



**International Journal of Biology, Pharmacy  
and Allied Sciences (IJBPAS)**

*'A Bridge Between Laboratory and Reader'*

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## ETHNOBOTANICAL AND PHYTOPHARMACOLOGICAL ASPECTS OF POTENT THERAPEUTIC: *HORDEUM VULGARE* LINN

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Received 15<sup>th</sup> July 2024; Revised 20<sup>th</sup> Sept. 2024; Accepted 1<sup>st</sup> Nov. 2024; Available online 1<sup>st</sup> Nov. 2025

<https://doi.org/10.31032/IJBPAS/2025/14.11.9546>

### ABSTRACT

Over the ages plant have been employed as the source of food as well as remedies in various health alignments. *Hordeum vulgare* Linn. (Fam. Poaceae), also known as sukhadhanya or yava is one of the largest grown cereal crop, globally. It is mostly used as animal fodder. The present review highlights *H. vulgare* Linn. as enriched functional food containing vitamins, minerals, dietary fibers along with phytochemicals such as saponins, flavonoids, terpenoids and also vitamins, minerals and  $\beta$ -glucan which contributes to the antioxidant, antidiabetic, anti-inflammatory, antiobesity, anticancer, antibacterial, antiaging, anti-fatigue and hyperlipidemia effects. The researcher has shown that *H. vulgare* is an efficient herb, when included in diet gives remarkable preventive and curative effects. The database used to summarize the potency of the drug are PubMed, Scopus, Google Scholar and Web of science. The review creates a wide ranging scope for the researchers to explore the potential of *H. vulgare* in terms of toxicity, therapeutic value, biomolecules and its biological efficiency.

**Keywords:** Yava, hypoglycemic, antiurolithiasis, antiapoptic, aphrodisiac

## 1. INTRODUCTION

The oldest and most widely grown cereal crop in the world, belonging to grass family is *Hordeum vulgare* Linn. (Fam. Poaceae). It is known as yava, barley, sukhadhanya and is used in Indian traditional system of medicine. Around 70% barley production is used as animal fodder and 30 % as primary material for beer production, beverages and in food. According to USFDA and Health Canada, intake of barley 3g/day lowers the blood cholesterol level and reduces cardiovascular risk. Consumption of whole grain barley is known to regulate the blood glucose levels. The Egyptian, Greek and Roman literatures had signified the dietary and medicinal values of *Hordeum vulgare* Linn [1]. In dietary form it is used for obesity, diabetes and leprosy [2, 3]. The seeds are also used to treat and stop the growth of urinary stones and hyperuricemia.[4, 5] The studies indicate that the drug has potential health benefits when included in regular diet, therefore, it was found worthwhile to compile a detailed commentary on the drug which may prove helpful to researchers to explore *H. vulgare* in terms of toxicity, therapeutic value, biomolecules and its biological efficiency.

### 1.1 Traditional uses

Kirtikar *et al.* 1980, [6] denoted the traditional uses of *H. vulgare* as, an agent mostly used in

bronchitis, asthma, ulcers and urinary discharges. The drug is used as demulcent, laxative, catarrhs of throat, diuretic, aphrodisiac, antidiarrheal and in urinary tract disorders [7]. *H. vulgare* has properties like astringent, digestive, expectorant, febrifuge, hypocholesterolemic, emollient, refrigerant, sedative, stomachic, tonic and used as a poultice for burns and wounds. The seeds have been significantly used in treatment of health alignments related to blood, skin, liver and intestine. It is thought to be an efficient emollient, anti-fatigue, expectorant, digestive, anti-inflammatory, antioxidant, diuretic, aphrodisiac, astringent, antiviral, antiprotozoal, antimutagenic and demulcent. Females in Afghanistan eat the flowers for contraception.[8] Oral intake of decoction of fruits is in practice in Argentina for urinary and respiratory infections and also for diarrhea while in China it is used for diabetes. Iran people use flour as food, decoction of seeds is used as emollient, diuretic, antipyretic. It is used in diarrhea, nephritis, hepatitis, gout, bladder and internasal inflammation and applied in ulcers and hemorrhoids, in Iran. Compressed seeds are used in Italy to sooth rheumatic pains while infusion is used as galactagogue [9].

Hot water extract is used by Koreans, in influenza, cough, diarrhea, dysentery, measles, beriberi, jaundice, diuretic, nephritis, and in female contraceptions. The decoction is consumed in Guatemala for erysipelas and dermatitis. China and Argentina utilizes decoction of seeds for diabetes and diarrhea. Infusion of seeds is used in US for gastrointestinal disorders and colic pain. [2] The other main uses are malting, brewing and animal feed [6].

