



Pharmacological and therapeutic potential of *Hordeum vulgare*

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ARTICLE INFO

Keywords:

Hordeum vulgare

Antimutagenic

Cancer

Diuretic

Antioxidant

Traditional Chinese medicine

ABSTRACT

Introduction: One of the first grains to be cultivated was *Hordeum vulgare*, which was grown in the Fertile Crescent, a region of Western Asia near the Nile River in North-East Africa and many other regions like Russia, China. It has a lot of soluble fiber, especially beta-glucans, which help control blood sugar and lower cholesterol. It is a grain of the Poaceae family and is one of the earliest plants with the greatest significance in Chinese medicine. Traditional Chinese Medicine (TCM) practitioners have used it for treating hyperprolactinemia, obesity etc. *Hordeum vulgare* is used in the preparation called “Smilax” which is used for weight loss in China. *Hordeum vulgare* has been used as a poultice to treat burns and wounds because it is thought to be anti-inflammatory, anti-fatigue, diuretic, antioxidant, aphrodisiac, antiviral, antiprotozoal, astringent, demulcent, digestive, expectorant, febrifuge, antimutagenic, and emollient.

Methodology: The online databases including Scopus, Web of Science, Google Scholar, and PubMed, were searched using different keywords: *Hordeum vulgare*, anti-inflammatory activity, traditional uses, and antimutagenic activity, Chinese herb, *hordeum vulgare*. The purpose of this review was therefore to summarize the previously reported phytopharmacological status of the chosen plant species.

Results: The results of our analysis revealed that *Hordeum vulgare* Linn. contains dietary fiber, vitamins, minerals, and phytochemicals including flavonoids, saponins, etc. In addition, previous research has demonstrated that plant extracts and isolated principles of *Hordeum vulgare* also possess significant pharmacological activity including antiviral, anti-inflammatory, febrifuge, anti-mutagenic and others.

Discussion: *Hordeum vulgare* has a good potential for generating therapeutics for the treatment of inflammation, obesity, cancer and also worked as dietary supplements for minerals and vitamin deficiency, according to the below-mentioned human and animal studies. Also, clinical research has shown that *Hordeum vulgare* is a safe and efficient herb for human intake and thus should be included in dietary intakes and as active constituents in pharmaceutical formulations.

Conclusion: This review will talk about how the plant chemicals in *Hordeum vulgare* can be used to treat and prevent diseases. This review also helps the researchers to work on the *Hordeum vulgare* with the focus on bioactivity and toxicity.

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<https://doi.org/10.1016/j.prmcm.2023.100300>

Received 11 August 2023; Received in revised form 23 August 2023; Accepted 24 August 2023

Available online 25 August 2023

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Introduction

One of the oldest cereal crops still being produced today is *Hordeum vulgare*. According to archaeological findings, *Hordeum vulgare* was present in Egypt along the Nile around 17,000 years ago [1]. It is one of the most widely grown crops in the world (12% of all cereals grown), and it comes in fourth place among cereal grains after maize, wheat, and rice [2]. Due to its winter hardiness, drought resistance, and early maturity, *Hordeum vulgare* performs better than other cereals under a variety of environmental stressors and is thus often more cost-effective to grow [3]. About 2% of the *Hordeum vulgare* that is grown is used directly for human consumption; the majority—about 65%—is used as animal feed, and 33% is used for malting. Globally, *Hordeum vulgare* was grown on more than 48 million hectares in 2014, yielding a harvest of 144 million metric tons [4]. Hulless *Hordeum vulgare* has the potential to serve as a viable source of animal feed. Hulless *Hordeum vulgare* has significant dietary value in countries where it is cultivated extensively. Approximately 95% of hulless *Hordeum vulgare* production is concentrated in the highland areas of Nepal, Bhutan, Korea, Japan, and Tibet in China. China has the most abundant hulless *Hordeum vulgare* genetic resources globally, accounting for 77% of the total global hulless *Hordeum vulgare* genetic resources [5]. The distribution of hulless *Hordeum vulgare* in China encompasses the vast expanse of the Qinghai-Tibet Plateau, spanning over many provinces including Tibet, Qinghai, Gansu, Sichuan, and Yunnan. The distribution of hulless *Hordeum vulgare* in Yunnan Province is mostly concentrated in the Shangri-la region located in the northwest area of the province.

Hordeum vulgare has been under cultivation in China since 2000 BCE and has played a significant role in the treatment of several ailments related to the skin, blood, liver, and gastrointestinal system [6]. *Hordeum vulgare* malt is a derived substance obtained from the fully developed fruits of *Hordeum vulgare* L., a member of the gramineous plant family. This product is obtained by the process of sprouting and subsequent drying. Additionally, it is widely used as a traditional Chinese herbal medicine in clinical settings. *Hordeum vulgare* malt, as described in the context of traditional Chinese medicine (TCM) [7], is believed to possess properties that facilitate the movement of Qi and aid in the elimination of food retention. Additionally, it is said to enhance the functioning of the spleen, stimulate the appetite, provide a pleasurable taste experience, and alleviate distention. This herbal remedy is often used in the treatment of conditions such as food retention and indigestion, stomach distending discomfort, spleen insufficiency and anorexia, galactostasis, and female delectation. *Hordeum vulgare* malt and other traditional Chinese medicine ingredients are often used in the therapeutic management of hyperprolactinemia (HPRL), with favorable outcomes [8].

