



GoBarley

Barley and Diabetes

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The Pathogenesis of Diabetes

Diabetes is a group of metabolic diseases characterized by hyperglycemia due to inadequate insulin secretion, diminished tissue response to insulin, or both.¹ Chronic hyperglycemia subsequently results in long-term organ damage, particularly to the eyes, kidneys, heart and vasculature.¹ Type 1 diabetes is the result of an absolute deficiency of insulin secretion, whereas type 2 diabetes is caused by a combination of insulin resistance and inadequate compensatory insulin secretion.¹ Type 2 diabetes is the far more common form of the disease, accounting for 90 to 95 per cent of cases.¹ Obesity and lack of physical activity are major risk factors for developing type 2 diabetes.¹ Table 1 shows the criteria for diagnosing type 1 and type 2 diabetes.

The number of adults with diabetes worldwide has more than doubled over three decades and is now estimated to be 8.3 per cent of the global population, or 371 million people.² In Canada, the prevalence of diabetes is projected to reach 3.2 million people by 2016.³ The disease is predicted to rise from being the 11th leading cause of death worldwide in 2002 to the seventh by 2030; in high-income countries, it is expected to climb to become the fourth leading cause of death.³ Diabetes is a health concern for people of all ages, as half of all those who die from the disease are under the age of 60.³ Type 2 diabetes was long regarded as an exclusively adult disease, but in parallel with the rise in childhood obesity, there has been an alarming emergence of youth-onset type 2 diabetes.⁴



Worldwide healthcare expenditure for diabetes among people aged 20 to 79 was estimated to be US \$376 billion in 2010 (12 per cent of healthcare expenditures), which is predicted to climb to US \$490 billion by 2030.⁵ In Canada, the healthcare expenditure on diabetes in 2010 was US \$11.2 billion, or 13 per cent of healthcare expenditures.⁵ In 2010, the United States had the highest expenditure for diabetes globally at US \$198.0 billion, or 14 per cent of healthcare expenditures.⁵

The prevalence of diabetes in developing countries is rising dramatically. For example, the Middle East has been one of the hardest hit areas by the disease, with an overall prevalence of 10 to 12 per cent among adults over age 19.^{6,7} An estimated 92.4 million adults in China now have diabetes, which accounts for almost 50 per cent of the global diabetic population.^{8,9} The prevalence of diabetes in China has increased from 2.6 per cent in 2002 to 9.7 per cent in 2008, though an estimated 30 to 50 per cent of individuals with diabetes remain undiagnosed.^{9,10}

Table 1. Criteria for the diagnosis of diabetes¹

Hemoglobin A1C $\geq 6.5\%$
OR
Fasting Plasma Glucose ≥ 7.0 mmol/L
OR
Two hour plasma glucose ≥ 11.1 mmol/L during a 75 g oral glucose tolerance test
OR
In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥ 11.1 mmol/L

Nutrition for Diabetes Prevention and Treatment

Medical nutrition therapy is important in preventing diabetes, managing existing diabetes and preventing or slowing the onset of diabetes complications.¹ Weight loss and physical activity are more effective than pharmacotherapy at preventing or delaying diabetes, and thus should be the first strategy for people at risk of type 2 diabetes.¹¹ The Canadian Diabetes Association recommends that people with diabetes should receive nutrition counselling by a registered dietitian followed by frequent follow-up to improve dietary adherence.¹² Studies indicate that nutrition therapy can significantly lower glycated hemoglobin by approximately one per cent in type 1 diabetes and by one to two per cent in type 2 diabetes within three to six months.^{12,13}

Barley (*Hordeum vulgare*) is an ancient grain that has been cultivated for thousands of years. In North America, barley is a major crop used for animal feed, but it is also grown for the food and beverage industries, including the malting industry for brewing beer. Barley is increasing in popularity as people focus on consuming more local, healthy whole-grain foods. Whole grain and fibre intake has been shown to be inversely associated with insulin resistance and the risk of developing metabolic syndrome and type 2 diabetes.¹⁴⁻¹⁶ Whole grains contain all the essential parts and naturally occurring nutrients of the entire grain kernel in their original proportions. Soluble fibre is the component of whole grains that has been associated with regulating postprandial blood glucose and insulin responses.¹⁷ As a whole grain, barley contributes to a healthy diet and can significantly contribute to total dietary fibre intake.

