Nutrient Composition and Glycemic Response of Five Species of Yam (*Dioscorea*) Commonly Consumed in South-East Nigeria

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ABSTRACT

Background: *Diabetes is one of the leading causes of death in the world especially in developing nations and nutritional management of blood glucose levels is a targeted tool in its prevention and management.*

Objective: *To determine the nutrient composition and glycaemic response of varieties of tubers diascoreaspp(yams) commonly consumed in south-eastern Nigeria*

Methods: *The study adopted a cross sectional design and simple random techniques. Forty participants were recruited for the study andfive species of yam Dioscoreaspp (D.rotundata, D.cavennesis, D. alata and D. dumetoru (white and yellow)) were purchased from new market in Enugu and from a farm in Umuahia, Nigeria. They were sorted, peeled, washed, cooked to tender and analyzed using AOAC method. Glycemic response was determined by the method described by Joint FAO/WHO ExpertConsultation.A structured questionnaire was used to elicit information on socio-demographic and anthropometric indices from the respondents. The blood glucose test was done using Accu-check Active meter and strips.*

Results: *The mean BMI of respondents was 21.05±1.39kgm-2 and 24.75±3.71kgm-2 for male and female respectively. A significant differences (p<0.05) was found in the proximate and micronutrient (vitamins and minerals) composition of the varieties of yam. The study revealed that white yam(D.rotundata) gave the highest glucose response (110.8mg/dl±6.63 and 102.4mg/dl±4.12)after 60 and 90 minutes respectively, while after 120 minutes, water yam(D.cavennesis)gave the highest (104mg/dl±6.10). However, both species of "Una"dioscoreadumentorumgave the lowest glucose response.*

Conclusion: *The variations in the nutrient composition and glycemic response of the varieties of yam can be explored for better dietary management especially for diabetes patients.*

Keywords: Nutrient Composition, Glycaemic Response, Blood Glucose Test, Varieties of Yam
Doi: https://dx.doi.org/10.4314/njns.v45i1.22

INTRODUCTION

Yams (*dioscoreaspp*) are commonly consumed foods in south-eastern Nigeria. *Dioscoreaspp* are starchy staples (1) with white yam (*dioscorearotudata)* being the most common of all. There are several other species of *dioscoreawhich* includes the yellow yam (*dioscoreacayanensis*), the water yam (*dioscoreaalata*), and the three-leaf yam (*dioscoreadomentorum*). *Dioscoreadomentorum* has two different kinds which are the white *dioscoreadomentorum* and the yellow *dioscoreadomentorum*. White yam and water yams are among the commonly consumed species of yams in Enugu State, Nigeria (2). These food products are rich in carbohydrates and are major sources of energy (1). They are eaten in various forms and are eaten with vegetables and other food products especially legumes. In south-eastern Nigeria, carbohydrate-based foods are staple foods. They are usually consumed in larger quantity. Carbohydrates make up for 45% - 70% of macronutrient requirement in daily feeding (3). Eating carbohydrate alone does not predispose to diabetes, but the risk of diabetes is increased in obesity and overweight (4). When down with diabetes, reducing intake of added sugar or refined sugar can help manage the disease from getting worse.

Diabetes is of public health concern as it has been found to be one of the leading causes of death in the world especially in developing nations (5). About 366 million people in the world have been diagnosed of diabetes and this prevalence is projected to be double by 2030 (6). If managed well, one can live with diabetes for a long time. However, poorly managed diabetes usually results in serious complications like renal failure, neuropathy, cardiovascular diseases, amputations and even death (7). Misconception on foods in management of diabetes, can lead to poor glycaemic control and hence increase the risk of complications which increases chances of morbidity and mortality. In a study carried out by Akbar *et al*. (8), 83% of patients with diabetes believed thatin diabetes, sugar cannot be used at any cost while 68% believe that special diabetic foods are used in the management of diabetes.