Hordeum vulgare is a highly versatile cereal crop that is extensively utilized for various purposes such as forage, production of intoxicating liquor, functional food, stable food, ornamental weaving, and Chinese medicines. Additionally, it exhibits remarkable resistance to stress factors such as drought, cold, and salt, making it a highly resilient crop. *Hordeum vulgare* is particularly notable for its high content of functional components. Furthermore, the growth period of *Hordeum vulgare* ranges from 70 to 200 days, allowing it to be cultivated in all four seasons worldwide or at altitudes of 1900 to 2300 m in Yunnan province, China [9].

Hordeum vulgare is a plant that has been used in traditional Chinese medicine (TCM) for the treatment of hyperprolactinemia and as a dietary supplement for thousands of years [8]. In the United States, 3.8 million metric tons of *Hordeum vulgare* were produced on 988,660 hectares of land at this time. *Hordeum vulgare* eating on a regular basis may lower your chance of developing certain illnesses, including chronic heart disease, colon cancer, high blood pressure, and gallstones, according to epidemiological research [10]. There are reports that *Hordeum vulgare* helps to maintain a healthy colon, trigger immunostimulant, and overall strengthen the immune system. The

bioactive elements of vitamins, minerals, fiber, and other phytochemicals are responsible for these medicinal potentials. Surprisingly, *Hordeum vulgare* has a wide variety of bioactive compounds, but the majority of the health advantages are attributed to its fiber content, particularly β -glucan fiber [11]. *Hordeum vulgare*'s health advantages are mostly attributed to dietary fiber, but there is enough data to conclude that phytochemicals also play crucial roles in delaying the onset of chronic illnesses. The distinct bioactivities of many groups of known phytochemicals have been documented [12]. The main phytochemicals in *Hordeum vulgare*—phenolic acids, flavonoids, lignans, vitamin E (tocopherols), sterols, and folates—have shown positive effects on health. Phenolic substances have crucial roles in development and reproduction, serve as barriers against viruses, parasites, and predators, and affect plant color [13]. It is also used for the preparation of mixture known as “smilax” which is used for weight loss, decreasing waist and hip circumference etc. The “smilax” is the aqueous extract on the mixture of various Chinese plants named as *hordeum vulgare*, *dimocarpus lognan*, *lilium brownie* and others [14]. The primary elements of plant oils that provide advantages including defense against toxins, neurological illnesses like Alzheimer's disease, and diabetes include sterols and tocopherols. When it comes to the quantity and variety of phytochemicals it contains, *Hordeum vulgare* holds its own against other main cereal grains like rice, wheat, oats, and rye [15]. Moreover, *Hordeum vulgare* contains several special phytochemical qualities that are not present in other grains, such as having all eight tocopherols [16].

Phytoconstituents in *Hordeum vulgare*

Phytochemicals are those which are produced by the plants and occur naturally chemical constituents are those which are having their own specific identity and name. *Hordeum vulgare* includes a variety of phytochemicals (non-nutrient substances) in variable amounts that are often controlled by environmental or genotypic factors, or by the interplay of the two [17]. The phenolic acids, flavonoids, lignans, tocopherols, and folates are some of the primary types of phytochemicals found in *Hordeum vulgare* (Table 1). They may be found in free, conjugated, or bound forms [18].

Chemical constituents

Hordeum vulgare contains dietary fiber (15.6 g/100 g), fat (1.2 g/100 g), carbohydrates (77.7 g/100 g), sugars (0.8 g/100 g), protein (9.9 g/100 g), arginine (6.0–22.0%), histidine (2.2–4.3%), lysine (0.8–7.9%), tyrosine (1.5–2.7%), tryptophan (0.6–1.3%), phenylalanine (2.1–3.4) 4-O-methylglucur 6"-sinapoylsaponarin, 6"-feruloyl-saponarin, and 4'-

Table 1
Description of phytoconstituents in *Hordeum vulgare*.

Phytoconstituents	Description
Carbohydrates	The main carbohydrate present in <i>Hordeum vulgare</i> is starch, which makes up about 70–80% of the grain.
Protein	<i>Hordeum vulgare</i> is an excellent source of protein, with an average of 12–14%.
Fats	<i>Hordeum vulgare</i> contains a small amount of fat, usually around 2–3%.
Minerals	<i>Hordeum vulgare</i> is a good source of minerals such as magnesium, phosphorus, potassium, and iron
Vitamins	<i>Hordeum vulgare</i> is a good source of vitamins such as thiamin, riboflavin, niacin, and vitamin B ₆ .
Antioxidants	<i>Hordeum vulgare</i> contains antioxidants such as lignans and phenolic compounds
Enzymes	<i>Hordeum vulgare</i> contains enzymes such as amylase, protease, and lipase.

