rats in vitro. To explain the mechanism of the extract's antioxidant activity, its putative scavenger activities against NO•, DPPH•, OH•, and H_2O_2 were determined. The extract (1, 5, 10, and 20 μg/mL) protected against SNP-induced decreases in cellular viability and increases in lipid peroxidation in the cortex, hippocampus, and striatum of rats.

T. officinale fruit extract is a potent antioxidant at low concentrations, as evident by the decrease in lipid peroxidation and protection against SNP-induced cellular dysfunction. One possible mechanism by which *T. officinale* fruit extract protects against oxidative stress is through ROS- and RNS-scavenger activity, which is attributed to phenolic compounds. The phenolic compounds in *T. officinale* fruit extract act as neuroprotective antioxidants or reducing agents (Dirleise et al. 2012a, b, c).

9.4.2 Diuretic Activity

Dandelion (*T. officinale*) was assessed for diuretic activity, that is, it increases the production of urine. The high K+ substance of dandelion is viewed as the specialist in charge of any diuretic movement. As per Duke's USDA database, dandelion has up to nine exacerbates that are diuretic. Given that the saluretic impacts of the dandelion leaf appeared to be because of numerous portions of the extract, the

Table 9.1 Diuretic compounds in *Taraxacum officinale* and their additional properties

S No.	Diuretic compound	Other activities
1	Ascorbic acid	Nutrient
2	Caffeic acid	Anti-aggregant, anti-inflammatory, anti-anxiolytic
3	Calcium	Nutrient
4	Chlorogenic acid	Antioxidant, cardioprotective, anti-inflammatory
5	Isoquercitrin	Antioxidant, hypotensive, anti-inflammatory
6	Luteolin	Anti-inflammatory, antioxidant, hypocholesterolemic, vasodilator
7	Magnesium	Nutrient
8	Mannitol	Antioxidant, anti-inflammatory
9	Potassium	Nutrient

diuretic action of dandelion might be expected due to several compounds by means of various diuretic and saluretic pathways (Table 9.1).

9.4.3 Hepatoprotective Effect

Dandelion (*T. officinale*) has been generally utilized in the treatment of the various liver issues. Shi et al. (2009) conducted investigation to survey the adequacy of dandelion root water–ethanol extract (DWE) in carbon tetrachloride (CCl4)-initiated hepatic fibrosis. Expanded hepatic collagen deposition due to CCl4-induced hepatotoxicity has shown the development of liver fibrosis. The Dandelion Water Extract (DWE) treatment has incited withdrawal of collagen stores in necrotic zones and the inversion of hepatic fibrosis. Furthermore, the examination proposes that polyphenolic acid, chlorogenic acid, etc. have been recognized in DWE, which has inhibitory potential on CCl4-instigated liver fibrosis in rodents by inactivating hematopoietic stem cells (HSCs) (Shi et al. 2009). *T. officinale* root has defensive activity against alcohol-prompted liver damage by lifting antioxidative properties and diminishing lipid peroxidation. Ethanol-prompted hepatic damage is portrayed by hepatic marker catalysts, for example, alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), and lactic dehydrogenase (LDH). The elevation of these proteins in serum proposes hepatocytic damage (Kasdallah et al. 2007). Irreversible liver damage prompted by the consumption ethanol is apparently connected with oxidative stress by means of improved lipid peroxidation and ROS creation. The aqueous extract from the tissues of *T. officinale* is considered as a potentially helpful radical scavenger for a large group of radicals. It is assumed that the cancer-preventing activity of the aqueous extract of *T. officinale* could be in charge of the amelioration of oxidative stress. In this way, the development of dietary supplementation utilizing *T. officinale* could be supportive to secure against alcoholic liver damage interceded by oxidative stress.

9.4.4 Hypolipidemic Activity

Dandelion (*T. officinale*) has the capacity to reduce lipid levels and lipoproteins in the blood. Especially, leaf extracts and unrefined powdered tissues of dandelion diminished triglyceride collection in adipocytes to a more noteworthy degree than that of the extract from the root. Treatment with dandelion root and leaf absolutely changed plasma and lipid profiles in cholesterol-sustained rabbits, and consequently may have potential hypolipidemic and cancer prevention activity (Choi et al. 2010).