Glycaemic index can be defined as a scale that measures the carbohydrate amount in foods from 0 – 100, which shows how food raises blood glucose (9). Glycaemic index measures the body's postprandial glucose response (PPGR) to ingested foods while glycaemic load deals with the measure of the PPGR to the diet (9). Maintenance of an appropriate blood glucose level is a key to maintaining a health especially in diabetes patients.

Diverse carbohydrate foods to some extent have various impacts on the blood glucose level and health when consumed (10). The glycaemic index of a particular food can be a useful value to understand the relative ranking of different foods, but does not accurately reflect the effect on blood sugar of an actual serving of food. This is where the glycaemic load (GL) comes in. The glycaemic load combines both the quality and the quantity of carbohydrate into one value. Glycaemic load has proven to be the most accurate route to foretell the effect of different types and amounts of foods on blood glucose level. GL accounts for how much of carbohydrate is in the food and how each gram of carbohydrate in the food raises blood glucose levels. GL is classified as: low (< 10), intermediate (10-18) and high (> 20). GL is a metric used as a basis for weight loss, or diabetes control (11).

Foods rich in Carbohydrate that are broken down into glucose rapidly are categorised as high glycaemic index foods, while those which have a slower conversion speed into glucose are classified as low glycaemic index foods (19). Foods with glycaemic index (GI) within 0-55 are classified as low GI foods, while 56–69 are classified as medium GI foods, and high GI foods are those within the range of 70-100 (19). For proper management of diabetes, it is imperative to understand the significant different in the nutrient composition and glycaemic response to the different varieties of yam which is a common staple in many regions. This study seeks to investigate these differences to provide useful information to patients, healthcare professionals consumers and policy makers.

MATERIALS AND METHODS

***Study Design*:** This is a cross sectional study

Study Population: The study population consisted of healthy male and female staff of Department of Nutrition and Dietetics, University of Nigeria Teaching Hospital (UNTH),Ituku-Ozalla, Enugu State.

***Sampling Technique*:** Simple random sampling was used for the study.

Study Samples and Materials: Five(5) varieties of yam (white yam, yellow yam, water yam, white and yellow three leaved yam).

***Recruitment and Training of Research Assistants*:** A total of twelve research assistants were recruited from the University of Nigeria Teaching Hospital (UNTH)and trained on the aim and procedures of the study, food portioning, and serving of the test meal and blood sample collection.

Sample Preparation for Test Meal: All the samples were purchased from new market in Enugu, Enugu State except the two types of three leaved yams that were purchased at Umuahia, Abia State. Each sample was sorted, peeled, washed and cooked with clean water (to tender), packaged and labeled separately. The prepared samples were served to the subjects with red oil

Preparation for Chemical Analysis: All the samples prepared same way as above.

Proximate and Micronutrient Content Determination: The prepared samples were taken to Department of Biochemistry of the University of Nigeria, Nsukka for proximate and micronutrient analysisusing standard methods of the Association of the Analytical Chemists (AOAC) (20). The portion size for the test meal was based on 50g digestible carbohydrate available in the varieties of yam which was determined by analysis.

Glycemic Response Determination: Glycaemic response was determined by the method described by Joint FAO/WHO Expert Consultation (21).

Data Collection: A structured questionnaire was used to elicit information on socio-demographic and anthropometric indices from the respondents. Weight and height of the respondents were taken and used to calculate their BMI. Waist-Hip ratio was also calculated from the waist and hip measurements taken and blood glucose test was assessed following the guidelines documented in previous literature (22,23).The forty respondents were grouped into five, with each group representing one test meal.

Group A: Yellow three leaved yam (yellow Una)
Group B: Water yam
Group C: White yam
Group D: Yellow yam
Group E: White three leaved yam (white una)

Statistical Analysis: IBM Statistical Package for the Social Sciences version 21 was used to analyze the data obtained from the study. Descriptive statistics (mean and standard deviation) was used to analyse the data. Analysis of variance (ANOVA) was used to generate the means while turkey HSD test was used to separate and compare the means. A p-value < 0.05 was considered statistically significant for hypothesis testing.