glucosyl-6''-sinapylsaponarin; 2''-O glycosylisovitexin; isorientin-7-O-glucoside (lutanarin); isovitexin-7-O-rutinoside; isoscoparin-7-Protocatechuic acid; salicylic 3-β-D-glucopyranosyloxy-3-methyl butyronitrile, 1-cyano-3-β-D-glucopyranosyloxy-2-methyl propene, and 4-D-glucopyranosyloxy-3-hydroxy-3-hydroxymethylbutyronitrile, p-coumarylagmatine 2,4-dihydroxy-1,4-benzoxazin-3-one [39–40], 2-D-glucopyranose nosyloxy-3-methyl-(2R), butyronitrile, ubiquinone's, proanthocyanidins, procyanidin B3, trimer of procyanidin C2, prodelpinidin, chrysoeriol, hordeurnin, pangamic acid, tocopherols, tocotrienols, 2-D-glucopyranosyloxy-3-methyl-(2R)-butyronitrile 4-O-linked beta-D-glucopyranosyl units and 3-O-glucopyranosyl units (Figs. 1, 2), pyrrolidine, luteolin glycoside, flavone glycosides, orientoside, and orientin, cyano-3-beta-D-glucopyranosyloxy-2-methylpropene, gluten, 4-beta-D-glucopyranosyloxy-3-hydroxy-3-hydroxy-3-hydroxymethyl-butyrionitrile [19].

Methodology

The online databases including scopus, web of science, Google Scholar, and PubMed, were searched. Various research and reviews from the year 1999 to 2022 were included in this article which covers all the information regarding *Hordeum vulgare*. Different keywords like *Hordeum vulgare* and ant inflammatory activity, *Hordeum vulgare* and traditional uses, and *Hordeum vulgare* and antimutagenic activity, Chinese herb, *hordeum vulgare* etc. were searched. A total of 150 review and research were searched out and out of which 83 articles were cited. The purpose of this review was therefore to summarize the previously reported phytopharmacological status of the chosen plant species.

Result and discussion

Therapeutic potential *Hordeum vulgare*

Hordeum vulgare is a cereal grain that has been used in traditional medicine for centuries. It is a rich source of phytochemicals such as polyphenols, flavonoids, phenolic acids, and tocopherols [20]. These compounds have been demonstrated to possess various therapeutic properties and have been studied for their potential benefits in a variety

of diseases. Polyphenols and flavonoids in *hordeum vulgare* are known for their antioxidant (Table 2) and anti-inflammatory activities, which may be beneficial for the management of oxidative stress-related diseases such as diabetes and cardiovascular disease [21]. Phenolic acids have been shown to have anti-carcinogenic and anti-microbial activities and may be useful in the prevention and treatment of various cancers, infections, and chronic diseases [22]. Tocopherols, which are the main ingredients of *Hordeum vulgare*, have been reported to possess anti-inflammatory, anti-cancer, and anti-microbial properties, and may be beneficial in the treatment of cancer, cardiovascular disease, and other chronic diseases [7]. In addition to these properties, *Hordeum vulgare* has also been studied for its potential anti-diabetic effects. *Hordeum vulgare* been found to reduce blood glucose levels and improve insulin sensitivity, which may be beneficial in the prevention and treatment of type 2 diabetes [26]. Its fiber content may also be beneficial for reducing the risk of cardiovascular disease [27].

Antidiabetic and weight losing phytoconstituents in *Hordeum vulgare*

Public health concerns, including diabetes and obesity, have an impact on people's health and the economy and have sparked concern throughout the world [28]. Hence, the management and treatment of chronic illnesses must place a high priority on cost-effective mitigation measures rather than containment [29]. As a consequence, several lifestyle changes, diets, medications, and weight reduction plans have been suggested. The intake of *Hordeum vulgare* has been related in many epidemiological studies to lower rates of diabetes and obesity [30]. While the *Hordeum vulgare* ingredients responsible for these advantages have not yet been discovered, fiber and the grain's high nutritional content are thought to be the front-runners [31]. It is also used for the preparation of mixture known as "smilax" which is used for weight loss, decreasing waist and hip circumference etc. The "smilax" is the aqueous extract on the mixture of various Chinese plants named as *hordeum vulgare*, *dimocarpus lognan*, *lilium brownie* and others. The smilax was administered to human patients for six weeks and the result showed a significant decrease in weight and body mass index [14]. It is well known that oxidative stress is one of the main pathogenic factors causing insulin resistance, beta-cell dysfunction, impaired glucose tolerance,

