

NUTRITION

The Glycemic Response—Its Effects and Factors That Affect It



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A recent Canadian study (8) reports impaired glucose homeostasis following consumption of caffeinated coffee. This was noted with both high and low glycemic index meals. This study, in which participants were fed a morning cup of coffee and breakfast cereal, confirmed results from a previous study in which subjects ingested a 75 g oral glucose load with 5 mg of caffeine per kg of body weight. The 10 healthy male subjects in this study ingested caffeinated (5 mg/kg) or decaffeinated coffee followed one hour later by either a low or a high glycemic index cereal providing 75 g of carbohydrate. Caffeinated coffee taken with the high glycemic cereal resulted in

147% higher blood glucose levels, 29% higher levels of blood insulin, and a 40% increase in the levels of C-peptide as compared to the same cereal when taken with decaffeinated coffee. Caffeinated coffee ingested with a low glycemic cereal also resulted in 216% higher levels of blood glucose, 44% higher levels of blood insulin, and 36% increased levels of C-peptide than was observed with decaffeinated coffee. Insulin sensitivity also decreased by 40% and 29% after caffeinated coffee ingested with the high and low glycemic index cereals, respectively.

The ingestion of caffeinated coffee with any carbohydrate-based food appeared to increase insulin resistance, and the effects lasted at least 6 hours. While caffeine has been previously noted as altering the body's response to sugar in diabetics and prediabetics, caffeine ingestion in healthy individuals also appears to affect blood sugar for a few hours. However, the effects of caffeine are less pronounced in healthy individuals. To summarize, the ingestion of caffeine in coffee with either a high or a low glycemic index meal significantly impairs acute blood glucose management and insulin sensitivity compared to decaffeinated coffee. Further research is needed to determine if caffeinated coffee should be considered a risk factor for insulin resistance.

Glucose tolerance is not only affected by what is ingested with the meal, but also by what is eaten the night before, according to a study of the University of Lund. Barley-based bread and white flour bread enriched with barley fiber and resistant starch as part of the evening meal improved glucose tolerance at the subsequent breakfast compared with unmodified white wheat flour (10). In addition, the glucose response was inversely correlated with colonic fermentation and plasma glucagon-like peptide-1 (GLP-1) and positively correlated with free fatty acids. Serum interleukin (IL)-6 was lower and adiponectin was higher at breakfast following an evening meal with barley-kernel bread compared with white wheat bread. Breath hydrogen, used as evidence of gut fermentation, correlated positively with satiety

and inversely with gastric emptying rate. In conclusion, the kind of carbohydrates eaten the night before may affect glycemic excursions and metabolic risk factors the next day through a mechanism involving colonic fermentation.

The results provide evidence for a link between gut microbial metabolism and key factors associated with insulin resistance. The study's results provided evidence linking gut microbial metabolism and insulin resistance (10).

Another study, also at the University of Lund, showed that the composition of an earlier meal could affect the glycemic response to a subsequent meal (9). In this study, 12 healthy subjects consumed either barley or rye kernels or standard white bread at breakfast, in the evening, or at other standardized meals. The meals that included the kernels resulted in lower blood glucose incremental areas under the curve (IAUCs) at breakfast, at the subsequent lunch, and for the cumulative IAUC that represented breakfast, lunch, and supper when compared to white bread. A barley and kernel evening meal also showed a similar pattern. The IAUC of the evening meal correlated well with that of a subsequent standardized breakfast. The conclusion of both of these studies from the University of Lund is that the choice of specific low GI foods and whole grain cereal product may improve glucose tolerance at subsequent meals (9,10).

Despite the seemingly positive effects of low glycemic foods on blood glucose response, there is still controversy surrounding the association between glycemic index (GI), glycemic load (GL), and the risk of developing chronic diseases (1). A meta-analysis of 37 prospective cohort studies on GI and GL and the risk for developing chronic diseases was conducted by Barclay et al. (1). They compared the highest and lowest quartiles of both GI and GL and found an inverse association between low GI and/or low GL and reduced risk of developing certain chronic diseases, particularly diabetes and cardiovascular disease. Their analysis suggests that low GI and GL have the same protective effects as whole grain and fiber intake. The authors concluded that their meta-analysis supported the hypothesis that higher postprandial glycemia is a universal mechanism for disease progression.

