Medicinal Value of Dandelion

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The genus *Taraxacum* is part of the *Asteraceae* family of the *Cichorioideae* subfamily, *Lactuceae* tribe. This plant's geographical distribution is usually around the warm areas of the Northern Hemisphere and its users have been cherishing it for its curative properties since ancient times. Reports show that traditional medicine practitioners used *Taraxacum officinale* L. for treating dyspepsia, spleen, liver disorders, hepatitis, and anorexia. Aqueous extracts of dandelion were also used traditionally through Asia, Europe, and North America for treating different types of cancer like leukemia and breast cancer, even if their working mechanisms were unknown.

The main reported components of dandelions consist of phenolic acids (chicoric, caffeic, and chlorogenic acids), terpenes (taraxacoside, ainslioside, taraxinic acid), and storage carbohydrates (inulin), which are thought to be accountable for the plant's health-related properties.

This entry is based on a literature review (https://www.mdpi.com/2223-7747/10/2/216) and highlights the beneficial and therapeutic action of dandelion extracts and their confirmed or hypothesized mechanism of action in diabetes, hepatic disorders, and cardiovascular disease, as indicated by the results of *in vivo* an *in vitro* studies, on cell lines, human and animal models.

Keywords: diabetes ; hepatic disorders ; cardiovascular disease ; dandelion ; taraxacum officinale ; natural products

1. Dandelion Extracts and Their Natural Products Studied for Therapeutic Potential in Diabetes

As seen in Table 1, several extracts of the whole dandelion plant were studied *in vivo* and *in vitro* settings. Moreover, a dandelion root extract in combination with other medicinal plants including chicory root and mulberry leaves was evaluated *in vivo* on non-obese diabetic mice. Some of the results suggested that dandelion extracts prevent diabetic complications, improve lipid metabolism, and present alpha-glucosidase inhibitory activity. However, some of the actual functional natural products of *T. officinale* responsible for the reported beneficial outcomes still had to be elucidated.

Table 1. Dandelion extracts in diabetes and their potentially responsible effective compounds

Extract Type and Plant Part	Type of Study	Results	Responsible Functional Natural Products	References
Dandelion water extract	***in vivo*, streptozotocin (STZ) -induced diabetic rats**	**- improve lipid metabolism, prevents diabetic complication resulted from lipid peroxidation and free radicals**	**NA**	[1]
Extract P-9801091 (*Taraxaci radix* 9.7% and other medicinal plant extracts among which *Cichorii radix* 17.7% and *Mori folium* 7.4%)	***in vivo*, in non-obese diabetic mice**	**- influence lipid peroxidation and increased antioxidant action of Glutathione S-transferases in the liver, likely via a reduction in hyperglycemia**	**NA**	[2]
Dandelion leaves and roots aqueous and ethanolic extracts	***in vivo*, in STZ-induced diabetes in rats**	**- enhance carbohydrate metabolism**	**- fructooligosaccharides (inulin)**	[3]

Extract Type and Plant Part	Type of Study	Results	Responsible Functional Natural Products	References
Dandelion leaves extract	***in vivo*, in rat models of NAFLD**	**- decrease insulin resistance, may prevent NAFLD associated disorders such as diabetes**	**- polyphenols, flavonoids**	**[4]**
Dandelion whole plant dried ethanolic extract (40 µg/mL)	***in vitro*, in insulin secretagogue activity INS-1 cells**	**- insulinotropic activity, potent antidiabetic action through hypoglycemic effect**	**NA**	**[5]**
Dandelion water extract	***in vitro*, on a-glucosidase from baker's yeast, rabbit liver, and small intestine**	**- potent alpha-glucosidase inhibitory activity along with other traditional medicinal plant extracts**	**- unspecified phenol**	**[6]**
Dandelion methanol and water extracts	***in vitro*, in carbohydrate metabolizing enzymes**	**- reduce carbohydrate enzymes activity (α-amylase and α-glucosidase)**	**- unspecified fructooligosaccharides**	**[7]**
Dandelion leaves and stem ethanolic & aqueous extracts	***in vitro*, in 3T3-L1 cell culture**	**- suppress advanced glycation end products formation**	**- polyphenols**	**[8]**