9.4.5 Cardiovascular Activity

Dandelion is helpful in averting hypercholesterolemia and atherosclerosis, and diminishing risk factors for coronary conduit sickness. In the human body, abnormal amounts of triglycerides in the circulation system have been connected to atherosclerosis, and, by expansion, the danger of coronary illness and stroke. Raised cholesterol level is a hazard factor for coronary illness. The development of plaque in the course may prompt narrowing (hypertension) or complete blockage (heart attack) of the vessel (Karantonis et al. 2006). It is generally acknowledged that decrease in plasma HDL is a hazard factor for developing atherosclerosis. The dandelion leaf supplemented-diet expanded the centralizations of serum HDL-c when it is contrasted, and the cholesterol-rich eating routine and the convergences of serum LDL-c were diminished (Jinju et al. 2008).

9.4.6 Probiotic Activity

Fluid root concentrates of *T. officinale* Weber were tried for their development animating movement of 14 unique strains of bifidobacteria. The development of some strains was essentially upgraded in the medium containing dandelion root separately, while just two strains grew marginally less serious in this medium contrasted with the control. The remaining six strains showed proportionate development in the two media.

Overall, 1–48% of utilization of oligofructans from dandelion has been revealed before and after incubation in all bifidobacterial cultures (Trojanova et al. 2004).

9.4.7 Neuroprotective Activity

Oxidative stress–mediated neuron damage is considered an important factor to the pathogenesis and development of neurodegenerative diseases. *T. officinale* has been reported to possess antioxidant activities. However, its protective ability and underlying molecular mechanisms have not been elucidated yet. However, the neuroprotective activity of ethanol extracts of this plant on glutamate-induced oxidative stress in HT22 cells has been demonstrated by Huang S and his coworkers in 2018. Both cell viability and reactive oxygen species (ROS) assays showed that its ethanolic extracts effectively attenuated glutamate-induced cytotoxicity and ROS generation. Ethanolic extracts also increased the expression of heme oxygenase-1 (HO-1) and promoted the nuclear translocation of nuclear factor erythroid 2-related factor-2 (Nrf2). The inhibitory effects of ethanolic extracts on glutamate-stimulated cell toxicity and ROS production were partially reversed by tin protoporphyrin (SnPP), an HO-1 activity inhibitor. Taken together, these results demonstrate that ethanolic extracts can protect HT22 cells against glutamate-induced oxidative damage by inducing the Nrf2/HO-1 pathways (Huang et al. 2018).

9.4.8 Antibacterial Activity

Dandelion (*T. officinale*) shows antibacterial activity, that is, it destroys or suppresses the growth of bacteria. Oligosaccharides were derived from dandelion by hydrolysis with hydrogen peroxide (H_2O_2). The extraction conditions were optimized using the response surface methodology, and the antibacterial activity of dandelion-derived oligosaccharides (DOs) was determined (Li et al. 2014).

The antimicrobial viability of rough and dialyzed extracts from the dandelion root was tried against three Gram-positive (*S. aureus*, methicillin-resistant *Staphylococcus aureus* [MRSA], and *B. cereus*) and two Gram-negative (*E. coli* and *S. Typhimurium*) bacterial strains. The hexane rough concentrate (DRE1) exhibited antimicrobial movement against *B. cereus* (MIC = 1000 μg/mL), while the DCM extricate (DRE2) was dynamic against *S. aureus* and MRSA (MICs = 1000 μg/mL). DRE3 showed the most grounded antimicrobial action, in relation to unrefined dandelion removes, and was dynamic against each of the three Gram-positive to resist MIC = 500 μg/mL. An investigation by Sengul et al. (2009) examined the zonal restraint of rough methanol and water Soxhlet extract from the aerial parts of dandelion against 32 bacterial strains. The most grounded movement was found in the methanol separate, which was active (MICs = 300 μg/mL) against 10 bacterial strains especially against *B. cereus* (6 cm range). Likewise, Sengul et al. (2009) credited the antimicrobial action of the methanol extract to the presence of phenolics and in this manner connected this to its cancer prevention agent movement. Another study by López et al. (2013) announced that a fluid methanol (90% v/v) extract of dandelion blossoms exhibited no restraint of bacterial development against *S. aureus* and *E. coli*. In this examination, DRE3 was obtained from a methanol extract of dandelion root material and was observed to be active (MIC = 500 μg/mL) against *B. cereus* and *S. aureus*, although no hindrance to *E. coli* development was reported. Based on the action shown by DRE3, further fractionation of this unrefined concentrate was completed utilizing NP flash chromatography. The methanol hydrophobic rough extract (DRE3) revealed the most antimicrobial action against *S. aureus*, MRSA, and *B. cereus* strains (250–500 μg/mL), while no movement was seen against *E. coli* and *S. typhimurium*.