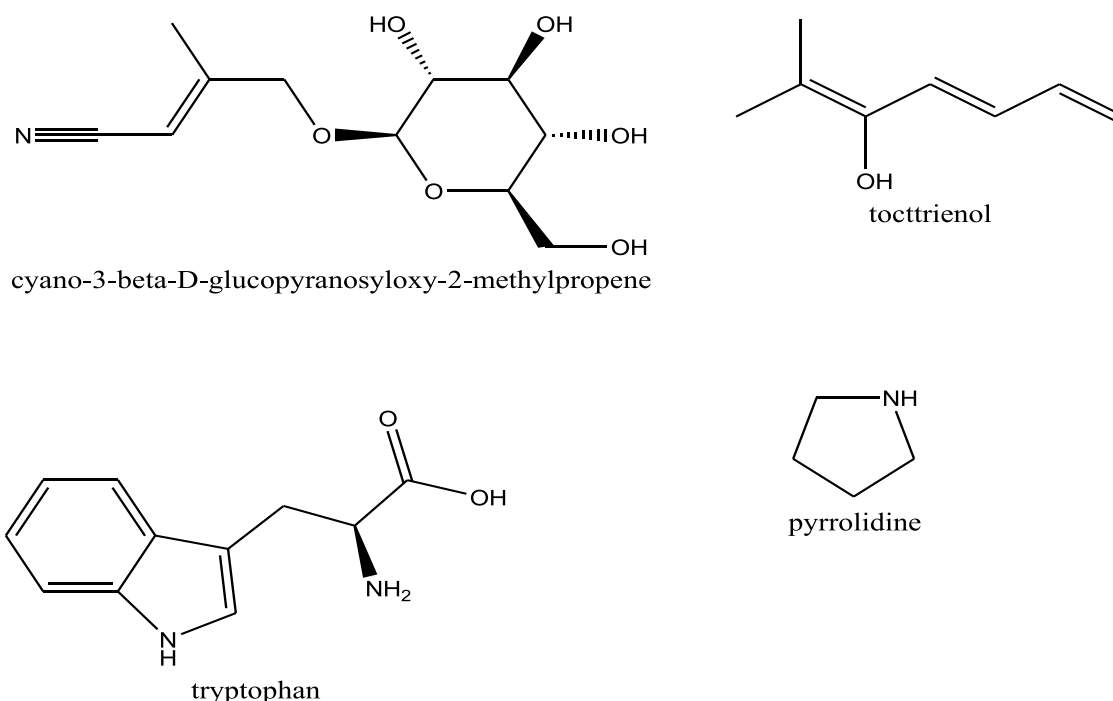


Fig. 1. List of some chemical structure of various chemical constituents.

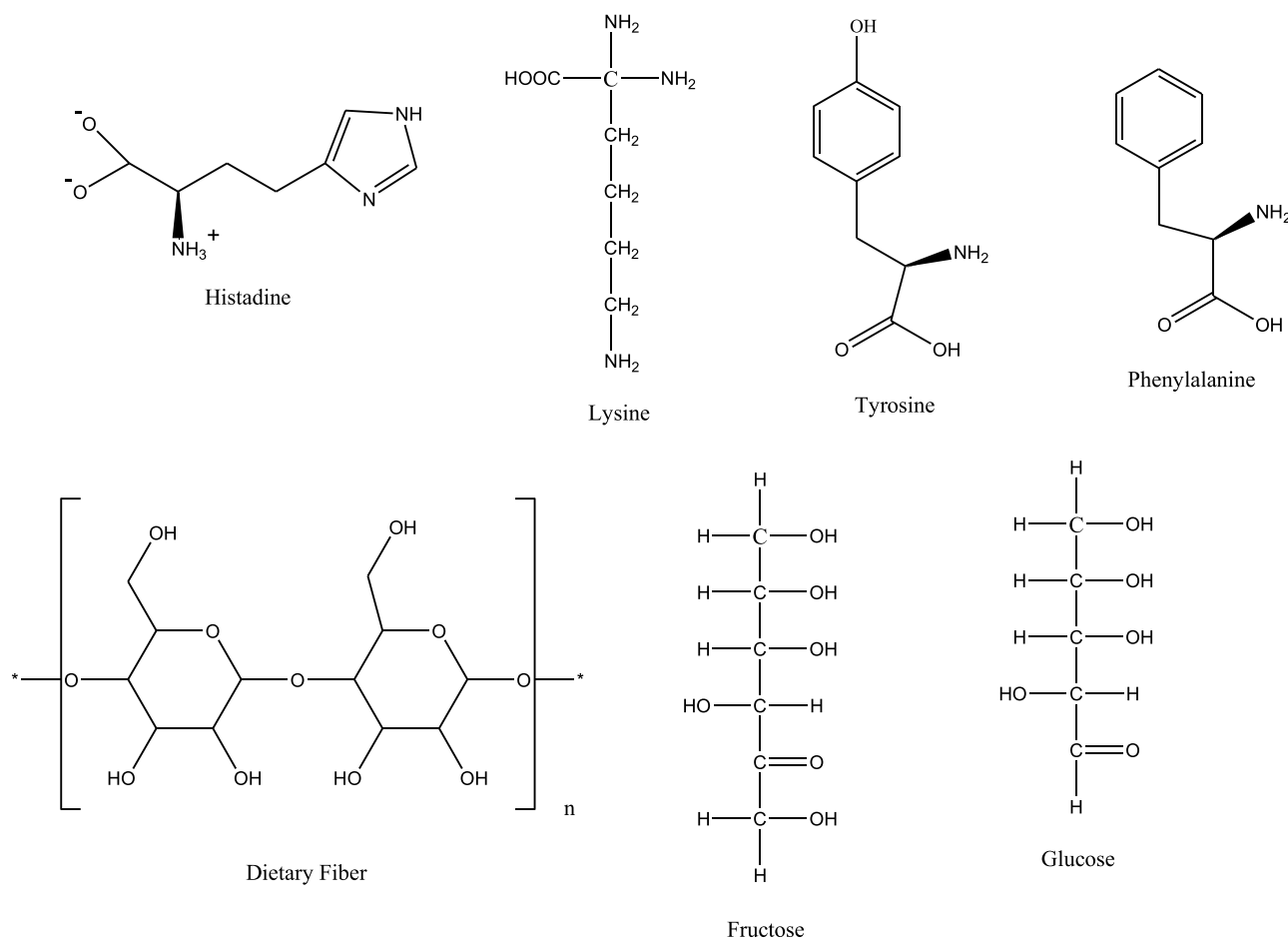


Fig. 2. Chemical structure of various chemical constituents.