Whole Grains, Glycemic Response, Weight Control, Prebiotics, and More

Satiety and glucose response of carbohydrate foods is known to be affected by the intactness of the grain and by the addition of vinegar to meal components. However, the precise mechanism as to how the acetic acid (vinegar) affects the glycemic response is not known. Researchers at the University of Lund tried to understand this phenomenon (5) in a study of 15 healthy subjects who ate equal-carbohydrate amounts of the following wheat-based meals. They ate either white wheat bread alone (control) or whole-kernel wheat bread or whole meal wheat bread served with white wine vinegar. The whole-kernel wheat bread with vinegar was found to be more satiating than the other breads. The authors explained this to be due to increased antral

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distension after ingestion of intact cereal kernels (5). There was no difference measured in gastric emptying rate with the different breads. The lowering of the pH and movement away from the pH optimum of amylase has been proposed to explain the decreased postprandial blood glucose response. Prior studies at the University of Lund in Sweden have shown meals containing vinegar to improve insulin sensitivity and postprandial insulin and glucose responses in insulin resistant subjects.

Researchers at the University of Wollongong in Australia recently reviewed whole grains and their effects on weight (12). They concluded that there is strong evidence that a diet high in whole grains is associated with decreased waist circumference and a lower body mass index and with a reduced risk of being overweight. They also concluded that there is weak evidence that high intakes of refined grains may cause small increases in waist circumference in women. Their review found that the restriction of cereal as part of a low-carbohydrate diet did not help with long-term, sustained weight loss. While the review did show there was a protective effect of whole grains on weight, the researchers noted that the data available at this time do not allow drawing the same conclusion for legumes.

Whole grain's effect on weight was also shown in a recent clinical trial. In this trial, 50 obese patients with metabolic syndrome were given advice about weight loss and either encouraged to make all their grain servings whole grain or to use refined grains (6). Both groups showed significant decreases in body weight, waist circumference, and percentage body fat, decreased total, HDL, and LDL cholesterol, and improved risk factors for cardiovascular disease. Whole grain eaters showed two positive changes in relation to the refined grain eaters. Whole grain eaters showed a greater decrease in percentage body fat in the abdominal area and had levels of C-reactive protein 38% lower at the end of the trial. Interestingly, C-reactive protein was unchanged in the refined grain group.

Another study showed that whole grains can modulate prebiotic gut microbiota, which may be important for health (2). In this double blind, randomized, crossover study, the impact of ingestion for 3 weeks of whole grain and wheat bran (48 g) breakfast cereal on human intestinal microbiota was assessed. Whole grain ingestion increased fecal *bifidobacteria* and *lactobacilli* more than wheat bran. The pronounced prebiotic effect observed after daily consumption of whole grain suggests that prebiotic activity may be responsible for some of the beneficial effects of whole grain wheat (2). Since whole grain and bran have differing effects, these must be due to components of whole grain rather than simply dietary fiber.

A Cochrane review applied its rigorous standards to assess the effects of whole grain on preventing type 2 diabetes (11). While they noted that prospective studies showed a 27–30% reduced risk for developing diabetes when whole grain intakes are high and a 28–37% decreased risk when cereal fiber intake is high, they considered the overall evidence too weak to definitively conclude that whole grain foods prevent the development of type 2 diabetes. The review cited the need for long-term, randomized, controlled trials that focus on relevant intermediate endpoints for type 2 diabetes. There is also a need to identify the genetic subgroups at risk of developing type 2 diabetes that are most likely to benefit from dietary intervention.

Wheat, Rye, and Sorghum

Specific dietary biomarkers are needed to help identify whole-grain intake. Because certain alkylresorcinols (ARs) are only present in wheat and rye grains, they were considered as potential biomarkers for wheat and rye intake in a recent study involv-

ing 22 women and 8 men (7). Plasma AR concentration positively correlated with wheat and rye intake calculated from food records. The strong correlation suggests ARs may be sound dietary biomarkers for whole grain wheat and rye intake.

Whole grain sorghum contains catechins and procyanidins. These have been shown to be beneficial to human health but may have low bioavailability (4). The effects of food processing on bioavailability have not previously been studied. Extrusion was shown to increase catechin bioavailability by 50%. Pigs fed extruded sorghum had significantly higher urinary levels of catechin than those fed white sorghum.

This column was prepared with the help of Tatenda Mupfudze, recent College of St. Catherine graduate in nutrition and dietetics.

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