



## **Health Effects of Barley Consumption**

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Obesity has reached epidemic proportions within the American population, such that 65% of Americans are classified by the Centers for Disease Control (CDC) as overweight or obese (1). The diseases associated with this epidemic include: type 2 diabetes, cardiovascular disease (heart disease and stroke), osteoarthritis, high blood pressure, some cancers, sleep apnea and gall bladder disease. Furthermore scientists have shown that people with the Metabolic Syndrome, those with at least three of the following risk factors: a large waist, high blood pressure, high triglycerides and cholesterol, low HDL cholesterol, glucose and insulin irregularities, have increased risk for diabetes and cardiovascular disease (2).

By necessity resolution of this health crisis in America will require multi-faceted interventions on the national level that focus on the prevention of obesity, the development of effective long-term weight loss strategies, the reduction of risk factors for disease in those who are already overweight, and the prevention of regain of weight in those who have achieved a weight reduction. All of these goals require dietary changes as part of total lifestyle changes.

### **Benefits of consuming grains**

Consumption of diets high in whole grains has been recommended in the 2005 Dietary Guidelines for Americans (3) and are reported to have a number of beneficial health effects including reduced risk of cancer (4), cardiovascular disease (5,6), and type 2 diabetes (7,8), which are leading causes of death in the USA. 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 (9), insulin (10), and cholesterol (11,12). Other more general beneficial physiological effects of consumption of whole grains include reduced transit time which may reduce risk of colon cancer (13,14), and reduced rate of absorption of energy containing nutrients (15, 16) which may reduce glucose and insulin responses and risk of obesity (17). Numerous studies have demonstrated that whole grains that are high in soluble fibers, such as beta-glucan, found in oats and barley are more effective in lowering blood cholesterol than those in which fibers are predominantly insoluble such as wheat or rice (18-21). Health claims that consumption of oats or oat products effectively lower blood cholesterol concentrations have been approved by the Food and Drug Administration (22). This claim states that consumption of oats or oat products containing a total of at least 3 grams of beta-glucan per day is necessary to observe a health benefit.

### **Benefits of Barley Consumption – Studies at BHNRC**

Because cardiovascular disease (1 in 4 people) and diabetes (1 in 18 people) are among the leading causes of morbidity and mortality in the USA, we have focused our research on the ability of soluble fiber from oats and more recently from barley on the

expression of the risk factors for these diseases. These factors include fasting plasma lipids, i.e., total cholesterol, triglycerides, the glucose and insulin response to a carbohydrate challenge, and blood pressure.

### Plasma Lipids

Compared to oats, barley has been utilized as the beta-glucan source in few studies. Work conducted in this laboratory (23-28) indicates that consumption of a diet rich in barley results in as great or even greater reduction in plasma cholesterol and other blood lipids. Data from these studies are currently being used as support for an application to the FDA for a health claim for barley similar to that for oats.

The long-term studies were conducted in adults who consumed each of the 4 study diets in a random order. The meal plans consisted of 1) the American Heart Association Step 1 diet, 2) a control diet containing 30% fat, 15% protein and 55% carbohydrate with no added soluble fiber (beta-glucan), 3) a moderate beta-glucan diet of 3 grams per day, and 4) a high beta-glucan diet of 6 grams per day. The food used to vary the beta-glucan content of the diets included granola, muffins, spiced cake, cookies, steamed grains, and tabouleh salad. The experimental food products were made with either whole wheat flour or flakes, with a 50/50 mixture of barley and wheat flour or flakes, or barley flour or flakes. Plasma total cholesterol and triglycerides decreased significantly in men with moderate and high beta-glucan intakes from barley and total cholesterol and LDL cholesterol decreased in post-menopausal women (Figure 1).

