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Barley Food Development and their Scope in India

Aisha Parween*[1] and Vidyanath Jha[2]

[1] University Department of Biotechnology, Lalit Narayan Mithila University, Kameshwaranagar, Darbhanga - 846 008, Bihar, India
[2] Retired Professor of Botany, Lalit Narayan Mithila University, Kameshwaranagar Darbhanga, Bihar, India, Former Principal, M. R. M. College, Lalbagh Darbhanga - 846 004, Bihar, India

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Abstract

Hordeum vulgare L. (barley) is one of the earliest domesticated cereal crops and has long been revered in India as a sacred and health-promoting grain. Despite its historical and cultural importance, barley cultivation declined during the Green Revolution era due to the expansion of high-yielding wheat varieties and changing dietary preferences. In recent decades, production has stabilized largely because of demand from the malt industry; however, renewed scientific evidence highlighting its nutritional and therapeutic benefits has repositioned barley as a promising functional food crop. This review compiles the present status of barley research in India with special emphasis on its potential in the food sector and outlines future prospects for its promotion as a health cereal. Barley is particularly valued for its high content of soluble dietary fibre, especially mixed-linkage β-glucans, which have been clinically associated with reduced serum cholesterol, improved glycemic response, and enhanced colon health. In addition to β-glucans, barley contains significant levels of amylose, arabinoxylans, essential minerals (Zn, Fe, Se), and diverse phytochemicals including phenolic acids, flavonoids, anthocyanins, and vitamin E compounds, contributing to strong antioxidant activity. Comparative analyses indicate that barley exhibits higher total phenolic content and antioxidant potential than several commonly consumed cereals, supporting its role in prevention of cardiovascular diseases, type 2 diabetes, and certain cancers. The review also highlights key physical and biochemical traits important for food barley improvement, including hulless grain types for enhanced processing efficiency, high β-glucan and amylose content for lower glycemic index, improved mineral biofortification, and enhanced disease resistance. Market analysis suggests a rapidly growing breakfast cereal sector in India, dominated by oats largely imported despite barley being an indigenous, climate-resilient crop with comparable health benefits. The limited development of palatable barley-based products and insufficient consumer awareness have constrained its market penetration. Potential value-added products such as multigrain atta, biscuits, bread, flakes, and ready-to-drink sattu offer significant opportunities for industry engagement. Strategic interventions including breeding high-yielding hulless varieties, product standardization, nutritional branding, awareness campaigns, and supportive pricing policies could revitalize food barley cultivation. With coordinated efforts among researchers, policymakers, and the food industry, barley has strong potential to enhance farmer income, strengthen nutritional security, and re-establish its position as a sustainable health cereal in India.

***Key words*:** Barley, Beta-glucan, Health benefits, Amylose, Antioxidants

Barley (*Hordeum vulgare* L.) is among the earliest domesticated cereals globally and has been regarded as a sacred grain in India since ancient times. Historical literature and beliefs highlight barley as a health-promoting cereal [1]. In various regions of India, barley-based sattu is still prepared and valued for its cooling effect on the body. However, the cultivation and production of barley significantly declined from the mid-sixties to the early nineties, primarily due to the introduction of dwarf wheat varieties, assured irrigation, and shifts in dietary preferences. The area got stabilized since last two decades mainly because of increasing consumption of barley-by-barley malt industry. But now a new ray of hope is emerging with the identification of health beneficial properties of barley and barley is reviving again in the food segment [2-6]. In this article present status of barley research and future prospects in India with respect to barley as food have been briefly compiled. Barley and oats are two cereals which have higher content of soluble fibres called beta-glucans as compared to other cereal grains [7]. The beta glucans have been clinically proven.

To lower the blood cholesterol and glucose levels. It has been shown that consumption of barley and oats lead to better colon health. The consumption of oats has increased phenomenally in last few years in the breakfast cereals and is expected to grow at a CAGR of 21% from 2015 to 2021 (https://www.linkedin.com/pulse/oats-highest-growing-category-indian-breakfast-cereal-anita-patil; accessed on 09.10.2018). According to Nielsen India report oats have a 26 per cent share in the Rs 720-crore breakfast cereal market (https://www.foodnavigator-asia.com/Article/2018/05/14/Nestle-India-competes-for-bigger-slice-of-breakfast-market-share-with-new-cereal-

