





# Effect of Five Vegetables on Glucose, Insulin and Antioxidant Activity in Type 2 Diabetics

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Abstract	Article History
<p><b>Purpose:</b> The study evaluated glycaemic index, insulinemic index and effect of vegetables on type 2 diabetics (T2D) after consumption of rice on postprandial plasma glucose (PPG), insulin and antioxidant activity.</p> <p><b>Methods:</b> This study was on 100 consenting T2D who were on diet alone. One hundred non-diabetic workers served as control. Control consumed each vegetable (bitter leaf, scent leaf, waterleaf, spinach leaf, bush-buck leaf) or glucose (control) containing 50g of glycaemic carbohydrate to establish glycaemic and insulinemic indexes. The T2D consumed rice with each vegetable's sauce or white sauce. Glucose and insulin were measured quarter hourly, for 2 hours.</p> <p><b>Results:</b> All vegetables resulted in significantly lower incremental Area Under the Curve (AUC) for PPG and insulin compared to control in healthy participants. Glycaemic and insulinemic indexes values of bitter leaf, scent leaf, waterleaf, spinach leaf and bush-buckleleaf were 38.51±2.21 and 42.33±3.22, 33.71±4.34 and 32.12±5.34, 35.62±3.52 and 38.32±5.32, 34.62±2.41 and 37.45±2.44 and 45.96±3.88 and 49.43±5.90 respectively which were considered low. Among T2D, there were significantly lower AUC for glucose and insulin and reduced PPG peaks after consumption of vegetables than white sauce. There was increased antioxidant activity after 2hours measured by 2,2-diphenyl-1-picrilhidracyl methods.</p> <p><b>Conclusions:</b> The vegetables could reduce PPG, insulin and increase antioxidant activity in healthy people and T2D.</p> <p><b>Keywords:</b> Diabetes, vegetables, glucose, insulin, antioxidants.</p>	<p>Received: 22 Mar 2025 Accepted: 02 Apr 2025 Published: 10 May 2025</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article.</p>
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## 1. Introduction

Vegetables are functional foods and good sources of dietary fiber and bio-active compounds with antioxidant activity in addition to being low in calories<sup>1</sup>. In the case of diabetes, consuming high-calorie meals can lead to exaggerated postprandial peaks in blood glucose and in lipids that generate reactive oxygen species which results in inflammation<sup>2</sup>. There are six major classes of nutrients essential for human health: carbohydrates, lipids, proteins, vitamins, minerals, and water. Carbohydrates, lipids and proteins can be metabolically converted to smaller molecules in the process of releasing energy<sup>3</sup>. Some vitamins are phytochemicals. They can be derived from various sources such as whole grains, fruits, vegetables, nuts and herbs<sup>1</sup>.

Phytochemicals also possess strong antioxidant activities (scavenging of free radicals). Phytochemicals have been associated with lowering of the risk of chronic diseases such as cancer, cardiovascular diseases and protection against

neurodegenerative diseases like Alzheimer and Parkinson. Examples of phytochemicals are polyphenols, anthocyanidins, carotenoids, flavonoids, catechins, glucosinolates, terpenes, tannic acid, saponin, alkaloids, chlorophyll, lectin and polyacetylenes<sup>4</sup>. The purpose for conducting this study was to evaluate the glycaemic index, insulinemic index and the effect of traditional vegetables (bitter leaf *Vernonia amygdalina*, scent leaf *Ocimum gratissimum*, water leaf *Talinum fruticosum*, spinach leaf *Amaranthus hybridus* and bush-buck leaf *Gongronema latifolium*) on patients with type 2 diabetes after consumption of rice meal on the postprandial response of glucose, insulin and antioxidant activity.

## 2. Materials and Methods

**Research design:** This is an experimental design study.

**Ethical Approval:** Ethical approval was obtained from University of Nigeria Teaching Hospital (UNTH) Health Research Ethics Committee. The registration number was NHREC/05/01/2008B-FWA00002458-IRA00002323. All the

procedures were conducted with an adequate understanding by, and the written consent of the participants.

**Informed consent:** Before the commencement of data collection of this study, informed consent of prospective subjects was duly sought and obtained after a clear explanation of the procedure behind the study in the language appropriate for each research participant. Each participant received a monetary compensation for travel, time and effort upon study completion.

