Research Article

Effect of Eating Vegetables Before Carbohydrates in Patients with Type 2 Diabetes

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Abstract

Vegetables are considered essential for well-equilibrated diets since they supply dietary fiber, vitamins, minerals, and phytochemicals. In the daily diet vegetables have been strongly associated with the improvement of gastrointestinal health, and reduced risk of some forms of chronic diseases such as diabetes.

Carbohydrates form an important class of foods in human nutrition supplying energy to the body. In the absence of carbohydrates in the diet, our body will convert protein, or other non-carbohydrate substances, into glucose. So it is not just carbohydrates that can raise our blood sugar and insulin levels.

Diabetes come in two main types, called Type 1 and Type 2 diabetes. Type 2 diabetes, the most common type of diabetes worldwide, is a chronic and lifestyle disease. Asia hosts more than 60% of worldwide diabetes population, predominantly Type 2 diabetes. By 2025 a fifth of the world's diabetic patients will be Indian.

Our vegetables and carbohydrates food choice and maximization of dietary fiber, vitamins, minerals and phytochemical value can either prevent diabetes or promote insulin resistance and resultant diabetes.

This article highlights the effect of eating vegetables before carbohydrates on postprandial plasma glucose, and glycemic control on patients with Type 2 diabetes.

Keywords: Vegetables; Carbohydrates; Type 2 Diabetes; Glucose Control; Healthier Life

Introduction

Vegetables play a significant role in human nutrition and health since they supply dietary fiber, vitamins, minerals, and phytochemicals [1-3]. Besides almost all vegetables are fat free, gluten free, cholesterol free, low calorie, and very low in sodium.

In the daily diet vegetables have been strongly associated with improvement of gastrointestinal health, and some forms of chronic diseases such as diabetes [4]. The mechanisms by which vegetables decrease risk of disease is complex and largely unknown [2,3]. Various components of the whole food are likely to contribute to the overall health benefit. Various vitamins, minerals and phytochemicals with antioxidant properties may work directly by quenching free radicals or indirectly by participating in cell signaling pathways sensitive to redox balance. The dietary fiber content and type of different vegetables may also contribute to the overall health benefit, such as improving bowel transit, helping manage blood glucose concentrations, and by transporting a significant amount of minerals and phytochemicals linked to the fiber matrix through the human gut.

Our vegetables choice and maximization of dietary fiber, vitamins, minerals and phytochemical value can either prevent diabetes or promote insulin resistance and resultant diabetes.

Carbohydrates form an important class of foods in human nutrition supplying energy to the body. They are broken down into glucose before being absorbed into the bloodstream. From there, the glucose enters the body's cells with the help of insulin.

Carbohydrates should be the body's main source of energy in a healthy and balanced diet. In the absence of carbohydrates in the diet, our body will convert protein, or other non-carbohydrate substances, into glucose. So it is not just carbohydrates that can raise our blood sugar and insulin levels. Cutting out carbohydrates or fat

doesn't necessarily mean cutting out calories if we are replacing them with other foods containing the same number of calories.

By those reasons eating an healthy balanced diet with vegetables and carbohydrates is an important part of maintaining good health.

Diabetes (Diabetes mellitus) is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood sugar. Hyperglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes [5]. Diabetes come in two main types, called Type 1 and Type 2 diabetes. Type 1 diabetes, called as insulin-dependent, juvenile or childhood diabetes, is characterized by deficient insulin production and requires daily administration of insulin, typically by injection. Type 2 diabetes, called as non-insulin-dependent or adult-onset diabetes, results from the body's ineffective use of insulin. Body produces insulin but can't use it well. Type 2 diabetes, the most common type of diabetes worldwide, is a chronic and lifestyle disease.

Asia hosts more than 60% of worldwide diabetes population, predominantly type 2 diabetes [6]. By 2025 a fifth of the world's diabetic patients will be Indian [4].

This article highlights the effect of eating vegetables before carbohydrates on postprandial plasma glucose, and glycemic control in patients with type 2 diabetes.

Vegetables and diabetes

Both starchy and non-starchy vegetables are important to our diet. Greater intake of all green leafy vegetables is associated with a decrease risk of Type 2 diabetes since they have dietary fiber and they deliver many phytochemicals, vitamins and minerals to our body in each calorie consumed [4]. Other non-green and non-starchy vegetables are also rich in fiber, and bioactive compounds and so keep also blood glucose low. Legumes are a good carbohydrate source due to their protein, fiber and resistant starch content. Vegetable fruits rich in fiber and antioxidants are also excellent vegetables for diabetics if low-sugar content. Some cucurbits like bitter gourd, ivy gourd, snake gourd, and ridge gourd are recommended and considered useful in treating Type 2 diabetes [4].

