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Pinto Beans and Green Beans Result in Comparable Glycemic Control in Adults with Type 2 Diabetes: A Randomized Pilot Trial

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Abstract

Aims: Glucose control is essential to slow disease progression in people with type 2 diabetes mellitus (T2DM). The acute effects of dry bean consumption on glucose control are well established, but their long-term effects in daily diets are less known.

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Results: Eight participants completed both treatment periods. There were no statistically significant changes ($p<0.05$) in fasting glucose, HbA1c or average postprandial glucose values between the two interventions.

Conclusions: Pinto beans and green beans result in comparable glycemic control when incorporated into the normal diet of adults with T2DM even though pinto beans have more available carbohydrate per serving.

Keywords

Legumes, Pulses, Phaseolus vulgaris, Diabetes, Glycemic Response, Available Carbohydrate

Disciplines

Endocrinology, Diabetes, and Metabolism | Food Chemistry | Food Processing | Food Science | Human and Clinical Nutrition | Molecular, Genetic, and Biochemical Nutrition | Nutritional Epidemiology

Comments

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Keywords: Legumes; Pulses; Phaseolus vulgaris; Diabetes; Glycemic Response; Available Carbohydrate

Abbreviations: DASH: Dietary Approaches to Stop Hypertension; HbA1c: Hemoglobin A1c Blood Concentrations; T2DM: Diabetes Mellitus; MANOVA: Multiple analysis of variance; GI: Glycemic Index; GL: Glycemic Load.

Introduction

Over 27 million people in the United States (US) have type 2 diabetes mellitus (T2DM) [1,2]. Long-term complications associated with T2DM, especially when blood glucose concentrations are not well controlled, include increased risks for cardiovascular disease, peripheral vascular disease, nephropathy, neuropathy, and retinopathy among others [3,4]. First-line therapy for controlling T2DM is lifestyle modification, including changes to diet and physical activity in combination with metformin [5]. As a component of the Mediterranean diet, and to a lesser extent the Dietary Approaches to Stop Hypertension (DASH) diet, dry bean (P.

vulgaris spp.) or legume consumption is a diet modification that has been associated with a reduced incidence of T2DM in adults [6,7] and promoted for improved glycemic control by decreasing insulin resistance [8].

Several single meal glycemic response studies have demonstrated that consumption of dry beans, a low glycemic index food, in combination with high glycemic index foods such as white rice or white bread lower the postprandial glycemic response in people with prediabetes or T2DM compared to consumption of the high glycemic index food alone [9,10]. These findings demonstrate that dry beans are metabolized differently than other foods that fall under the 'carbohydrate' umbrella in diabetes education materials. The difference in metabolism may be due, in part, to the lower available carbohydrate (total carbohydrate – dietary fiber) found in dry beans compared to other types of carbohydrates [11]. The American Diabetes Association, in their 2019 standards of medical care, state "Carbohydrate intake should emphasize nutrient-dense carbohydrate sources that are high in fiber, including vegetables, fruits, legumes, whole grains, as well as dairy products," and also emphasize the importance of legumes as a source of viscous fiber [6]. Regardless of the American Diabetes Association's view, beans are grouped with other starches in many diabetes nutrition education materials. Subsequently, these information tools teach people with T2DM to view dry beans as equivalent to rice, pastas, breads and other starchy vegetables such as potatoes and corn [12,13].

Despite evidence suggesting that consumption of dry beans with a high glycemic index food in a single meal will lower the overall postprandial glycemic response, few studies exist that investigate the effect of cooked dry beans eaten as part of a normal diet over several weeks on glycemic response in persons with T2DM [9,14,15]. Long-term glucose control, through diet, exercise and, if necessary, medications, is important for people with T2DM to slow disease progression. Prolonged elevation of postprandial glucose concentrations contribute to factors, such as tissue damage and impaired vascular endothelial function, that result in increased risk of related diseases such as cardiovascular disease and, over time, a decline in the normal physiologic functioning of the pancreas [16,17]. Therefore, this study was designed to determine the efficacy of pinto beans compared to green beans for glycemic control. The hypothesis stated that pinto beans and green beans would provide equivalent glycemic control as indicated by fasting glucose, postprandial glucose, and hemoglobin A1c (HbA1c) blood concentrations in adults with T2DM. The findings of this study are clinically important for advancing medicine and nutrition scientific research regarding the glycemic properties of dry beans in the diet, particularly for control of T2DM.