### Participants

One hundred outpatients (29 men and 71 women), diagnosed with type 2 diabetes mellitus and recruited randomly from the diabetes clinic at the University of Nigeria Teaching Hospital, Ituku-Ozalla, participated in the study. Patients with type 2 diabetes mellitus were treated with medical nutrition therapy alone, and were aged 40-70 years [mean  $\pm$  standard deviation (SD) of  $55.64 \pm 7.84$  years], with a body mass index (BMI) of  $< 30 \text{ kg/m}^2$  (mean  $\pm$  SD of  $26.85 \pm 3.76 \text{ kg/m}^2$ ). The duration of diabetes mellitus was  $\leq 5$  years, with fasting plasma glucose  $< 6.7 \text{ mmol/l}$  and mean HbA1c level of less than 6.5%. The participants had not experienced dyslipidaemia, hypertension, acute illness, fever, undue stress, gastrointestinal disease, autonomic dysfunction or severe hypoglycaemic episodes during the past year, nor taken oral or inhaled prednisone or cortisone medication in the previous 30 days. Exclusion criteria also included current cigarette smokers, presence of known medical problem or currently on any medication. This group was used to evaluate the effect of the five vegetables on postprandial plasma glucose and serum insulin concentration after the consumption of the five different vegetables and rice. One hundred apparently healthy non-diabetic University of Nigeria Teaching Hospital workers who were matched in age and sex with the type 2 diabetes mellitus patients formed the control group. They had a BMI  $< 30 \text{ kg/m}^2$  (mean  $\pm$  SD of  $23.14 \pm 4.13$ ), fasting plasma glucose  $< 5.8$  and  $> 3.3 \text{ mmol/l}$  and  $> 7.7 \text{ mmol/l}$  120 minutes after the ingestion of 75 g oral glucose. This group was used to determine the glycaemic and insulinemic indexes of the five vegetables. Individuals with coronary heart disease, a history of renal and liver disease, surgery in the six months preceding the study, or who were currently on any medication were ineligible to participate. Eligible participants attended a screening visit<sup>5</sup>.

### Protocol

Subjects with type 2 diabetes were tested on six separate occasions. A washout period of one week was allowed, which preceded the next test. Control subjects were tested on seven separate occasions. The non-diabetics (control group) presented at the hospital for a sixth and seventh weekly visit for the 50 g glucose administration. Each participant arrived at 7h00 after a 12-hour overnight fast. Fasting plasma glucose and serum insulin readings were taken twice, and the average of the two values was recorded. Subjects were randomly given one of the six meals to consume with 240 ml of water within 15 minutes. The non-diabetics also consumed 50 g glucose within this time. The subjects remained sedentary, with the exception of trips to the bathroom, during the two-hour study period. Blood samples were drawn through an intravenous catheter placed in the upper arm in the antecubital vein before the consumption of the test meal 15, 30, 45, 60, 90 and 120 minutes after starting to eat. Venous blood glucose (plasma with potassium oxalate and sodium fluoride anticoagulant) and serum insulin were measured in the University of Nigeria Teaching Hospital chemical pathology laboratory by a medical laboratory scientist using the glucose oxidation method (Roche/Hitachi 902® auto analyzer, Roche Diagnostics, Japan) and human radioimmunoassay kit (Linco Research Inc) respectively. The antioxidant capacity was determined by methods of 2,2-diphenyl-1-picrylhydrazyl which has been previously described<sup>6</sup>.

**Test meals:** The test meals were composed of portions of each vegetable containing 50g of available carbohydrates (approximately 140grams) which is defined as total carbohydrate minus dietary fiber according to the recommendation of the joint Food and Agricultural Organization of the United Nations, World Health Organization Expert Consultation<sup>7</sup>. Because raw vegetables contain a significant amount of water, dehydrated vegetables were utilized to determine their glycaemic and insulinemic indexes. The vegetables were purchased from Ogbete market in Enugu and dried for 48hours at 55°C. The macronutrient composition of the meals in dried (Table I) and cooked weight basis was determined according to the Association of Analytic Communities method.

