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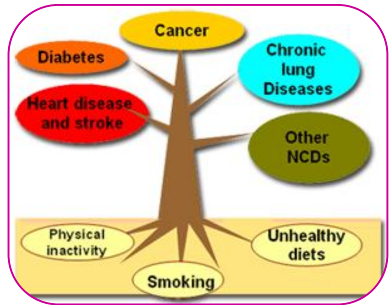
FUNCTIONAL PROPERTIES OF BARLEY IN PREVENTING NON COMMUNICABLE DISEASE



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ABSTRACT
Objective

The purpose of this systematic review was to summarize the evidence on the potential role of barley in the prevention and management of unhealthy dietary habits increasing the risk of obesity as well as non-communicable diseases (NCDs) such as hypertension, type 2 diabetes and cardiovascular diseases.

The article outlines the motive and scope for the review, and methodology including the risk of bias, statistical analysis, screening and study criteria.

Methods

Studies published from 2000 till September 2018 were included in the review with a clear delineation about health benefits of barley in terms of managing dyslipidemia, blood pressure , glycemic control and weight reduction. Pubmed, Embase and Google scholar were searched for epidemiological and interventional studies. After scrutinizing 151 studies , 12 were included in the final review and the results were presented based on the type of study and methodology used.

Results

The review was conducted between January 2018 and September 2018. Findings from the reviewed studies have highlighted multiple health benefits of barley such as lowering of total and low-density lipoprotein cholesterol and blood glucose levels and improved bowel movement. Studies also showed an increased insulin response & significant reduction in fasting blood glucose. Thus, the replacement of other cereals in moderation with barley has shown to provide beneficial effects in reducing the risk of metabolic syndrome.

KEYWORDS: *barley, beta-glucan, type 2 diabetes, dyslipidemia &NCDs.*

INTRODUCTION:

The prevalence of non-communicable diseases (NCDs) such as type 2 diabetes, hypertension, cardiovascular diseases, and cancer has significantly increased globally, particularly in developing countries (Mendis, 2014). Two key reasons have been proposed for this increase in prevalence: decreased mortality from infectious diseases and concomitant negative changes in dietary habits combined with lower levels of physical activity. Diet is considered to play a crucial role in the prevention and management of NCDs. One of the primary changes in dietary consumption because of nutrition transition is the shift in the type and processing of staple foods: from less-processed traditional foods to highly refined foods (Popkin, 2005).

Cereals and fats form the primary source of daily calorie intake in most Asian diets, including Indian diet. Research suggests that whole grain and cereal fiber consumption is inversely associated with body mass index (BMI), waist circumference, total cholesterol, metabolic syndrome, mortality from cardiovascular diseases, insulin resistance, and incidence of type 2 diabetes (deMunter et al., 2007; Newby et al., 2007; Pereira et al., 2002; Mc Keown, 2009).

However, cereals such as rice and wheat, the primary contributors to daily calorie intake, are mostly refined. Several studies from India as well as the West have shown a positive association between intake of refined grains and NCDs such as obesity and type 2 diabetes (Aune et al., 2013; Sun et al., 2010; Radhika et al., 2009).

Barley is the fourth most common cereal grain (after wheat, rice, and corn) that has recently gained renewed interest worldwide as a food item owing to its several health benefits. Although 80–90% of the barley produce is used for the production of malted beverages and animal feed, it remains an important food item in many regions, including several regions in North Africa and the Near East, the highlands of Central Asia, the Horn of Africa, the Andean countries, and the Baltic States (Grando & Macpherson, 2005). Barley is a versatile cereal crop, is available at a reasonable cost, and has the highest amount of dietary fiber among the cereals, which may be beneficial in prevention and management of diet-related NCDs (Minaiyan et al., 2014).