9.4.9 Anti-Inflammatory Activity

Inflammation is an intricate response of the host against several injuries. This reaction generally occurs by the means of immune cells like monocytes and macrophages, which stimulate inflammatory mediators such as nitric oxide (NO), prostaglandin E_2 (PGE_2), and tumor necrosis factor (TNF)-a (Munhoz et al. 2008). *T. officinale* has been used since earlier times as a herbal medicine to treat various medical issues, along with inflammatory disorder (Jeon et al. 2008). The anti-inflammatory effects of *T. officinale* extracts have been stated in both in vitro and animal models (Kim et al. 2000). Among the identified constituents in HPLC evaluation, protocatechuic acid (Jiang et al. 2015), caffeic acid (Kim et al. 2014), chlorogenic acid (Hebeda et al. 2011), and ferulic acid have showed anti-inflammatory activity inside the endothelial system. New research of Hu et al. suggested that aqueous extracts of *T. officinale* suppressed both TNF-α and Intercellular Adhesion Molecule-1 (ICAM-1) expression in lipopolysaccharide (LPS)-stimulated microvascular endothelial cells of mammary glands in rats. It is also shown that the anti-inflammatory effect of the TO methanolic extract on human endothelial cells is mediated via reduction of Vascular Cellular Adhesion Molecule-1 (VCAM-1) and pro-inflammatory cytokine expression. As endothelial VCAM-1 is considered as an important factor of mononuclear cell (monocytes and a few T lymphocytes) adhesion, lowered VCAM-1 expression considerably explains the inhibited monocyte adhesion to LPS-stimulated endothelial cells.

Overproduction of NO, via inducible NO Synthase (NOS), is responsible for the synthesis of NO from l-arginine, and is intently linked with inflammatory diseases, as well as the evolution of atherosclerosis and cancer (Kolb and Kolb 1992). Cyclooxygenase (COX)-2 is the enzyme that helps in the production of PGE_2 from arachidonic acid. The abnormally high levels and overexpression of COX-2 enzyme is determined in numerous premalignant and malignant tissues (Na and Surh 2006). The inflammatory phenomenon is also mediated via pro-inflammatory cytokines and chemokines, including interleukin (IL)-1, TNF-a, and IL-8, which are generated by activated macrophages. It has been reported that TNF-a plays an important role in the inflammatory processes (Yang et al. 1998). The expression of NOS, COX-2, and TNF-a is mediated through nuclear factor kappa B (NF-kb), which exists universally within the cytoplasm. This inflammatory transcription factor contains p50 and p65 subunits which are attached to an inhibitory protein, IkBa. In response to inflammatory stimuli brought about by bacterial endotoxin lipopolysaccharide (LPS), and IkBa is phosphorylated and secreted from NF-kB. The activated NF-kB subunits, p50 and p65, then transfer into the nucleus and upregulate inflammation-associated genes (Sha 1998). LPS stimulation can result in the activation of numerous intracellular signaling molecules. It has been shown that LPS can activate the Mitogen-Activated Protein Kinase (MAPK) (Anand et al. 2009) and NF-κB pathways in endothelial cells (Ghosh and Hayden 2008). These pathways are concerned in controlling the expression of adhesion molecules and pro-inflammatory cytokines. Western blot evaluation indicated that TO have no effect on LPS-induced MAPK activation, while immunofluorescence staining showed that TO markedly suppresses LPS-precipitated NF-κB nuclear translocation. As NF-κB nuclear translocation is mediated by IκBα, the degradation of which is brought about by means of phosphorylation, TO treatment was linked with suppression of IκBα phosphorylation. This suggests that TO reduces the LPS-induced endothelial expression of VCAM-1 and pro-inflammatory cytokines by means of suppressing activation of the NF-κB pathways.

T. officinale was found to have acute anti-inflammatory activity by showing its dominant effect against cholecystokinin-induced acute pancreatitis in rats (Seo et al. 2005). The flavonoid compounds, luteolin and luteolin-7-O-glucoside, present in the ethyl acetate fraction of *T. officinale* inhibit the synthesis of nitric oxide (NO) and prostaglandin E_2 in LPS-activated RAW264.7 macrophage cells, which occurs due to the inhibition of inducible nitric oxide synthase (NOS) and cyclooxygenase-2 (COX-2) (Hu and Kitts 2004). However, in primary cultures of rat astrocytes activated with LPS and TNF-a inducing substance P, *T. officinale* considerably inhibits production of TNF-a by inhibiting IL-1 secretion, indicating an anti-inflammatory property of *T. officinale* in the central nervous system (CNS) (Kim et al. 2000). It was reported that pretreatment with *T. officinale* extracts protect against LPS-induced acute lung injury in mice (Liu et al. 2010).