**Table 1:** Chemical composition of each test vegetable per 100 g edible portion

	Bitter-leaf	Scent-leaf	Water-leaf	Bush-buck-leaf	Spinach-leaf
Moisture	9.32 $\pm$ 0.04	6.26 $\pm$ 0.06	16.43 $\pm$ 0.01	7.75 $\pm$ 0.91	10.04 $\pm$ 0.05
Ash	13.65 $\pm$ 1.20	10.79 $\pm$ 0.01	10.34 $\pm$ 0.02	13.59 $\pm$ 0.18	13.86 $\pm$ 0.69
Crude fat	4.33 $\pm$ 0.30	2.92 $\pm$ 0.03	2.90 $\pm$ 0.04	5.31 $\pm$ 0.21	4.16 $\pm$ 0.31
Dietary Fiber	18.17 $\pm$ 0.23	24.93 $\pm$ 0.10	16.40 $\pm$ 0.01	27.46 $\pm$ 2.42	17.44 $\pm$ 0.01
Crude Protein	18.50 $\pm$ 0.20	19.19 $\pm$ 0.02	19.14 $\pm$ 0.13	9.34 $\pm$ 0.14	18.49 $\pm$ 0.02
Glycaemic				36.55 $\pm$ 0.03	
Carbohydrate	36.03 $\pm$ 1.50	35.91 $\pm$ 0.04	34.79 $\pm$ 0.03	0.37 $\pm$ 0.01	36.01 $\pm$ 0.03
Alkaloid	3.42 $\pm$ 0.13	0.12 $\pm$ 0.03	6.00 $\pm$ 0.02	6.32 $\pm$ 0.02	0.41 $\pm$ 0.01
Tannic acid	0.51 $\pm$ 0.01	8.00 $\pm$ 0.18	0.14 $\pm$ 0.01	4.04 $\pm$ 0.86	0.51 $\pm$ 0.01
Saponin	1.78 $\pm$ 0.03	0.86 $\pm$ 0.04	1.41 $\pm$ 0.01	0.57 $\pm$ 0.25	2.56 $\pm$ 0.01
Flavonoids	1.27 $\pm$ 0.03	9.22 $\pm$ 0.34	9.51 $\pm$ 0.03	15.84 $\pm$ 0.12	8.50 $\pm$ 0.08
Vitamin C	48.40 $\pm$ 0.56	186.73 $\pm$ 0.76	31.01 $\pm$ 0.10		49.69 $\pm$ 0.02

The boiled rice (300g) with bitter-leaf sauce (contained 467.85kcal and comprised 57.68% carbohydrate, 30.45% protein and 13.77% fat), scent-leaf sauce (contained 458.29kcal and comprised 57.08% carbohydrate, 31.48% protein and 11.44% fat), water-leaf sauce (contained 456.66kcal and comprised 57.06% carbohydrate, 31.31% protein and 11.44% fat), bush buck-leaf sauce (contained 469.75kcal and comprised 57.71% carbohydrate, 30.34% protein and 13.95% fat), spinach sauce (contained 462.56kcal and comprised 57.12% carbohydrate, 30.42% protein and 12.12% fat) and plain white sauce (contained 472.56kcal and comprised 67.12% carbohydrate, 30.12% protein and 12.22% fat). The sauce contained 300g steamed vegetable served as side dish.