Barley is mainly composed of starch (60%), dietary fibre (20%), and crude protein (12%). In addition, barley is a good source of vitamins (including B1, B3, B6) and minerals (including magnesium, manganese, selenium, copper, chromium, phosphorus). Barley is also rich in several antioxidants and does not contain any known antinutritional factors (Minaiyan et al., 2014).Despite its several health benefiting properties, barley remains an underutilized cereal crop in human foods and in industrial applications. This review summarizes the nutritional properties and highlights the health benefits of barley.

METHODS

An integrative review of this literature was conducted to understand the health benefits of barley in preventing non- communicable disease, critique research questions and to find conceptual gaps.

DATA SOURCES AND STUDY SELECTION

Prior to beginning the review, developed a protocol to guide the conduct of this review. Studies were identified by searching the Embase, Medline via PUBMED and Google scholar database (till June, 2018). Researcher searched for a study that includes health benefit of barley, medicinal properties of barley in preventing non-communicable disease including type 2 diabetes and cardiovascular diseases. Researcher compiled a list of potential search terms identified through preliminary searches which is attached in the table no 1; pilot tested them and modified them to improve the thoroughness of final search. In addition to the database searches, researcher also reviewed the bibliographies of relevant studies for additional citations to evaluate for inclusion in the review. MeSH terms such as “type 2 diabetes” and “Cardiovascular disease” and “non - communicable disease” and, combined with “Health benefits” or “Medicinal properties” and “Barley” or “Hordeum vulgare ” were used in data base search. The selected studies were reviewed by the investigator (SM)using inclusion and exclusion criteria. Titles, abstracts, and then full text were reviewed for inclusion after the initial search.

A data extraction tool developed for the purpose of this study utilized the framework of Cooper (1998). Narrative synthesis methods were used to extract and summarize findings from multiple studies across the world. The data extraction tool included the following categories: Study Author, Year, Participants, Test food and Major findings. Each full-text manuscript was independently reviewed and verified by the researcher (SM).Results for these health benefits of barley in preventing non-communicable disease are presented with epidemiological and interventional studies each based on the type of study and methodology used.

Table No 1
Search Terms

Search	Query Embase	Query Medline via Pubmed	Query Google scholar
1	Search 'Medicinal properties'/exp or Search 'Non communicable disease'/exp	Search #1 Medicinal properties [All Fields] OR Non communicable disease[All Fields]	Search "Medicinal properties or Health benefits or Non communicable disease"
2	Search 'Barley'/exp	Search # 2 "Barley"[MeSH Terms] OR "Hordeum vulgare"[All Fields]	Search "Barley"
3	Search #1 AND #2	Search Boolean Operator #1 AND #2	Search #1 AND #2

RESULTS

The initial database search retrieved 151 articles. After reviewing titles, 82 studies were eliminated, another 24 studies are eliminated based on abstract, and the final 33studies were eliminated after reading the full article, resulting in a final inclusion of 12studies (see Fig. 1). The main reasons for exclusion that the study did not report evidence focusing on health benefits of barley.Table 2 describes the key constructs, methodologies, and findings from each of the 14 papers reviewed and the table is summarized below.