### 1.2 Traditional combinations

Decoction of *H. vulgare* seeds with pears, apples and figs shows anti-cough property [10]. Roasted seeds (125 gms) with *Elettaria cardamomum* *Cicer arietinum* three times a day controls blood glucose level [11]. Flour is used in plasters to soothen joint pains in rheumatism and gout. Powdered seeds along with water and sugar three times a day is used in jaundice and hepatitis. [12] Hartwell denoted *H. vulgare* as anticancer for stomach, breast, uterus, sclerosis and parotid gland tumors. Cataplasms derived from the seed are believed to help cancers [10]. The literature proved *H. vulgare*, as a potent drug, which when utilized in daily diet may provide several protective and curative health benefits.

### 2. Botanical description

*H. vulgare* is an erect annual grass around 50-100 cm high with flaccid, acuminate and

linear leaves having sessile spikelets in two or more rows. Roots are brown in color, fibrous and leaves developed at nodes. Leaves are yellowish grey, lanceolate with linear venation. Stem is smooth, thick and flattened generally hollow between the nodes and grows upto 5-7 nodes. The terminal spike is 5-6 cm long, linear, compressed and densely flowered. Glumes are short awned, two in number, containing three spikelets. The sessile spikelets are arranged on two sides of a flattened rachis. The long bracts are narrow and parallel to each other, known as glumes. The solitary flower is enveloped in lemma, known as inferior and superior palea. Grains are elliptic, 9 cm long, smooth, pointed and free or adhered with plea, lemma or both and grooved in front. Season for flowering and fruiting is February to April. Cereal are cultivated in various varieties in the area such as Sindh, Bombay Presidency and other provinces of India. [10]

### 3. Phytochemical review

*H. vulgare* is a rich source of flavonoids, saponins and terpenoids [13]. The beta-glucan and acetylcholine are the compounds responsible for anticholesterol effects and nourishment of nervous system i.e. memory enhancement; it is easily digestible due to low levels of gluten and high riboflavin, lysine and thiamin content [7]. The seeds are majorly rich

in cyanogenic glycosides such as proanthocyanidins, hordatines A and B, ubiquinones, prodelphinidin, procyanidin C2, procyanidin B3, 2  $\beta$  D glucopyranosyloxy methyl (2R) butyronitrile, hordeumin, chrysoeriol, pangamic acid, carbohydrates, protein, iron, phosphorus, and calcium [2]. According to Dhiman Anil Kumar's, Ayurvedic drug plants, leaves of *H. vulgare* contain cyanogenic glucoside, arabinogalactan (4 - 0 methylglucurono) xylan, 6'' feruloylsaponarin and sinapolysaponarin, 2''-0 glycosylisovitexin and 4' glucosyl 6'' sinapolysaponarin. The whole plant revealed presence of hordenine (*N,N*-dimethyl-triamine) along with its derivative, p-coumaroylagmatine, orientin, cynoglucosides 3 beta D glucopyranosyloxy 2 methylpropene, 4  $\beta$  D glucopyranosyloxy 3 hydroxyl 3 hydroxymethylbutyrobtrile (K. Singh *et al.*, 2023) [10]. The whole plant is rich in luteolin glycoside, isoorientin-7-*O*-glucoside (lutonarin), flavones, glycosides- orientoside, hordenine and its derivative, pyrrolidine, 4 – beta – D – glucopyranosyloxy – 3- hydroxyl –

3- hydroxymethyl- butyrobtrile, 4-*O*-linked beta-D-glucopyranosyl units and 3-*O*-glucopyranosyl units, cynoglucosides-3- beta-D – glucopyranosyloxy- 2- methylpropene (Panizo-Casado *et al.*, 2020) cynoglucosides-3-beta-D-glucopyranosyloxy-3-methylbutyroe-1, cyano-3-beta-D-glucopyranosyloxy-2 methylpropene and coumarins such as *m*-coumaric acid, *o*-coumaric, *p*-coumaric acid. The other compounds prominently observed are hydroxycinnamic acid, chlorogenic acid, ferulic acid, *p*-hydroxybenzoic acid, protocatechuic acid, 5-hydroxyferulic acid, salicylic acid, vanillic acid, apigenin, catechin, saponarin and cyanadin [14, 15]. Highland barley contains various nutrients, such as carbohydrates, vitamins, minerals, polyphenols, flavonoids, phenolic compounds, and  $\beta$ -glucan (Table 1-2). This contributes to the antidiabetic, anti-inflammatory, antiobesity, anticancer, antibacterial, antiaging, anti-fatigue and hyperlipidemia effects [16].