**Study Design**

This study adopted an experimental study design

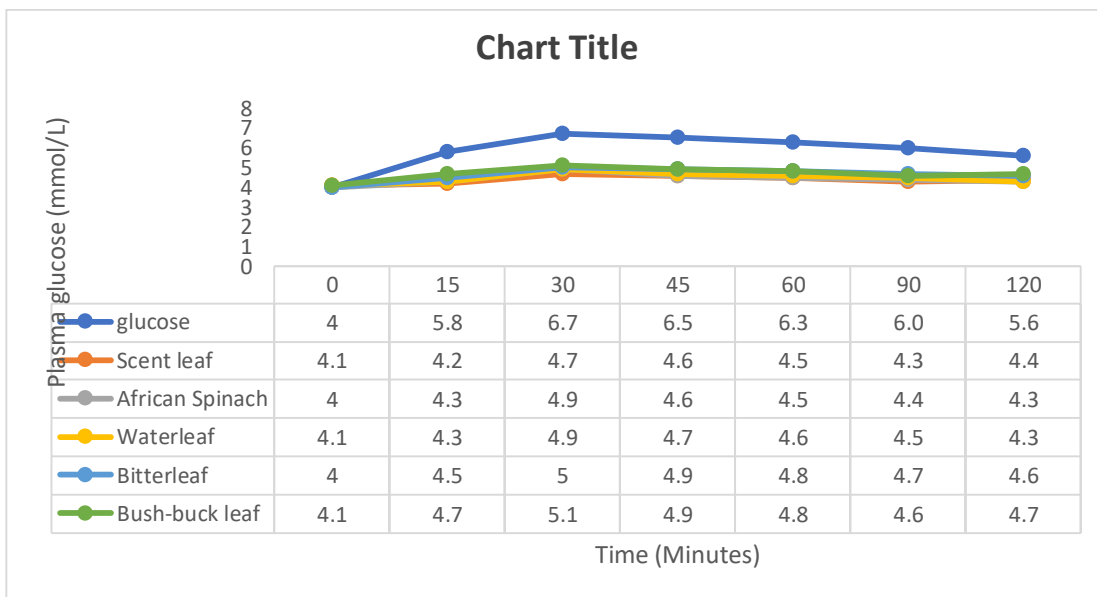
all of the statistical tests. Statistical analysis was performed with Statistical Package for Social Sciences® version 23.

**Statistical analysis**

Calculation of the glycaemic index (GI) and incremental area under the curve (IAUC), excluding the area below fasting were calculated using the trapezoid rule. The GI for each non-diabetic subject (control) was calculated by determining the average IAUC of the reference food, and then dividing the IAUC of the test meal by the average IAUC of the reference food, multiplied by 100. Data were expressed as mean ± SD. Student’s t-test was used to compare the IAUC between the groups. A p-value < 0.050 was considered to be significant in

**3. Results**

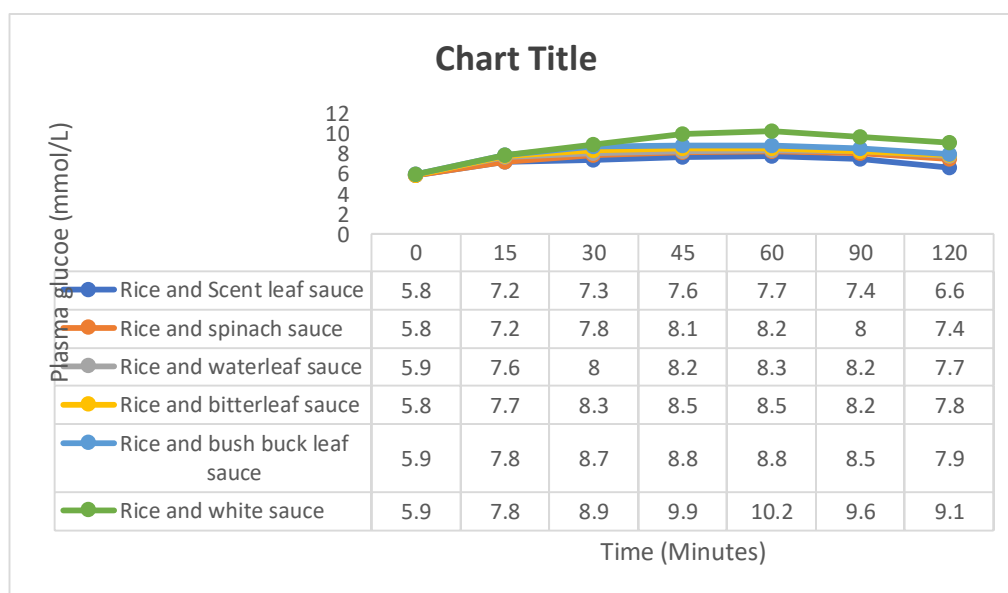
There was significantly lower fasting plasma glucose, fasting serum insulin and postprandial glucose recorded among the control group compared with the type 2 diabetes mellitus patients (p-value <0.05) figure 1, 2, 3 and 4. There was a significant decline in postprandial plasma glucose levels after 30 minutes of the administration of the vegetables compared with glucose among the control participants. This decline was lowest in scent leaf (figure 1) (p-value <0.05).