Materials and Methods

Study Design and Participants

This study utilized a randomized, pretest-posttest, crossover (within-group) design that includes two treatment periods (½ cup green beans each day and ½ cup pinto beans each day), each 12-weeks in duration with a 4-week wash-out period to determine the effect on fasting glucose, postprandial glucose and HbA1c concentrations. Adults aged 20-75 years with T2DM were recruited from the University of Colorado Colorado Springs campus and surrounding community between March 2009 and July 2010. Eligibility criteria included (1) diagnosis of T2DM by a physician; (2) currently attempting control of T2DM by diet and/or metformin; (3) fasting glucose ≥ 90 mg/dL (confirmed by fasting blood draw or potential participant provided lab analysis conducted within last 30 days) and/or HbA1C ≥ 6.5% (confirmed by blood draw or potential participant provided lab analysis conducted within last 30 days); (4) body mass index (BMI) of 22-40 kg/m2; (5) no unresolved health conditions (i.e., health conditions that were not controlled by diet, lifestyle and/or medication) and no diagnosis of gastrointestinal disease; (6) limited history of dry bean intake; (7) willingness to follow study protocol, scheduling, and ability to come to the testing location; (8) no recent weight gain or loss (>10% over 6 months); (9) no use of medications and/or dietary supplements other than metformin that affected glucose; (10) women could not be pregnant or breastfeeding; and (11) habitual alcohol consumption had to be less than 2 drinks per day (specifically ≤ 720 ml of beer, 240 ml of wine, or 90 ml of hard liquor). Individuals who met the eligibility criteria were enrolled by study personnel and assigned to an intervention sequence (green bean-pinto bean or pinto bean-green bean) by the primary investigators using simple randomization technique [18]. Due to the interventions used, the investigators and participants were not blinded to intervention or sequence.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the University of Colorado Colorado Springs Institutional Review Board (#09-028). Informed written consent for inclusion was obtained from all participants. Participants received an incentive in the form of gift cards for the completion of each intervention period. The study is registered with ClinicalTrials.gov, NCT04003194.

Participants completed a 2-week wash-in period to allow for baseline collection of diet information via four 24-hour diet records and familiarization with diet recording protocols prior to beginning the first of the two interventions. Participants were instructed to not eat other dry beans, fresh or canned string or wax beans during the intervention phases.

The researchers explained to participants which 'beans' they should not be consuming and provided an information sheet. During each intervention week, participants completed one 24-hour diet record, providing 12 diet records during each intervention for a total of 28 diet records, including those completed during the wash-in period. Diet records were analyzed to determine macro- and micronutrient intake during the wash-in period and interventions (The Food Processor® version 11.4.0; ESHA Research, Salem, OR, USA). Diet records were also used to determine total carbohydrate (CHO) and available CHO for the day and for the meal at which the intervention food was consumed. Each week participants completed a gastrointestinal symptom questionnaire for the 7-days preceding. Questions asked about changes in flatulence, stool frequency, stool consistency, and bloating. Those who answered yes, were asked if these changes interfered with their daily activities or social events [19].

Participants were provided with and trained to use OneTouch® Ultra glucometers (LifeScan, Inc. Malvern, PA). Testing supplies, including glucometer test strips (OneTouch® Ultra test strips; LifeScan, Inc. Malvern, PA), were also provided. During the wash-in period and interventions, on the days during which the participants kept a diet record, participants measured their glucose concentration one (1) hour after the meal (postprandial glucose) during which they consumed the pinto beans or green beans. There were no changes to the methods once the study commenced.

