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Hypoglycemic Response of Alloxan-Induced Diabetic Rats Fed with Sweet Potato (*Ipomoea batatas)* and Irish (*Solanum Tuberosum)* Potato Flour Supplemented with Vitamins

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ABSTRACT

The hypoglycemic effect of feeding normal and alloxan-induced diabetic rats with Sweet Potato (*Ipomoea batatas)* and Irish Potato (*Solanum tuberosum)* flour fortified with vitamin for 21 days was studied. Forty-five white albino rats were divided into groups of five rats each. The groups are Normal control, Normal control + diet, positive control, negative control, test control 1 and test control 2. Fasting blood glucose and 2 hours post-prandial were measured at 7 days, 14 days and 21 days. It was found that sweet potato and irish potato flour diet significantly ($P<0.05$) reduced the fasting blood glucose and 2 hours post-prandial blood glucose compared with those of diabetic and normal rats fed with control diet. Maximum reduction in fasting and 2 hours post-prandial blood glucose was observed at day 21 with 119.6 ± 5.59 mmol/L in the sweet potato fed group compared to the diabetic control (223.6 ± 9.31mmol/L and normal control (106.6 ± 7.83) mmol/L. While the irish potato group had (133 ± 2.45) mmol/L, compared to the diabetic control (233.6 ±9.31) mmol/L and normal control (106.6 ±7.83) mmol/L. However sweet potato showed a better hypoglycemic effect than irish potato. This shows that the hypoglycemic effect of sweet and irish potato is time dependent.

Keywords: *Diabetes; Hypoglycemia; Irish potato; Sweet potato.*

INTRODUCTION

Diabetes is a chronic metabolic disorder, characterized by high blood glucose (Hyperglycemia), associated with impaired carbohydrate, fat and protein metabolism, resulting from either insufficient or no release of insulin by pancreas in the body. Diabetes mellitus divided into two groups namely insulin dependent diabetes mellitus (IDDM) and non-insulin dependent (NIDDM) (Tankoy *et al.,* 2008). This classification is based on their requirement of insulin treatment. This disease is associated with several metabolic defects (Ahmed et al., 2012). Most important among them are hypoglycemia, ketoacidosis and hyperglycemia, diet, exercise and drug is the management option in diabetes (Satarayana *et al*., 2006). Approximately 50% of the new cases of diabetes can be adequately controlled by diet alone. Oral hypoglycemic drugs like sulfonylureas and iguanid are used for treatment but have side effects. Though the use of herbal drugs has been considered to be less toxic with less few side effects (Kim *et al*., 2014).

Tubers are the third largest carbohydrate food service in the world. Sweet potato (*Ipomea botatas*) is the leading form of staple food for millions of people in the tropical and subtropical countries. An acid – soluble glycoprotein present in sweet potato extract, "*ciao*" has been reported to posses' hypoglycemia effect (Ludvik *et al.,* 2004) .in "folk machine" extract of sweet potato tubers has been used in the treatment of diabetes because of its hypoglycemic effect. Irish potato (*Solanum tuberosum*) is a herbaceous perennial plant belonging to the "*Solanacea*" Family. Irish potato has also been reported in folk medicine in the management of diabetes mellitus, since the use of medicinal plants in traditional management of diabetes mellitus could serve as good alternative for the management of this diabetes and its complications (Chadra *et al*., 2004). Thus, these motivate the necessity for this research work. Yam (*Diocorea spp)* and cocoyam (*Colocasia esculanta*) have also been reported to posses' hypoglycemic properties in dietary management of diabetes (Okon *et al*., 2013).

Diabetes mellitus is characterized by recurrent or persistent hyperglycemia, and is diagnosed by demonstrating any one of the following:

- Fasting plasma glucose level ≥ 7. 0mmol/L(126mg/dl)

- plasma glucose ≥ 11.1mmol/L (200mg/dl) two hours after a 75g oral glucose load as in a glucose tolerance rest.
- Glycated hemoglobin (HbAIC) ≥ 6.5% (Saydah *et al.,* 2001).

People with fasting glucose level from 100 to 125mg/DL (5.6 to 6.9mmol/L) are considered to have impaired fasting glucose. Patient with plasma glucose at or above 140mg/dL (7.8mmol/L) but not over 200mg/dl (11.1mmol/L), two hours after a 75g oral glucose load are considered to have impaired glucose tolerance. These two are considered as pre-diabetic states, the latter in particular is a major risk factor for progression to full-blown diabetes mellitus as well as cardiovascular disease (Nagarchi *et al*., 2014). Glycated Hemoglobin is better than fasting glucose for determining risks of cardiovascular disease and death from any causes (Saydah *et al.,* 2001).

Diet and exercise are the foundation for management of hypoglycemia in a type 2 diabetes mellitus. Patient who do not achieve adequate glycemic control through these methods are candidates for pharmacological agents to help manage glucose levels. There are several medications for the control of diabetes combination treatments with oral hypoglycemic drugs or strict subcutaneous insulin are today currently accepted methods for the management of diabetes. Insulin is the more common form of diabetes control used by most patients (Salih *et al*., 2014) In this study, the hypoglycemic effect of sweet potato and Irish potato was investigated using wistar albino rats.