Figure 1

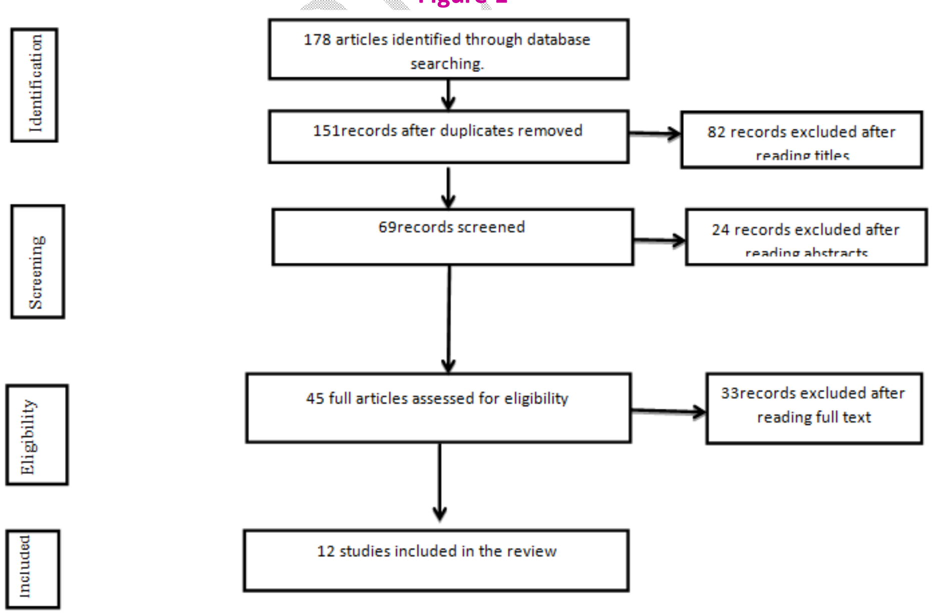

Table 2 Summary of Clinical trials with barley supplementation

S.No	Author name	Year	Participants	Test Food	Major Findings
1	Aman	2006	Men and women with mild hypercholesterolemia	Activated barley in packages, 3 g/d β-glucan	LDL cholesterol level decreased by 5%
2	Behall et al.	2004	Men with mild hypercholesterolemia	Diets containing 0.3, 3, or 6 g/d of β-glucan from barley in pancakes, bars, hot cereal	Decrease in total cholesterol level by 14%, 17%, and 17% and LDL cholesterol level by 17%, 17%, and 24%, respectively
3	Behall et al.	2004	Men and women with mild hypercholesterolemia	Diets containing 0.3, 3, or 6 g/d of β-glucan from barley in pancakes, bars, hot cereal	Decrease in total and LDL cholesterol levels, particularly with higher concentrations and in men and postmenopausal women
4	Biorklund et al.	2005	Men and women with mild hypercholesterolemia	Beverage containing 5 or 10 g/d barley β-glucan	Non-significant decrease in total and LDL cholesterol levels, possibly because of low mean molecular weight of β-glucans
5	Dongowski et al.	2006	Men and women with mild hypercholesterolemia	Extruded whole-grain barley meal containing 7.2 g/d β-glucan added to usual diet	Change in insulin but not glucose response. LDL-C level decreased by 6%
6	Hinata et al.	2007	Male prisoners with type 2 diabetes	Cooked rice and barley mixture (7:3 ratio) containing 18.7 g/d soluble fiber	Total cholesterol level decreased by 9.7%. Fasting plasma glucose levels significantly decreased
7	Keenan et al.	2007	Men and women with mild hypercholesterolemia	Diets containing 3 or 5 g LMW or 3 or 5 g HMW barley β-glucan concentrate in cereal, juice beverage	Decrease in LDL cholesterol level by 9%, 13%, 9%, and 15%, respectively
8	Keogh et al.	2003	Men and women with mild hypercholesterolemia	Extracted barley β-glucan incorporated into snacks and food products, 9.9 g/d β-glucan	No change in glucose and insulin response. Decrease in total cholesterol level
9	Li et al.	2003	Healthy men	Cooked rice and barley mixture (7:3 ratio) containing 8.9 g/d soluble fiber	Significant decrease in total and LDL cholesterol levels and no difference in glucose response
10	Shimizu et al.	2008	Men with hypercholesterolemia	Diets of rice and pearl barley (1:1) containing 7.0 g/d β-glucan	Decrease in total and LDL cholesterol levels
11.	Behall , Scholfield, & Hallfrisch	2006	Pre-menopausal and post-menopausal women	Half barley	Reduce blood pressure and may help to control weight.
12.	Nilsson, Johansson & Bjorck	2015	Middle-aged participants	Bread from barley kernel	Helps reduce chronic low-grade inflammation; prevent the

					occurrence of both cardiovascular disease and diabetes

SUMMARY OF FINDINGS

Whole grains such as barley may contribute to a significant supply of antioxidants to prevent oxidative stress if they are consumed in considerable amounts.The cardioprotective effects of barley are mainly attributed to its cholesterol-lowering effects. Beta-glucan, a soluble fiber present abundantly in barley, binds with bile acids that are essential to digesting fat synthesized by the liver from cholesterol, leading to their excretion in feces. Consequently, liver synthesizes more bile acids that utilize more cholesterol; this in turn lowers the concentration of cholesterol in circulation (Behall et al., 2004a and Roberfroid et al., 2010).Diets rich in high fiber whole grains are associated with lower risk of coronary heart disease (CHD) and T2DM due to their positive influence on dyslipidemia and dysglycemia (Liu S.,2002)