Diet Interventions

Participants incorporated ½ cup of pinto beans or ½ cup of green beans into their normal diet during the 12-week interventions. The beans were consumed as part of one meal of the participants' choice each day. Canned pinto beans or sliced French style green beans each purchased from the same lot number (both from The Kroger Co. Cincinnati, OH) were provided every 2 weeks when participants came to the testing center to be weighed and submit diet records. Each can contain three ½ cup servings. Instructions regarding the measurement and proper storage of the pinto bean or green bean servings once a can was opened were given verbally and in writing at study start. Participants drained and rinsed both beans prior to consumption. Measuring cups and storage containers were provided at the beginning of the study.

The quantity of ½ cup of pinto beans was chosen because it conformed with the US Dietary Guideline recommendation for consumption of dry beans as a vegetable or protein food that was current at the time the study was conducted [20]. The portion also follows with the serving recommendation for dry beans as a starchy vegetable for people with diabetes who are using carbohydrate counting as a means of controlling blood glucose concentrations [12,13]. The total carbohydrate, available (or net) carbohydrate, glycemic index and glycemic load values are found in Table 1.

Green beans were chosen as a comparison food because they are not classified as a dry bean or legume but are a commonly consumed and accepted canned vegetable that provides a low amount of available carbohydrate, has a low glycemic index and glycemic load (Table 1) and may be beneficial for glycemic control [21]. A ½ cup portion conforms to the serving recommendation for non-starchy vegetables for people with diabetes who are using carbohydrate counting as a means of controlling blood glucose concentrations [12].

	Amount	Carbohydrate (g)	Dietary Fiber (g)	Available carbohydrate[1] (g)	Protein (g)	Fat (g)	Glycemic Index[2]	Glycemic Load[3]
Pinto Beans, canned	½ cup (128 g)	16	5	11	6	1	39	5
Green Beans, canned	½ cup (120 g)	4	2	2	1	0	20	0.4

Table 1: Macronutrient content, glycemic index and glycemic load of pinto beans and green beans [22-26].
Available (or net) carbohydrate = total grams of carbohydrate – dietary fiber [11].
Glycemic index presented uses glucose as a comparison [26].
Glycemic Load = GI/100 multiplied by the net grams of planned carbohydrate (net carbohydrate is the total grams of carbohydrate minus the dietary fiber) [11].

Anthropometric and Biochemical Evaluations

After an overnight fast (approximately 12 hours) at the beginning and end of each intervention, participants came to the test site where they were weighed to the nearest 10th of a pound on a scale (Tanita TBF300A, Arlington Heights, Illinois, USA). Participants were weighed every 2 weeks when they came to the testing site to turn in diet records and pick up cans of the intervention foods during each intervention period. Height was measured to the nearest ¼ inch using a stadiometer at the beginning of the baseline wash-in period. Body mass index was calculated using the standard formula weight (kg)/height (m)^2.

Venous forearm blood samples were taken at the start and conclusion of each intervention by a certified phlebotomist to determine fasting glucose and HbA1c. Serum was separated by centrifugation at 1000g for 10 min and picked up from an insulated lockbox on the same day it was drawn for analysis of glucose and HbA1c by a commercial laboratory (Centura Laboratory, Centura Health, Colorado Springs, CO, USA) using standard commercial methodologies. There were no changes to the trial method or primary or secondary outcomes once the trial commenced.

Data Analysis and Variable Transformation

Data are expressed as means (±SD) change (end value – beginning value) for each end point during each intervention. Data were tested for normality via the Kolmogorov-Smirnov and Shapiro-Wilk tests and no transformations were necessary for analysis. Multiple analysis of variance (MANOVA) for repeated measures with time and diet as factors was used to establish differences between treatments. Once a significant change was identified by MANOVA, paired t tests were performed to determine differences by treatment. Variables for flatulence increase, stool change, and bloating increase were examined by intervention type for each week using Chi-square. If a person reported that the change was due to other food or illness, a change was not counted as relevant to the treatment (n=4). Dietary intake data (macro- and micro-nutrients) was analyzed using multivariate analysis to determine if nutrient intake changed during the pinto bean or green bean period or was significantly different between the meals during which the pinto beans or green beans were consumed. The level of significance was $p \leq 0.05$.