**Figure 1:** Mean plasma glucose concentration after consumption of test vegetables and glucose among the control

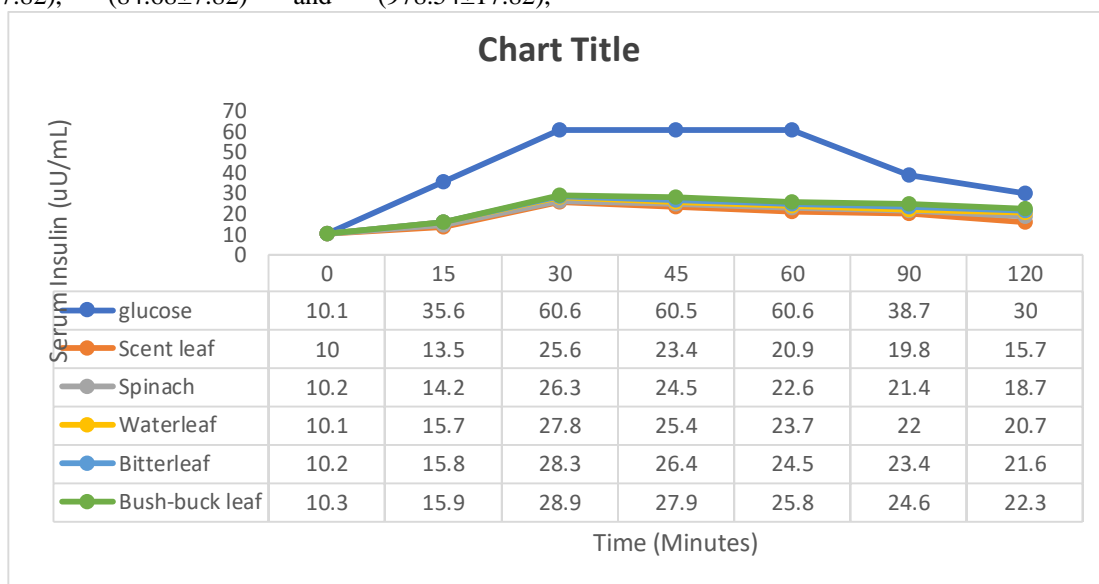
There was significant difference in plasma glucose at 0 (fasting) and 15, 30, 45, 60, 90 and 120 minutes after the consumption of boiled rice with test vegetables sauces compared with boiled rice and white sauce (p-value <0.05) among the type 2 diabetes participants. Peak plasma glucose

was recorded at 60 minutes in all the traditional vegetables consumed by the diabetes participants with lowest value recorded in rice and scent leaf sauce (7.6mmol/L). Rice and white sauce recorded highest peak postprandial plasma glucose at 60 minutes (10.2mmol/L) (figure 2).



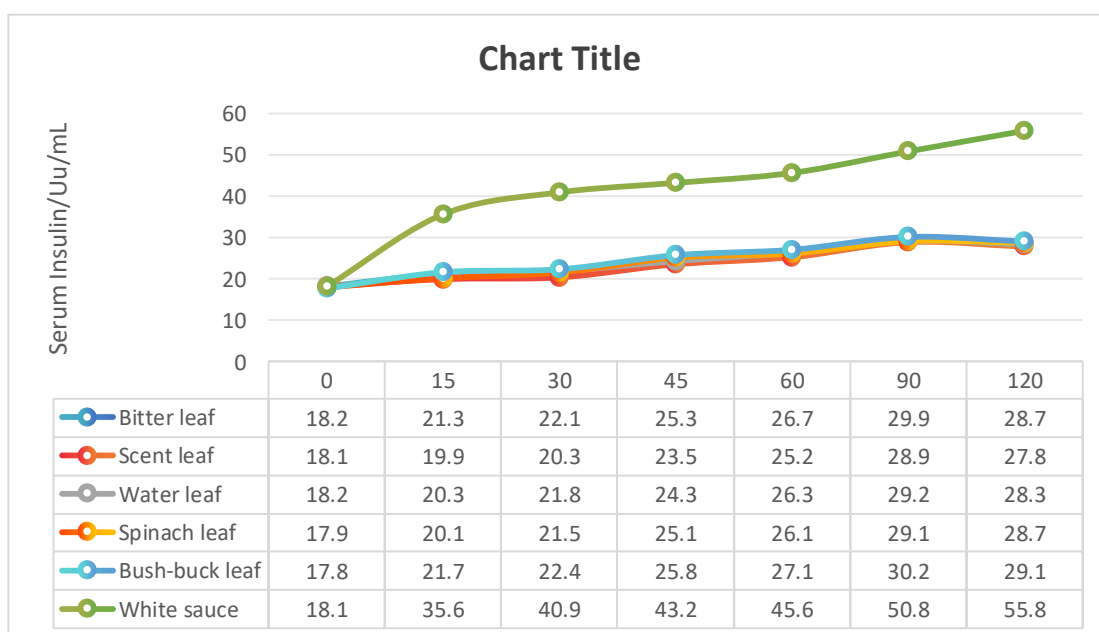
**Figure 2:** Mean plasma glucose concentration after consumption of test meals and glucose among Type 2 diabetes participants