β -glucan is a type of soluble fibre found in some whole grains. It is a mixed group of non-starch polysaccharides consisting of D-glucose monomers linked by β -glycosidic bonds.¹⁸ The β -linkages in the polymer make β -glucan indigestible by human digestive enzymes.¹⁸ Barley is one of the richest sources of β -glucan (3.5 to 5.9 per cent of dry matter), which slows gastric emptying, delays glucose absorption and improves postprandial glycemic response.¹⁹ A meta-analysis of six prospective cohort studies from the United States and Finland found that increasing whole grain consumption by two servings per day was associated with a 21 per cent decrease in risk of type 2 diabetes.²⁰

A high-fibre diet (25 to 50 grams/day; 15 to 25 grams/1,000 kcal) is likely the most effective diet for diabetes due to the effect of fibre in reducing glycemia, insulinemia and lipemia.^{13,21} For the general population, the Institute of Medicine has set the Adequate Intake for fibre at 14 grams per 1,000 kcal, or about 25 grams/day for women and 38 grams/day for men.²² However, in Canada, average intake is only about half the recommended amount.²³ It is estimated that 90 per cent of the U.S. population does not consume enough dietary fibre, with the average American consuming only 15 grams/day, or even less for those on low carbohydrate diets.²⁴

Although the Dietary Approaches to Stop Hypertension (DASH) dietary pattern was originally developed to reduce hypertension, it has also been shown to be of benefit to people with diabetes. The DASH diet emphasizes vegetables, fruits and low-fat dairy products and includes whole grains, poultry, fish and nuts. Systolic and diastolic blood pressure, hemoglobin A1C, fasting blood glucose, body weight, waist circumference, low density lipoprotein cholesterol (LDL-C), C-reactive protein and high-density lipoprotein cholesterol (HDL-C) have been shown to improve with the DASH diet in people with type 2 diabetes.¹² In addition, 20 to 60 per cent of people with diabetes also have hypertension.²⁵ Thus, the DASH diet helps modify both cardiovascular disease and diabetes risk factors to improve the overall health of people with diabetes. As a whole grain, barley aligns with the DASH dietary pattern.

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Barley and Glycemic Control

The amount of ingested carbohydrate is usually the primary factor that determines postprandial response, but the type of carbohydrate also plays a role.¹³ The glycemic index (GI) was developed to rank carbohydrate-containing foods based on their effect on postprandial glycemic response.²⁶ The GI of a food is determined by calculating the area under the blood glucose response curve after ingestion of a food divided by the response to a reference food, typically glucose or white bread.¹³ The glycemic load (GL) is calculated by multiplying the GI (as a percentage) by the carbohydrate content of the food. For example, pearled barley has a GI of 40 (Table 2) and a 100 gram serving provides 25.5 grams of available carbohydrate²⁷ (available carbohydrate = total carbohydrate - total dietary fibre). Thus, the GL of 100 grams of barley is calculated as follows: $0.4 \times 25.5 = 10.2$. Some research studies use both GI and GL while others use only one.



Consuming a high-GI diet is associated with increased risk of developing type 2 diabetes.^{28,29} A low-GI diet may decrease the need for anti-hyperglycemic medications.¹² Barley is classified as having the lowest GI of the food grains (Table 1).^{30,31} Soluble fibres, such as the β -glucan in barley, form gel-like substances when mixed with water, resulting in viscous gastrointestinal contents and a reduced rate of gastric emptying and carbohydrate absorption.^{32,33} This affects the physiological response to carbohydrate ingestion by blunting the increase in postprandial plasma glucose and insulin.³² Soluble fibres may also attenuate the postprandial glycemic response due to their fermentation in the large intestine. Fermentation produces the short-chain fatty acids butyrate, acetate and propionate, which may decrease endogenous glucose production or increase extrahepatic insulin action.³⁴

It has been demonstrated that for each gram of β -glucan, GI may be lowered by as much as four to 15 units.^{28,29} Jenkins et al.²⁹

performed a randomized cross-over study in which GI was calculated after participants consumed white bread, a commercial oat bran breakfast cereal, and a prototype β -glucan-enriched breakfast cereal and bar. The oat bran cereal provided 3.7 grams of β -glucan, and the β -glucan-enriched cereal and bar provided 7.3 and 6.2 grams of β -glucan, respectively. The GI of the test foods was found to decrease by 4.0 ± 0.2 units per gram of β -glucan.²⁹