***Correspondence to:** Aisha Parween, E-mail: aparween133@gmail.com

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launches). As per the information (https://www.prnewswire.com/news-releases/india-breakfast-cereal-market-outlook-2022-kelloggs-india-bagrrys-marico-and-pepsico-are-the-leading-players-300503259.html) the Indian breakfast cereal market is growing with more than 17% CAGR since last five years. As per this report two kinds of breakfast cereals are available in the market, first category is hot cereals and ready-to-eat (RTE) cereals which include products like oats, oat bran, wheat bran and porridge while the second category encompasses ready-to-eat (RTE) cold cereals like cornflakes, wheat flakes, muesli, etc. As per this accessed information Indian consumers prefer hot breakfasts and therefore this segment may have more potential from market perspective. Oat grains/products are generally imported, as grain oats have limited area in India. However, barley is the indigenous grain and thrives well in the adverse growing conditions. It has comparable health benefitting properties too. Hence, it is point to ponder why barley-based products have not made that impact as Oats could do? The possible reasons and actions could be following:

i) There is little or lesser development of palatable barley-based products for Indian market. As per a report (https://www.businesstoday.in/lifestyle/health/oats-gain-popularity-at-indian-breakfast-tables/story/206925. Taste is clearly a window of opportunity for marketers to introduce new recipes, interesting mixes and different flavours. Given the inherent health benefits of oats, tastier options will surely be a winning mix, it says. Therefore, development of barley-based products which suits the taste and food habits of Indian consumers is the foremost priority area. The Indian food manufacturers must focus on development of barley-based products like multigrain *atta* for chapatti, biscuit, bread, flakes, daliya, noodles, *sattu* etc. All these products need to be standardized and flavoured to make them palatable. *Sattu* can be a ready to serve flavoured drink.

ii) Consequent upon the availability of barley-based products, there will be an urgent need for aggressive awareness campaign through media regarding health benefits of barley. In the present scenario of increasing urbanization and sedentary lifestyles, barley-based products can be a boon by providing health benefits on regular consumption of products.

iii) There is an immediate need for the development of high yielding, biotic and abiotic stress tolerant hulless food barley varieties. Hulled barley possess problem in processing as removal of hull leads to extra expenditure and some of the nutrients lying in upper layer(s) get depleted.

iv) Policy makers may also consider increasing the support price of barley as it will encourage the resource poor farmers to grow barley as *Rabi* crop and increasing production of food barley will lead to availability of health food alternates to the population in general.

Some of the physical and biochemical constituents important for food barley

There is renewed interest in the barley grain since last few years due to its health benefits and it is expected that in coming years the consumption of food barley may increase [8]. For food barley there could be certain physical and quality aspects which may be incorporated to increase its health benefits. A brief account of these traits is being presented in following section.

Hull content

The food barley should preferably be hulless as mentioned above. The presence of hull may lead to lower recovery of end product, loss of nutrients upon dehulling or pearling and palatibity issues. However, the products where very high fibres may be required like multigrain chapattis and manufacturers add extra source of fibre like *Psyllium* husk, hulled barley may be used. Though there is need to standardize the grinding in such a manner that the final product i.e. *atta* or flour remain palatable. Again, the industry may specify the hull percentage, in most of the Indian varieties the approximate range is 10-12%.

One of the problems with hulless barley is comparatively lesser yield as compared to hulled ones. One of the factors could be loss of 10-12% as husk, but similar is the situation in wheat. Barabaschi *et al*. [9] have stated that the reason for the difference in yield between hulled and hulless is not clearly understood. They have studied the effect of the *nud* gene on yield and stated that nud genes affect the hull content and did not find any pleiotropic effect on other traits. They suggested that together with the finding of a QTL contributed by the hulless barley parent, there is great scope for improving the yields of hulless barley. Djelel *et al.* [10] reported that seeding rate also affects the hulless barley yields. Thus breeding, molecular biology and agronomic interventions taken together can help improve the yields of hulless barley yields. Further incorporation of disease resistance for rusts, blight, smuts etc. may be an additional trait besides the quality requirements. The quality traits have been discussed in following sections.

Table 1 Antioxidant activity and phenolic content in barley and wheat

Genotype	Beta glucan (% dwb)	Grain type
BCU 554	7.1	Hulled
DWR 30	6.9	Hulled
DWRUB 75	6.6	Hulled
BHHS 352	6.5	Hulless
HBL 256	6	Hulless
Dolma	5.5	Hulless

Beta-glucan content

Barley and oats are two cereals blessed by nature to have a special polysaccharide, mixed linkage beta glucan (1 → 3, 1 → 4)-β-D-glucans) which have been reported to have several health benefitting properties [11]. Beta glucan in major component of endosperm cell walls and on an average contribute 70-75 % to cell wall composition. Beta glucans have been shown to reduce LDL cholesterol and triglycerides while not affecting the HDL cholesterol [12]. Shimizu *et al*. [13], have shown that consumption of pearl barley with a high beta-glucan content reduces not only low-density cholesterol but also visceral fat area. Barley has a lower glycemic index as compared to cereals like rice. These lines can serve as source of high grain beta glucan trait in hulless barley and already attempts are underway in this regard. The objective of these attempts is to develop high grain beta glucan hulless varieties with higher yields and disease resistance for plains of India.