This study used a crossover, repeated measures design in which each participant served as his or her own control. Continuous data sample size determinations indicated a sample size of approximately 10 participants would be necessary to prove the hypothesis with a power of 80% at an α of 0.05. Therefore, an initial sample size of 13 participants was recruited to provide sufficient numbers to detect differences by repeated measures of analysis of variance and allow for a~25% dropout rate due to the length of the intervention periods over the course of the study. SPSS version 19 (SPSS, Chicago, IL, USA) was used for all analyses.

Results

Thirteen participants began the study and 8 participants completed both interventions (Figure 1).

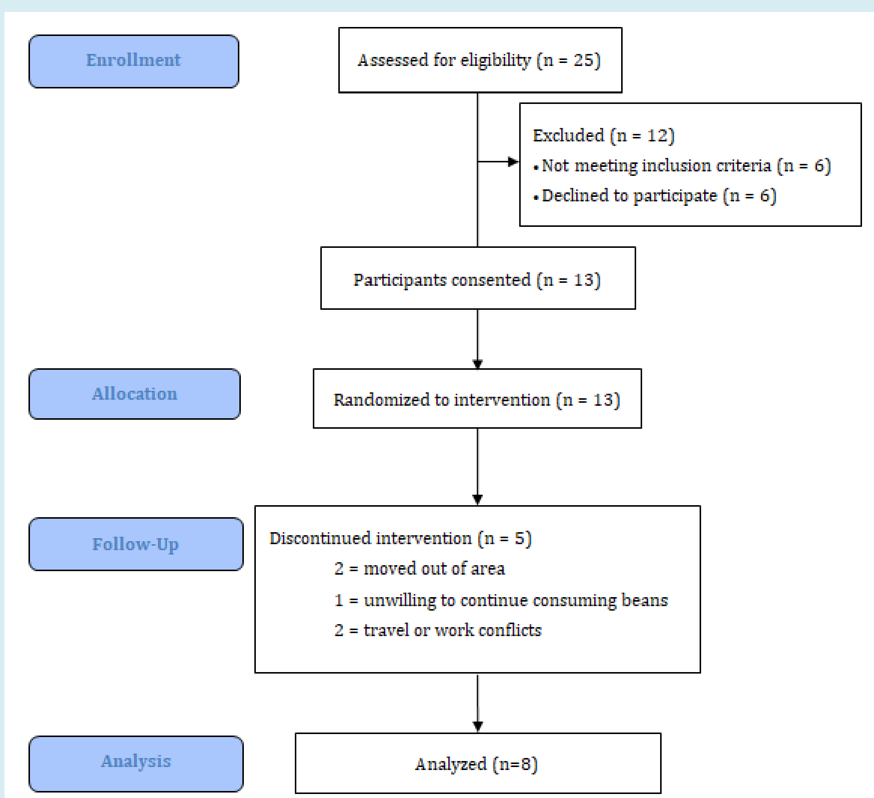

Figure 1: CONSORT 2010 Flow Diagram.

The reasons for participants dropping out included: moved out of the area (n=2), unwilling to continue consuming beans (n=1) and travel or work conflicts (n=2). All participants who dropped did so during their first intervention (three were on the green bean intervention and two were on the pinto bean intervention).

Participant characteristics are shown in Table 2. The average BMI at baseline was 33.7 ± 6.0 kg/m^2 (Table 2). Body weight and BMI were not significantly different compared to the baseline, nor between interventions (data not presented). The HbA1c and fasting glucose at the beginning of each intervention were analyzed to determine if there was any effect of order or carryover effect from the previous period. No statistically significant differences or correlations were noted; therefore, the 4-week washout between intervention periods was adequate.

