Biomedical effects of barley -A Review

Jamilah M Hashemi

Food and Nutrition Dept., Faculty of Home Economic, Ministry of Higher Education,
King Abdul-Aziz University

Abstract: Consumption of diets high in whole grains such as barely has been highly recommended. Studies have shown a reverse relationship between regular consumption of barely and the risk of developing certain diseases. These relationshipshave been attributed to the effects of the soluble and insoluble fiber content of barley. Numerous studies have demonstrated that whole grains that are high in soluble fiber, such as *beta*-glucan, found in barley are more effective against certain diseases. Barley's claim to nutritional fame is based on its being a very good source of dietary fiber, manganese, selenium, copper, vitamin B1, chromium, phosphorus, magnesium and niacin. These components found in barely have positive biological effects on human health. In this review, we briefly examine the potential of barley's compounds in diseases prevention. Evidenceswere shown to support the positive impact of different compounds such as soluble and insoluble fiber and *beta*-glucan, on human health and disease prevention.

[Jamilah M Hashemi **Biomedical effects of barley- A review** New York Science Journal 2015;8]. (ISSN: 1554-0200). http://www.sciencepub.net/newyork.

Introduction:

Barley (*Hordeumvulgare* L.) is a member of the grass family. It is a plant widely distributed and cultivated in eastern Asia and used as foodstuffs such as bread and cakes **(Koga *et al*., 2013 Takano *et al*., 2013).** In ranking of cereal crops in the world, barley is the world's fourth most important cereal crop after wheat, rice and maize. It is readily available with reasonable cost, and has the highest amount of dietary fiber among the cereals which may be beneficial for metabolic syndrome**(FAOSTAT,2009 and Minaiyan*et al*., 2014)**. Barley varies greatly in chemical composition, nutritive value and bioavailable energy content, due to genetic and environmental factors **(Andersson*et al*., 1999)**. The major components of barley are starch, dietary fibre, and crude protein, constituting: 60, 20, and 12% of dry matter, respectively **(Oscarsson *et al*., 1996).** However, considerable variation exists in the dietary fibre and starch content of barley grain which results in a tremendous amount of variation in digestible energy content**(Bowman *et al*., 2001)**. Moreover, barley is very good source of dietary fiber, manganese,selenium, copper, vitamin B1, chromium, phosphorus, magnesium, and niacin**(Minaiyan*et al*., 2014).**

Bioactive compounds of barley:

Barley (*Hordeum spp*.) is gaining renewed interest as an ingredient for functional foods due to its bioactive compounds, such as *β*-glucans and tocols. Phenolics have been identified and quantified in nine varieties of barley as flavan-3-ols, flavonols, phenolic acids and apolar esters. Flavan-3-ols are monomers, (+)-catechin and (−)-epicatechin, and polymers constituted mainly by units of (+)-gallocatechin. The most abundant compounds were the dimers procyanidin B3 and prodelphinidin B3. The main trimericprocyanidin was procyanidin C2. After malting, the phenolic content decreased for all varieties,catechin monomers were the most affected. Beside polyphenols, barley extracts contained other antioxidants as carotenoids (lutein and zeaxanthin) and tocopherols (α, δ and γ)**(Goupy*et al*.,1999).**

Health benefits of barley:

Consumption of diets high in whole grains has been recommended**(Dietary Health Guidelines,2005).** Barley have number of healthbeneficial effects including, reduced risk of cancer **(Jacobs *et al*., 1998)**, cardiovascular disease **(Trustwell, 2002)**, and type II diabetes (**Liu *et al*., 2000 and Fung *et al*., 2002)**, which are leading causes of death.These results have been attributed to the effects of the soluble and insoluble fiber content of whole grain foods on risk factors for these diseases including blood glucose **(HallfrishandBehall, 2000)**, insulin **(Willet *et al*., 2002)**, and cholesterol **(Leinonen*et al*., 2000)**. Other more general beneficial physiological effects of consumption of whole grains include reduced transit time which may reduce risk of colon cancer **(Bruce *et al*., 2000)**, and reduced rate of absorption of energy containing nutrients **(Bridges *et al*. 1992**) which may reduce glucose, insulin responses and risk of obesity **(Wisker*et al*., 1992).**

