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Importance of Barley (*Hordeum vulgare* Linn.) as food and medicine from past to present: A brief overview

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ABSTRACT

Barley (*Hordeum vulgare* L.) is one of the most ancient cereals that has been used for food and medicinal purposes since the distant past. Historically, Egyptian, Greek, Roman, Chinese, and Indian civilizations have relied heavily on barley as a nutritious food source as well as a therapeutic agent for various ailments. Its health-protective activity is endorsed by many religions and traditional medicines including the Unani system of medicine. In Unani medicine, barley is prescribed for many health conditions such as anti-inflammatory, wound-healing, anti-diabetic, anti-obesity, etc. In Prophetic medicine, barley is prescribed to be consumed as *talbina* (porridge made from barley flour, milk and honey) to remove weakness of the heart. Because of its unique chemical composition and health effects, barley is gaining unprecedented attention from food scientists, dieticians, food industries and consumers throughout the world. In comparison with other cereal crops, like wheat, rice and maize, barley grains are superior in dietary fiber (such as β -glucan) and tocopherols, which are valuable for human health. It is well-documented that diets rich in these chemical compounds can protect against hypertension, cardiovascular disease, and diabetes. Owing to the present knowledge of barley's health-promoting constituents, it can also understand why it was a popular food ingredient in the diets of our ancestors. This review article attempts to briefly summarize the origin, classification, and description of barley grain besides its use as a food and medicinal supplement from ancient times to the present era with scientific evidence.

Keywords: Barley, Beta-glucan, Functional food, *Hordeum vulgare*, Unani medicine.

INTRODUCTION

Barley (*Hordeum vulgare* Linn.) is one of the earliest domesticated cereal grain crops that has served as a sustaining food source in the evolution of humans [1,2]. In ancient cultures, it was a major source of fermented foods, especially in the form of beverages, as well as soups, porridges and breads [3]. Barley is frequently referred to as one of the most adaptable crops and is also considered a poor man's crop because of its low input requirements like irrigation, fertilizers and insecticides, and better adaptability to cold, drought, salinity, alkalinity and marginal lands [4,5,6,7]. It can be grown in wide-ranging topography like plains and hills as well as under rain-fed and irrigated ecosystems [7]. It can be readily planted in regions with severe temperature fluctuations such as in the Himalayan ranges, Ethiopia, Tibet, and Morocco [8]. Since ancient times, barley has been used as human food but evolved primarily into a feeding, malting, and brewing grain due to the ample availability of more palatable food crops such as wheat and rice [9]. It is presently utilized as fodder in developed countries, and as a staple diet in developing countries, whereas malt and beer constitute the most important application from an economic standpoint. In recent times, about 70% of barley has been employed for feeding livestock, 21% has been utilized for malting, brewing and distilling industries, and 6% has been consumed as human food [10]. However, there is renewed interest in barley as a functional food throughout the world due to advancements in consumer awareness of healthy and natural foods and a better understanding of the chemical makeup of grain and its impact on human health. This article briefly summarizes the origin of cultivated barley, as well as its use as food and medicine from ancient times to the present.

ORIGIN OF CULTIVATED BARLEY

According to archaeological findings, barley (*Hordeum vulgare* Linn.) was first domesticated in the Fertile Crescent about 10,000 years ago from its wild relative *Hordeum spontaneum* [11,12]. During the process of domestication, barley gradually attained the traits that facilitated agricultural productivity [11]. Selection of key traits like six-rowed spike, non-brittle rachis, and naked caryopsis were associated with the transition from wild barley to cultivated barley. Reduced vernalization requirement and photoperiod insensitivity were the core traits responsible for the spread of barley to different geographic areas far from its actual place of origin [1]. It is widely accepted that it took many millennia for wild barley to develop into a cultivated crop [13].

The theory that barley was first domesticated in the Fertile Crescent in the Near East has been widely accepted but the evidence presented over the past few years suggests a hypothesis for a multicentric origin for this crop. *H. spontaneum*, the wild progenitor of cultivated barley has been found in several distinct regions other than the Fertile Crescent, including Morocco, Algeria, Libya, Egypt, Crete, Ethiopia, and Tibet. Moreover, several studies have conveyed clear genetic differentiation among barley populations from Eastern and Southern Asia and those from Western Asia, Europe, and North Africa. As indicated by recent molecular evidence, Central Asia along the eastern border of the Iranian Plateau may be another location for barley domestication events^[14]. The Himalayas, Morocco, and Ethiopia have also been proposed as centres for barley domestication^[12]. Studies regarding wild and cultivated barley genotypes suggested that Tibet was an area where barley domestication occurred, and thus further confirmed the multiple origins of barley^[14,15,16].