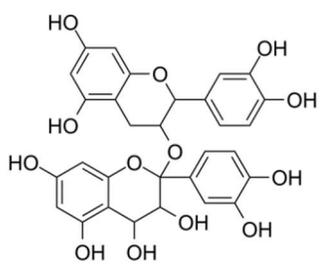
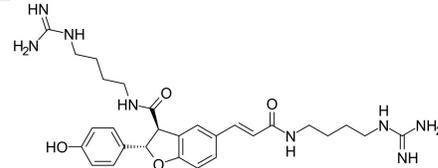
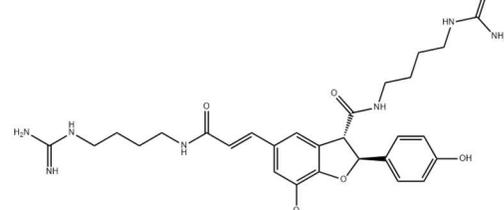
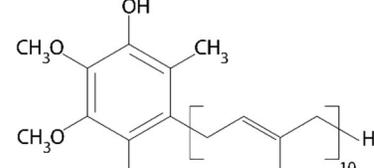
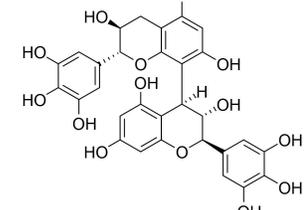
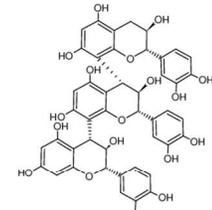
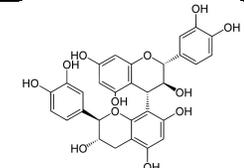
Table 1: Overview of phytoconstituents present in *H. vulgare*

Phytoconstituents	Proportion
Protein	Proteins 12-14%
Carbohydrates	Starch 70-80%
Minerals	Potassium, phosphorous, magnesium, iron
Vitamins	Thiamin, niacin, riboflavin, pyridoxine
Fats	Fats around 2-3%
Enzymes	Amylase, protease, lipase, catalase, cellobiase, diastase, lichenase, mannase, manniase, oxidase, peroxidase, and phytase
Sugars	0.8 %
Dietary fiber	15.6 %

Amino acids	Arginine, histidine, lysine, tyrosine, tryptophan, phenylalanine, cysteine, methionine, threonine, leucine, isoleucine, valine, glycine,
Antioxidants	Lignans, phenolic compounds
Saturated fatty acids	Palmitic (16:0), linoleic (18:2), and linolenic (18:3) acids [35]
Phospholipid	Phosphatidylcholine and phosphatidylethanolamine
Free sterols	Campesterol (15%), Stigmasterol (23%), Sitosterol (62%)

Table 2: Bioactive phytochemicals in *H. vulgare*

Compounds	Structure																
Phenolic acids																	
Phytosterols																	
Flavonoids																	
Tocol (Tocopherols), tocopherols, tocotrienols	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Name</th> <th>R<sub>1</sub></th> <th>R<sub>2</sub></th> <th>R<sub>3</sub></th> </tr> </thead> <tbody> <tr> <td>Tocopherol</td> <td>CH<sub>3</sub></td> <td>CH<sub>3</sub></td> <td>CH<sub>3</sub></td> </tr> <tr> <td>Tocophenol</td> <td>CH<sub>3</sub></td> <td>H</td> <td>CH<sub>3</sub></td> </tr> <tr> <td>Tocotrienol</td> <td>H</td> <td>H</td> <td>H</td> </tr> </tbody> </table>	Name	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	Tocopherol	CH <sub>3</sub>	CH <sub>3</sub>	CH <sub>3</sub>	Tocophenol	CH <sub>3</sub>	H	CH <sub>3</sub>	Tocotrienol	H	H	H
Name	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>														
Tocopherol	CH <sub>3</sub>	CH <sub>3</sub>	CH <sub>3</sub>														
Tocophenol	CH <sub>3</sub>	H	CH <sub>3</sub>														
Tocotrienol	H	H	H														
Lignans																	
Folates																	
Cyanogenic glycosides																	

<p><b>Proanthocyanidins</b></p>	
<p><b>Hordatines A</b></p>	
<p><b>Hordatines B</b></p>	
<p><b>Ubiquinones</b></p>	
<p><b>Prodelphinidin</b></p>	
<p><b>Procyanidin C2</b></p>	
<p><b>Procyanidin B3</b></p>	