Ethical Approval and Informed Consent: Ethical approval for the use of forty human subjects was obtained from the research and ethical committee of University of Nigeria Teaching Hospital (UNTH) Ituku-Ozalla Enugu State. Participants who consented to partake in the study were assigned a unique code and were permitted to either sign or provide a thumbprint on the informed consent form. Their phone numbers were also written on the consent form for easy communication.

RESULTS

Socio-Demographic Characteristics and Anthropometric measurements of Participants

Table 1 presents the socio-demographic characteristics of participants. Majority (80%) of the study participants were females while 20% were males. About 45% were between 18-25 years, 47.5% were between 26-35 years while 7.5% were above 35 years. The mean waist hip ratio was 0.82±0.05 and 0.78±0.05 for male and female, respectively, three quarter of the study participants had normal waist hip ratio, 15% had a waist hip ratio that put them at moderate risk, while 1 in every 10 participants had a waist hip ratio that put them at high risk. The mean body mass index was 21.05±1.39Kgm^2 and 24.75±3.71Kgm^2 for male and female participants respectively, three out of every five participants had a normal body mass

Table 1: Socio-Demographic and Anthropometric Characteristics of Participants

Characteristics		Frequency	Percentage
Gender			
	Male	8	20.0
	Female	32	80.0
Age (Years)			
	18-25	18	45.0
	26-35	19	47.5
	36-40	3	7.5
Waist Hip Ratio (WHR) Classification			
	Normal	30	75.0
	Moderate risk	6	15.0
	Highly risk	4	10.0
Mean WHR	Male: 0.82±0.05	Female: 0.78±0.05	
Body Mass Index (BMI)			
	Normal	24	60.0
	Overweight	16	40.0
Mean BMI	Male: 21.05±1.39Kgm^2	Female: 24.75±3.71Kgm^2	

index while the remaining 40% were overweight.About 88% were single, 92.5% were Igbo, 5% were Yoruba, while 2.5% were Ibibio and all (100%) the participants were Christian.

Proximate Composition of the varieties of Yam

Table 2 reveals the proximate composition of the varieties of yam.There was significant difference (P<0.05) in the proximate composition of the varieties of yam. The moisture content ranged from63.27% in yellow yam to74.33% in white una. The fat content ranged from 0.53% to 0.8%. Ash contentof the varieties of yam tested ranged from 0.17% to 1.27%. Protein constituent ranged from 1.42% to 3.23%; crude fibre ranged from 1.88% to 3.73% and carbohydrate, from 20.19% to 29.80%.

Micronutrient Composition of the varieties of Yam

Table 3 presents the micronutrients composition of all the varieties of yam.Yellow yam and yellow una had the highest vitamin C content with 60.89mg/dl and 40.7mg/dl, respectively. All the varieties were relatively low in vitamins B1 and B2.The Beta Carotene content ranged from 54.67μg/100g (yellowuna) to 80.10 (μg/100g) (white yam). A significant difference was found in the mineral composition across the samples (p<0.05). The result also showed that yams are a good source of potassium with values ranging from 657.23mg/100g to 972.87mg/100g.

Table 2: Proximate Composition of the varieties of Yam

Samples	Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Crude fibre(%)	Carbohydrate (%)
D. rotundata	69.27±0.12[b]	0.72±0.02[b]	0.87±0.12[b]	1.52±0.44[a]	1.89±0.12[a]	26.43±0.43[c]
D. alata	71.87±0.12[d]	0.80±0.12[b]	0.17±0.12[a]	3.23±0.08[b]	1.87±0.11[b]	22.06±0.24[b]
D. domentorum (white)	74.33±0.12[e]	0.73±0.06[b]	1.13±0.12[c]	1.73±0.41[a]	1.88±0.11[b]	20.19±0.39[a]
D.domentorum (yellow)	71.13±0.12[a]	0.53±0.07[a]	1.27±0.12[c]	1.56±0.14[a]	2.90±0.10[c]	22.64±0.31[b]
D. cayenensis	63.27±0.12[c]	0.65±0.06[ab]	1.13±0.12[c]	1.42±0.07[a]	3.73±0.11[d]	29.80±0.19[d]