9.4.10 Antidiabetic Activity

Type 2 diabetes is the metabolic disorder which is spread over wide range of developed and developing countries. In 2007, it was reported that 3.5 million deaths occurred due to diabetes (Das and Rai 2008). The world is dealing with a massive medical and financial burden because of the rise in the occurrence of diabetes. It is calculated that approximately 382 million people in the world is suffering from type 2 diabetes today, and it is anticipated that by 2035 this number would rise by more than 200 million if precautionary measures are not taken (Whiting et al. 2011). The huge increase in the economic burden of type 2 diabetes has led to look for replacement of expensive medicines with the affordable ones. Dandelion gives a compelling profile of bioactive components with capability of antidiabetic properties. These bioactive components are sesquiterpene lactones, triterpenes/phytosterols (taraxasterol), phenols, flavonoids, and phenolic acids (Schütz et al. 2006). Dandelion is also the abundant source of the vitamins (A, C, D, E, and B), inositol, lecithin, etc., and minerals such as iron, magnesium, sodium, calcium, silicon, copper, phosphorus, zinc, and manganese (Ata et al. 2011). The movement of some of these ions (e.g., calcium ions in beta cells) may help to trigger insulin exocytosis (Komatsu et al. 1997).

Insulin resistance occurs in various tissues including liver, adipose tissues, and muscle cells and is the primary reason for hyperglycemia and a characteristic in pathogenesis of T2D (Hamden et al. 2008). There is one more widely known mechanism that has an impact on glucose homeostasis and that is oxidative stress, which is drifted by means of auto-oxidation and protein glycation (Giugliano et al. 1996). This process may increase the synthesis of lipid peroxide, which in turn decreases the antioxidative protection (Seo et al. 2005), as a consequence supporting the development of β-cell dysfunction. β-cell dysfunction impairs secretion of insulin due to glucotoxicity and lipotoxicity, which negatively influences the conversion of proinsulin to insulin. Hussain et al. (2004) reported that dandelion extracts could stimulate the secretion of insulin from pancreatic β-cells, which consequently opposes the influence of hyperglycemia. He further reported that rat insulinoma cells (INS-1E cells) have insulin activity. Dried ethanolic extract (40 μg/ml) of *T. officinale* was given to cells in presence of high glucose (6.0 mM), using glibenclamide (an anti-diabetic drug) as a control. The authors reported that an extensive insulin secretion occurred with the aid of INS-1E cells compared to ordinary glucose (3.0 mM). It has been revealed that chicory acid (CRA) also increase the uptake of glucose in muscle cells due to the stimulation of insulin secretion in the pancreas (Tousch et al. 2008). Dandelion, when administered as a 9.7% herbal preparation of ethanolic extract, has anti-hyperglycemic property in non-overweight diabetic mice (Petlevski et al. 2003). Moreover, CRA and TS (Taraxasterol) blocks α-glucosidase and α-amylase, stopping the digestion of complex carbohydrates consisting of starch and as a result contributing to the anti-hyperglycemic effect (Schütz et al. 2006).

The important factor in T2D is the impairment of insulin secretion and insulin sensitivity that leads to rise of blood sugar levels (hyperglycemia) and T2D, which can later lead to the development of vascular diseases (Resnick and Howard 2002). Since T2D is a huge economic and social burden and an epidemic phenomenon, many countries are becoming more dependent on antidiabetic medicines (Onal et al. 2005). The mature root of dandelion contains 40% of inulin which is a mixture of complex carbohydrates called as fructo-oligosaccharides (FOS). Intake of FOS benefits bifidobacteria that destroy pathogens in the gastrointestinal tract (Mir et al. 2015). FOS stimulates the immune system due to increase in the mineral absorption and thus inhibits abnormal cell growth. This complex carbohydrate helps to maintain constant blood sugar levels. According to Amin et al. (2015), it lowers hyperglycemia when used in high levels of water extract. Chlorogenic acid (CGA) has been found to be the potential compound for preventing obesity and inflammation. It also have effect on insulin secretion and sensitivity, making it an alternative for use as a future antidiabetic drugs (Xiao et al. 2013).

9.4.11 Antidepressant Activity

Depression is a wide spread disorder that is often persistent and is associated with physical and psychosocial problems including suicide (Dos et al. 2016). Now-a-days, the treatment regimens which are used for the control of depression show a number of adverse effects and have a negative impact on patient health (Polyakova et al. 2015). Therefore, we need to develop alternative therapeutics with better efficacy and lesser adverse effects. Natural products have been used since ancient times for the alleviation of human ailments and they have been used to cure many diseases including depression (Mhalla et al. 2018).