In 2012, dandelion leaves and roots were tested on streptozotocin (STZ)-induced diabetes in rats. The findings provided some evidence of hypoglycemic effects resulting after administering *T. officinale* leaves and roots of aqueous and ethanolic extraction. It was presented that the extracts, particularly the ethanolic extract, can enhance carbohydrate metabolism. It was also suggested that ethanolic extraction was more effective than the aqueous extraction and that the roots were more therapeutically effective than the foliage in managing and treating diabetes. The experimental findings also indicated that *T. officinale* extracts and their effects were dose-dependent. However, it was only hypothesized that the functional natural products responsible for this action might be dandelion's root fructooligosaccharide, such as inulin [3].

Natural products and plant-derived compounds reveal anti-diabetic effects through mechanisms like inhibiting renal glucose reabsorption, reducing the activity of carbohydrate enzymes (α-amylase with β-galactosidase and α-glucosidase), lowering dietary blood sugar, and inhibiting potassium channel flow [9]. In this sense, an *in vitro* study conducted in 2015 on dandelion methanol and water extracts explored their α-amylase and α-glucosidase inhibitory actions and concluded that water and methanol extracts of the dandelion stem, roots, and flowers exhibit inhibitory activities powerful enough to consider the effective usage of this plant in managing diabetes [7]. The authors pointed out that the water extracts possessed the highest anti-diabetic properties than those of methanol extracts. In contrast, the stem extracts had the highest activity, followed by dandelion roots and flowers. Once again, the actual functional natural products accountable for the anti-diabetic action were thought to be dandelion's fructooligosaccharides.

A review from 2015 noted that *T. officinale* exhibits therapeutic properties like those of black soybeans. In rat models of NAFLD treated with dandelion extracts, there was a substantial decrease of lipidic buildups in the liver, decreased hepatic tissue, and body weight, and a diminished serum cholesterol level. After administering dandelion leaf extracts, decreased insulin resistance was noted by activating the (5' adenosine monophosphate-activated protein kinase) AMPK pathway. Additionally, the authors highlighted that polyphenols as well as flavonoids, and several other natural compounds have beneficial effects on NAFLD while preventing the emergence of some associated disorders. Natural products of dandelions can regulate the expression of several genes whose dysfunctions contribute to the buildup of lipid, fibrosis, swelling, oxidative stress, and insulin resistance [4].

T2DM is often met in connection with NASH and NAFLD. Since an increasing number of data shows that NAFLD elevates the risk of developing T2DM, it is presumed that NAFLD and NASH are specific clinical signs of T2D through a concurrent process of lipidic buildup, chronic inflammation, and hepatic fibrosis [10].

Recently, dandelion leaves and stem extracts were evaluated *in vitro* along with other medicinal plants for their anti-diabetic and anti-obesity properties and it was shown that the ethanolic extract of dandelion, roseroot, and water extracts of *Myrica gale* displayed substantial suppression of advanced glycation end-products formation (IC50 = 69.4, 74.0, 70.4 mg/L) in comparison to aminoguanidine (IC50 = 138 mg/L), which is the usual anti-glycation drug. It was concluded that the polyphenols of the previously mentioned plants are potentially useful in managing T2D and obesity [8].

Figure 1 shows some of the mechanisms of actions investigated regarding *T. officinale*'s effect in managing diabetes.