The impact of β -glucan on GI was even greater in a study by Casiraghi et al.²⁸ The study compared the postprandial glucose, insulin and lipid response of crackers or cookies made from barley flour enriched with β -glucan or whole wheat flour. The barley products provided 12 grams of dietary fibre with 3.5 grams of β -glucan per portion, whereas the whole-wheat products provided 14 grams of dietary fibre with negligible β -glucan. The results showed that GI was reduced by 8.5 to 15.2 GI units per gram of added β -glucan for the crackers and cookies, respectively.²⁸

Barley may not only have a beneficial effect on the glycemic response after the meal in which it is consumed, but may also impact glycemia and insulinemia after subsequent meals.^{35,36} The objective of a study by Liljeberg et al.³⁶ was to examine the effect of the GI of a breakfast meal on glucose tolerance after lunch in healthy individuals. Test breakfasts containing four types of high-amylose barley bread, with a GI between 60 and 99, were evaluated using white wheat bread as the reference breakfast. The barley-bread breakfast with the lowest GI resulted in lower glucose levels at 30 and 70 minutes after lunch, compared to the white wheat bread breakfast.³⁶

This finding was supported by a more recent study by Nilsson et al.³⁵ that examined the extent to which postprandial glycemia can be modulated by the GI of previous meals. The test meals were white wheat bread, wheat kernels, rye kernels, oat kernels, barley kernels, whole grain barley flour porridge and white wheat bread enriched with barley fibre. The results found that compared to white wheat bread, the barley or rye kernel breakfast lowered the postprandial glucose response at breakfast, at a subsequent lunch as well as the cumulative glucose response at breakfast, lunch and dinner.³⁵ In addition, the barley kernel evening meal resulted in lower postprandial glucose response after a subsequent breakfast compared with white wheat bread.³⁵

Table 2. Glycemic Index of Selected Foods³¹

Food Item	GI*
Barley	40
Lentils	41
Corn	75
Rolled oat porridge	79
Buckwheat	78
Couscous	93
Rice, brown	94
Bread	100
Millet	101
Potato	117

*Glycemic index determined using white bread as reference food in subjects with normal glucose tolerance

Glycated hemoglobin (HbA1C) is used to assess blood glucose control over the preceding two to three months. HbA1C $\geq 6.5\%$ is a criterion for diabetes diagnosis¹ with a 0.3 per cent reduction considered clinically meaningful.³⁷ Several systematic reviews and meta-analysis studies have examined the effect of low-GI diets on blood glucose control in patients with diabetes.^{21,38-41} The most recent systematic review of 12 trials found that low-GI diets reduced HbA1C by 0.4 per cent compared to control diets.⁴¹ A previously published Cochrane review by the same authors also reported that low-GI or GL diets decreased HbA1C (-0.5 per cent).⁴⁰ A meta-analysis of 16 studies found that low GI diets significantly reduced HbA1C



by 0.27 per cent and total cholesterol by 0.33 mmol/L in subjects with type 2 diabetes.³⁹ A trend was also observed toward decreased LDL-C (-0.15 mmol/L; $P=0.06$). Results of a meta-analysis of nine trials demonstrated that fasting plasma glucose was significantly lower on low-GI diets than high-GI diets.²¹ HbA1C, total cholesterol and LDL-C were also lower on a low-GI diet, though the difference was not statistically significant.²¹ Lastly, low-GI diets were shown to reduce HbA1C by 0.43 per cent compared to high-GI diets in a meta-analysis of 14 studies.³⁸ Together, these studies provide strong support for the use of low-GI foods such as barley to improve glycemic control in diabetes.

A review of 34 human clinical trials that investigated the glycemic response to oats and barley found that for barley, 64 per cent of treatments demonstrated significant reductions in area under the glucose response curve and/or GI compared to a suitable control food.⁴² Oat and barley products were not significantly different in their average reduction in area under the glucose response curve, with an average combined reduction of 48 ± 33 mmol•min/l compared to control. This is a substantial decrease in glycemic response with biological relevance.⁴² The combined data from these studies provides information about the effect of a wide variety of oat and barley products from different food formats (e.g. bread, pasta, hot and cold breakfast cereals, beverages as well as intact grains) and food-processing technologies (e.g. isolates and extracts), suggesting that products containing β -glucan consistently provide glycemic benefits in both healthy individuals as well as those with type 2 diabetes.⁴² A summary of studies reporting the post-prandial effects of barley is shown in Table 3.