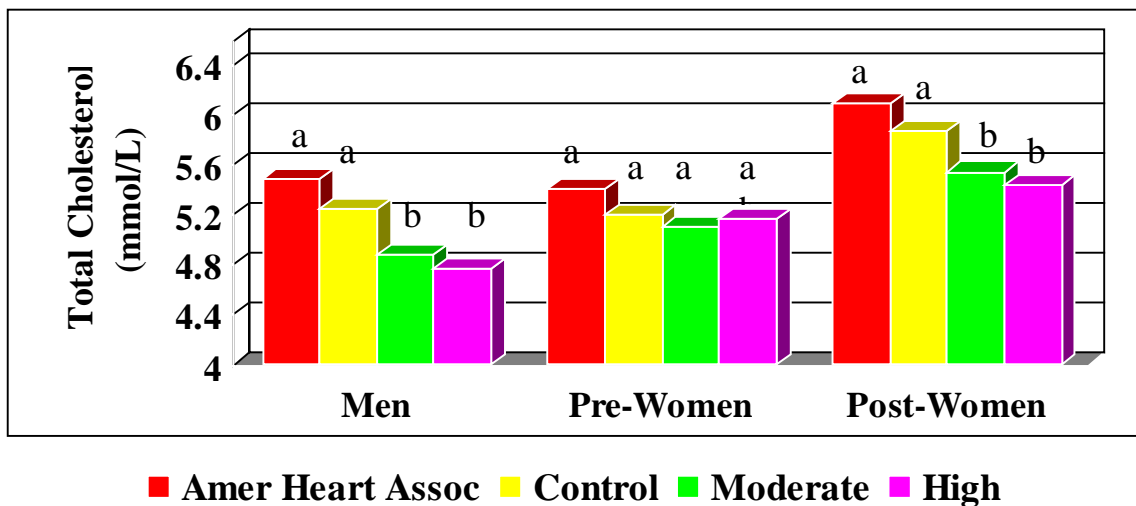


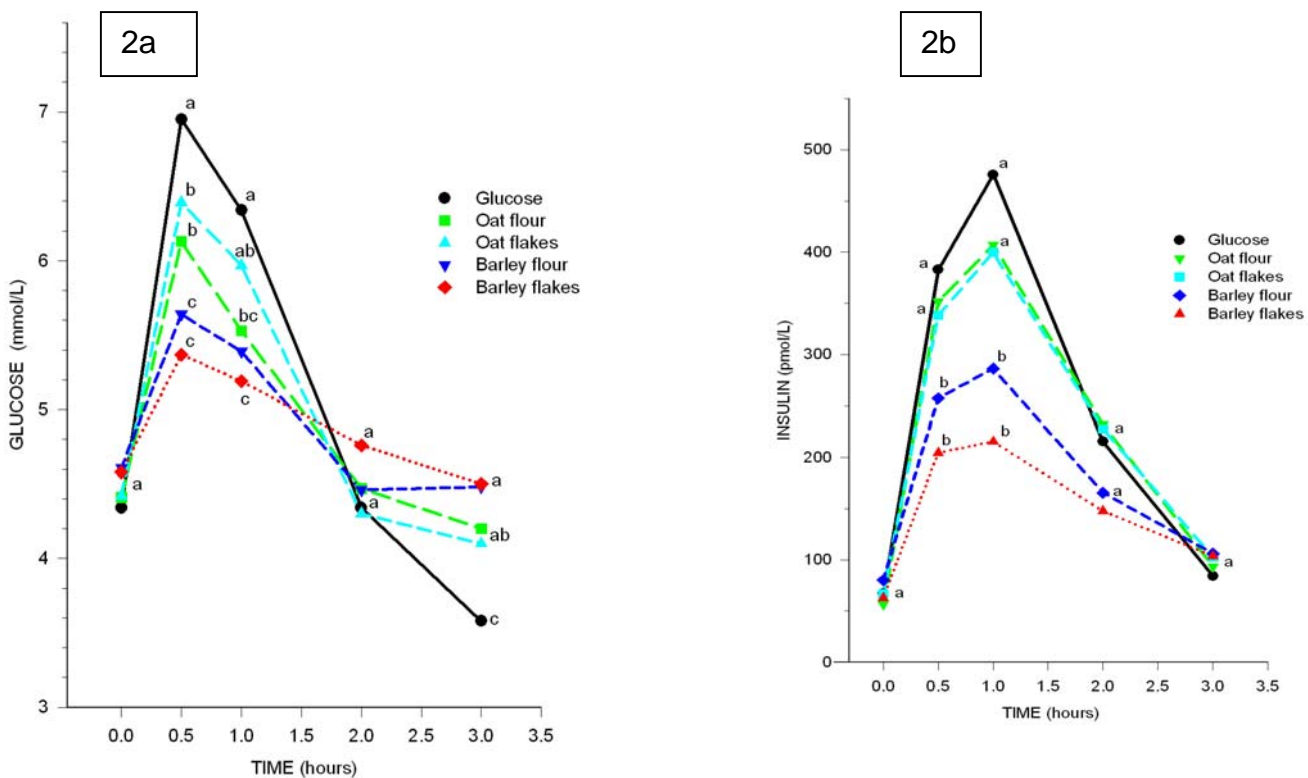
Figure 1. Total cholesterol response to the American Heart Association's Step 1 diet, to a control diet low in beta-glucan and diets containing moderate and high levels of beta-glucan from barley. Pre-women = pre-menopausal women; Post-women = post-menopausal women. For dietary comparisons, within gender groups, treatments with different letters are different.