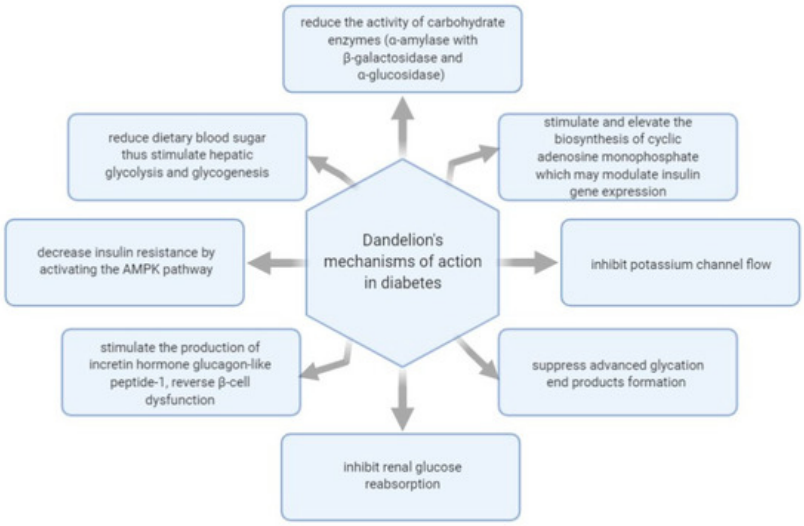

Figure 1. Mechanisms of action regarding dandelion's effect in managing diabetes

2. Dandelion Extracts and Their Natural Products Studied for Therapeutic Potential in Hepatic Disorders

As seen in Table 2, dandelion extracts were investigated by several *in vivo* and *in vitro* studies regarding their beneficial therapeutic outcomes on a hepatic level. Among other findings, the results suggested that some of the dandelion's natural products prevent hepatic necrotizing processes, modulate drug-metabolizing enzymes, inhibit tumor cell growth, and are beneficial in treating fatty liver hepatotoxicity caused by persistent alcohol consumption.

Table 2. Dandelion extracts in hepatic disorders and their potentially responsible effective compounds

Extract Type and Plant Part	Type of Study	Results	Responsible Functional Natural Products	References
Aqueous extract of dandelion whole plant, *Vitis vinifera*, *Schizandra Chinensis*, *Gardenia jasminoides*, *Angelica acutiloba*, and *Paeonia japonica*	*in vivo*, alcohol-induced hepatotoxicity in male Sprague Dawley mice	- lessen triglycerides, free fatty acids, and total cholesterol (TC) in the serum and liver, beneficial in fatty liver hepatotoxicity caused by chronic alcohol consumption	NA	[11]
Dandelion leaves hydroalcoholic extract	*in vivo*, in rat models of acetaminophen (APAP)-induced hepatotoxicity	- hepatoprotective impact, diminishes hepatic dysfunction induced by APA	- phenolic compounds	[12]
Dandelion whole plant extract (polysaccharide fractions)	*in vivo*, in rat models of CCl4-induced hepatic damage	- hepatoprotective action by regulating inflammatory responses and oxidative stress	- polysaccharides	[13]
Dandelion root ethanolic extracts	*in vivo*, in rat models of CCL_4-induced hepatotoxicity	- attenuated hepatotoxicity as it reduced levels of (alanine aminotransferase) ALT, (aspartate transaminase) AST, (alkaline phosphatase) ALP, and total bilirubin	- sesquiterpene lactones	[14]
Dandelion root hydroethanolic extract	*in vivo*, in CCl_4-induced hepatic fibrosis on male BALB/c mice	- reduced hepatic fibrinous deposits and reinstated histological architecture	- chlorogenic acid and other polyphenolic compounds	[15]
Dandelion leaves aqueous extract	*in vivo*, in CCl_4-induced hepatitis in Sprague-Dawley rats	- decrease of oxidative stress and inflammatory processes	- luteolin, luteolin-7-O-glucoside, and polyphenols	[16]