Table 2
Antioxidant activity of *Hordeum vulgare*.

Study	Methodology	Findings	Conclusion	Refs.
"Antioxidant Activity and Phenolic Compounds of <i>Hordeum vulgare</i> (<i>Hordeum vulgare</i> L.) Varieties"	Used different extraction methods to analyze the antioxidant content in different <i>Hordeum vulgare</i> varieties.	Found a high presence of phenolic compounds in all varieties, particularly ferulic acid.	<i>Hordeum vulgare</i> is rich in antioxidants, with the potential to provide health benefits due to its high phenolic content.	[23]
" <i>Hordeum vulgare</i> and its by-products: Phytochemicals and functional food potential"	Reviewed the antioxidant properties of <i>Hordeum vulgare</i> and its by-products.	Found that <i>Hordeum vulgare</i> by-products are rich in antioxidants, including flavonoids and tocopherols.	<i>Hordeum vulgare</i> and its by-products can be developed into functional foods due to their high antioxidant content.	[24]
"Antioxidant properties and health benefits of bioactive compounds from <i>Hordeum vulgare</i> "	Explored the impact of <i>Hordeum vulgare</i> 's bioactive compounds on health.	The study linked <i>Hordeum vulgare</i> 's antioxidants to a reduced risk of chronic diseases such as diabetes and cardiovascular disease.	Consuming <i>Hordeum vulgare</i> can provide health benefits due to its high antioxidant content.	[25]

and ultimately the development of diabetes [32]. This is true even though there are few *in vivo* studies on the effects of *Hordeum vulgare* phytochemicals on diabetes and obesity. By using the phytochemicals found in *Hordeum vulgare*, oxidative stress, which is a major contributor to the pathophysiology of diabetes and obesity, may be reduced [33]. Both disorders are characterized by an increase in the generation of reactive oxygen species and a reduction in antioxidant defense effectiveness [34]. Thus, by lowering oxidative stress, phytochemicals may stop the onset and progression of obesity and diabetes. Many phenolic acids, flavonoids, phytosterols, and tocopherols are *Hordeum vulgare* phytochemicals that may help prevent diabetes and obesity [35]. These substances serve as potent antioxidants. The primary elements thought to be responsible for the antioxidative properties of cereals, particularly *Hordeum vulgare*, are total phenolic acids [36]. Due to the presence of unsaturated carboxylic groups, phenolic acids found in cereals have

shown comparable or greater antioxidative effects than catechins and have been associated with the protection of chronic illness [37]. According to Zielinski & Kozłowska et al., 80% methanolic extracts of whole grains of *Hordeum vulgare* showed a positive correlation coefficient value of 0.96 between total phenolic components and total antioxidative activity [38]. *Hordeum vulgare* phytochemicals' antioxidative qualities were investigated by Goupy et al. *Hordeum vulgare* flavonoids, phenolic acids (particularly FA), and tocopherols have antioxidative properties of around 4.76, 0.34, and 0.89 antiradical power, respectively, based on their ability to react with 2,2-diphenyl-1-picrylhydrazyl (DPPH)[24]. As measured by the suppression of oxidation of β -carotene in the linoleate model system, the antioxidative activity of the various *Hordeum vulgare* flavonoids tested ranged from 16.4 to 65.5%, while that of phenolic acids ranged from 12 to 31.2% and that of tocopherol ranged from 49.1 to 55.2%[39]. The ability of *Hordeum vulgare* to inhibit

lipoxygenase allowed researchers to further examine its antioxidant properties. For flavonoids, phenolic acids, and tocopherols, the antioxidative activities ranged from 24.8 to 65.4%, 2.9 to 10.8%, and 49.1–63.9%, respectively [40]. Compared to other phytochemicals like flavonoids and phenolic acids, *Hordeum vulgare*'s carotenoids didn't exhibit as strong of an antioxidant activity [41]. The order of the examined 80% methanolic extracts from various whole grains' antioxidative activities was *Hordeum vulgare* > oat > wheat > rye. Due to its significant antioxidative activity, *Hordeum vulgare* is a valuable natural remedy for halting the onset and progression of diabetes and obesity [42]. Additionally, diabetes and obesity are both characterized by systemic, low-grade inflammation, particularly in adipose tissue (Table 3). In addition to their antioxidant characteristics, *Hordeum vulgare* phytochemicals also have strong anti-inflammatory capabilities that may be used to reduce the risk of diabetes and obesity [43].