Recent studies have shown that *T. officinale* exhibit antidepressant activity (Li et al. 2014). It was confirmed by Tail Suspension Test (TST) that the hydromethanolic extract of *T. officinale* possesses antidepressant activity, showing that the extract can considerably alleviate the TST-induced immobility and the results had been similar to the positive control bupropion that is an antidepressant. It has also been suggested that stresses such as the TST in mice results in human depression-like situation and stimulates corticosterone production, which in turn results in a series of endocrine events (Van Donkelaar et al. 2014). The hydromethanolic extract of *T. officinale* exhibit antidepressant activity by reducing corticosterone levels and by increasing the adrenaline, noradrenaline, and dopamine levels. Further, it has been found that this extract can upregulate the expression of the brain-derived neurotrophic factor (Bdnf), which is associated with decreased expression of mitogen-activated protein kinase phosphatase-1 (Mkp-1), and thus exhibit protective effects in TST-stressed mice (Kondo et al. 2015). The active constituents of *T. officinale* responsible for antidepressant activity are identified as isoetin, hesperidin, naringenin, kaempferol, sinapic, and gallic acid. Thus, *T. officinale* might be beneficial in the control and management of depression.

9.4.12 Anti-Fatigue and Immunostimulatory Activity

T. officinale has been used to enhance energy levels in Korean herbal medicine. The anti-fatigue and immune-enhancing effects of *T. officinale* were examined in mice by performing Forced Swimming Test (FST) and in vitro via use of peritoneal macrophages, respectively. After daily oral intake of *T. officinale*, blood biochemical parameters related to fatigue were measured after the FST. FST immobility time was significantly decreased in the *T. officinale*-treated group (100 mg/kg) and also increased glucose levels, acting as an energy source. Swimming is known to initiate changes in biochemical parameters of blood (Lee et al. 2012). Blood urea nitrogen (BUN), creatine kinase (CK), lactic dehydrogenase (LDH), glucose, and albumin are biochemical parameters of blood related to fatigue. The BUN test is often used to assess renal function. The BUN level decreased when *T. officinale* was administered to mice. CK and LDH are known to be specific indicators of muscle damage. LDH catalyzes the interconversion of pyruvate and lactate; consequently the level of LDH increases rapidly after exercise. It was found that LDH levels were reduced after *T. officinale* treatment whereas CK levels does not change. After the FST, glucose levels had been considerably increased by the oral intake of *T. officinale*. Thus, these results suggest that *T. officinale* might be useful as an energy source.

There are various functions of macrophages including tissue remodeling during embryogenesis, wound repair, removal of broken or senescent cells subsequent to infection or injury, hematopoiesis, and homeostasis. One more function of macrophages is to prevent microbial invasion and to recognize and kill tumor cells. In vitro tests were carried out in mouse peritoneal macrophages to illustrate the immune-enhancing effect of *T. officinale*. Cytokines such as IL-12 and TNF-α are produced by macrophages, which enhance cellular-mediated immunity

(Kim et al. 2011). TNF-α production and mRNA expression were upregulated by *T. officinale* in combination with recombinant Interferon gamma (rIFN-γ) treatment in mouse peritoneal macrophages. *T. officinale* treatment may additionally enable the induction of cellular-mediated immunity and restrict inflammatory reactions in a severe inflammatory state. We advise that IL-10 is a key cytokine within the *T. officinale*-mediated law of immune function in murine macrophages. Furthermore, *T. officinale* extended TNF-α, interleukin IL-12p70, and IL-10 stages, and NO production in primary cultured peritoneal macrophages. It can be concluded that *T. officinale* has the capability to improve immune effects.

9.4.13 Anticancer Activity

As it is well known that cancer is the disease of stem cell (Zhang et al. 2012), therefore cancer stem cells (CSCs) have the potential for countless proliferation, and play an important role in case of carcinogenesis, metastasis, recurrence, and drug resistance. Sox2 is one of the gene that retains self-complacency of embryonic stem cells; is related to the differentiation capacity of these cells; and is expressed abnormally in several human tumors which include ovarian cancer, pancreatic cancers, breast cancer, lung squamous cell carcinoma, and gastrointestinal tumors (Yang et al. 2014). Sox2 plays an important function in breast carcinogenesis and excessive expression may incite metastatic potential (Lengerke et al. 2011). Therefore, goal therapy of CSCs is very essential in cancer control and management.