Behall et al. (2004b) in their study including 25 adults with hypercholesterolemia found that inclusion of barley in daily diet significantly lowered total cholesterol in all participants; in addition, the levels of less-atherogenic large LDL and large and intermediate HDL fractions increased whereas the levels of atherogenic small LDL and VLDL cholesterol decreased considerably. An epidemiological study including 10,000 adults showed that individuals consuming 21 g/day of high-fiber dietary barley had 12% and 11% reduction in coronary heart disease (CHD) and cardiovascular disease (CVD) risk compared to those consuming only 5 g/day. Individuals consuming the most water-soluble dietary fiber fared even better with a 15% reduction in risk of CHD and a 10% reduction in CVD risk (Anderson, 2004).

Another study conducted by Keenan et al. (2007) compared the effect of consuming high molecular weight (HMW) and low molecular weight (LMW) concentrated barley β-glucan (BBG) at both 3 g and 5 g doses for 6 weeks among adults with moderate dyslipidemia. The findings showed that LDL-c levels decreased by 15% and 13% in the 5 g/d HMW and LMW group respectively and by 9% in both the 3 g/d groups. The authors reported similar findings with respect to total cholesterol, whereas the concentration of HDL-c remained unchanged during the study. Similarly, a randomized, double-blinded, placebo-controlled trial comparing the effect of rice and a mixture of rice and pearl barley with a high β-glucan content (test group, 7.0 g β-glucan per day) among 44 overweight Japanese men with hypercholesterolemia also showed a significant reduction in LDL-c and total cholesterol levels (Shimizu et al., 2008). In addition to β-glucan, propionic acid derived from barley's insoluble fiber can inhibit the activity of HMG-CoA reductase, an enzyme essential for production of cholesterol by the liver, which perhaps contributes to the cholesterol-lowering properties of barley (Jenkins et al., 2002; Muetzel et al., 2003 and Behall et al., 2004a). Barley is a good source of niacin; 1 cup of barley provides approximately 14.2% of the daily value of niacin, which perhaps also contributes to the cardioprotective effects of barley. Barley plausibly exerts its cardioprotective effects via the following 3 mechanisms:

- Reducing total cholesterol and lipoprotein(a)levels.
- Preventing the oxidation of LDL-c by free radicals.
- Reducing platelet aggregation, thereby preventing formation of blood clots.

Furthermore, pyridoxine (Vitamin B6) and folate, both present in barley, prevent the increase in homocysteine concentration; accumulation of excessive amounts of homocysteine could damage blood vessels and lead to cardiovascular diseases (Bazzano et al., 2003; Erkkilaet al., 2005).Thus, evidence suggests that increased consumption of barely products could be considered a dietary approach for CVD risk reduction.

The β-glucans present in barley not only lower blood cholesterol but also help maintain blood glucose level. Behall et al. (2005) assessed the effects of consuming oats or barley on glucose response among 10 overweight women (mean BMI, 30 kg/m^2). They found that consumption of both oats and barley reduced glucose response by 29%-36% and 59%-65%, respectively. Significant reduction in insulin response (44%-56%) was observed only with barley consumption. This effect of barley is mainly attributed to its soluble fiber content.