The vegetable bio-compounds usually associated to the reduction or reversion of Type 2 diabetes are dietary fiber, resistant starch, vitamins C and E, carotenoids, flavonoids, thiosulfides, magnesium, selenium, chromium, and zinc [4].

Dietary fiber is very important since it works to keep blood-sugar levels stable and transport a significant amount of polyphenols and carotenoids linked to the fiber matrix through the human gut [2,3]. Dietary fiber is classified into water soluble and water in-

soluble fiber. Non-cellulosic polysaccharides, such as pectin, gums, and mucilages, are components of soluble fiber. Soluble fiber delays gastric emptying, slows glucose absorption, and lowers serum cholesterol levels, and is completely or partially fermentable in the large intestine [7]. Soluble fiber supplies a gelatinous-like material in the bowel. It is very important for diabetics, as it slows the absorption of glucose [2,3]. Insoluble fiber it is important too. It is mainly cell wall components, such as cellulose, lignin, and hemicelluloses found in the vegetables. Health benefits of insoluble fiber include shortening of the bowel transit time and bulkier and softer feces.

Resistant starch is the starch that it is resistant to stomach acid and digestive enzymes. It escapes digestion in the small intestine but passes to the large intestine, where it undergoes fermentation by bacteria in the colon. Acts like a fiber too. It supplies few calories, and most of the calories do not raise glucose levels. When the bacteria in the bowel degrade the resistant starch it forms new compounds that have health benefits and beneficial effects for diabetics.

Eating vegetables with dietary fiber and resistant starch will reduce hunger and appetite and for diabetics it is critical for lowering insulin requirement for starch digestion.

Vitamins C and E have been inversely associated with diabetes since they are antioxidants that counterbalance the endothelial dysfunction and glutathione to normalize blood glucose pressure. Hyperglycemia activates many pathways which lead to endothelial dysfunction and hence to diabetes complications.

Carotenoids such as α- and β-carotene, lycopene, lutein, zeaxanthin, and β-cryptoxanthin, have a protective effect against development of diabetes by relieving oxidative stress that interferes with the glucose uptake by cells.

Flavonoids such as anthocyanins, flavonols, flavones, isoflavonoids, and syringic acid are associated with diabetes since their intake was found to be related to reduced Type 2 diabetes risk.

Thiosulfides reduce blood glucose level by stimulating insulin secretion by the pancreas.

Magnesium is important since insulin secretion and function requires magnesium. It helps to regulate blood sugar. It is also the relaxation mineral.

Selenium is also important, but high selenium levels may contribute to diabetes (besides hyperlipidemia, prostate cancer, cardiovascular disease and impaired immune and thyroid function).

Chromium is an insulin cofactor that helps insulin work better, since it helps the hormone escort glucose from the blood-stream

into cells. Diabetic-promoting diets are low in chromium. Eating refined grains, sweets, and processed foods leads to chromium deficiency and worsens diabetes.

Zinc is necessary for the production of insulin which regulates blood sugar levels and interacts also with other nutrients.

Effect of eating vegetables before carbohydrates on glycemia

Figure 1 shows a Continuous Glucose Monitoring (CGM) data, of one patient with Type 2 diabetes (T2D), after eating carbohydrates before vegetables and after eating the reverse regimen. When the patient ate carbohydrates before vegetables, we can see values of the postprandial hyperglycemia of 360, 320, and 340 mg/dl; and also hypoglycemia before the meal. When the patient ate vegetables before carbohydrates, postprandial hyperglycemia were decreased, and no hypoglycemia was observed.

Figure 1: Continuous Glucose Monitoring (CGM) data of one patient with Type 2 diabetes (T2D) after eating carbohydrates before vegetables and the reverse regimen.

Imai., *et al*. [8] examined whether eating vegetables before carbohydrates could reduce the daily postprandial glucose excursions assessed by a CGM system (CGMs) in 19 Japanese patients with T2D and 2 subjects with Normal Glucose Tolerance (NGT) (Figure 2). The 19 outpatients with T2D enrolled in the study were: male/female=6/13; age=65.5 ± 9.4 years; duration of diabetes=16.4 ± 10.2 years; BMI=22.5 ± 3.1 kg/m^2; HbA1c=7.2 ± 1.0%; and Fasting Plasma Glucose (FPG)=8.06 ± 2.67 mM/l. And the 21 subjects with NGT were: male/female=2/19; age=29.8 ± 11.3 years; BMI=20.8 ± 3.0 kg/m^2; HbA1c=5.4 ± 0.6%; and FPG=4.89 ± 0.50 mM/l). All these 40 participants were assigned to a CGM system (Medtronic Minimed Gold, Northridge, CA) for 72 hours by eating test meals of vegetables before carbohydrates and carbohydrates before vegetables on the 2nd and the 3rd day in a randomized crossover design.