Extract Type and Plant Part	Type of Study	Results	Responsible Functional Natural Products	References
Dandelion ethanolic and n-hexane leaves extract	*in vivo*, in rat models of CCL_4-induced hepatotoxicity	- decrease thiobarbituric acid reactive substances, hydrogen peroxide, and nitrite contents	- unspecified polyphenols, flavonoids	[17]
Dandelion leaves water extract	*in vivo*, in rat models of sodium dichromate-induced liver damage	- antioxidant action with a positive effect on alleviating hepatotoxicity and genotoxicity	- polyphenols, flavonoids, tannins, and ascorbic acid	[18]
Dandelion root extract	*in vivo*, in murine model of APAP-stimulated liver damage	- hepatoprotective, activating the Nrf2-Keap1 pathway	- glucose, galactose, arabinose, rhamnose, and galacturonic acid	[19]
Dandelion root extract (microspheres)	*in vivo*, in lead-induced hepatic damage in rats	- protects offspring from lead poisoning	- terpenes and phenolic compounds such as flavonoids	[20]
Dandelion leaves extract	*in vivo*, on murine models of high-fat diet-induced hepatic steatosis	- reduce hepatic lipid accumulation	- luteolin and chlorogenic acid	[21]
Dandelion leaves extract	*in vivo*, on murine models of hepatic steatosis induced by choline and methionine deficient diet	- hepatoprotective due to antioxidant and anti-inflammatory actions	- luteolin and polyphenols	[22]
Dandelion root water extract	*in vivo*, on mice and *in vitro*, on HepG2 following ethanol exposure	- hepatoprotective action of alcohol-exposed cells and mice	- luteolin and other flavonoids	[23]
Lyophilized extract of dandelion roots and leaves	*in vitro*, on rat liver microsomal fraction	- reduced the enzymatically stimulated lipid peroxidation, can protect the structure of membranes, and prevent necrotizing processes	- antioxidant compounds (flavonoids)	[24]
Herbal tea mixture (peppermint, chamomile, dandelion)	*in vitro*, on the activity of hepatic enzymes using rat liver microsomes	- significantly inhibited some CYP isoforms, can cause alteration of phase I and II drug-metabolizing enzymes	- antioxidant compounds (polyphenols and flavonoids)	[25]
Dandelion whole plant aqueous extract	*in vitro*, human hepatoma cell line, HepG2	- inhibited tumor cell growth, substantially induced cell death of human hepatoma cells, triggered up-regulation of TNF-a and IL-1a, being potentially useful in cancer therapies	- terpenoid and sterol bitter principles (taraxasterol)	[26]

Hepatic damage can occur after prolonged administration of medications prescribed as part of specific pharmacotherapies. Such a case is APAP-induced hepatotoxicity, acetaminophen being an antipyretic and analgesic drug linked to several cases of hepatitis, cirrhosis, and liver transplants when its administration is prolonged or in overdose. In this sense, research was performed to evaluate dandelion's capacity to diminish hepatic dysfunction induced by APAP through its natural antioxidant compounds. Thus, it was found that APAP orally dispensed to murine models at a dose of 200 mg/kg produced biochemical and histological lesions in the liver tissue. However, pre-treatment with hydroalcoholic extract of *Taraxacum officinale* L. leaves over 10 days managed to prevent damage to the biochemical parameters produced by APAP, indicating a substantial hepatoprotective impact, most likely triggered by the extract's content of phenolic compounds [12].

Throughout 2010, several studies focused on various dandelion extracts' therapeutic action in similar models of oxidative stress and hepatic damage caused by carbon tetrachloride (CCl_4). In one of the studies regarding this topic, the extracts were administered for seven days, and hepatitis was induced by a single dose of CCl_4 (50% CCl_4/olive oil; 0.5 mL/kg bw)

administration. Although CCl_4 drastically raises serum AST and ALT activities, the pre-treatment with dandelion water extract significantly decreases the AST and ALT activities along with the hepatic lesions. It was suggested that the evaluated dandelion polysaccharides have hepatoprotective action by regulating inflammatory responses and oxidative stress [13].

During the same month of June 2010, another study was published on the hepatoprotective potential of two other dandelion root fractions, known as an ethanolic extract (ETO) and sesquiterpene lactones enriched fraction (SL), against CCL_4-induced hepatotoxicity in mice. This time, the post-treatment with ETO and SL substantially attenuated hepatotoxicity, as was shown by the reduced levels of hepatic enzyme markers, like ALT, AST, ALP, and total bilirubin. Finally, it was concluded that dandelion-sourced sesquiterpene lactones are protective against acute hepatotoxicity produced by CCl_4 administration in mice [14].