The ingestion of 50 g available carbohydrates from bitter leaf, (79.40±8.22) and (1089±27.82), (108.82±9.82) and (1328.67±37.82) were recorded in bitter leaf, scent leaf, water leaf, spinach leaf and bush-buck leaf respectively. The glycaemic and insulinemic index values of bitter leaf, scent leaf, water leaf, spinach leaf and bush-buck leaf were 38.51±2.21 and 42.33±3.22, 33.71±4.34 and 32.12±5.34, 35.62±3.52 and 38.32±5.32, 34.62±2.41 and 37.45±2.44 and 45.96±3.88 and 49.43±5.90 respectively which were considered low.



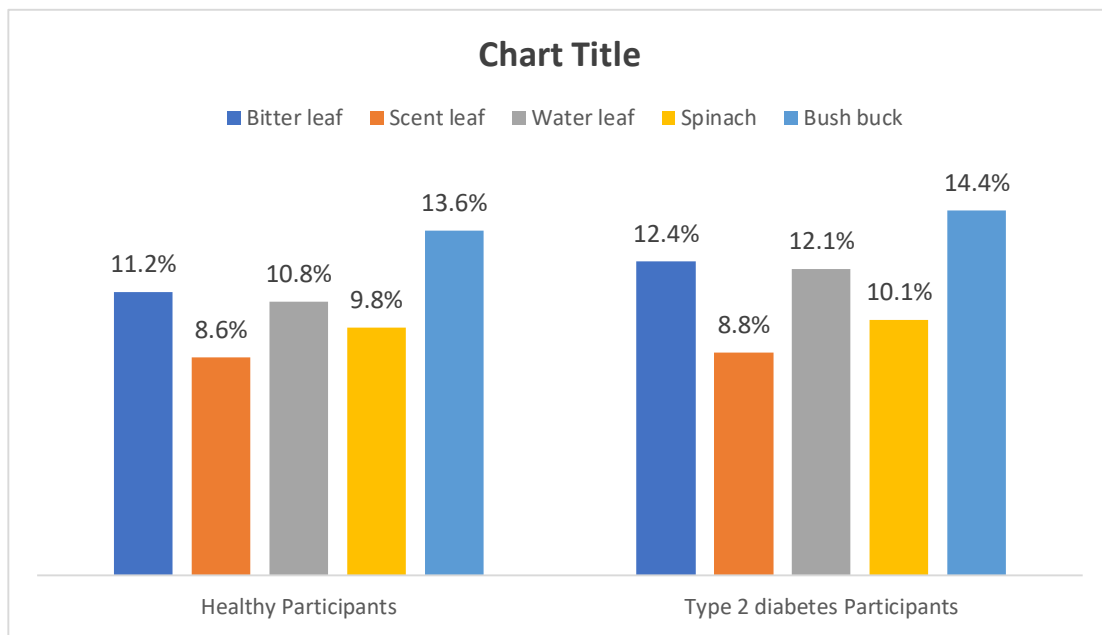
**Figure 3:** Mean serum insulin concentration at fasting state and 15, 30, 45, 60, 90 and 120 minutes after consumption of test meals by control participants.