CLASSIFICATION

Barley (*Hordeum vulgare* L.) is a self-pollinating^[17], diploid species belonging to the tribe *Triticeae*, the genus *Hordeum*, and the family *Poaceae* (also known as *Gramineae*)^[11]. It can be classified as food, feed or malting, spring or winter, two-rowed or six-rowed, and hulled or hullless types^[5,18,19]. Winter or spring varieties differ chiefly in their vernalization requirements^[19]. Depending on the number of rows of grain in the barley heads, barley is classified as two-rowed barley and six-rowed barley. In the two-rowed type, the head of the stalk contains two rows of barley kernels and only the middle spikelet is fertile. Each stalk produces 15-30 kernels. In six-rowed barley, the lateral spikelets are also fertile and the head of the stalk contains six rows of barley kernels. Each stalk produces 25-60 kernels^[20]. Hulled and hullless types are distinguished based on the presence or absence of a hull tightly adhering to the grain^[5]. In hulled types, the hulls (husks) are tightly attached to the pericarp and processed minimally to remove the tough inedible outer hull, while in hullless types these structures are loose and fall out during the harvesting process and do not require any processing to remove the hull^[21]. Barley is further characterized as normal, waxy or high amylose starch types, high lysine, high β -glucan, and proanthocyanidin-free based on the grain composition^[5]. Barley of different classes differ in their physical and compositional properties and accordingly have different processing characteristics and end-use quality.

DESCRIPTION OF THE BARLEY GRAIN

Barley kernel is mainly composed of husk, pericarp, testa (seed coat), aleurone layer, endosperm, and embryo^[10]. Husk which accounts for approximately 14% of the grain is mainly composed of β -glucan, cellulose, arabinoxylan, lignin, and vitamins^[22]. By fully enclosing the entire seed, the pericarp and the testa protect the seed against external injuries^[23]. The aleurone layer is generally few-celled thicker and encloses the entire endosperm. Storage protein is present in the form of aleurone granules in aleurone cells^[24]. It is rich in lipids, proteins, minerals, B-type vitamins, such as niacin and folates, β -glucan, and arabinoxylans^[24,25]. This layer plays an important role in the expression of degrading enzymes of the endosperm during germination including β -glucanases, α -amylase, α -glucosidase, limit dextrinase, proteinases and peptidases^[23]. The endosperm is the next part which makes up about 70-83% of the seed and constitutes starch embedded in a protein matrix and occupies most of the grain composition^[22]. It is the major storage area for energy, protein, enzymes, and other nutrients required for the germination and growth of the plant. The endosperm cell wall is made up of non-starch polysaccharides (NSP) primarily β -glucan and arabinoxylan^[26]. The embryo, also known as the germ, is the most important component of the grain for filial generation and makes up about 3% of the seed^[22]. It is rich in lipids, proteins, cellulose, sugar, vitamins, minerals, enzymes and phytochemicals^[22,25].

USE OF BARLEY IN ANCIENT TIMES

As Food

Regardless of the exact location where barley originated, the important fact is that the cultivation of barley played a crucial role in human health and nutrition as well as in the development of many civilizations across the ages. Historically, the Middle East, North Africa, northern and eastern Europe (Iran, Morocco, Ethiopia, Finland, England, Denmark, Russia, and Poland), as well as several regions of Asia (Japan, India, Tibet, and Korea) have relied heavily on barley as a nutritious food source^[9]. It was a common ingredient in bread preparation in both ancient Egypt and Mesopotamia^[2] and has been found as general food for Roman gladiators who were known as 'hordearii' or 'barley men'. They ate it for greater strength and stamina^[5,13,27]. Greeks trained their athletes on a diet based on barley^[28]. In Ethiopia, barley has been grown for the last 5,000 years and is called the 'king of crops' owing to its vast range of applications and adaptability for preparing numerous traditional dishes (such as *Kinche*, *Injera*, *Beso*, *Genfo*) and beverages for daily consumption or holidays and celebrations^[29]. Bread prepared from barley and rye flours was the basic meal of peasants and poorer people in England during the 15th century AD. A six-rowed barley variety called bere was fairly common in the Orkney Islands of northern Scotland for grinding into flour and the milled flour was utilized for making Bannocks, breads and pastries^[13]. Pearled barley grains were used in many foods, including soups, pudding, porridges, and sausages in Denmark, Sweden, Finland, and England^[2]. The use of *bolon* or *boulon*, a kind of ancient barley bread still survives in Jura, a mountainous region of France^[3]. Barley has been and continues to be an essential part of the Tibetan's people diet. *Tsampa*, made from roasted grain barley flour mixed with salty butter tea, has been their traditional staple food with high energy and nutrition for thousands of years^[30]. Asia has a long history with barley tea, which is still consumed in many parts of the continent, such as Japan, China, and Korea. It is prepared traditionally from whole roasted barley grains and consumed either hot or cold as a thirst quencher in the summer^[3,31]. In the Indian subcontinent, The Indus Valley was an important and early agricultural center where wheat and barley served as the principal foods of the Harappan civilization (3200-200 BCE)^[13].