Dandelion (*T. officinale*) is well known as a folk medication as anticancer. The crude aqueous extract of dandelion leaf has been found to decrease the growth of MCF-7/AZ breast cancers cells, whereas the aqueous extracts of dandelion flower and root had no impact on its growth. Moreover, root extract blocked invasion of MCF7/AZ while dandelion leaf extract was found to block the invasion of LNCaP prostate cancers cells (Sigstedt et al. 2008). Ethanolic extract of *T. officinale* leaves have been stated as immunostimulatory agent for lowering side effects of doxorubicin in Sprague Dawley rats (Kasianingsih et al. 2011). Chatterjee et al. reported the potency of dandelion root extract in causing apoptosis in drug-resistant human melanoma cells, without noxious effect to healthy cells. For human primary culture cervical cancer stem cells (CCSCs), it has been shown that TO is effective in causing apoptosis, initiating RARß2 gene expression and suppressing Sox2 expression. Hata et al. found that upon screening of different compounds from wild flora, *T. officinale* was found to be the powerful inducer of differentiation in mouse melanoma cells. Moreover, this group of coworkers also located that one constituent of Chinese dandelion, Lupeol-a triterpene, stimulated melanogenesis and reduced cellular proliferation in mouse melanoma (Hata et al. 2000). This triterpene is considered as cytostatic and not cytotoxic.

T. officinale extract was found to treat Hep G2 human hepatoma cells and was discovered to lessen cellular viability and initiate cytotoxicity via interleukin-α and TNF-α (Koo et al. 2004). Phytochemicals in *T. officinale* encompass sesquiterpene lactones, triterpenoids, tannins, alkaloids, flavonoids, steroids, and phenolic acids

(Kim and Lee 2007). Oleic acid has additionally been discovered inside the stem of *T. officinale* demonstrating antiproliferative activity (Laszcyk et al., 2009). The flavonoid luteolin is found to be the effective anticancer constituent of *T. officinale* (Cheng et al. 2005). Luteolin kills cancer cells through initiation of apoptotic cellular death in various cell types.

Cytotoxicity is an important aspect of the anticancer activity of a therapeutic agent; however apoptosis is a desired mechanism of action of such agents. *T. officinale* is found to have antioxidant properties as well. This property additionally plays a crucial role in scavenging reactive materials that would otherwise be the reason for causing number of diseases including cancer. Apoptosis is critical mechanism for the preservation of cellular homeostasis by means of regulating cell division and cellular death (Yan et al. 2008). The system is mediated via activation of certain conservative intracellular pathways resulting in the exhibition of weird characteristics by apoptosed cells such as morphological modifications and DNA fragmentation. Some research have shown that apoptosis is related to cancer, as most cancers cells are characterized by means of reduced apoptosis. Hence, activation of apoptotic pathways is taken into consideration as an important mechanism taken up by most cytotoxic drugs to damage cancer cells (Xu et al. 2009). The compound oleanolic acid which is known to block cell proliferation and result in apoptosis has been found within the stem of *T. officinale* (Li et al. 2013). This compound has same structure as that of ursolic acid with moderate variations within the substituents on carbon 20. Consequently, the presence of oleanolic and taraxanic acid are considered to be responsible for the growth inhibitory and apoptotic outcomes of the *T. officinale* extracts.

9.5 Phytochemistry of *T. officinale*

T. officinale, a herbaceous perpetual plant of the family Asteraceae, is observed to have numerous medicinal properties including antidiabetic, antimicrobial, diuretic, carminative, hepatoprotective, antioxidant, and anticancer features. These properties have been ascribed to the extensive number of bioactive constituents in their tissues, including terpenes, flavonoids, and phenolic compounds, which are referenced as in charge of the therapeutic action of the plant (Table 9.2).

9.5.1 Constituents of Dandelion Roots

Various sesquiterpenes like taraxacolide-O-glucopyranoside, the guaianolides 11,13-dihydrolactucin and ixerin D, eudesmanolides, tetrahydroridentin B and three germacranolide esters, taraxinic acid glucopyranoside, including 11,13-dihydro-derivative and ainslioside have been documented in *T. officinale* WEBER root extracts (Hinsel et al. 1980; Kisiel and Barszcz 2000).

Furthermore taraxacoside, an acylated-butyrolactone glycocide have been isolated from *Taraxacum officinale* roots (Rauwald and Huang 1985). In addition,

Table 9.2 Phenolic constituents of dandelion tissue

Compound	Plant tissue		
	Leaf	Flower	Root
Luteolin −7-glucoside	+	+	−
Luteolin −7-diglucoside	+	+	−
Luteolin −7-diglucoside	+	+	−
Free luteolin	−	+	−
Free chrysoeriol	−	+	−
Chicoric acid	++	+	++
Mono caffeoyl tartaric acid	+	+	+
Chlorogenic acid	+	+	+
Cichoriin	+	−	−
Aesculin	+	−	−

traxacum species are known to have matricarin-type guaianolides (Kisiel and Michalska 2005).