## 4. Pharmacological review

### Antidepressant effect

The antidepressant effect of barley was studied on mice using force swim test. The animals were given oral dosage of leaves (400, 1000 mg/kg) against the standard imipramine (100 mg/kg). Parameters assessed were expression of mRNA, glucocorticoid receptors, and brain neurotropic factors using PCR. Barley leaves represented significant effect at both the dose, mediated by reduction of NGF in hippocampus [17]. *H. vulgare* and fluoxetine at the dose of 200 mg/kg, p. o. and 20 mg/kg, i. p. respectively when given to the mice 4 weeks' prior of reserpine (2 mg/kg, i. p.) treatment and further, assessed for the behaviors with respect to tail suspension test, forced swimming test, novel place/object recognition, hole-board test, social interaction test, stereotype movement and spontaneous locomotor movement (SLMA) indicated significant antidepressant effects [18].

### 4.1 Antiuroolithiasis

The wistar albino rats were induced with ethylene glycol for 28 days in drinking water, to develop urolithiasis. The ethanolic extract was analyzed for its preventive (1<sup>st</sup> to 28<sup>th</sup> day) and curative (15<sup>th</sup> to 28<sup>th</sup> day) effects. The parameters assessed were renal injury, urine volume, uric acid, urea, oxalates, calcium and phosphates and found to have

significant effects as preventive and curative treatment [4].

### 4.2 Antioxidant

The ethanolic extract of *H. vulgare* has represented significant reduction in lipid peroxidation and rise in superoxide dismutase and catalase [4]. Aqueous methanolic extract of kernels was evaluated for total phenolic content, oxygen and hydroxyl radical scavenging efficiency, lipid and cholesterol oxidation and antiproliferative property using colorectal adenocarcinoma cell line. The kernels were proved to possess antioxidant, antiproliferative and antiradical activity [19]. The malt extract, in vivo and in vitro has ability to scavenge free radicals and protect against biological macromolecular oxidative damage. It also decreases activities of antioxidant enzyme such as carbonyl content and malondialdehyde levels. The water extracts of roasted and unroasted barley when evaluated for antioxidant activities using linoleic acid and liposome model system which indicated that unroasted samples showed markable protection against deoxyribose and proteins damage [19]. Barley grass contains alpha-tocopherol succinate is considered a potent inhibitor of cancer such as prostate cancer, leukemia and brain tumors [21]. Barley grass juice is suggested to be a potent antioxidant [13, 22].

### 4.3 Antidiabetic activity

The hydroalcoholic extract and protein rich fraction of *H. vulgare* seeds was investigated on normal and STZ (55mg/kg i.p.) induced diabetic rats, which effectively at the dose of 0.25 and 0.5 g/kg diminished blood glucose levels of diabetic rats after 11 days treatment [23]. A study including patients undergoing dietary treatment without medication for postprandial hyperglycemia indicated improved glycemic control on intake of barley mixed rice [24]. The prolamine fraction and protein isolate of barley revealed the highest total phenolic content, ACE inhibitor activity, antioxidant activity and  $\alpha$ -amylase inhibitory activity [25]. The ethanolic extract signifies protective effect STZ induced diabetic rats against diabetic nephropathy and a potent antioxidant [26].

Aqueous alcoholic extract of seeds and protein enriched fraction was estimated for its activity against STZ induced diabetes (55 mg/kg) i.p. Male wistar rats were treated with the extract and fraction for 11 days at the dose of 0.1, 0.25, 0.5 g/kg and 0.1, 0.2, 0.4 g/kg respectively using glibenclamide as standard. Protocol represented reduction in blood glucose level concluding diabetes control on long term consumption [23]. Oral administration of sprout juice of barley reduces glucose levels and increases lipid

profile [27]. The drug has soluble fibers, especially beta-glucans; it helps to lower cholesterol and controls blood sugar [10].

### 4.4 Anti-inflammatory activity

The crude extract and fractions were prepared and studied for inhibition of platelet aggregation using turbidometry, arachidonic acid metabolism using radioimmunoassay, and antioxidant effect using commercial kit and spectrophotometer. Results revealed antagonistic effects on platelets aggregation, LOX and COX pathways. This suggests anti-inflammatory and cardiovascular effects with like mechanisms. The inflammation induced by lipopolysaccharide was found to be inhibited by methanolic extract of the aerial parts of *H. vulgare* [1].