In studies comparing the response of plasma cholesterol and triglycerides to diets rich in oats or barley, barley appeared to be more effective in lowering plasma cholesterol than oats, perhaps because of its higher beta-glucan content.

### Plasma glucose and insulin

In acute studies where volunteers were fed carbohydrate containing meals the glucose responses to oats, barley, and extracts of both grains were significantly lower than responses to the glucose solution (23). Insulin responses for the barley extract were lowest and were significantly lower than after the glucose solution. Oat and barley extracts retain the beneficial effects of the grains from which they are extracted. Barley, which is high in the soluble fiber beta-glucan, is more effective than standard oats. Barley, as a whole grain or as an extract, can serve as a fat replacer in food products and can provide a useful addition to menus to control plasma glucose responses.

The effect of acute barley consumption on post-meal glucose and insulin values (Figures 2a and 2b) was similar to that of the other grains tested in that there was a blunted post-meal glucose and insulin response in comparison to the response after a glucose load (25).



Figures 2a and 2b. Comparison plots of glucose (2a) and insulin (2b) response to carbohydrate test meals containing glucose, oat flour and flakes and barley flour and flakes. Glucose or insulin values with different letters at each time point are different.

The analyses are ongoing from a long-term study of barley intake on glucose and insulin responses.

In a review of the effect of fiber-rich carbohydrates on features of the Metabolic Syndrome, Davy and Melby (29) report that consumption of 20-35 g/day of total dietary fiber and at least 3 g/day of soluble fiber, as recommended by the American Dietetic

Association, results in a reduction in risk factors for cardiovascular disease and diabetes.

### **Soluble Fiber Intakes**

The typical American diet contains less than half the amount of soluble fiber or total dietary fiber recommended to provide health benefits. The median reported total dietary fiber intake for men and women in the U. S. was 17.0 and 13.8 g/d, respectively (30). This is approximately half the level of intake suggested by many health organizations (29) and the National Academy of Sciences, Institute of Medicine's Dietary Reference Intakes (30). The recommended intake for total fiber for adults 50 years and younger is set at 38 grams for men and 25 grams for women, while for men and women over 50 it is 30 and 21 grams per day, respectively, due to decreased food consumption. It is essential to determine ways to increase intake of total fiber and, especially, soluble fibers. Increasing the intake of whole grain products such as barley would increase both total and soluble dietary fiber in the diet and most likely would result in decreasing the risk factors for disease even in men and women already overweight.

### **Dietary Fiber, Satiety, and Body Weight Regulation**

Few studies have been conducted on the short or long term effect of the soluble fiber beta-glucan on satiety or the feeling of fullness after a meal. Howarth et al. (32) conducted a pilot study of the effect on body weight of dietary fiber supplementation (to an *ad libitum* diet for 3 weeks) which compared a methylcellulose supplement with a pectin/beta-glucan (2:1 ratio) supplement. No significant effect on food intake, assessed by 24 h recalls, or on body weight was found.

In a position paper for The American Dietetic Association on the health implications of dietary fiber, Marlett et al, (33) provide support to the hypothesis that meals rich in fiber are processed more slowly thereby promoting satiety and potentially reduce overall energy intake. Pereira and Ludwig (34) reviewed the literature on dietary fiber and body-weight regulation and concluded that many short term and epidemiological studies support the role of dietary fiber in body-weight regulation. Further they suggested an increase in fiber intake as a means of preventing obesity in children. They also note that there is a need for further research and for long-term dietary intervention studies.