Dandelion roots offer various phytoconstituents including various phytosterols such as taraxasterol, their estates and their 16-hydroxy derivatives arnidol and faradiol; triterpenes and amyrin, citosterol, citosterol-D-glucopyranoside and stigma sterol (Table 9.3) (Burrows and Simpson 1938; Hinsel et al. 1980; Akashi et al. 1994).

Dandelion roots have identified numerous phenolic compounds, for example, caffeic acid, chicoric acid along with its various isomers, 4-caffeoylquinic acid, p-coumaric acid, mono caffeoyl tartaric acid, chlorogenic acid, ferulic acid, vanillic acid, p-hydroxybenzoic acid, protocatechuic acid, syringic and p-hydroxy phenyl acetic acid. Furthermore, presence of many coumarins including scopoletin, esculetin, and umbelliferone have been established in *T. officinale* roots (Clifford et al. 1987; Wolbis et al. 1993; Williams et al. 1996). In addition to secondary metabolites present in taraxacum roots, it also contains inulin in an appreciable amount. Inulin content (storing carbohydrate) varies due to seasonal changes, being high in autumn (40%) and low in spring (2%) (Bisset et al. 1994).

9.5.2 Constituents of *T. officinale* Leaves

Analogous to dandelion roots, *T. officinale* leaves are also known to have bitter components, that is, sesquiterpenes like 11,13-dihydrotaraxinic-acid α-D-glucopyranoside and taraxinic acid α-D-glucopyranoside. The bitter taste of dandelion leaves may also be attributed to the presence of sitosterol and *p*-hydroxyphenylacetic acid (Kuusi et al. 1985). The leaves of *Taraxacum* are known to have higher concentration of polyphenolic compounds. Williams et al. (1996) have measured the concentration of cinnamic acid in both dandelion roots and leaves, which was obtained to be 1.2 mg/g and 16 mg/g respectively. Certain phenolic groups are present in abundance in leaves and flowers of dandelion as hydroxycinnamic acid derivatives, specifically caffeic acid esters such as

Table 9.3 Compounds in *Taraxacum officinale* with thei documented pharmacological activity

Compound	Nature of compound	Isolated from	Pharmacological activity	Used	References
Quininic acid	Phenolic	Root and leaf	Hypolipidemic and antioxidant hepatic disorders, diuretic, anti-rheumatic	Whole extract	Williams et al. (1996), Kim et al. (2008)
Quinic acid	Phenolic	Roots, flower, leaves and stem	Type i2iDiabetes (T2D), hepatic disorders	Ethanolic extract	Mingarro et al. (2015), Kenny et al. (2015), Fraisse et al. (2011), Choi et al. (2010), I Schütz et al. (2006)
Quercetin triglycoside	Flavone glycoside	Leaves and root	Treatment of gout	Whole extract	AbdAziz et al. (2011), Kong et al. 2001)
Quercetin pentoside	Flavonoids	Root and stem	Antioxidant	Methanolic extract	Clifford et al. (2003), Hu and Kitts (2005), Jeon et al. (2008)
11,13-Dihydrolactucin	Terpene	Root	Antidiuretic	Hydroethanolic extract	Kisiel and Barszcz (2000)
Ixerin D	β-D glucopyranose	Root	Choleretic anti-diuretic and anti-inflammatory	Ethanolic extract	Williams et al. (1996)
Ainslioside	Flavone glycoside	Leaves and roots	Against herbivore attack	Secondary metabolite	Schütz et al. (2006)
Taraxacoside	Glycoside	Root	Anti-inflammatory	Aqueous methanolic extract	
Taraxasterol	Triterpenoid	Root	Anti-cancer activity, Alzheimer's and parkinsonism prevention, Antiallergic, alpha-amylase inhibitory activity, antioxidant activity	Plant tissue culture	Sharma et al. (2009), Whang et al. (2011), Kumar et al. (2008), Jamshieed et al. (2010)
Faradiol	Triterpenoid	Root	Appetite stimulating and laxative property gall bladder disorder, digestive complaints	Root tincture	Blumenthal et al. (2000)