Mean ± standard deviation
Values with the same letters in the same column are not significantly different (p<0.05)

Table 3: Micronutrient Composition of the varieties of Yam

Samples		White yam	Water yam	White una	Yellow una	Yellow yam
Vit. B1	(mg/100g)	0.13±0.02[c]	0.10±0.01[bc]	0.05±0.007[a]	0.09±0.03[b]	0.05±0.01[a]
Vit. B2	(mg/100g)	0.05±0.01[b]	0.03±0.003[a]	0.03±0.003[a]	0.10±0.13[a]	0.05±0.01[b]
Vitamin C	(mg/100g)	10.14±1.45[a]	10.35±1.79[a]	19.73±3.49[a]	40.70±11.93[b]	60.86±3.43[c]
Beta Carotene	(μg/100g)	55.37±5.10[a]	57.57±1.23[ab]	80.10±6.19[c]	54.67±3.59[a]	63.97±3.71[b]
Iron(mg/100g)		1.47±0.15[c]	2.10±0.03[e]	0.23±0.05[a]	1.72±0.20[d]	0.92±0.16[b]
Calcium	(mg/100g)	27.41±0.85[a]	39.78±2.56[b]	28.89±1.30[a]	39.01±3.06[b]	57.78±0.85[c]
Magnesium	(mg/100g)	20.92±0.51[b]	16.38±0.15[a]	30.28±1.46[c]	28.15±2.71[c]	18.19±0.67[ab]
Potassium	(mg/100g)	947.57±86.42[b]	956.81±47.65[b]	972.87±16.05[b]	898.84±22.22[b]	675.23±48.69[a]

Mean ± standard deviation vit=vitamin
Values with the same letters in the same column are not significantly different (p<0.05)
Available Carbohydrate in the Varieties of Yam

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Table 4 revealed the available carbohydrate in the varieties of yam.At $p<0.05$, There was no significant difference between the mean values of the available carbohydrate in the varieties of yam. The available carbohydrate in the samples ranged from 12.15% in water yam to15.20% to yellow una.

Blood Glucose Response to the Varieties of Yam

Table 5 reveals the mean blood glucose response of the participants. Yellow and white una had a relatively lower effect on blood glucose, while white yam was highest at 30 minutes, 60 minutes and 90 minutes, and water yam had the highest blood glucose response at 120 minutes of ingestion. Fasting blood glucose across the group wasnot significantly different. This is however, expected as fasting blood glucose is independent ofthe yam varieties given the participants.

Figure 1 presents the graphical representation of the effect of 50g carbohydrate in the varieties of yam on blood glucose with reference to the control meal-glucose. When compared with the reference meal-glucose, white una and yellow Una had the least effect on blood glucose while white yam and yellow yam had almost the same effect as the reference meal.

DISCUSSION

In this study, the nutrient content of different species of yams varied. Similar result has been published for various species of yam (12). However, this is different from the research done by Chaudhury et al.(13) where yam species like D. alatawas reported to have high protein levels (18.7%). This study further revealed that yellow yam (dioscoreacayanensis) and yellow Una (dioscoreadomentorum) had the highest vitamin C content with 60.89mg/dl and 40.7mg/dl, respectively. Mineral composition varied among the varieties of yam in this study. This variation have been attributed to factors like environmental effects, genetic component, estimation methods, cultural practices, planting and harvesting time, type and chemical composition of the soil that they were

Table 4: Available Carbohydrate in the Varieties of Yam

Sample	Available Carbohydrate (%)
White yam	14.15 ± 0.96^{b}
Water yam	12.15 ± 0.37^{a}
White una	13.44 ± 1.60^{ab}
Yellow una	15.20 ± 0.35^{b}
Yellow yam	15.00 ± 1.05^{b}

Mean ± standard deviation (n=3)

Values with the same letters in the same column are not significantly different ($p<0.05$).