### 4.5 Cardioprotective and hepatoprotective activity

The influence of non-starch polysaccharide source barley and wheat food was examined on 21 mild hypercholesterolemic men.  $\beta$  glucan from barley, source of soluble fiber caused significant fall in total cholesterol and low density lipoprotein concluding positive effects of dietary fibers from barley [28]. Flour 44g/day when administered to adults having hypocholesteremia revealed decrease in total cholesterol and LDL [29].

Adult male wistar rats fed with high fat diet to induce obesity when treated with *H. vulgare* grass juice at the dose of 200 and 600 mg/kg for 60 days indicated improved lipid profile. The function of markers like AST, ALT, ALP was found increased and the expression of PPAR-gamma and caspase 3 was decreased. The histopathological studies of liver and carotid artery revealed reduction in atherosclerosis and conserved hepatocytes [13]. The grass at dose of 200 and 400 mg/kg on high fat diet mice indicates reduced obesity, lipidemia, fats, organ enlargement, oxidative stress and prove helpful in liver injury. Ethanol-induced liver damage and acetaminophen-induced liver damage in rats was assessed using methanolic extract of seeds of *H. vulgare* revealed significant hepatoprotective effect [28, 29].

#### 4.6 Anti-mutagenic activity

Dried talbinah (soup prepared from barley) was prepared on extraction with 80% methanol. The extract was tested against gram positive bacteria and fungi; it revealed reproducible strong bacteriostatic and bactericidal effects. The antimutagenic activity was found significant at all doses (250, 500, 1500, 2500 µg/mL) [30]. The studies revealed 0.25 to 1.03 µmol/g total α tocopherol content in talbinah prepared using 2 tablespoon of barley flour in water for 10-

15 mins. shows better antimutagenic activity in 2500 µg/plate concentration of *S. typhimurium* TA98 [31]. The DNA damage in the cells was reported to be protected by 3,4 dehydroxybenzaldehyde present in the hot water extract of *H. vulgare*. This extract exhibited inhibitory action on induced tumor by blocking damage due to oxidative stress, cell death and apoptosis [32]. Barley bran used in mediterranean diet when assessed for its effects on splenocytes proliferation, caused inhibition in cancer cell proliferation. The *n*-hexane and aqueous, methanolic extract indicated rise in lymphocyte proliferation, pinocytosis activity of macrophages, caused lower levels of TH2 cytokine, T regulatory cytokine and high levels of TH1 cytokines i.e. (IL-4) (IL-10) (IFN- γ, IL-2) indicating immunomodulatory activities and anti-cancer activity [33].

#### 4.7 Antiprotozoal Activity

A double blind, randomized trial included 70 jaundice infants. Control group was treated with phototherapy i.e., LED light exposure and tropical barley flour. The mean bilirubin level was found higher in control group which could prevent severe complications of bilirubinemia [34].

#### 4.8 Obesity

*H. vulgare*, a multinutrient food grain is rich in nutraceuticals such as conjugated linolenic

acid, curcumin, polyunsaturated fatty acids and psyllium fiber which work as efficient antiobesity agent [13].

#### 4.9 Diuretic activity

Decoction of dried seeds was administered at the dose of 1g/kg to rats nasogastrically, represented efficient diuretic activity [26, 35].

#### 4.10 Lactagogue

Polysaccharides in barley were found responsible for rise in prolactin revealing antilactagogue effects [36, 37].

### 5. CONCLUSION

The present study provided the knowledge of the huge therapeutic potential of *H. vulgare* in terms of its phytochemical and pharmacological aspects. The thorough screening of literature has defined *H. vulgare* as a better substitute for proteins, minerals, fibers and carbohydrates with high nutritional value. Therefore, it can be said that, when consumed in daily diet it may provide several protective and curative health benefits.

#### Conflict of interest

The authors have no conflict of interest.

#### Acknowledgement

The authors wish to acknowledge Department of Pharmaceutical sciences Rashtrasant Tukadoji Maharaj Nagpur university for providing facilities for conduction of present work.

### Abbreviations

PCR: Polymerase chain reaction

NGF: Nerve growth factor

STZ: Streptozotocin

LDL: Low density lipoprotein

LOX: Lipoxygenase

COX: Cyclooxygenase

AST: Aspartate amino transferase

ALT: Alanine transaminase

ALP: Alkaline phosphatase

IL-4: Interleukin 4

IL-10: Interleukin 10

IL-2: Interleukin 2

IFN-  $\gamma$ : Interferon gamma

**Funding resource:** Rashtrasant Tukadoji Maharaj memorial fellowship, RTM Nagpur University Nagpur, Maharashtra.

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