The ingestion of the traditional vegetables lead to decreased in concentration in patients with type 2 diabetes during the the insulin concentration in patients with type 2 diabetes postprandial period with maximum value exceeding 120 during the postprandial period reaching a maximum value at minutes (figure 4). 90 minutes. White sauce led to the increase in the insulin



**Figure 4:** Mean serum insulin concentration at fasting state and 15, 30, 45, 60, 90 and 120 minutes after consumption of test meals by Type 2 diabetes participants.

Healthy participants showed similar antioxidant activity compared with patients with type 2 diabetes after consumption of the traditional vegetables with increased antioxidant activity more evident after the consumption of bush-buck leaf (figure 5).



**Figure 5:** Serum Antioxidant Activity after ingesting steamed vegetable sauce.

#### 4. Discussion

The four principal ways of managing diabetes include: insulin and diet; drug and diet; drug and insulin and diet; diet alone. In this study, the type 2 diabetes subjects were on diet alone and are referred by the physician. Dietary management for these subjects were a variety of interventions such as reduced energy (1200-1500kcal/day) intake for overweight participants and 2000-2200kcal/day for normal weight participants, fat intake (25% of energy intake), three fruit servings/day, carbohydrate counting (45% of energy intake), consistency in day-to-day carbohydrate intake, lean protein intake, healthy food choices, increased vegetable intake, increased complex carbohydrate intake, avoidance of empty calories and simple carbohydrate and food exchange list<sup>8</sup>. Diet is effective at any time in the disease process however; it appears to have its greatest affect in lowering HbA<sub>1c</sub> at initial diagnosis. After 9 years of monotherapy with diet, 8% achieved FPG levels of less than 7.8 mmol/L (140 mg/dL) and 9% achieved HbA<sub>1c</sub> levels below 7%<sup>9</sup>. The cost of medication is exorbitant and the attendant side effect of synthetic drugs is a drawback to consumers and people suffering from type 2 diabetes<sup>10</sup>.

We developed a dietary strategy including the use of inexpensive traditional vegetables to minimize postprandial peaks. Our results shows that the five traditional vegetables have low glycaemic and insulinemic indexes that could be recommended for patients with type 2 diabetes. Eating vegetables with rice ameliorate postprandial plasma glucose and insulin. Insulin resistances was avoided in these participants and glucose spike were reduced. The hypoglycaemic and hypoinsulinemic effects of these vegetables may be attributed to their low calorie, low carbohydrate, high fiber and phytochemical contents which dilutes the high carbohydrate content of rice. Lowest and highest postprandial peak glucose and insulin values were recorded in rice and scent leaf sauce and rice and white sauce respectively. This study revealed that scent leaf had a higher fiber, tannic acid, flavanoids and vitamin C content, less dense in carbohydrate, with moderate fat, significantly lower GI, GL per serving, significantly lower insulinemic index, peak plasma post prandial blood glucose and IAUC than bush buck leaf. Akerele et al<sup>12</sup> recorded similar estimated glycaemic index for scent leaf 38.51, bitter leaf 35.62, water leaf 33.71 and spinach 34.62.

The presence of tannic acid, flavonoids and vitamin C in the traditional vegetables contributes to their antioxidant activity. We demonstrated that consumption of traditional vegetables provides antioxidant activity in the serum of both healthy people and patients with type 2 diabetes 2 hours after consumption. The consumption of the traditional vegetables have a compensatory effect on the decreased endogenous antioxidants during type 2 diabetes. Hyperglycemia, an inevitable consequence of T2DM, promote auto-oxidation of glucose to form free radicals. The generation of free radicals beyond the scavenging abilities of endogenous antioxidant defenses results in macro- and microvascular dysfunction and polyneuropathy. Antioxidants such as N-acetylcysteine, vitamin C, tannic acid and flavanoids are effective in reducing diabetic complications<sup>11</sup>. The inclusion of bitter gourd leaf powder as smoothies showed promising antioxidant potentials and a positive impact on stress biomarkers

by reducing pancreatic inflammation caused by diabetes mellitus thus protecting the pancreas from oxidative stress<sup>10</sup>.