Barley is available in a variety of forms, including pearled barley, barley flour, flakes and grits. Pearl and pot barley are the most common barley products available.²⁷ Dehulled and hullless barley is also available and is the whole-grain form because only the very outer husk, the hull, has been removed. Pot and pearl barley have been processed or “pearled” to remove the inedible hull and polish the kernel. Pot and pearl barley are still excellent sources of β -glucan since the fibre is found throughout the kernel. The difference between pot and pearl barley is that pot barley has been pearled for a shorter amount of time, so some of the barley bran remains intact. Dehulled and hullless barley takes longer to cook than either pearl or pot barley. High β -glucan fractions and extracts as well as whole-grain barley flour are also available.

Interest in the health-enhancing properties of barley has led to the development of new barley cultivars with unique functional characteristics, such as high β -glucan and slowly digested starch.⁴³ The genetic diversity in barley cultivars as well as processing factors may influence the GI of barley products.⁴³ A study that examined the effects of barley cultivar, degree of pearling and food form on GI found that all three variables affected the GI of barley.⁴³ Pearling increased the GI of barley by an average of nine units.⁴³ The amylose to amylopectin ratio influences the rate of starch digestion, with amylose being a more slowly digestible form of starch. Unexpectedly, in this study the barley cultivar with the lowest amylose had a lower GI than a high-amylose cultivar, which may have



been due to the high β -glucan and total fibre content of the low-amylose variety.⁴³

A study by Behall et al.⁴⁴ examined the effect of particle size (flour versus flakes) of oats and barley on postprandial glycemic responses in overweight women. The results found that particle size had less effect on glycemia than soluble fibre content.⁴⁴ Area under the glucose response curve after the test meals was 109.3 ± 16.3 for oat flour, 122.4 ± 16.3 for oat flakes, 70.0 ± 16.3 for barley flour, and 60.6 ± 16.3 mmol•min/L for barley flakes. The values for barley flour and flakes were not statistically different. The results suggested that particle size had less effect on glycemia than soluble fibre content.⁴⁴

Table 3. Randomized controlled studies of the effect of barley products on postprandial glycemic response*

Study	Food format (subjects, n)	β -glucan dose (g)	Change in AUC [†] (mmol • min/L)	Change in GI units [†]
Aldughpassi et al. ⁴³	Pearled boiled barley (10)	2.8	-80	-30
	Pearled boiled barley (10)	4.2	-101	-38
	Pearled boiled barley (10)	8.9	-111	-41
	Pearled barley pasta (10)	2.8	-24	-14
	Pearled barley pasta (10)	4.2	-36	-14
	Whole grain boiled barley (10)	3.0	-104	-41
	Whole grain boiled barley (10)	3.7	-92	-35
	Whole grain boiled barley (10)	3.8	-102	-43
	Whole grain boiled barley (10)	3.4	-100	-42
	Whole grain boiled barley (10)	3.1	-98	-42
	Whole grain boiled barley (10)	4.3	-118	-46
	Whole grain boiled barley (10)	8.4	-128	-49
	Whole grain boiled barley (10)	5.7	-105	-45
	Whole grain boiled barley (10)	4.9	-111	-47
Alminger & Eklund-Jonsson ⁴⁵	Barley tempe (13)	1.7	-147	-70
Behall et al. ⁴⁴	Pudding with barley flour (10)	12.1	-101	---
	Pudding with barley flakes (10)			
Casiraghi et al. ²⁸	Barley crackers (10)	3.6	-16	-25
	Barley cookies (10)	3.5	-33	-48
Cavallero et al. ⁴⁶	Bread with barley fraction (50)	1.8	-19	-0.8
	Bread with barley fraction (50)	3.3	-38	-18
	Bread with barley fraction (50)	4.9	-42	-28
Chillo et al. ⁴⁷	Pasta with barley concentrate (9)	1.5	-21	-19
	Pasta with barley concentrate (9)	3.0	-29	-26
	Pasta with barley concentrate (9)	4.4	-35	-32
	Pasta with barley concentrate (9)	6.1	-47	-43
	Pasta with barley concentrate (9)	7.7	-57	-52
Finocchiaro et al. ⁴⁸	Bread 40% waxy barley flour (9)	5.3	-23	-13
	Bread 40% non-waxy barley flour (9)	4.8	-46	-26
Granfeldt et al. ⁴⁹	Boiled barley kernels (10)	4.5	-74	-35
	Boiled barley kernels (10)	6.6	-69	-34
	Boiled barley kernels (10)	6.2	-80	-29
	Boiled barley flour (9)	4.7	-36	-61
	Boiled barley flour (9)	6.8	-45	-55
Hallfrisch et al. ⁵⁰	Barley flour (20)	7.4	-49	---
	Barley extract (20)	5.2	-60	---