Gastrointestinal Benefits of Barley:

Barley can give your intestinal health a boost. It provides bulk and decreases the transit time of fecal matter, thus decreasing the risk of colon cancer and hemorrhoids, barley's dietary fiber also provides food for the "friendly" bacteria in the large intestine. When these helpful bacteria ferment barley's insoluble fiber, they produce a short-chain fatty acid called *butyric acid*, which serves as the primary fuel for the cells of the large intestine and helps maintain a healthy colon. These helpful bacteria also create two other short-chain fatty acids, *propionic* and *acetic acid*, which are used as fuel by the cells of the liver and muscles **(Behall *et al*., 2004 a). Kim *et al*. (2012)** reported that reduced colonic transit time has been implicated in reducing the incidence of colon cancer, as evidenced by populations consuming diets rich in fiber. Whole grains such as barley may contribute to a significant supply of antioxidants to prevent oxidative stress if they are consumed in large amounts.

Cardiovascular Benefits of Barley:

Numerous studies have demonstrated that, whole grains that are high in soluble fiber, such as *beta*-glucan, found in barley are more effective in lowering blood cholesterol than those in which fiber are predominantly insoluble such as wheat or rice.The propionic acid produced from barley's insoluble fiber may also be partly responsible for the cholesterol-lowering properties of fiber**(Lupton *et al*., 1994 and Jenkins *et al*., 2002).**

In animal studies, propionic acid has been shown to inhibit HMG-CoA reductase, an enzyme involved in the production of cholesterol by the liver. By lowering the activity of this enzyme, propionic acid helps lower blood cholesterol levels **(Muetzel*et al*., 2003 and Behall*et al*., 2004 a)**. In addition, barley's dietary fiber is high in *beta*-glucan, which helps to lower cholesterol by binding to bile acids and removing them from the body via the feces. Bile acids are compounds used to digest fat that are manufactured by the liver from cholesterol. When they are excreted along with barley's fiber, the liver must manufacture new bile acids and uses up more cholesterol, thus lowering the amount of cholesterol in circulation. Soluble fiber may also reduce the amount of cholesterol manufactured by the liver **(Behall *et al*., 2004a and Roberfroid*et al*., 2010).**

A study by **Behall *et al*. (2004 b)**reported that barley's fiber has multiple beneficial effects on cholesterol. In this study of 25 individuals with high cholesterol (postmenopausal women, premenopausal women, and men), adding barley to diet resulted in a significant lowering in total cholesterol in all subjects, plus their amount of large LDL and large and intermediate HDL fractions (which are considered less atherogenic) increased, and the smaller LDL and VLDL cholesterol (the most dangerous fractions) greatly decreased. Moreover, eating high fiber foods, such as barley, helps prevent heart disease. In a study included 10,000 adults eating high fiber dietary barley and followed for 19 years. The results revealed that 21 grams per day had 12% less coronary heart disease (CHD) and 11% less cardiovascular disease (CVD) compared to those eating the least 5 grams daily. Those eating the most water-soluble dietary fiber fared even better with a 15% reduction in risk of CHD and a 10% risk reduction in CVD**(Anderson, 2004).**

Barley is a good source of niacin, that provides numerous protective actions against cardiovascular risk factors. Niacin can help reduce total cholesterol and *lipoprotein (a)* levels. (*Lipoprotein (a)* or Lp(a) is a molecule composed of protein and fat that is found in blood plasma and is very similar to LDL cholesterol, but is even more dangerous as it has an additional molecule of adhesive protein called *apolioprotein (a)*, which renders Lp(a) more capable of attaching to blood vessel walls.Niacin may also help prevent free radicals from oxidizing LDL, which only becomes potentially harmful to blood vessel walls after oxidation. Lastly, niacin can help reduce platelet aggregation, the clumping together of platelets that can result in the formation of blood clots. One cup of barley will supply you with 14.2% of the daily value for niacin**(Rimm*et al*., 1996 ,Bazzano *et al*., 2003 and Erkkilä*et al*., 2005).**

Hypoglycaemic effect of barley:

The fiber in barley can also help to prevent blood sugar levels from rising too high in people with diabetes. Barley and other whole grains are rich sources of magnesium, a mineral that acts as a co-factor for more than 300 enzymes, including enzymes involved in the body's use of glucose and insulin secretion **(Dam *et al*., 2006).** In this 8-year trial, involving 41,186 participants of the Black Women's Health Study, research data confirmed inverse associations between magnesium, calcium and major food sources in relation to type II diabetes that had already been reported in predominantly white populations **(Dam *et al*., 2006).**

In a study, which involved 10 overweight women (mean age: 50 years, body mass index: 30), subjects ate a controlled diet for 2 days and were then given, in rotation, glucose alone and then 4 test meals in which 2/3 of the carbohydrate came first from oat flour then oatmeal, barley flour or barley flakes.Glucose responses were reduced after test meals by both oats and barley, although more by barley (29-36% by oats and 59-65% by barley). Insulin responses after test meals were significantly reduced only by barley (44-56%). Interestingly, whether the oats or barley was consumed in the form of meal, flakes or flour had little effect. What seems to have been responsible for barley's significantly greater effectiveness in reducing both glucose and insulin responses is barley's soluble fiber content **(Behall*et al*., 2005). Minaiyan*et al*. (2014)** reported that barley has a role in diabetic control in long term consumption, and this effect might be at least due to its high fiber content.

Weight reduction effect of barley:

The beneficial properties of barley in the treatment of diabetes were investigated. Rates of growth, water and food (digestible energy) intakes, and blood glucose concentrations were measured before and after the induction of diabetes in rats fed diets containing either barley or wheat. In the diabetic state the blood glucose concentration, water consumption and weight loss was significantly lower in the rats fed barley. It is suggested that a factor other than the fibre content of the barley may be responsible for the difference in response **(Naismith *et al*., 1991)**.**Dongowski*etal*. (2002)**investigated the effects of barley-rich diets in the intestinal tract of rats. Male Wistar rats were fed diets containing 50 g/100 g barley for 6 wk, the control diet contained no barley. These supplements contained 7-12 g/100 g *beta*-glucan and 7-24 g/100 g resistant starch. Additionally, 5 g microcrystalline cellulose/100 g was present in all diets. Carbohydrate utilization (indirect calorimetry) was lower ($P< 0.05$) in rats fed the barley-containing diets than in the controls. Diets containing more soluble macromolecular dietary fibers beta-glucans affected the excretion of bile acids and neutral sterols. These results suggest that dietary fiber-rich barley-containing diets have beneficial physiologic effects.

The soluble fiber β-glucan, a natural component of barley, has been shown to lower the postprandial glucose response and is thought to improve insulin resistance in obesity. **Brockman *et al*. (2013)** examined the effect of chronic consumption of the high *β*-glucan barley flour on glucose control, liver lipids and markers of muscle fatty acid oxidation in diabetic fatty rat. Two groups of rats were fed diets containing either 6% β-glucan in the form of barley flour or cellulose as a control for 6 weeks. The results revealed that, barley flour group had an increased small intestinal contents viscosity compared to the obese control group. After 6 weeks, the barley flour group had a reduced area under the curve during a glucose tolerance test, indicating improved glucose control. Fasting plasma adiponectin levels increased in the barley flour group and were not different than the control group. Rats on the barley flour diet had lower relative epididymal fat pad weights than the obese control and a greater food efficiency ratio. The barley flour group also had reduced liver weights and a decreased concentration of liver lipids. Therefore, chronic consumption of *β*-glucans can improve glucose control and decrease fatty liver in a model of diabetes with obesity.

Conclusion:

Humans have consumed barley for centuries. Despite the fact that it is one of the oldest foods it has only recently been extensively studied for health promoting effects. Barley may be effective at treating a number of chronic diseases and illnesses. Various studies have outlined the benefits of barley consumption. Among these benefits are lower cholesterol, a healthier digestive system, and preventing atherosclerosis. It is clear that barley promotes health however there still remains work to be done in order to incorporate barley into an effective and widely use treatment for chronic diseases conditions.

Acknowledgements

The author takes this opportunity to express her gratitude to Chair **Yusuf Abdul- LateefJameel of Prophetic Medicine** for their support and contribution in publishing this review besides another paper entitled “Biomedical Effects of Grape Products”.

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