As Medicine

The oldest documented proof of barley used as a medicine has been found from ancient Sumer in Lower Mesopotamia around 2700 BCE inscribed on clay tablets that provided a prescription for a poultice composed of dried powdered herbs and fruits blended with barley ale and oil. Barley has been considered an important drug since the old days in Egyptian, Greek, Roman, Chinese, and Indian civilizations for its therapeutic actions in various ailments. In ancient Egypt, it was widely prescribed in different forms for various maladies such as preparations made of ground barley, usually mixed with oil were used as purgatives, applied to wounds, used as anal suppositories and phlegm remover, and to treat eye disorders^[13]. Additionally, barley is mentioned in the Berlin Papyrus, an ancient Egyptian Medical Papyrus that describes a pregnancy confirmation test using barley and wheat^[32]. The ancient Greeks utilized the mucilage derived from this cereal (known as *ptisane*) to alleviate gastrointestinal inflammation^[27]. Hippocrates also supported the medicinal value of barley foods and drinks. He compiled a book on barley water, referred to as "*Kitab Ma'ul Shaeer*" in Arabic^[33]. Aulus Cornelius Celsus (25 BC-50 AD), the Roman encyclopedist in his work *De Medicina* recommended the use of enema with barley, wheat, milk, eggs, and deer marrow in patients suffering from dysentery or gastric disorders. When describing stomach problems, he also stated that the introduction of either barley or spelt gruel into the bowel from below is the last resource that supports the patient's strength^[34]. Pliny the Elder (23/24 BC-69 AD), who was a Roman philosopher and author of an imperative encyclopedia namely *Naturalis Historia*, suggested that boiled barley can be used as a plaster to soften tumors, fill voids left by ulcers, and enhance the appearance of unsightly scars and

blemishes [35]. He is also cited as saying that consuming barley would heal stomach ulcers [13]. During the Golden Age of Islamic medicine (also known as Unani or Greco-Arab Medicine), which spanned from approximately 8th to 13th century AD [36], Muslim physicians from the Arabian Peninsula, Persia, Iran, and surrounding countries widely favored the use of barley as a nutritious food and medicinal remedy. Zakariya Razi (Rhazes, 865-925 AD) in the 11th volume of his imperative compilation '*Al-Hawi fit Tib*' (The Comprehensive Book of Medicine), mentioned the use of barley flour to be applied locally to the joints in case of gout and arthritis to relieve pain and inflammation [37]. Ibn Sina (Avicenna, 980-1037 AD) described the use of barley in his treatise 'The Canon of Medicine' for a variety of disorders including fever, respiratory disorders, musculoskeletal disorders, dermatological disorders, etc. [38] Ibn Hubal Baghdadi (1122-1213 AD) in '*Kitab al-Mukhtar fit Tib*' (The Book on Choice of Medicine) recommended the use of decoction made with barley and some other drugs in the form of eye drops to treat conjunctivitis [39]. Ibn Baitar (d. 1248 AD) in his manuscript '*Al Jamai-ul-Mufradat al Advia wa al Aghzia*' (Compendium on Simple Medicaments and Foods) prescribed various formulations of barley to treat numerous illnesses such as headache, conjunctivitis, pain and inflammation of the throat, acute swelling of joints and gout, scrofula, chronic swellings, flatulence, diarrhoea, fever, erysipelas, skin eruptions, hyperpigmentation of the skin, itching, etc. [40] The description of barley in Prophetic medicine strengthens its nutritional as well as medicinal significance [27]. Whenever a member of the family the Prophet Mohammad (PBUH) fell sick, it was ordered that *talbina* (porridge made from barley flour, milk and honey) should be prepared for him. He stated that "it removes the grief of the patient's heart, removes its weakness as anyone you remove the dirt from your face after washing it" [41]. Research studies also revealed that *talbina* has a potential nutritional and therapeutic impact on human health. It lessens depression, enhances mood, modulates the immune system, and functions as a good diuretic to help the body flush out toxins [42].