	Participants who started the study (n=13)	Participants who completed both interventions (n=8)
Gender	2 male, 11 female	1 male, 7 female
Age (years)	53 ± 12	54 ± 15
Height (inches)	65.0 ± 2.8	64.7 ± 2.9
Weight (pounds)	209.6 ± 38.8	200.3 ± 37.6
BMI	35.0 ± 5.4	33.7 ± 6.0
HbA1c (%)	6.5 ± 1.0	6.6 ± 1.0
Good control (HbA1c < 7%) [16] Fair control (HbA1c 7-9%) [16]	n = 10 n = 3	n = 6 n = 2
Fasting Glucose (mg/dL)	131 ± 27	132 ± 30
Baseline Postprandial Glucose (mg/dL)	143 ± 49	154 ± 49

Table 2: Baseline characteristics of T2DM participants.

Data presented as means ± SD. There were no statistically significant differences between participants who started the study, participants who dropped out (data not presented), and those who completed both interventions.

Participants reported both the pinto beans and green beans were palatable. Based on the diet records, both were consumed as single component of a meal rather than being combined with other foods (e.g., beans and rice). Diet records and return of the empty cans every 2 weeks indicated compliance with the intervention protocol (> 83% of beans consumed during interventions). Based on self-administered 24-hour dietary recalls, no significant differences were observed in mean daily energy, protein, carbohydrate, total fiber, available carbohydrate, or fat between baseline and the interventions or between the interventions (Table 3).

	Baseline	Pinto Beans	Green Beans
Total kcal	2125 ± 621	2024 ± 534	1889 ± 575
Protein (g)	83 ± 31	88 ± 23	84 ± 28
Carbohydrate (g)	257 ± 85	236 ± 58	216 ± 57
Total fiber (g)	22 ± 10	24 ± 10	21 ± 5
Available Carbohydrate (g)	236 ± 76	212 ± 58	195 ± 54
Total fat (g)	90 ± 35	83 ± 33	80 ± 38

Table 3: Dietary intake across treatment periods.
Data presented as means ± SD. n = 8 for all dietary intake values presented.

There were no significant differences between the interventions in energy or macronutrients consumed (Table 4) or correlations between postprandial glucose and total carbohydrate or available carbohydrate at the meals at the meals at which the beans were consumed (Table 5).

	Pinto Beans	Green Beans
Total kcal	388 ± 321	461 ± 396
Protein (g)	20 ± 19	34 ± 102
Carbohydrate (g)	49 ± 33	43 ± 37
Total fiber (g)	8 ± 3	6 ± 6
Available Carbohydrate (g)	41 ± 30	37 ± 32
Total fat (g)	22 ± 90	21 ± 26

Table 4: Dietary intake for meals at which pinto beans or green beans were consumed.
Data presented as means ± SD. n = 8 for all dietary intake values presented.

	Pinto Beans				Green Beans			
	Postprandial Glucose	Total CHO	Dietary Fiber	Available CHO	Postprandial Glucose	Total CHO	Dietary Fiber	Available CHO
Week 1	141 ± 29	47 ± 31	7 ± 2	40 ± 30	144 ± 42	74 ± 46	11 ± 12	63 ± 38
Week 2	167 ± 65	50 ± 23	10 ± 5	40 ± 20	147 ± 37	41 ± 34	6 ± 4	35 ± 30
Week 3	147 ± 40	51 ± 31	9 ± 4	42 ± 28	147 ± 25	46 ± 48	7 ± 6	39 ± 43
Week 4	166 ± 60	52 ± 35	8 ± 3	45 ± 33	167 ± 41	34 ± 28	5 ± 4	28 ± 24
Week 5	130 ± 32	42 ± 23	7 ± 2	35 ± 21	144 ± 30	37 ± 32	4 ± 4	33 ± 28
Week 6	123 ± 30	51 ± 40	9 ± 5	42 ± 35	144 ± 30	31 ± 30	3 ± 3	27 ± 27
Week 7	136 ± 22	45 ± 24	9 ± 4	36 ± 21	139 ± 28	38 ± 33	4 ± 3	34 ± 31
Week 8	139 ± 35	54 ± 56	8 ± 4	46 ± 53	141 ± 31	27 ± 33	3 ± 3	24 ± 30
Week 9	150 ± 48	40 ± 34	7 ± 3	33 ± 31	138 ± 32	36 ± 25	7 ± 5	29 ± 22
Week 10	150 ± 35	44 ± 33	7 ± 2	37 ± 31	126 ± 38	54 ± 40	6 ± 3	48 ± 38
Week 11	145 ± 30	52 ± 34	8 ± 3	44 ± 31	148 ± 49	63 ± 42	11 ± 10	52 ± 34
Week 12	152 ± 46	55 ± 39	8 ± 3	47 ± 36	137 ± 29	36 ± 42	5 ± 6	31 ± 36
12-week average	145 ± 29	49 ± 33	8 ± 3	41 ± 30	143 ± 27	43 ± 37	6 ± 6	37 ± 32