Liljeberg et al. ⁵¹	Wholemeal barley bread (10)	2.8	-14	-5
	Bread with coarse boiled barley (10)	2.4	-30	-17
	Bread with coarse scalded barley (10)	2.5	-39	-26
Liljeberg & Bjorck ⁵²	Barley bread 80% scalded kernels (8)	4.5	-93	-67
	Barley bread 40% scalded kernels (8)	2.8	-54	-34
	Wholemeal barley bread (8)	4.1	-11	1.2
	Sourdough wholemeal barley bread (8)	4.0	-29	-15.8
	Scalded wholemeal barley bread (8)	3.8	-3	10.1
Liljeberg et al. ⁵³	Barley porridge (9)	2.3	-3	-3
	Barley porridge 50% PW (9)	7.6	-18	-22
	Barley bread 50% PW (9)	8.0	-24	-29
	Barley bread 80% PW (9)	14.1	-32	-39
Nilsson et al. ³⁵	Boiled barley kernels (12)	2.9	-77	-51
	Bread with barley fibre (12)	6.3	-29	-7
	Barley porridge (12)	2.6	-11	12
Ostman et al. ⁵⁴	Barley bread 50% (10)	1.1	-15	-17
	Barley bread 35% PW (10)	2.9	-19	-25
	Barley bread 50% PW (10)	4.6	-18	-36
	Barley bread 75% PW (10)	9.2	-26	-45
Thondre & Henry ⁵⁵	Barley chapattis (8)	2	-1	0
	Barley chapattis (8)	4.1	-41	-43
	Barley chapattis (8)	6	-16	-16
	Barley chapattis (8)	7.8	-48	-47
Thondre et al. ³⁰	Barley porridge - high fibre (10)	2.7	-112	-61
	Barley porridge - medium fibre (10)	2.7	-105	-57
Yokohama et al. ⁵⁶	Barley pasta (5)	12	-92	---

*Adapted from Tosh42

†Compared to suitable control

AUC, area under the curve; PW, prowashonupana variety (high β -glucan)

Effect of Barley on Chronic Diseases Associated with Diabetes

Obesity

Obesity is a global epidemic with a prevalence of 24.¹ per cent in Canada and 34.4 per cent in the United States in 2007-09.⁵⁷ An estimated 80 to 90 per cent of patients with type 2 diabetes are obese, with obesity itself causing some degree of insulin resistance.^{1,12} Insulin resistance, glycemic control, hypertension and dyslipidemia is improved with modest weight loss (five to 10 per cent of initial body weight) in overweight and obese individuals.¹³

High-fibre foods such as barley contribute to satiety and weight management.¹⁸ Since fibre is not enzymatically digested and absorbed, but instead undergoes various degrees of fermentation in the large intestine, it effectively lowers dietary energy density.⁵⁸ Soluble fibres, such as the β -glucan in barley, contribute to satiety by absorbing large amounts of water and forming gels, thereby increasing stomach distension and slowing gastric emptying.⁵⁸ A daily intake of approximately three servings of whole grains is associated with lower body mass index and reduced central adiposity.⁵⁹ The Academy of Nutrition and Dietetics has concluded that dietary fibre may promote weight loss with intakes of 20 to 27 grams of fibre per day.⁶⁰ Barley is a high-fibre, low-fat, whole-grain food with a low-energy density that aligns with recommendations for a low-calorie, high-fibre diet for weight control.⁶¹

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Cardiovascular Disease

Cardiovascular disease (CVD) has been the number one killer worldwide during the past decade.⁶² An estimated nine in 10 Canadians have at least one CVD risk factor, with over 40 per cent of individuals aged 20 to 79 having elevated levels of total cholesterol and 25 per cent having unhealthy triglyceride levels.^{63,64} Patients with diabetes are at significantly increased risk of CVD, which accounts for 70 per cent of all deaths among individuals with diabetes.⁶⁵ An estimated two-thirds of patients with coronary artery disease have abnormal glucose homeostasis.⁶⁶ Compared to patients without diabetes, mortality rates one month following an acute myocardial infarction are 50 per cent higher among those with diabetes.⁶⁵