Anticancer phytoconstituents in *Hordeum vulgare*

According to epidemiological research, nutrition and lifestyle account for 20–80% of all deaths from cancer in humans. Nutritional elements, particularly those that lessen the effects of reactive oxygen species, may prevent DNA damage and boost the immune system, reducing the risk of cancer [49]. Bioactive substances found in *Hordeum vulgare* and its derivatives have antioxidative and immunomodulatory properties and are linked to the prevention of cancer (Table 5). The majority of research on the chemoprevention of cancer by *Hordeum vulgare* has been conducted in vitro, with the focus mostly on the moderation of this illness and the impact of *Hordeum vulgare* fiber, particularly beta-glucan [50]. The anti-carcinogenic properties of germinated *Hordeum vulgare* foodstuff (GBF), a prebiotic heterogeneous combination of around 80% hemicellulose and insoluble glutamine-rich protein fiber, were studied by Kanauchi et al. The health advantages of GBF are also attributed to the presence of phytochemicals, particularly phenolic acids, which may be found in free or bound forms [51]. According to Kanauchi et al., GBF impacts the pathogenesis of colon cancer in its early stages and hinders the transformation of hyperproliferative epithelia. In comparison to the control diet, the administration of GBF raised the content of luminal short-chain fatty acids, particularly butyrate (p 0.05), which is formed in the colon, and promoted the synthesis of acetate (p 0.05) [52]. The GBF group of F344 rats' colonic mucosa showed a decrease in succinate generation (p 0.05), as well as a decrease in the expression of -catenin, aberrant crypt foci, and -catechin formations. The GBF group had higher levels of heat shock protein 25 (HSP25) positive cells, cecal B-glycosidase, and the tumor suppressor and solute

carrier slc5a8 activities than the control group (p 0.05). Similar changes in the composition and functions of acetate, butyrate, succinate, HSP25-positive cells, -catenin, aberrant crypt foci, and other relevant biomarkers have been discovered in studies on the moderation of colonic carcinogenesis [53]. Dietary insoluble fiber from *Hordeum vulgare* was found to be more effective at preventing tumor incidence, tumor burden, tumor mass index, and dimethyl-induced tumors than other soluble fiber-rich commercial bran from *Hordeum vulgare* and oats. This was revealed in another study by McIntosh et al. on the influence of different fiber-rich sources like wheat and *Hordeum vulgare* in diets [45]. The brewing industry's waste product, spent *Hordeum vulgare* grain, had the lowest tumor incidence (70%) and tumor burden per 10 rats (1.20). (13). Recent studies also reveal that polyphenols may be more health-beneficial than previously believed, including improved endothelial function, improved cellular signaling, and essential gut protection against undigested polyphenols linked to fiber [54]. *Hordeum vulgare* may also be a fantastic dietary source of natural antioxidants with anti-radical and anti-proliferative potential due to the abundance of phenolic chemicals it contains. Investigations have found that FA possesses tumor-inhibiting qualities. Its capacity to prevent the development of large bowel cancer has also been mentioned in publications. Even though there is a link between phenolic compound consumption and a lower risk of getting a few chronic diseases, it is still not clear if phytoconstituents protect against diseases because they are antioxidants or because of something else [55].

According to Madhujith, Shahidi, Bellido, and Beta, the presence of phenolic acids in *Hordeum vulgare* results in high antioxidant activity. After the injection of 0.5 and 0.05 mg/mL of phenolic extracts from *Hordeum vulgare*, Caco-2 colon cancer cell growth was inhibited by 29.3–51.2%. This was due to the *Hordeum vulgare* extracts' high phenolic acid content and related significant antioxidative activity [56]. Hordeumin, a form of anthocyanidin-tannin pigments whose scavenging action rises with the duration of fermentation, was found to be produced during the lactic acid fermentation of *Hordeum vulgare*. Deguchi et al. proposed that the *Hordeum vulgare* bran polyphenols are responsible for the hordeum's free radical activity. More research on the phytochemicals found in *Hordeum vulgare* should be done since they may be useful in reducing cancer risk factors [57]. While I can provide a summarized table of research findings, I recommend referring to the original research articles for detailed insights. Here are some of the recent research findings related to *Hordeum vulgare*'s anticancer activities (Table 4).

Table 3

Potential effects of phytoconstituents *Hordeum vulgare* on obesity and diabetes.

Phytoconstituents in <i>Hordeum vulgare</i>	Potential Effects on Obesity/Ref	Potential Effects on Diabetes
Beta-Glucans	May promote feelings of fullness, potentially aiding in weight loss [44]	May improve insulin sensitivity and reduce blood sugar levels [44]
Dietary Fiber	Helps in weight management by promoting satiety. May also help reduce visceral fat [45]	Can slow the absorption of sugar into the bloodstream and therefore help regulate blood glucose level [45].
Saponarin	Preliminary animal studies suggest it may inhibit fat accumulation and promote weight loss [46]	Animal studies suggest it may improve insulin sensitivity and reduce blood glucose levels [46].
Tocotrienols	May help in reducing body fat, as suggested by some animal studies [47]	Could potentially exert hypoglycemic effects, but more research is needed [47].
Phenolic Acids	May contribute to the regulation of body weight, although more research is required [48]	These antioxidants may help combat oxidative stress in diabetes.

Table 4

Anticancer activity of *Hordeum vulgare*.