Table 5: Mean blood glucose response to the ingestion of 50grams of carbohydrates

Samples	FBG (mg/dl)	30minutes	60minutes	90minutes	120minutes
*Glucose	78 ± 1.31^{a}	116.3 ± 3.09^{bc}	105.7 ± 2.90^{b}	102.8 ± 2.72^{b}	91.9 ± 3.31^{ab}
White una	81.6 ± 2.60^{a}	101.3 ± 2.60^{ab}	87.9 ± 5.42^{a}	80.9 ± 4.01^{a}	83.1 ± 3.80^{a}
Yellow una	79.5 ± 4.11^{a}	95.1 ± 6.51^{a}	93.4 ± 3.10^{ab}	85.5 ± 3.43^{a}	83 ± 2.42^{a}
White yam	72.6 ± 3.42^{a}	120.9 ± 5.10^{c}	110.8 ± 6.63^{b}	102.4 ± 4.12^{b}	98 ± 5.21^{ab}
Yellow yam	78.8 ± 3.03^{a}	108.8 ± 8.00^{abc}	98 ± 6.51^{ab}	91.9 ± 3.90^{ab}	89.1 ± 5.13^{ab}
Water yam	78.5 ± 2.10^{a}	113.3 ± 4.91^{abc}	109.9 ± 6.71^{b}	101.6 ± 5.61^{b}	104 ± 6.10^{b}

mean ±standard deviation for glucose

Values with the same letters in the same column are not significantly different ($p<0.05$).

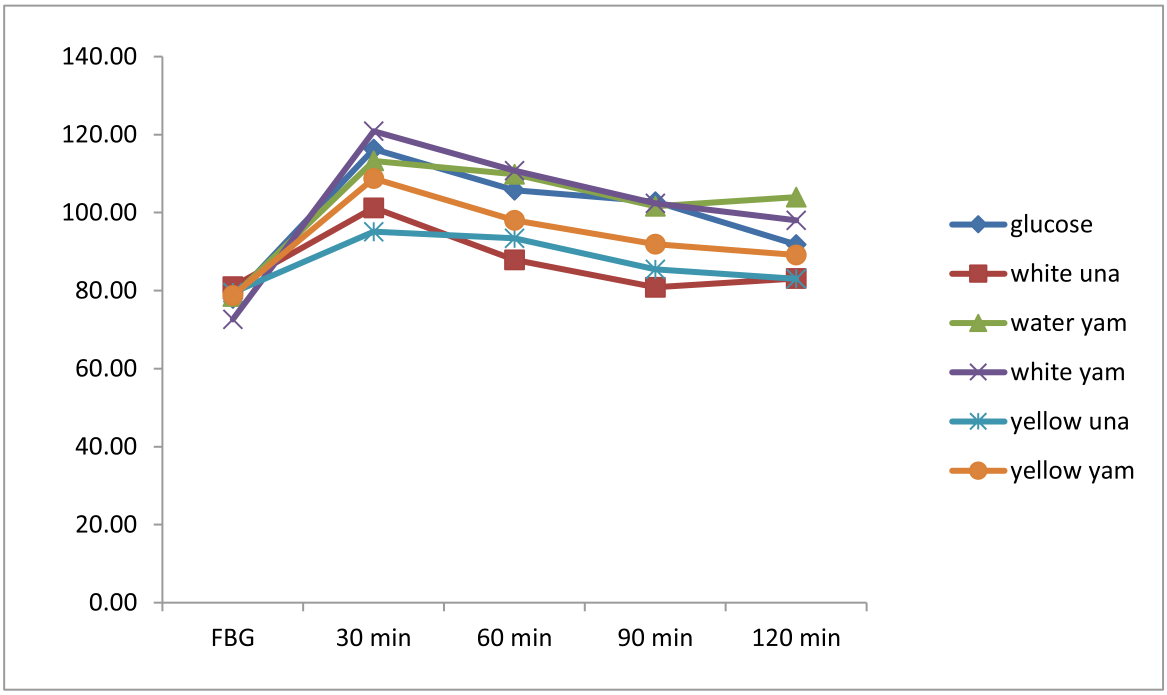

Figure 1: Graphical Representation of the effect of 50g Carbohydrate in the various varieties of yam on blood glucose with reference to the control meal (Glucose).