The effectiveness of dandelion root hydroethanolic extract was evaluated in CCl_4-induced hepatic fibrosis on male BALB/c mice. The mice were treated with CCl_4 dissolved in olive oil (20%, *v*/*v*, 2 mL/kg) intraperitoneally (i.p.), twice/week for four weeks. The extract was administered i.p. once/day for the next 10 days, in doses of 200 and 600 mg/kg body weight. The results showed that the dandelion treatment reduced hepatic fibrinous deposits, reinstated histological architecture, and modulated the expression of glial fibrillary acidic protein and α-smooth muscle actin. It was suggested that the beneficial outcome of dandelion root hydroethanolic extract on CCl_4-induced liver fibrosis is due to the inactivation of hepatic stellate cells and improved hepatic recovering abilities, which are actions possibly triggered by the extract's content of chlorogenic acid or its other polyphenolic chemical constituents [15].

In September 2010, another study was published by a previously referenced research group, investigating the protective impact of a dandelion leaf aqueous extract (DLWE) in CCl_4-induced hepatitis in Sprague-Dawley rats. The animals were divided into normal control, DLWE control, CCl_4 control, and two DLWE groups (0.5 and 2 g/kg bw). After seven days of treatment, it was shown that the extract's administration significantly decreased CCl_4-induced AST and ALT activities in a dose-dependent manner, most likely due to the contents of luteolin, luteolin-7-O-glucoside, and polyphenols. The authors suggested that DLWE has a protective impact against CCl_4-induced hepatic damage partially due to the decrease of oxidative stress and inflammatory processes resulting from cytochrome P450 activation by CCl_4 [16].

Later, another *T. officinale* ethanolic leaf extract was studied compared to n-hexane dandelion leaf extract for its therapeutic action in CCl_4-induced liver toxicity in rats. It was observed that the ethanolic leaf extract had a superior hepatoprotective action in CCl_4-induced liver toxicity, possibly due to the presence of various phytochemicals (e.g., polyphenols, flavonoids), as it decreased the concentration of thiobarbituric acid reactive substances, hydrogen peroxide, and nitrite contents, which is usually over-increased by CCl_4 toxicity [17].

Dandelion leaf extracts were also tested on acute liver damage induced by sodium dichromate intoxication in a murine model. It turned out that the leaf extract had a significant positive action on hepatotoxicity, oxidative stress, and genotoxicity. It was speculated that the hepatoprotective effect of dandelion leaf water extract results from its active compounds such as polyphenols, flavonoids, tannins, and ascorbic acid. As previously observed, it is thought that the therapeutic properties of dandelion leaf extracts in managing liver lesions result from their antioxidant compounds [18].

In 2017, two purified water-soluble polysaccharide fractions were isolated from dandelion root and tested for their hepatoprotective effects in a mouse model that mimicked APAP-stimulated liver damage in humans. The research showed that the two dandelion root polysaccharides composed of glucose, galactose, arabinose, rhamnose, and galacturonic acid can defend the liver from APAP-stimulated hepatic damage by activating the Nrf2-Keap1 pathway, which is the main regulator of cytoprotective responses to endogenous and exogenous stresses triggered by reactive oxygen species (ROS) and electrophiles [19].

On a hepatic level, the therapeutic properties of dandelions are also explored in lead poisoning. A group of researchers assessed the hepatic toxic actions of prenatal exposure to lead in rats and the probable protective action of dandelion-enriched diets. It was concluded that adding dandelions to pregnant and lactating rats' diet protects offspring from lead poisoning, likely through the decrease of oxidative stress and hepatic damage. Moreover, it was shown that supplementing female rats' diet with up to 2% dandelion extract does not provide a toxic effect, nor does it increase oxidative stress. It was finally assumed that the microsphere extract's antioxidant action from the dandelion root would be responsible for improving the oxidative status during lead poisoning [20].