In a crossover trial, Keogh et al. (2007) evaluated the glycemic response and satiety effects of high-amylose barley and wheat formulated meals among healthy women. This study showed that the average areas under the glucose and insulin curves were 22% and 32% lower, respectively, for barley-containing versus wheat formulated meals. However, despite the reduced glycemic and insulinemic effects, barley-containing meals did not reduce spontaneous food intake. In another study, the effects of β-glucan concentrate (BGC) obtained from an extract of barley and a similar oat product (Inglett, 2000) on glucose and insulin responses were compared. Healthy men and women consumed test meals containing a pudding of oat bran, barley flour, oat BGC, or barley BGC, with glucose as a control. Beta-glucan extract from barley had the lowest area under the glucose curve; however, no significant difference as compared to other β-glucan sources was observed. Thus, the researchers concluded that the β-glucan concentrate extracted from oats or barley has the same beneficial effects as the original whole grain. In another study including normal and overweight men, barley β-glucan extract had lower areas under glucose and insulin response curves than did resistant starch in muffins.Minaiyan et al. (2014) reported that consumption of barley has a key role in management of diabetes, a benefit of barley partly attributed to its high fiber content. Rendell et al. (2005) reported low postprandial glycemic excursion and insulin response post consumption of pearl barley flakes as compared to those with oat meal and a low-fiber liquid meal replacer used as a control. The study included both adults with and without type 2 diabetes and similar responses were seen in both the groups. A study among male prisoners reported markedly improved glycemic control post consumption of a high-fibre diet composed of 50% each of boiled rice and barley (Hinata et al., 2007). It, however, does not appear to reduce the risk of T2DM. In contrast, insoluble fiber reduces the risk of diabetes, even though it has negligible influence on postprandial glucose levels (Dakshinamurti, 2005).

Barley has a low glycemic index (28)and lower glycemic load in comparison to refined cereal grains. A low-glycemic load diet has been found to improve the serum concentrations of triglyceride and high density lipoprotein cholesterol ,irrespective of insulin secreted by an individual.(Ebbeling CB etal, 2007).Barley is a good source of magnesium, a mineral that acts as a cofactor for a number of enzymes, including enzymes essential for effective utilization of glucose and insulin secretion (Vandam et al., 2006).

An inverse relationship was found between dietary fiber intake from cereals and whole grain and body weight/diabetes/cardio vascular disease (CVD). Soluble dietary fiber is associated with improved glycemic control and insulin sensitivity in both diabetic and healthy subjects, generally attributable to its viscous propertiesalso shows to reduce the risk of diabetes. (Hua et al., 2018).

Barley has high dietary fiber content and hence adds bulk and decreases the transit time of fecal matter, thereby reducing the risk of intestinal cancer and hemorrhoids (Kim et al., 2012). Furthermore, these fibers are fermented by the bacteria in the large intestine, leading to the production of short chain fatty acids (SCFA)including butyric, propionic, and acetic acid. These short chain fatty acids aid in the maintenance of a healthy colon and also serve as primary fuel for the cells of the large intestine, the liver, and muscles (Behall et al., 2004a).The intake of whole grain barley induces an increase in Bifidobacteria which is considered a positive indicator of prebiotic activity SCFA. (Clara et al., (2016).The SCFA produced by the action of gut microbiota and undigestible fiber present in whole grains and vegetables interacts with specific organs showing reduction or reversal of Metabolic Syndrome risk factors in animal models. (Minatel et al., (2017).

The Western calorie dense diet , rich in fat , red meat, and poor dietary fibre is associated with unfavourable gut microbiota and is associated with obesity, diabetes and several other diseases. It is noticed that plant-based diet rich in indigestible carbohydrate is associated with a healthy gut microbiota profile thereby providing metabolic health benefits.(Wilson K, et al., (2017).

CONCLUSION

Barley has been consumed by humans for centuries; however, studies regarding its health benefits have only been recently conducted. The several health benefits of regular consumption of barley include decreased total and LDL cholesterol, a healthier digestive system, lower glycemic and insulin response, reduction in blood pressure, control weight gain and reduced risk of atherosclerosis. Although the health benefits of barley have been established, long term studies on effective utilization of barley in foods and its use in prevention and management of NCDs are needed.

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