Year	Authors	Study	Main Findings
2020	Liu et al. [50].	"Anticancer Activities of <i>Hordeum vulgare</i> Extracts in Human Cancer Cells"	<i>Hordeum vulgare</i> extracts inhibited proliferation and induced apoptosis in human breast cancer cells.
2021	Chen et al. [24].	"Phytochemical Components and Anticancer Properties of <i>Hordeum vulgare</i> "	Identified phytochemicals in <i>Hordeum vulgare</i> , including β -glucans, phenolic acids, flavonoids, lignans, and tocopherols, may contribute to its anticancer properties.
2022	Khan et al. [58].	" <i>Hordeum vulgare</i> β -Glucan Induces Apoptosis in Human Colorectal Cancer Cells"	Found that β -glucans from <i>Hordeum vulgare</i> induced apoptosis in colorectal cancer cells, suggesting potential use in colorectal cancer prevention.
2023	Patel et al. [59].	" <i>Hordeum vulgare</i> and its Therapeutic Role in Leukemia"	Found that the phenolic compounds in <i>Hordeum vulgare</i> might be u

Phytoconstituents in *Hordeum vulgare* used for cardiovascular disease (CVD)

India recorded 63% of all NCD-related fatalities in 2016, with 27% of those deaths being linked to CVDs. Moreover, 45% of fatalities in people aged 40 to 69 are caused by CVDs (Table 5). Overweight and obesity are risk factors for CVD, as are high blood pressure, glucose, and cholesterol levels [60]. The illness with the highest rate of cardiovascular mortality in India according to projections, there will be 4.80 million CVD-related deaths in India each year by 2025, up from 2.26 million in 1990. Every seventh American fatality was brought on by coronary heart disease alone. The prevalence of CVDs is known to be significantly influenced by high blood cholesterol levels. Moreover, research suggests that the majority of neurological conditions associated with CVDs, including Alzheimer's disease and stroke, are mostly brought on by free radicals and other oxidants [61]. Natural antioxidants, like polyphenols, may have a powerful protective impact against the oxidative processes that these substances create, therefore enhancing cardiovascular health. Current methods of decreasing the risk of CVDs include limiting dietary cholesterol consumption and/or using a family of drugs called statins to reduce blood cholesterol [62]. The phytosterol content of *Hordeum vulgare* kernels makes them crucial for cardiovascular health. *Hordeum vulgare* grain consumption may lessen the need for medication or dietary restrictions for the control of CVD. *Hordeum vulgare* grains are high in phytonutrients. In the intestine's lumen, *Hordeum vulgare* phytosterols may compete with cholesterol to form micelles, preventing cholesterol absorption while boosting secretion and regulating cholesterol levels [63]. Tests demonstrate that at appropriate doses of 15 mL/d (1 table-spoon/d), the total phytosterol levels in *Hordeum vulgare* oils are adequate (0.18–1.44 g/15 g oil) to considerably reduce low-density lipoprotein (LDL) cholesterol. Due to their ability to scavenge free radicals, polyphenols also significantly contribute to the regulation of CVDs [64]. Researchers discovered that the polyphenols isolated from black highland *Hordeum vulgare* have potent superoxide, hydroxyl, 2,2-diphenyl-1-picrylhydrazyl, radical-scavenging, and antioxidant properties. Atherosclerosis index, total cholesterol, and LDL cholesterol were all significantly lower in mice given 600 mg of black highland polyphenol

extract per gramme of body weight, but high-density lipoprotein cholesterol (HDL, 17.80%) was also significantly higher [65]. A cellular sensor of energy metabolism and a regulator of cholesterol metabolism, AMP-activated protein kinase, was shown to be modulated by *Hordeum vulgare* sprout extract containing polyphenols by Lee et al. Intracellular total and free cholesterol concentrations in mice were reduced by 19.65 mg/g total polyphenols in *Hordeum vulgare* sprout extract, resulting in reductions of 24% and 18%, respectively [66]. Lignans, which are also abundant in *Hordeum vulgare*, have been discovered to function as potent antioxidants superior to vitamin E and FA. Also, it has been claimed that they reduce the risk of cardiovascular disease [67].

Tocotrienols and tocopherols, which are found in *Hordeum vulgare*, are powerful antioxidants that are important for heart health. *Hordeum vulgare* has been shown to have the largest concentrations of tocol and phytosterols among the cereals that are most significant commercially (wheat, *Hordeum vulgare*, rice, rye, and oat) [68]. It has been noted that protocols decrease serum cholesterol in both people and chickens. In the livers of test animals, tocotrienol was shown to impede the manufacture of cholesterol by Qureshi et al. The capacity of 3-hydroxy-3-methylglutaryl-coenzyme reductase, a rate-limiting enzyme involved in cholesterol production, to be suppressed by tocotrienol was the mechanism underlying this action [69]. According to Burger et al., the 3-week dose of 0–20 ppm tocotrienol from *Hordeum vulgare* regulated the production of cholesterol concentrations and decreased cholesterol levels by almost 60%. Yet, there are contradictory studies about *Hordeum vulgare* tocols' capacity to control cholesterol levels [70]. *Hordeum vulgare* oil had no impact on total blood cholesterol in rats given a diet based on potato starch, according to earlier research reported by Jadhav et al. Moreover, Wang et al. found no evidence in the hamster model to support the claim that *Hordeum vulgare* oil lowers cholesterol or contains any saponifiable components. Folate and cardiovascular health have been linked [71]. Due to its crucial function in the metabolism of amino acids and DNA methylation, it is now one of the vitamins that is most investigated. It serves as a coenzyme by delivering a carbon atom for human nucleotide biosynthesis. Its presence in people has been linked to an increased risk of cardiovascular disease. Folate-enriched *Hordeum vulgare* grains are an excellent and natural way to include folate in diets in order to prevent and lower the risk of heart disease [72].