Alcohol intake is a contributing factor to the onset of hepatitis and liver damage. Therefore, in 2010, the effects of *Taraxacum officinale* (dandelion) root against alcoholic liver damage were explored in HepG2/2E1 cells and Institute of Cancer Research mice. The hot water dandelion root extract managed to provide hepatoprotective action in the cells treated with ethanol, while the ethanolic root extract did not reveal compelling hepatoprotective action. The aqueous

dandelion root extract, containing 2% of flavonoids and 0.013 mg/g of luteolin, ameliorated the malondialdehyde levels, indicating that it carries protective action in alcohol-induced liver toxicity by decreasing lipid peroxidation and increasing antioxidant potential [23].

In vitro and *in vivo* studies looked for a clear insight into the plant's therapeutic properties in alleviating liver disorders when these are caused by improper nutrition. In this sense, a study was conducted on murine models of hepatic steatosis induced by a high-fat diet. It has shown that administering dandelion leaf extracts resulted in high antioxidant activity and overall therapeutic action. More specifically, it was noted that the administration of *Taraxacum officinale* L. leaf extract along with the high-fat diet dramatically reduced hepatic lipid accumulation. Moreover, liver and body weight was higher in the model group where dandelion extracts were not administered along with the high-fat diet than those who had dandelion extracts added to their meals in concentrations of 2 g/kg and 5 g/kg. Besides, dandelion leaf extract suppressed the levels of triglycerides, TC, and insulin, as the authors suggested, most likely due to the extract's contents of luteolin and chlorogenic acid [21]. Another *in vivo* experiment conducted by the same group of researchers on murine models suffering from hepatic steatosis induced by choline and methionine deficient diets further concluded that dandelion leaf extracts are hepatoprotective due to their antioxidant and anti-inflammatory actions, which may be triggered by the contents of luteolin and polyphenols [22].

In 2019, another study was published, which evaluated the effect of dandelion root extract on radiation-induced hepatic and testicular tissue injury. Male Wistar rats (WR) were exposed to 8.5 Gy of gamma radiation applied as a shot dose, and the extract (200 mg/ kg/day) was orally supplemented 14 days before and after irradiation. The findings indicated that administering dandelion root extract reduced oxidative stress in hepatic and testicular tissues, showing a substantial decrease in the levels of malondialdehyde and protein carbonyl with noticeable growth in glutathione and the activity of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). These results were thought to be triggered by the extract's contents of chlorogenic acid and taraxasterol. However, although the extract reduced histopathological alterations, it was suggested that the protective action was more significant in testicular tissue injury, adding that the extract should be better administered before radiation [27].

Figure 2 shows some of the mechanisms of actions investigated regarding *T. officinale*'s effect in managing hepatic disorders.

Figure 2. Mechanisms of action regarding dandelion's effect in managing hepatic disorders

3. Dandelion Extracts and Their Natural Compounds Studied for Therapeutic Potential in Cardiovascular Diseases

As seen in Table 3, *T. officinale* extracts were evaluated regarding their activities on a cardiovascular level by several *in vivo* and *in vitro* studies. Thus, dandelion root ethanolic extracts and leafy vegetable mix of dandelion and other plants were shown to be effective in platelet anti-aggregating activity and in protecting cells from lipid peroxidation and oxidative DNA damage.

Table 3. Dandelion extracts in cardiovascular disease and their potentially responsible effective compounds