#### *Acute satiety studies*

A study (Figure 3) is currently underway to test the effect of cooked whole grain barley and a barley or oat extract containing beta-glucan on satiety. Twenty men and women who are at risk for the Metabolic Syndrome have been recruited to consume a "breakfast" test meal of 75 g of glucose or a food product, such as yogurt or whole grain cereal containing doses of soluble fiber, as beta-glucan, varying from 0 to 3 grams. Blood glucose and Visual Analogue Scales (VAS) are measured at -¼, 0, ¼, ½, 1, 2, 2½ hours to test hunger, satiety, desire to eat, nausea, drowsiness, etc. A standardized lunch offering of a casserole containing approximately 2000 kcal is fed at 2 hours after the breakfast test meal. Satiety is evaluated based on the VAS results and on the amount of energy consumed at lunch.

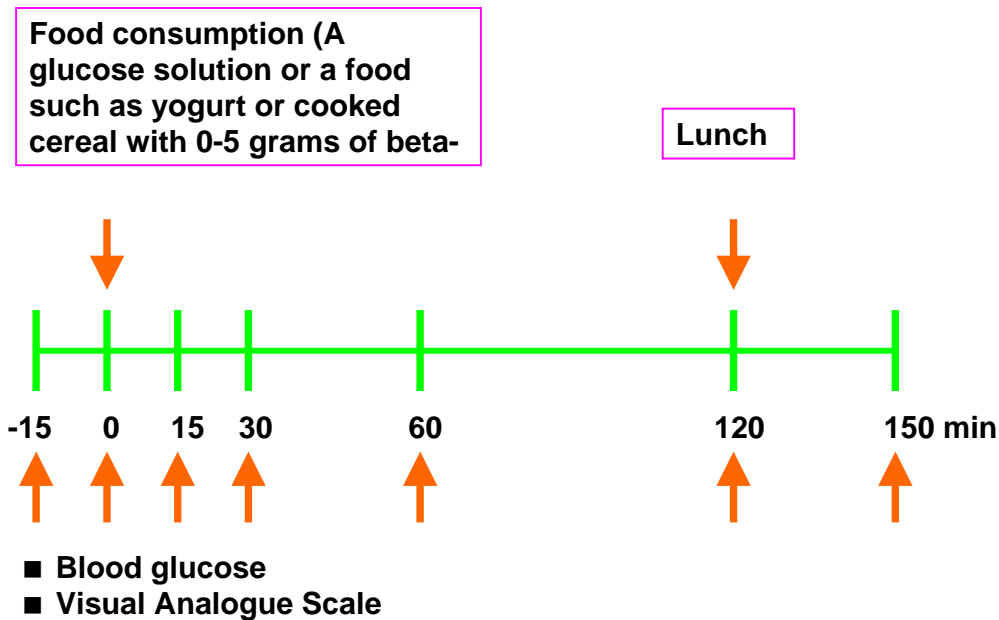


Figure 3. The time course of an acute satiety study underway at USDA, ARS, BHNRC, DHPL.

#### Planned Long-term Studies

Future studies will examine the effect of supplementation of the diet in people who have successfully lost weight with high soluble fiber food items. The metabolic measurements that are planned include resting metabolic rate, body weight, body fat, fasting plasma glucose, insulin, triglycerides and cholesterol, insulin sensitivity, blood pressure, body composition, measures of satiety, and behavioral measures. These studies will be long-term and will take place over a period of time of at least 6 months to one year.

#### Conclusion

Consumption of soluble fiber improves risk factors for cardiovascular diseases and diabetes mellitus. It also provides satiety value. Soluble fiber reduces plasma cholesterol concentrations, lowers postprandial plasma glucose and insulin concentrations and ameliorates insulin resistance. Most research on soluble fiber has focused on oats. Barley, another excellent soluble fiber source, has received little attention. Many forms of barley or barley extracts have not been investigated in human subjects. Thus, research is needed to assess the health effects of human consumption of barley and barley products including germinated barley foodstuff, barley co-products, and barley Nutrim. This paper describes research that uses controlled feeding of human subjects to determine the ability of barley and barley products to affect risk factors for cardiovascular disease and diabetes in normal weight and overweight adults. Moreover, the research will assess the ability of diets high in soluble fiber to aid in weight loss and maintenance of weight-reduced subjects. The proposed research will extend the number of barley products and extracts examined for health benefits.

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