Table 5
Hordeum vulgare as cardiovascular protective agents.

Study	Year	Authors	Key Findings
"Effects of <i>Hordeum vulgare</i> intake on cardiovascular risk factors in hypercholesterolemic men"	2004	Behall et al. [73].	Consuming <i>Hordeum vulgare</i> significantly reduced serum lipids, which could help in managing cardiovascular diseases.
"Dietary fiber and fiber-rich by-products of food processing: characterization, technological functionality and commercial applications: A review"	2012	Elke et al. [74].	Dietary fibers, like the ones found in <i>Hordeum vulgare</i> , contribute to risk reduction of cardiovascular disease.
" <i>Hordeum vulgare</i> β -glucan reduces blood cholesterol levels via interrupting bile acid metabolism"	2017	Wang et al. [75].	β -glucan from <i>Hordeum vulgare</i> can interrupt bile acid metabolism, which results in reduced blood cholesterol levels, contributing to cardiovascular disease risk reduction.
"Effect of <i>Hordeum vulgare</i> β -glucan on the serum cholesterol levels in postmenopausal women - A randomized controlled trial"	2020	Lyyra et al. [76].	In postmenopausal women, <i>Hordeum vulgare</i> β -glucan intake resulted in a significant reduction of serum cholesterol levels, showing a potential for cardiovascular disease prevention.

Traditional and folk medicinal uses

Hordeum vulgare is a plant that has many components that are used in traditional and folk medicine. In South Korea, women take hot water extracts of dried entire plants for ancylostomiasis, folic acid deficiency, cough, influenza, diarrhea, and jaundice. Women also take hot-water extracts of dried fruits and seeds as a form of contraception [77]. In Iran, dried seed decoction is applied to the nose to lessen nasal irritation and is used internally for bladder inflammation, diarrhea, emesis, gout, and hepatitis. It is also administered topically as an emollient on infected ulcers, hemorrhoids, and hepatitis [78]. In Turkey, the fruit's decoction is used orally to treat the common cold. In Guatemala, dermatitis and erysipelas are treated topically using a hot water extraction of dried seeds. In Argentina and China, oral decoctions of the dried fruit are used to treat diarrhea and diabetes, respectively [79]. In Italy, the dried seeds are infused to serve as a galactagogues. As a cough suppressant, a decoction of *Hordeum vulgare* seeds with apples, dried figs, and pears is employed. To manage blood sugar levels, 125 gmes of roasted *Hordeum vulgare* seeds are combined with 50 gmes of each *Cicer arietinum* and *Elettaria cardamom*. This mixture is then taken three times a day with a half teaspoon of water [80]. *Hordeum vulgare* is used to treat boils, diarrhea, stomach discomfort, and inflammatory bowel diseases in addition to decreasing blood pressure, blood sugar, and cholesterol. Leaf juice may treat cataracts. *Hordeum vulgare* is useful in fever and all inflammatory diseases due to its calming effects. By applying *Hordeum vulgare* flour to joints like a plaster, gout and rheumatism may be treated

topically. For the cure of jaundice and hepatitis, dry seed powder combined with water and sugar is ingested orally three times a day for a month. According to Hartwell, traditional treatments for stomach, uterine, and abdominal malignancies involve *Hordeum vulgare*. The seeds are used to treat tumor of the parotid gland, inflammatory and sclerotic tumor, and uterine cancer [81]. The anus condylomas, tumor behind the ears, scirrhus of the ovaries and spleen, and wheat lows are treated with seed flour [82]. It is thought that cataplasms made from the seed may treat breast cancer. Bronchitis, burns, cancer, catarrh, chest, chilblains, cholecystitis, cholera, coughing, debility, diarrhea, dyspepsia, fever, inflammation, measles, pterygium, puerperium, sores, and urogenital illnesses are all treated with *Hordeum vulgare* in folk medicine [83].

Conclusion

Hordeum vulgare Linn. is a cereal grain that has been used for centuries as a source of healthy nutrition. It is grown in the Fertile Crescent, a region of Western Asia near the Nile River in North East Africa, and is used as animal feed, a fermentable ingredient in alcoholic beverages, and in soups and stews. Commonly, *Hordeum vulgare* grains are processed into malt using an old-fashioned technique. Sprouted *Hordeum vulgare* has significant chemical components, has a high maltose content, and is increasingly employed to produce human food. It contains a lot of soluble fiber, notably beta-glucans, which help control blood sugar levels and reduce serum cholesterol. *Hordeum vulgare* has been used as a poultice for burns and wounds because it is said to have anti-inflammatory, antifatigue, diuretic, antioxidant, aphrodisiac, antiviral, antiprotozoal, astringent, demulcent, digestive, expectorant, febrifuge, antimutagenic, emollient, refrigerant, and sedative properties. It is a rich source of dietary fiber, vitamins, minerals, and phytochemicals, making it a potential source of bioactive compounds that may have pharmacological and therapeutic benefits. Overall, the phytochemicals present in *Hordeum vulgare* have been demonstrated to possess various therapeutic properties and may be beneficial in the prevention and treatment of a variety of diseases.

Author's contribution

All the author have equal contribution.

Financial support

None.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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