Extract Type and Plant Part	Type of Study	Results	Responsible Functional Natural Products	References
Dandelion root ethanolic extracts	*in vivo*, on platelet anti-aggregating activity	- dose-dependent inhibition of the adenosine diphosphate - induced aggregation (40 mg dried root/mL of human platelet-rich plasma)	- polysaccharides, triterpenes, steroids	[28]
Leafy vegetable mix (12.5% each: beet leaf, angelica, red leaf lettuce, dandelion, green cos lettuce, lollo rosso, romaine lettuce, 6.25% each-scotch kale, red kale)	*in vivo*, in C57BL/6 mice on a high fat and cholesterol diet	- improved antioxidants (glutathione and b-carotene) and antioxidant enzyme activities (glutathione peroxidase, glutathione reductase, and superoxide dismutase), protects cells against lipid peroxidation and oxidative DNA damage	- polyphenolic contents	[29]
Dandelion roots and leaves	*in vivo*, in rabbits on a high-cholesterol diet	- may protect against atherosclerosis related to increased oxidative stress	- phenolics (catechol, caffeic acid, ferulic acid, m-coumaric acid, p-coumaric acid, vanillic acid, and syringic acid)	[30]
Dandelion leaves and petals	*in vivo*, in male Wistar rats	- antioxidant action, diminish triglycerides, TC, lipoprotein, and plasma atherogenic index	- L-chicoric acid	[31]
Dandelion flower extract	*in vitro*, in both biological and chemical models on antioxidant activity and lipid oxidation	- suppressed reactive oxygen species and nitric oxide, prevented lipid oxidation	- phenolic contents (flavonoids and coumaric acids)	[32]
Dandelion leaves, petals, and root phenolic fractions	*in vitro*, in human plasma, and blood platelets	- antioxidant properties, anti-platelet, and anticoagulant actions	- luteolin, cinnamic acid, L-chicoric acid, amino acid-sesquiterpene adducts	[33][34][35]
Dandelion root fractions	*in vitro*, in human platelets' model	- protective action against lipids and proteins oxidation of platelets, anti-platelet action	- SL-amino acid adducts, hydroxyphenylacaetate inositol esters	[36]
Dandelion leaves and petals fractions	*in vitro*, in human plasma, and blood platelets	- antioxidant and anti-adhesive action	- chicoric acid	[37]

In 2010, a group of researchers published their results after investigating the hypolipidemic and antioxidative actions of dandelion roots and leaves in rabbits following a high-cholesterol diet. A total of 28 male rabbits were distributed into four smaller groups: the normal diet group, the high-cholesterol diet group, the high-cholesterol diet with 1% (*w/w*) dandelion leaf group, and the high-cholesterol diet with a 1% (*w/w*) dandelion root group. Following four weeks of treatment, the plasma antioxidant enzymes and lipid profiles were evaluated. The findings indicated that diets containing dandelion roots and foliage, containing phenolics like catechol, caffeic acid, ferulic acid, m-coumaric acid, p-coumaric acid, vanillic acid, and syringic acid, beneficially influenced plasma antioxidant enzyme activities and lipid profiles. Therefore, dandelion roots and leaves might protect against atherosclerosis related to increased oxidative stress [30].

The antioxidant properties of dandelion leaves and petals were also studied *in vitro*, in 2017, on the production of thiobarbituric acid reactive substances (TBARS, a lipid peroxidation marker) in human plasma. Four phenolic fractions from dandelion leaves and petals were studied, and they all had antioxidant properties since they suppressed lipid peroxidation, protein carbonylation, and protein thiols oxidation. It was also concluded that, in this case, petal fractions, containing the highest luteolin contents, had greater antioxidant activity than leaf fractions regardless of their concentration. The dandelion was finally indicated as helpful for managing diseases associated with oxidative stress and hemostasis alterations [33].

In 2018, phenolic fractions from dandelion leaves and petals (at the dose range of 1–50 µg/mL) were studied *in vitro* for their anti-platelet and antioxidant activities in blood platelets. It was noted that phenolic fractions extracted from dandelion leaves and petals varied in their anti-platelet, anticoagulant, and antioxidant activities due to the different chemical profiles. The four fractions were defined as phenolic-rich fractions (A and B, leaves and petals of 50%), a flavonoid-rich fraction (D, petals of 85%), and a mixed fraction (C, leaves of 85%). Fractions A and B, rich in cinnamic acid derivates, seemed more efficient in antiplatelet and antioxidant action than flavonoid-rich fractions (fractions C and D). The main phenolic acid in fractions A, B, and C consisted of L-chicoric acid. The study finally demonstrated the anticoagulant activity

of dandelion leaf and petal extracts and suggested that the analyzed phenolic fractions' anticoagulant actions are correlated with modulation of thrombin activity due to its suppression. Moreover, it was concluded that the dandelion leaf and petal extracts of 50% fractions offer natural compounds beneficial in preventing and treating cardiovascular diseases through antioxidant, anti-platelet, and anticoagulant actions [34].