Cinnamic acid	Phenolic	Flowers and leaves	Anti-rheumatic and anti-inflammatory	Methanolic extract	Bradley (1992), Gonzalez et al. (2012)
Luteolin	Flavonoid	Flower and leaver	Anticancer and anti-inflammatory activity	Whole extract	Cheng et al. (2005)
Taraxinic acid	Phenolic	Flowers and leaves	Antiproliferative activity	Whole extract	Li et al. (2013)
Chlorogenic acid	Phenolic	Root	Antiproliferative activity	Whole extract	Hebeda et al. (2011)
Chicoric acid	Phenolic	Root	Antidiabetic activity	Ethanolic extract	Tousch et al. (2008)
Naringenin	Flavonoid	Leaves and flowers	Antidepressant activity	Hydro-methanolic extract	Van Donkelaar et al. (2014)

dicaffeoyltartaric (chicoric acid), chlorogenic, and monocaffeoyltartaric acids (Williams et al. 1996; Budzianowski 1999). *Taraxacum* leaves and flower extracts bring forth several flavonoid glycosides such as isorhamnetin 3-*O*-glucoside, luteolin 7-*O*-glucoside, quercetin 7-*O*-glucoside, apigenin 7-*O*-glucoside, and luteolin 7-*O*-rutinoside extract (Wolbis and Krolikowska 1985; Wolbis et al. 1993; Williams et al. 1996; Kristo et al. 2002). Schuetz et al. (2006) in another study has demonstrated various di- and triglycosylated flavonoids in dandelion herb and root extract. In addition to flavonoids, some coumarins namely aesculin and cichoriin have been shown to be present in leaf extract of dandelion extract (Williams et al. 1996; Budzianowski 1999). Potassium content of leaves and stem (4.89% and 7.73% dry matter, respectively) have been calculated as well, justifying the diuretic properties of dandelion tea (Hook et al. 1993; Wilman and Riley 1993; Wilman and Derrick 1994). Luteolin 7-glucoside and two luteolin 7-diglucoside glycosides have been isolated from dandelion leaves and flowers, and also two flavonoid components chrysoeriol and luteolin were obtained in free state for the very first time in dandelion flower tissue, although free luteolin has been reported earlier in a collective leaf and flower extract of Polish dandelions (Wolbis et al. 1993; Power and Browning 1912). In addition to the presence of these flavonoids, many carotenoids are also surprisingly present. Caffeic acid esters were seen to be major constituent of dandelion leaf, flower, and root extracts. Table 9.2 shows a comparison of the phenolic constituents of dandelion tissues. Coumarins have been detected in leaf only, and no flavonoids have been reported in dandelion roots (Racz et al. 1974). Grieb Von and Duqunois (1960) have reported that since dandelion root and leaves are high in potassium content, it might be present in taraxacum species in combination with cinnamic acid (being adequately present in dandelion species); alike sesquiterpene lactones which are present in dandelion roots, linked to glycosides. Taraxacoside was reported for the first time as an acylating acidic compound in sugar ester (Rauwald and Huang 1984). Other documented compounds comprise taraxasterol from the root latex (Power and Browning 1912).

9.5.3 Constituents of *T. officinale* Flowers

The dandelion flowers are comprised of b-sitosterol, carotenoids, for example, lutein epoxide, triterpenes (b-amyrin, faradiol, arnidiol) (De Smet 1993; Melendez et al. 2006) and flavonoids like luteolin 7-O-glucoside and luteolin. Yellow oil had been extracted from the flowers of dandelion via hydro-distillation, and GCMS techniques have revealed many compounds from *T. officinale* like straight chain and branched aliphatic hydrocarbons, alkylated benzenes, ketones, alcohols, and esters (Hu and Kitts 2003; Hu and Kitts 2005).

The phytochemistry of *T. officinale* may be summarized as a bunch of phytoconstituents including triterpenes, sesquiterpene lactones, fatty acids, carotenoids, volatile oils, tannins, carbohydrates, phenolic acids, flavonoids, minerals, phytosterols, sugars, choline, vitamins, micronutrients, mucilage, pectin, calcium, inositol, fats, gluten, proteins, and resin (Blumenthal et al. 2000; Williams et al. 1996).

Some of the potent bioactive compounds present in *T. officinale* are summarized in Fig. 9.1.

9.6 Conclusion

T. officinale significantly possess wide variety of secondary metabolites, thus representing useful source of bioactive compounds and preparations with health encouraging effects like antioxidant, diuretic, hypolipidemic, prebiotic, neuroprotective, antibacterial, anti-inflammatory, and antidiabetic. The diverse effects of dandelion are attributed to the presence of various triterpenes, sesquiterpenes, fatty acids, and phytosterols. The pharmacological investigations confirmed the empirical traditional application of dandelion in humans for the treatment of digestive disorders. Dandelion evaluated for phytochemical constituents had great potential to act as a source of useful drugs and ameliorate health condition of consumers due to the presence of various compounds that are indispensable for good health.

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