grown in as well as amount of water available . Studies have shown that the level of potassium in diet is inversely proportional to the risk of diabetes and the result showed that yams are a good source of potassium with values ranging from 657.23mg/100g to 972.87mg/100g. Yams are richer sources of potassium when compared to other foods classified as root and tuber (ptatoes species and cassava),and even cereals (Wheat, Maize and Rice) (16). Similar to the result from this study, Otegbayoet al. (14) showed a result between 775 to 1850 mg/kg of potassium in Yams. Furthermore, a study has revealed that D.bulbiferais calcium rich specie of yam with its content up to 1410 mg/100 g (17).

A varying result in the blood glucose response was observed in this study. There was a mean peak rise with time at 30minutes after ingesting both the control meal (glucose) and the experimental meal, after which the blood glucose levels fell gradually. When given 50g glucose (control meal), the highest blood glucose response was recorded when compared to test meals at each postprandial time. This is as expected because glucose is directly absorbed into the upper gastrointestinal tract and then the blood stream (18). At 30 minutes postprandial, yellow yam had the highest record of blood glucose response, followed by white yam. At 60 and 90 minutes postprandial, white yam gave the highest record of blood glucose response. This is similar to the study done byIhediohanmaet al. (24)while at 120 minutes, water yam became the highest. The value for water yam at 120 mins is different from other studies (24, 25) which can be due to the type of soil and the environment where it was cultivated. Both species of dioscoreadumentorum gave relatively lower blood glucose postprandial response across time. This is similar to the study done by Bobadoye and Enujiugha(25). It was discovered both species of dioscoreadumentorumhad the least blood glucose response at 30, 60, 90 and 120 mins (4.73mmol/L, 5.86mmol/L, 4.66mmol/L, 4.19mmol/L, respectively) when compared to other varieties.

According to Russell et al. (26), fasting blood glucose depends on the quantity of glucose and/or the speed at which glucose is absorbed during the previous meal and this shows the rate of glucose production in the liver, in which gluconeogenesis and glycogenolysis plays a key role in this mechanism. Ingestion of foods high in glycaemic index, results to a rapid increase in the blood glucose level (25). This can be explained by the process of gelatinization;when yam is boiled in water at a high temperature, it gelatinises and becomes easily digested by the action of digestive enzymes on it. Increase in food processing, increases the glycaemic response (26).

CONCLUSION

According to the findings of this study, one in every four of the study population has a waist hip ratio that put at risk (either moderately or severely) while the prevalence of overweight was found to be 40%. The proximate and mineral composition varies significantly across the yam species and they are found to be a very good source of potassium which is inversely proportional to the risk of diabetes. The highest glucose response at 30, 60, and 90 minutes postprandial was from white yam while water yam accounted for the highest result at 120 minutes after ingestion. Therefore it could be concluded that both species of dioscoreadumentorumare the best options in blood glucose control.

Recommendation

The following recommendations have been made based on the findings of the study:

- Further studies should be done on water yam(dioscoreaalata) obtained from different parts of the country to compare their glycemic response on healthy individuals.
- Nutrition education should be carried outto correct any misconceptions on dioscoreasppin the management of diabetes.
- Clinical dietitians should encourage diabetic patients to introduce three leaved yam (Una)(dioscoreadumentorum) to their menu.

Conflict of Interest

- There is no conflict of interest

Funding

- This study was self-sponsored

ACknowledgement

- Authors acknowledged all the staff of the Department of Human Nutrition and Dietetics, University of Nigeria Teaching Hospital (UNTH), Enugu, study participants, research assistants, and every other person who contributed to the success of this study.

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