Elevated serum cholesterol is a major risk factor for CVD.⁶⁷ Increasing consumption of soluble fibres such as β -glucan has clinically significant effects by reducing low-density lipoprotein cholesterol (LDL-C) an estimated five to 10 per cent.⁶⁸ Barley β -glucan consumption was consistently associated with statistically significant reductions in both total cholesterol and LDL-C in 78 per cent of 19 trial arms.⁶⁹ Due to the substantial evidence that β -glucan lowers cholesterol, both Canada and the United States have approved cardiovascular health claims for products containing barley β -glucan.^{69,70}

Hyperglycemia is associated with the initiation of pro-inflammatory events and oxidative stress, which may adversely affect vascular structure and function by damaging the endothelium.⁷¹ Even in the absence of overt diabetes, postprandial hyperglycemia may exert a negative effect on cardiovascular health.⁷² Postprandial glucose concentration may be a better predictor of vascular dysfunction and adverse cardiovascular events than fasting glucose in both healthy and diabetic patients.⁷³ Individuals with impaired fasting glucose and/or impaired glucose tolerance, but without glucose levels high enough to be diagnosed with diabetes, are often referred to as having prediabetes and are at high risk for future development of diabetes and cardiovascular disease.¹ It is estimated that 20 per cent of all cases of diabetes in Canada remain undiagnosed.⁷⁴ The prevalence of undiagnosed diabetes may be as high as 30 to 50 per cent in less developed countries such as China.¹⁰ Moderately elevated HbA1C (5.7 to 6.4 per cent) levels below the threshold for diabetes diagnosis are also an indicator of increased risk of diabetes and cardiovascular disease, but can be reduced with weight loss and physical activity.¹

A systematic review concluded that a diet with a lower GL can help to improve lipid profiles.⁷⁵ In addition, a meta-analysis of 14 prospective studies found that a high-GL diet was associated with a 23 per cent increased risk of CVD, while high GI increased risk by 13 per cent.⁷⁶ Thus, the low GI of barley is one attribute, in addition to its β -glucan content, that may help to promote cardiovascular health.

Metabolic Syndrome

Type 2 diabetes and the metabolic syndrome are closely linked. Both diseases frequently exhibit similar metabolic abnormalities that increase risk for cardiovascular disease, including central obesity, insulin resistance, dyslipidemia, hypertension and coagulopathy.⁷⁷ Whole grain intake has been shown to be associated with decreased prevalence of metabolic syndrome.¹⁴ Barley consumption has been shown to prevent insulin resistance, a characteristic of the metabolic syndrome and an important risk factor for diabetes, and may also improve insulin sensitivity among those with impaired glucose tolerance, even in the absence of weight loss.^{17,78,79}



Abdominal obesity is a risk factor for CVD and is one of the characteristics of the metabolic syndrome.⁸⁰ A diet containing seven grams per day of barley β -glucan has been shown to significantly reduce body mass index, waist circumference and visceral fat area, but not subcutaneous fat area in hypercholesterolemic men.⁸¹ In this study, energy intake and pedometer-measured physical activity between the barley and control groups did not differ, suggesting that barley supports weight loss and may help protect against metabolic syndrome by promoting body fat loss preferentially from visceral adipose tissue.⁸¹

Barley Aligns with Dietary Guidelines for People with Diabetes

In general, people with diabetes should follow *Eating Well with Canada's Food Guide*.^{12,82} Barley aligns with Health Canada's nutrition guidelines and with guidelines established by the Canadian Diabetes Association, the American Diabetes Association, and the Academy of Nutrition and Dietetics for the prevention and management of diabetes:

- A dietary pattern that includes carbohydrates from fruits, vegetables, whole grains, legumes and low-fat milk is encouraged.¹³ As a whole grain, barley should be part of a healthy diet.
- The use of glycemic index and glycemic load in diet planning may provide a modest additional benefit over only considering total carbohydrates.¹³ Replacing high-GI carbohydrates with low-GI carbohydrates has benefits for glycemic control.¹² Barley has the lowest GI of cereal grains.^{30,31}
- It may benefit people with diabetes to consume more fibre (25 to 50 grams per day) than is recommended for the general population.¹² Diets providing 30 to 50 grams fibre per day from whole foods produce lower serum glucose levels than low-fibre diets.⁶⁰ Barley contains more fibre than other cereal grains such as wheat and oats.²⁷
- The percentage of daily energy intake from carbohydrates should be no less than 45 per cent. Glycemic and lipid control may be improved in adults with type 2 diabetes with diets that provide greater than 60 per cent of total daily energy from low-GI, high-fibre carbohydrate sources such as barley.¹²



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