Even though many of the dandelion root's potentially bioactive components have been already discussed, such as hydroxycinnamic acids (HCAs) and sesquiterpene lactones (SLs), new compounds are being revealed. In an *in vitro* study, five dandelion root formulations (A–E) with different chemical contents were evaluated. About 100 phytochemicals were identified, comprising novel compounds for the genus *Taraxacum* and the plant kingdom, like amino acid-SL adducts. Moreover, none of the dandelion root extracts triggered blood platelet lysis (tested range of 0.5–50 µg/mL). It was indicated that dandelion roots are a secure and effective source of a diverse class of natural compounds holding antioxidant, anticoagulant, and anti-platelet properties [35].

In 2019, an *in vitro* study examined five dandelion root fractions with different chemical profiles for modifications produced in the human platelets' model using selected hemostatic parameters. The greatest anti-platelet prospective was displayed by the formulation supplemented with hydroxyphenylacaetate inositol esters—PIEs (fraction C). Nevertheless, the greatest overall protective action against lipids and proteins oxidation of platelets, and the top suppressing action on the production of superoxide anion, were noticed using fraction A (SL-amino acid adducts enriched fraction). Thus, it was once again suggested that extracted biomolecules of the dandelion root can be regarded as suitable natural products to be employed in preventing and treating cardiovascular diseases linked to blood platelet hyperactivation [36].

The purpose of another *in vitro* research was to assess the action of dandelion's chicoric acid on the biological profile of human plasma and blood platelets. Four phenolic fractions, acquired from leaves (fraction A and B) and petals (fraction C and D), with different concentrations of chicoric acid and L-chicoric acid extracted from dandelion foliage, were studied on biomarkers of oxidative stress, coagulation parameters, and blood platelet activation. The results suggested that chicoric acid extracted from dandelion leaves and petals offers antioxidant and anti-adhesive potential without cytotoxicity [37].

In 2020, phenolic extracts of dandelion leaves and petals were investigated as potential regulators of antioxidant and lipid profiles in male WR. The animals were supplemented over four weeks with *T. officinale* extracts (694 mg/kg of diet = 11.9 ± 0.6 mg daily). The dandelion leaf and petal extracts assured a dose of ± 0.05 and 1.41 ± 0.07 mg l-chicoric acid per day and have demonstrated antioxidant actions, noted as diminished levels of thiobarbituric acid-reactive constituents in the spleen (≈0.8-fold, leaves and petals), brain (0.53-fold, leaves), and thoracic arteries (0.59-fold, petals). Moreover, dandelion leaf extracts impacted the lipid profile by diminishing triglycerides (0.44-fold), TC (0.73-fold), a lipoprotein combined index (0.32-fold), and a plasma atherogenic index (0.62-fold). Finally, it was suggested that dandelion leaf and petal phenolic fractions containing high contents of l-chicoric acid are valuable plant materials with potential beneficial antioxidant actions on a cardiovascular level [31].

Another recent study reported the phytochemical profile of dandelion fruit extract and assessed its antiradical, antiplatelet, and antioxidant characteristics on a model of hemostasis. Thus, it was shown that the main flavonoids and phenolic acids of dandelion fruits consist of luteolin and L-chicoric acid compounds, which might be employed in cardiovascular disease therapies [38].

4. Conclusion

The highlighted therapeutic actions of *Taraxacum officinale* L. leaves are mainly ascribed to their content of natural products like polyphenols, flavonoids, tannins, and sesquiterpenes. Given this, extracts of dandelion leaves were reported to have hepatoprotective properties in liver cancer, lead-poisoning, drug-induced hepatic damage, and non-alcoholic fatty liver disease. Nevertheless, other studies indicate that water extracts of dandelion leaves are also advantageous in managing diabetes by improving carbohydrate metabolism and having α-amylase and α-glucosidase inhibitory activities. In what concerns cardiovascular disease, dandelion root extracts were reported to have anti-platelet, hypolipidemic, and antioxidant action, which are beneficial in the management of cardiovascular diseases.

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