Table 5: Postprandial glucose values (mg/dL) (a), total carbohydrate (CHO; g), dietary fiber (g) and available CHO (g) for meals at which pinto beans or green beans were consumed (b).
(a)Recommendation for peak postprandial glucose is <180 mg/dL [16].
(b)Data presented as means ± SD.

There were no significant differences in the beginning values, ending values or change in values for fasting glucose and HbA1c with either the pinto bean or green bean interventions (Table 6).

	Pinto Beans			Green Beans		
	Beginning	**End**	**Δ**	**Beginning**	**End**	**Δ**
Fasting Glucose (mg/dL)	144 ± 54	144 ± 48	0.3 ± 19	133 ± 31	151 ± 48	18 ± 20
HbA1c (%)	7 ± 1.5	7 ± 1.5	0.01 ± 0.9	6 ± 1.1	7 ± 1.2	0.3 ± 0.7

Table 6: Fasting glucose and HbA1c values and change measured from the interventions.
Data presented as means ± SD. n = 8 for all values presented.

Data analysis of the gastrointestinal questionnaires showed no significant differences in flatulence increase, stool change, or bloating increase between the two treatment phases, or by treatment week (Table 7). Out of a total 185 valid observation weeks, participants were fully compliant with eating the intervention food daily and no eating of other dry beans for 47.6% of the weeks. For 21% of the reported weeks, participants ate the treatment food less than daily and did not eat any other beans. For 18.9% of the weeks, the intervention food was eaten daily, but the participant also consumed more than a ¼ cup of other beans at least once. Twelve percent of the weekly reports indicated non-compliance for both daily treatment consumption and the exclusion of other dry beans. Two of the 8 participants had family medical emergencies or travel which affected their ability to participate fully.

	Flatulence		Stool Change		Bloating	
	Pinto Beans	Green Beans	Pinto Beans	Green Beans	Pinto Beans	Green Beans
Week 1	29% (2)	0	57% (4)	25% (2)	0	37% (3)
Week 2	12% (1)	12% (1)	25% (2)	37% (3)	12% (1)	12% (1)
Week 3	38% (3)	0	25% (2)	25% (2)	38% (3)	12% (1)
Week 4	12% (1)	12% (1)	12% (1)	25% (2)	25% (2)	25% (2)
Week 5	12% (1)	0	12% (1)	12% (1)	25% (2)	12% (1)
Week 6	0	0	12% (1)	25% (2)	25% (2)	0
Week 7	12% (1)	0	12% (1)	25% (2)	25% (2)	12% (1)
Week 8	12% (1)	0	12% (1)	12% (1)	25% (2)	0
Week 9	12% (1)	0	12% (1)	12% (1)	25% (2)	25% (2)
Week 10	0	0	25% (2)	12% (1)	0	12% (1)
Week 11	0	0	12% (1)	12% (1)	12% (1)	0
Week 12	0	0	12% (1)	12% (1)	25% (2)	0

Table 7: Percentage of cross-over trial participants reporting increased flatulence, stool change, or bloating each week by pinto bean or green bean intervention.
Data presented as percentage and (n).