Amylose content

As discussed above it has been shown that barley has lower glycemic index. Barley has relatively lower glycemic index as compared to several other cereals. As per *https://www.health.harvard.edu/diseases-and-conditions/glycemic-index-and-glycemic-load-for-100-foods* the glycemic index of barley is 28, Chapati (roti) has 54-62, whole wheat bread is 74, brown rice is 68, rolled oats 55 and cornflakes of 81. Thus, barley can be a perfect blend to lower the glycemic index of multigrain foods. Though beta glucans and insoluble fibres are the major contributor to lower glycemic index, amylose content also adds to lower the glycemic index.

The amylose content of barley ranges from a 24% in normal barley to an exceptionally high-45% as in glacier barley [14]. The amylose molecule provides a high fiber source with a low glycemic index. More the amylose present, lower the glycemic index would be.

Arabinoxylans

Arabinoxylans consist of a linear chain backbone of ß-D-xylopyranosyl residues linked through (1 → 4) glycosidic linkages [15]. The barley arabinoxylans content is affected by genetic and environmental factors [15]. The content of arabinoxylans in barley is comparable to wheat (5.8), lower than in rye (7.6–12%), but higher than in oats (2.7–3.5%), sorghum (1.8%) or rice (2.6%) [16]. Fleury *et al*. [17] reported that the amount of arabinoxylans in hullless barley is lower than the hulled barley and has been linked to absence of hull in naked barleys. Six-rowed barley cultivars generally contain slightly higher levels of arabinoxylans than two-rowed cultivars [17]. Recently, arabinoxylans have attracted a great deal of attention because of its biological activities such as immunomodulatory potential [18]. Information on arabinoxylans content in hulless barley could not be traced and hence there is need of basic studies on this aspect and as a quality component in development of improved hulless barley genotypes.

Essential mineral

It has been estimated that around 792.5 million people across the world are malnourished, out of which 780 million people live in developing countries [19]. To make food barley a healthy combination of nutrients, content and bioavailability of essential mineral Zn, Fe and Se needs to be increased. Biofortified crops generated through different means are need of the hour [20]. Attempts have been made to increase the Se content in barley through agronomic interventions [21]. At ICAR-Indian Institute of Wheat and Barley Research, a hulless genotype DWRB 191 for high grain zinc content and DWRB 192, a hulless genotype with higher iron content has been developed [22].

Barley phytochemicals and antioxidant activity

Besides providing basic nutrition, barley is also a store house of a number of phytochemicals. These substances have a number of biological functions and therefore called the bioactive compounds. Important groups of phytochemicals with great beneficial nutritional and health effects are phenolics, carotenoids, vitamin E compounds, lignans and β -glucan. The bioactive phytochemicals in barley have been recently reviewed by Idehen *et al*. [23]. Phenolics are the predominant compounds in cereals like barley which contribute to the antioxidant potential. Barley grain phenolics are composed of phenolic acids, flavonoids, tannins and proanthocyanidins and are concentrated in the hull, testa and aleurone. Barley can serve as an excellent dietary source of antioxidants with antiradical and antiproliferative potentials for disease prevention and health promotion [24]. Epidemiological studies have shown that regular consumption of whole grains and wholegrain products is associated with reduced risks of various types of chronic diseases such as cardiovascular diseases (CVD), type 2 diabetes and some cancers. Barley consumption has been associated with lower total & serum cholesterol, improved postprandial glucose and insulin response and reduced heart disease and colon cancer [25].

Barley has been found to have high antioxidant activity than other common cereals such as wheat and maize [26-27]. Barley grains contain much greater amounts of phenolic compounds than other cereal grains [28-29]. The coloured barley types have high anthocyanin content which are health promoting flavonoids. Purple and blue barley groups contain higher average contents of anthocyanins than black. The content of various phenolic compounds and antioxidant activity in barley are significantly affected by the growing location, the growth year and the genotype. The malting process allows better release and/ or extraction of phenolic compounds. Individual reports are also available in the literature regarding changes in the antioxidant activity and phenolic content in barley during malting [29-31]. In beer, 70 to 80% of the phenolic constituents originate from malted barley. Polyphenols and phenolic acids present in malt are natural antioxidants, capable of delaying, retarding or preventing oxidation processes and therefore are thought to have a significant effect on malting and brewing as inhibitors of oxidative damage. Other processes like sand roasting also results in significant increase in antioxidant activity [32].