USE OF BARLEY IN THE PRESENT ERA

As Food

As diet-related human health issues (type 2 diabetes mellitus, obesity, coronary heart disease, and certain cancers) have become more prevalent in recent times, interest in incorporating barley into diet has grown significantly. For food consumption, the barley grain is dehulled, pearled, roasted, rolled, or ground to flakes, grits, and flour, and then incorporated into a variety of foods that are specific to various parts of the world [2]. Barley flour is usually prepared by milling pearled, covered or naked barley and can be used for making wheat-based products (bread, flatbread, cakes, muffins, cookies, pasta, noodles, extruded snack foods) and for producing bread as a component of composite flours [10,19]. In Western countries, pearled barley is used in breakfast cereals, stews, soups, bakery flour blends, and baby foods. In the Middle Eastern and North African countries, it is used in bread (as flour) and ground as porridge [9]. Barley flour is usually prepared by milling pearled, covered or naked barley and can be used for making wheat-based products (bread, flatbread, cakes, muffins, cookies, pasta, noodles, extruded snack foods) and for producing bread as a component of composite flours [10,19]. In India, barley is consumed as a staple food grain in the form of *chapatti*, *sattu*, *daliya* in Uttar Pradesh, Bihar, parts of Madhya Pradesh, Rajasthan and Haryana [43]. In addition, barley is consumed in the form of energy drinks like barley water, bournvita and horlicks, and biscuits, prepared with malt extract [7].

Studies have revealed that the addition of barley to various food preparations significantly increased the content of bioactive compounds. Sharma *et al.*, in a study showed that barley flour incorporation increased the total phenolic content, antioxidant activity, reducing power, and total flavonoid content in the blends [44]. Narwal *et al.*, used a hull-less barley variety to enhance the nutritive value of *chapatti* and biscuits made from wheat flour. A significant increase in β -glucan content and antioxidant activity of flour blends

and their products was observed at a 30% blending level [45]. Due to their high digestibility, barley flour *chapattis* can be given to patients with fever, stomach disorders and diabetes. The same amounts of protein, fat, and minerals with acceptable organoleptic properties may be found in barley *rabadi* made by fermenting barley flour and buttermilk. It may be used to enhance the rural nutritional status of rural people [43].

As Medicine

The U.S. Food and Drug Administration approved a health claim for barley in 2006 based on studies showing that regular barley consumption could reduce blood cholesterol and, thus prevent or manage cardiovascular disease [24]. Further, the USFDA has recommended a daily intake of at least 0.75 g per serving or a total of 3g of beta-glucan from whole-grain barley or barley products to achieve the claimed effect [46]. European Food Safety Authority (EFSA) also documented the cause-and-effect relationship between the consumption of barley beta-glucans and the lowering of blood LDL-cholesterol concentrations [47]. Scientific studies have revealed that barley has a chemical composition extremely useful for human health since it contains complex carbohydrates, low-fat, balanced amount of proteins, vitamins, and minerals, as well as a myriad of bioactive compounds (phenolic acids, flavonoids, lignans, phytosterols, folates, tocopherols) that play numerous biological activities such as prebiotic, probiotic, hypoglycemic, hypocholesterolemic, immunomodulatory, anti-inflammatory, anti-obesity and anticancer activities [8,25,48,49]. It has antioxidants that prevent cell damage from free radicals, improve immunity, fight against infection, and prevent the aging process [50]. Barley's high fiber content aids in the passage of food through the gut and supports a good balance of gut flora, both of which are important for proper digestion [51]. It is unique among cereals in containing a high concentration of β -glucan. The effectiveness of β -glucan in protecting against hypertension, stroke, cardiovascular disease, and type 2 diabetes is well documented [24]. The resistant starch of barley helps to reduce blood glucose levels as well as improves lipid profile and bowel health [52]. In addition to having anti-oxidant properties, tocopherols found in barley modulate the immune system, reduce the risk for cardiovascular diseases and stroke [49], and can suppress cancer by its molecular mechanisms of cellular proliferation, apoptosis, angiogenesis, metastasis, and inflammation [53]. Additionally, barley has been reported to possess anti-inflammatory [54], wound-healing [55,56,57], gastroprotective [58,59,60], hepatoprotective [61], neuroprotective [62], nephroprotective [63] and skin-booster activities [64]. Moreover, barley is beneficial when applied locally to treat burns [55,56], dermatitis [65], hyperpigmentation [66], etc. due to its anti-inflammatory, wound healing, and anti-melanogenic properties.

CONCLUSION

Based on the information retrieved above, it can be concluded that barley is one of the most important cereals that has been utilized by mankind through centuries as food and medicine. Various traditional barley foods, drinks and medicinal preparations are mentioned in the article used by different civilizations for nutrition, good health, and treating a number of ailments since the olden days. Today, scientific studies unearthed numerous bioactive compounds inherent in the barley kernel that exhibit positive health effects on the human body and help in the prevention and management of diseases. Owing to the present knowledge of barley's health-promoting constituents, the use of barley as food and medicine by our ancestors appeared to be reasonable. Barley is rich in beta-glucan, tocopherols, vitamins, minerals and bioactive phytochemicals which induce low glycaemic response and cholesterol and high antioxidant activity, thus aiding in the effective control of diet-related health issues such as type 2 diabetes mellitus, obesity, chronic heart disease and certain cancers. Discussing the uses and health benefits of barley from ancient times to the present era, this review article tries to sensitize the use of barley in day-to-day meal habits to lead a hale and hearty life.

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Conflict of interest

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