Discussion

This study sought to determine if there was a link between pinto bean consumption and improved health or nutritional outcomes in adults with T2DM by exploring the strength of the relationship between regular pinto bean ingestion, as part of a 'normal' diet, and glycemic control. Comparing a starchy vegetable, pinto beans, with non-starchy vegetable, green beans, challenged the conventional paradigm that all starchy food (grains, vegetables, cereals) are the same and have equivalent impacts on glycemic control. Many studies examining glycemic control compare foods with similar total or available carbohydrate content. Some foods, such as dry beans, are classified as a 'starch' under the current food categorizations utilized for education of people with diabetes. We chose to compare a starchy and non-starchy vegetable to demonstrate dry beans provide a glycemic response that more closely resembles that of foods classified as non-starchy vegetables.

Our results from glycemic response trials utilizing beans indicate that black beans or chickpeas provided as a whole bean reduced the glycemic response to a rice test meal in non-diabetic women [27]. Pinto beans, black beans and dark red kidney beans provided as a whole bean lowered the glycemic response to a rice test meal in people with T2DM [10]. This intervention expanded on those single-meal results in people with T2DM by measuring the response to daily consumption of whole pinto beans as part of their normal diet over a 12-week intervention period.

Education on carbohydrates and carbohydrate counting is part of the diet counseling provided to people diagnosed with T2DM. Conventional education on carbohydrates includes identification of foods, such as grains, breads, starchy vegetables (including dry beans), milk and fruits, which are the primary sources of carbohydrate in the diet [12]. People with T2DM will be prescribed a specific amount of carbohydrate to consume each day, but the amount of available carbohydrate in the foods is rarely considered when determining that part of the nutrition prescription.

Expert opinions are mixed on the use of glycemic index (GI), glycemic load (GL), total carbohydrate and/or available carbohydrate in the education of people with T2DM to help them improve glycemic control [28-30]. Although the specific GI number assigned to a food can vary based on the comparison used (white bread vs. glucose), source, etc [25,26,31], there is consensus that foods can be grouped into high, medium and low GI categories based on the glucose response following their ingestion [31]. The use of GL instead of GI may be encouraged since it considers the portion size consumed which is known to impact the postprandial glucose response as well as the available carbohydrate, instead of total carbohydrate, in the food [11]. Available carbohydrate represents the total carbohydrate minus the dietary fiber in the food, representing the portion of the carbohydrate in the food that will impact postprandial glucose concentrations [11].

Dry beans are rich in fiber, resistant starch and amylase, dietary constituents that slow carbohydrate digestion and absorption [32]. These dietary constituents result in dry beans, including pinto beans, to be considered a medium or low GI food with a low GL [25,26]. They also lower the available carbohydrate in dry beans compared to many of the other carbohydrates included in the "Grains, breads, starchy vegetables" category commonly found in diabetes education materials [12]. Therefore, we expected the glycemic response to a meal that includes pinto beans to be no greater than a meal that includes the green beans. Green beans are included in the 'non-starchy vegetable' list in diabetes education materials [12] due to their low carbohydrate content. Green beans also have a low GI, GL and available carbohydrate [25,26].

This study found that daily consumption of ½ cup pinto beans as part of a normal diet did not significantly increase postprandial glucose concentrations compared to 'non-starchy' green bean consumption, even though pinto beans have a higher GI, GL and amount of available carbohydrate. Participants' 1-hour postprandial glucose concentrations fell within the normal range (60-200 mg/dL) for both interventions, indicating that the carbohydrate from the pinto beans did not have a negative impact on glucose control. Demonstrating the glycemic response to a food classified as a 'starch' can be similar to a food classified as 'non-starchy', is clinically relevant because it challenges the validity of the categorizations used for diabetes education that are based on total carbohydrate content.