It is recommended to include 300g of boiled traditional vegetables (bitter leaf, scent leaf, water leaf, spinach leaf and bush-buck leaf) as side dish, juice, smoothie, grilled, soup or sauce for patients with type 2 diabetes. Another option is to consume dehydrated traditional vegetable (15g) dried at low temperature (no higher than 55°C to maintain antioxidant activity).

#### 5. Conclusion

This study revealed that bitter leaf, scent leaf, water leaf, spinach leaf and bush-buck leaf had higher fiber, tannic acid, flavanoids and vitamin C content, less dense in carbohydrate, with moderate fat, significantly lower GI, GL per serving, significantly lower insulinemic index, peak plasma post prandial blood glucose and IAUC than glucose and rice and white sauce. It is recommended that these vegetables should be added to meals consumed by type 2 diabetes patients.

#### References

- <sup>1</sup>Angulo-López J.E, Flores-Gallegos A.C, Ascacio-Valdes J.A, Esquivel J.C, Torres-León C, Rúelas-Chácon X, Aguilar C.N. 2022. Antioxidant Dietary Fiber Sourced from Agroindustrial By products and Its Applications. *Foods*. 12(1):159. doi: 10.3390/foods12010159.
- <sup>2</sup>Evans J.L, Goldfine I.D, Maddux B.A, Grossdky G.M. 2002. Oxidative stress and stress-activated signaling pathways: A unifying hypothesis of type 2 diabetes. *Endocr Revi*. 23(5):599-622.
- <sup>3</sup>Coss-Bu J.A, Mehta N.M. 2016. Energy Metabolism in Encyclopedia of Food and Health. <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/energy-metabolism>.
- <sup>4</sup>Sheneni V.D, Muhammad S.S, Shaibu I.E. 2023. Natural chemicals for healthy living: plant secondary metabolic compounds. *MOJ Food Processing & Technology*. 11(2) 98–104.
- <sup>5</sup>Nnadi I.M, Keshinro O.O. 2016. The effect of the glycaemic response of three commonly consumed meals on postprandial plasma glucose in type 2 diabetics at the University of Nigeria Teaching Hospital, Enugu. *South African Journal of Clinical Nutrition*, 29(2):90-94.
- <sup>6</sup>Koren E, Koren R, Ginsburg I. 2010. Polyphenols enhance total oxidant-scavenging capacities of human blood by binding to red blood cells. *Exp Biol Med (Maywood)*. 235(6):689-699.
- <sup>7</sup>Food and Agriculture Organization of the United Nations, World Health Organization. *Carbohydrate in Human Nutrition*. 1998; Rome. Italy.
- <sup>8</sup>Franz M.J, Powers M.A, Leontos C, Holzmeister L.A, Kulkarni K, Monk A. Wedel N, Gradwell E. 2010. The Evidence for Medical Nutrition Therapy for Type 1 and Type 2 Diabetes in Adults. *Journal of American Dietetic Association*. 110; 12:1852-1889.
- <sup>9</sup>Turner R.C, Cull C.A, Frighi V, Holman R.R 1999. Glycaemic Control With Diet, Sulfonylurea, Metformin, or Insulin in Patients With Type 2 Diabetes Mellitus Progressive Requirement for Multiple Therapies (UKPDS 49). *The Journal of the American Medical Association*. 281(21):2005-2012.
- <sup>10</sup>Michael J.A, Olatuyi V.T, Adelu A.O, Falodun A.I, Ogungbenro G.M, Nwanna E.E, Elekofehinti O.O, Badejo A.A. 2024. Antioxidant activities of developed natural smoothies and their effects on blood glucose levels and expression of pro-inflammatory genes in streptozotocin-induced diabetic rats. *Food Production, Processing and Nutrition*. 6: 78; 1-13.
- <sup>11</sup>da Silva S.B, Costa J.P, Pintado M.E, Ferreira D.C, Sarmiento B. Antioxidants in the Prevention and Treatment of Diabetic Retinopathy - A Review. *J Diabetes Metab*. 2010;1:111.
- <sup>12</sup>Akerele G.P, Oyeleye I.D, Busari G.M, Oyeleye I. S, Busari G.M, Obboh G. 2021. Glycaemic Indices, Possible Antidiabetic Potentials and Phenolic Contents of some Indigenous Green Leafy Vegetables (GLVs). *Natural Product Research* 5(3):597-602

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