The test meals consisted of 500 g of vegetables (tomato, spinach, broccoli, and radish, etc.), meat or fish as the main dish and rice or bread as carbohydrates. And contained 21 grams of dietary fiber and 125.6 kJ.kg^{-1} per day. Energy intake was adjusted by the amount of rice and bread for each participant and the rest of the meals were identical. The energy ratio of protein, fat, and carbohydrates was 17%, 25%, and 58%, respectively. The subjects ate the first dishes of vegetables for 5 minutes, then the main dish for 5 minutes, and consumed rice or bread for 5 minutes successively within a 15 to 20 minutes total eating time for each meal, and vice versa.

Figure 2 shows the plotted mean of the daily glucose values in the 19 patients with T2D and the 21 subjects with NGT after eating carbohydrates before vegetables, and the reverse regimen. The results reveal a significantly reduction in glucose excursions when the participants ate vegetables before carbohydrates compared to the reverse regimen in subjects with T2D and NGT.

Figure 2: Effect of eating vegetables before carbohydrates in glucose concentration of 19 patients with T2D and 21 NGT subjects. Plotted mean of the daily glucose values in the T2D patients and in the NGT subjects NGT after eating carbohydrates before vegetables, and the reverse regimen.

In addition to lowering acute postprandial glucose levels Imai., *et al*. [9] studied whether educating diabetic patients to eat vegetables before carbohydrates was effective on long-term glycemic control. To test this hypothesis they carried out another study in patients with T2D where they compared changes in HbA1c (NGSP-%) as the primary outcome. A total of 333 outpatients were divided into two groups: one educational group (n=196) that received instructions about eating vegetables before carbohydrates; and a control group (n=137) who underwent only on a medical examination by a doctor. In the educational group depending on the patient's current dietary intake, intervention aimed to encourage increased consumption of vegetables, including seaweed and mushrooms, and eating them first for 5 minutes, then the main dishes (meat,

fish, soybeans, etc.) for 5 minutes, and by last carbohydrates (rice or bread, but also potatoes, pumpkin, corn, etc.), successively within a 15 to 20 minutes eating time using an original educational brochure in the educational group. Student's t tests were used to assess the difference between the changes in HbA1c (NGSP%) in the two study groups and paired t tests were performed to analyze them within groups over time.

Figure 3: Effect of eating vegetables before carbohydrates on long-term glycemic control. Study carried out during 30 months (2,5 years) in two groups of patients with T2D: educational (n=196), eating vegetables before carbohydrates, and the control. It was compared changes in HbA1c (NGSP %). Data are expressed as mean ± SD. Baseline vs. after intervention (months): ***= p<0.001. Educational group (Veg. before carbo.) vs. control group: #=p<0.05, ###= p<0.001.

Improvements in HbA1c levels over 30 months were maintained from 8.6 to 7.5% (NGSP%) with the education group (p < 0.001) while no change was observed with the control group (8.2 to 8.1%), and HbA1c levels in the education group were significantly lower than the control group after 3 to 30 months of the study period [8,10].

The reason for the reduction of postprandial plasma glucose levels by eating vegetables before carbohydrates can be explained, partly, by the dietary fiber content in the vegetables taken before the carbohydrates. Dietary carbohydrates consumed after vegetables were digested slowly and required less insulin for subsequent metabolic disposal [11]. Other factors may influence the glycemic response and digestion of carbohydrates in the small intestine, including the rate of digestion, cooking method, transit time and rate of intestinal absorption. Vegetables given before carbohydrates might stimulate incretin hormone secretion, which leads to the reduction in glycemic excursions [12].

Conclusion

Vegetables are associated with a decrease risk of Type 2 diabetes since they have dietary fiber and they deliver many phytochemicals, vitamins and minerals to our body in each calorie consumed.

Eating vegetables before carbohydrates is effective to reduce postprandial hyperglycemia (and less hypoglycemia) in Type 2 diabetes patients. So Type 2 diabetes patients should eat vegetables before carbohydrates. This advice is also applicable to healthy people in order to prevent future diabetes. Raw vegetable salads should be eaten in large quantities at the beginning of each main meal. This easy approach of consuming vegetables before carbohydrates supports the new concept of the diabetic diet of eating first vegetables, as opposed to concentration on energy or carbohydrate restrictions.

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