Participants' long-term glucose control indicated by HbA1c values at baseline as well as at the beginning and end of each intervention, was also equally good when consuming the pinto beans and the green beans. Even though fasting glucose concentrations were higher than desirable (< 100 mg/dL) at both the beginning and end of the interventions, neither of the interventions had a statistically relevant impact on the ending fasting glucose concentrations or change in concentrations.

Strength of this study was asking the participants to incorporate the interventions as part of a normal diet, representing how people will typically use and consume these foods. Unlike other long-term studies, meals were not provided. Based on diet records and biweekly face-to-face interactions with participants, the 12-week duration was tolerable. Results substantiate that adding the ½ cup of beans (110 calories pinto beans vs. 20 calories green beans) did not cause weight gain.

Limitations

This study has limitations that effect the ability to generalize the results to other populations. The study included people with T2DM, so whether other populations with impaired glucose and insulin utilization, such as those with prediabetes or polycystic ovarian syndrome, would respond in a similar manner is unknown. Documentation of consumption relied on return of the canned food products and was not validated by a biomarker. Full compliance with the protocol for all weeks was met by almost half of the participants for the two 12-week intervention periods. Due to a high drop-out rate, the small final sample size may have resulted in significant differences which would impact the conclusions to be missed. Glycemic response studies using beans have noted postprandial glucose differences at 90- and 120-minutes following meal consumption [9,10,27,33-35]. In non-diabetic individuals, the peak postprandial glucose concentration often occurs at approximately 60 minutes. However, in people with T2DM, abnormalities in insulin release and metabolism and glucose uptake and metabolism result in postprandial glucose concentrations that may peak later, often at approximately 120 minutes [36]. Although the current recommendation for postprandial glucose testing for persons with T2DM is that it is conducted 1-2 hours after the meal [16], testing the postprandial glucose 1 hour following the bean meal may have missed postprandial glycemic differences due to bean consumption.

Conclusions

This study demonstrated that glycemic control when pinto beans were incorporated into the normal diet of men and women with T2DM was similar to glycemic control when a non-starchy vegetable, green beans, was included as part of the daily diet. Conventional diabetes education on carbohydrates and controlling carbohydrate intake emphasizes the difference between 'starchy' and 'non-starchy' vegetables, with non-starchy vegetable consumption encouraged and starchy vegetable intake controlled or limited. However, this study suggests that some starchy vegetables, such as pinto beans, may influence postprandial glucose or long-term glucose control in a manner similar to non-starchy vegetables, suggesting that their intake should be encouraged as well.

This study was designed as a short-term trial and, based on the results obtained, provides enough preliminary evidence to support a longer-term trial exploring this relationship. A longer-term trial should include participants tracking their fasting and 2-hour postprandial glucose values daily using a glucometer to better assess the day-to-day impact of dry bean consumption on glucose concentrations. In addition, we recommend exploring this relationship in other populations with compromised glucose and insulin utilization such as people with prediabetes or those with polycystic ovarian syndrome.

Study Highlights

- Daily consumption of ½ cup pinto beans as part of a normal diet results in similar postprandial glucose concentrations compared to 'non-starchy' green bean consumption, even though pinto beans have a higher GI, GL and amount of available carbohydrate.
- This study demonstrates the glycemic response to a food classified as a 'starch' can be similar to a food classified as 'non-starchy', challenging the categorizations based on total carbohydrate content used for diabetes education.
- Participants' long-term glucose control, indicated by HbA1c values at baseline as well as at the beginning and end of each intervention, was equally good when consuming the pinto beans and the green beans.
- Consumption of dry beans, like pinto beans, should be encouraged by people with diabetes due to their positive impact on glycemic control.

Contributions

The authors contributed the following: conceptualization, A.M.H. and D.M.W; methodology, A.M.H. and D.M.W; formal analysis, A.M.H. and D.M.W; investigation, A.M.H.; writing-original draft preparation, A.M.H.; writing-review and editing, A.M.H. and D.M.W; project administration, A.M.H.; funding acquisition, A.M.H.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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