Since, direct use of barley as food is very limited, it has now been used in number of multigrain products due its health benefits. Studies have shown that blending of barley in different food preparations significantly increases the level of the phenolics and other bioactive compounds. Blending of barley in wheat flour can enhance the nutritive value and the health benefits of wheat flour and its products like chapatti, bread and biscuit [32-34].

Total phenolic content of flour blends and their products was observed at 30% blending level. The processing of hulled barley is quite difficult and laborious. Therefore, the hulless barley can have the additional advantage of the minimal requirement of the processing. At home, barley flour can be easily blended with the wheat flour in order to make more nutritious and healthy products for daily consumption.

Table 2 Antioxidant activity and phenolic content in barley and wheat

Fraction		Antioxidant activity (µMTrolox Eq/g)	Total phenolic content (mg GAE Eq/g)
Wheat	Whole meal	2.0-10.0	0.2-1.2
	Bran	15th May	2.9-5.6
Barley	Whole meal	8.0-17.0	1.9-3.9

Potential barley-based health products

Multigrain atta: The hulled barley can be used to increase the soluble and insoluble fibre content of wheat *atta* (flour). This may bring down the glycemic index of chapattis, which is consumed as staple food especially in northern India.

Multigrain biscuits and bread: Incorporation of hulless barley may increase the health beneficial properties of both bread and biscuits. Preliminary trials conducted at ICAR-Indian Institute of Wheat and Barley Research has shown feasibility of barley-based biscuits. Similarly, barley malt can also be used to make flavoured biscuits.

Barley flakes: Hulless barley can be used to make breakfast cereals like flakes, however it needs to be flavoured to increase its palatability.

*Ready to drink Sattu***:** *Sattu* is a traditional drink utilizing barley and/or gram flour, however if ready to drink flavoured barley based sattu is develoed it can make a dent in health drinks.

Future directions

Food barley can be an important area of research and development in India from the perspective of farmers, industry and consumers. If consumption of food barley increases, farmers may get better prices with lesser inputs as compared to another same season crop/s. However, industry has to come forward to introduce barley-based products in the market with aggressive information on its health benefitting properties. There is an urgent need to develop hulless or naked barley varieties with comparable yield to hulled barley, better quality traits and biotic and abiotic stress tolerance. There will be challenge as under subtropical climates the grain filling period is much shorter as compared to temperate climates of Europe. Spring barley is a summer crop in Europe having longer photoperiod, congenial temperatures and longer growing duration of the crop. On the contrary in sub-tropical climates of India barley is a winter crop having relatively shorter photoperiod, externally lower temperatures sometimes frost, foggy weather with shorter growing duration. Availability of high yielding hulless barley, development/standardization of barley-based products and popularization of health benefits of barley is one of the keys to increase the income of resource poor farmers and providing the healthy foods to the people.

CONCLUSION

Barley holds immense yet underutilized potential as a functional food crop in India. Although its cultivation shifted predominantly toward malting purposes during the post Green Revolution period, emerging scientific evidence on its nutraceutical properties has re-established barley as a promising health cereal. The grain's richness in β-glucans, dietary fibre, resistant starch, arabinoxylans, essential minerals, and diverse antioxidant phytochemicals provides strong support for its role in reducing the risk of cardiovascular diseases, type 2 diabetes, obesity, and certain cancers. Its comparatively low glycemic index and superior antioxidant capacity further enhance its value in combating lifestyle-related disorders that are rapidly increasing in urban and semi-urban populations. Despite these advantages, barley's direct use in the Indian food basket remains limited. The success of oats in the breakfast cereal segment demonstrates that consumer acceptance is strongly influenced by product diversification, palatability, branding, and health awareness. Barley, being an indigenous, climate-resilient crop capable of thriving under marginal conditions, offers a strategic advantage for India in terms of sustainability, reduced input requirements, and suitability for resource-poor farmers. However, translating its health potential into market success requires coordinated interventions. Future efforts should focus on (i) development of high-yielding, hulless food barley varieties with enhanced β-glucan, amylose, mineral content, and stress tolerance; (ii) standardization and commercialization of diversified barley-based products such as multigrain atta, bakery items, flakes, and ready-to-drink beverages; (iii) strengthening biofortification and quality trait research; and (iv) implementing effective consumer awareness and policy support mechanisms, including improved minimum support price structures. Integration of breeding, molecular tools, agronomic management, food processing innovations, and nutritional advocacy will be essential to realize the full potential of barley. Barley represents a multidimensional opportunity enhancing farmer income, promoting sustainable agriculture, and contributing to nutritional and health security. With scientific advancement, industry participation and supportive policy frameworks, barley can reclaim its traditional stature and emerge as a key component of future functional and health-oriented food systems.

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