MATERIALS AND METHODS

Sample Collection

The test tubers, which are sweet potato *(Ipomea batatas)* and Irish potato *(Solanum tuberosum)* were obtained from Monday Market Maiduguri. The samples were identified by a taxonomist in the Department of Biological Science University of Maiduguri. The control diet (growers mash) used was Normal control, Normal control + diet, positive control, negative control, test control 1 and test control 2.

Vital feeds® (Grand Cereals Ltd). Vitamin supplement (multivitamins) was obtained from Agro allied products®.

Preparation of Samples

The tubers were peeled and the endodermis was grated to produce small size flakes which were subsequently shade dried to obtain crispy flakes. The crispy flakes were then pulverized into fine powder using the grinding machine (Idowu *et al*., 1992)

Experimental Animals

Forty-five (45) Wistar albino rats of both sexes weighing 150-250g were procured from the animal house of the Department of Biochemistry, University of Maiduguri. The animals were housed in well ventilated cages, they had free access to water and growers mash over a two-week period for acclimatization and their body weights were also recorded. They were also maintained under standard conditions of humidity, temperature and 12 hours' light/darkness cycle. A standard protocol was drawn in accordance with the principles of laboratory animal care in this study (NIH, 1995).

Induction of Diabetes Mellitus

Prior to induction of Diabetes mellitus, the rats were fasted overnight, weighed and their baseline fasting blood glucose levels (FBG) using the Accucheck® Active glucometer and strips with blood drawn from tail vein of the animals.

Diabetes mellitus was induced by a single intraperitoneal injection of 150mg/kg body weight of alloxan monohydrate (Sigma Aldrich Chemical Co, St Louis USA) dissolved in normal saline. About 2 hours following the administration of alloxan, the rats were fed with their normal feed (growers mash) to prevent alloxan induced acute hypoglycemia. Seventy-two hours later, FBG levels of the animals were assayed to ascertain development of diabetes mellitus (DM) and FBG level ≥ 200mg/dl was considered diabetic.

Table 1: Treatment Groups and Diet/Drug given

GROUPS	TREATMENT	DIET/DRUG
I	Normal control	Normal feed
II-III	Normal + test diet	1) Sweet potato OR 2) Irish potato
IV	Positive control (Diabetic rats)	Normal feed+ Glucophage
V	Negative control (Diabetic rats	Normal feed
VI-VII	Test control (diabetic rats)	1) Sweet potato OR 2) Irish potato
VIII-IX	Test control (diabetic rats)	1) Glucophage 2) Sweet potato + Glucophage 3) Irish potato + Glucophage

Method of Intubation

The intubation was done using stomach tube.1000 mg of Glucophage was dissolved in 10 ml of distilled water. Each rat was given 1ml each containing 100 mg of Glucophage were administered to the group III and VI animals.

Administration of Diets

The administration of the diets was done by dissolving the test diets (sweet potato and Irish potato) respectively 100 g in 100 ml of distilled water. The respective diets were administered to Groups II, V and VI respectively. This procedure was done for a period of 21 days.

Measurement of Blood Glucose

The fasting blood glucose and 2 hrs post prandial was measured by using Accucheck® (Roche Diabetes Care, Inc.) active glucometer strips with blood drawn from tail vein of each rat. The Accucheck® glucometer operates on the principle of glucose dehydrogenase method and have a model number of RC100 (Germany). (Booker and Yazdi (2008).

Statistical Analysis

Data obtained from this study were presented as means ± SEM and the differences between the groups were analyzed

using ANOVA and Duncan multiple range test was used to compare the mean differences across the groups.

Ethical Statement

The ethics governing the use and conduct of experiments on animals were strictly observed, and the experimental protocol was approved by the Research and Ethics Committee, University of Maiduguri.

RESULTS

Table 2 shows the hypoglycemic effect of feeding normal/alloxan induced rats with sweet potato flour fortified with vitamins. There was a significant difference ($P<0.05$) in the diabetic group when compared with the normal control. At day zero there was significant difference ($P<0.05$) which increases FBG 97.0 ± 5.66 to 248.6 mmol/L, then the diabetic control was compared with normal control. At day 7, it was observed that the FBG level and 2hrs post-prandial diabetic rats fed with sweet potato flour diet showed significant decrease ($P<0.05$) from 297.2 ± 10.50 to 133.6 ± 18.55 mmol/L and 399.4 ± 42.32 to 144.4 ± 19.79 mmol/L respectively, when compared with the normal control.

The FBG and 2hrs post-prandial glucose level of the normal rats fed with sweet potato flour showed significant decrease ($P<0.05$) from 100.8 ± 5.12 to 76.4 ± 3.67mmol/L and 101.8 ± 4.56 to 99 ± 18.67mmol/L respectively, when compared with the normal control.

At day 14, there was a significant decrease ($P<0.05$) in FBG (133.6 ± 18.55 to123.0 ± 12.41) and 2hrs post-prandial (144.4 ± 19.79 to132.2 ± 12.88) levels. At day 21. there was a significant decrease ($P<0.05$) in FBG and 2hrs post-prandial level from 140.4 ± 8.81 to 119.6 ± 5.59 and 154.2 ± 9.08 respectively. On the other hand, the group fed with sweet potato and glucophage showed significant decreases ($P<0.05$) when compared with the diabetic control (292.8± 8.87 to 102.2±2.52 mmol/L).

Table 3: Shows the hypoglycemic effect of feeding normal/alloxan induced rats with Irish potato flour fortified with vitamins. The fasting blood glucose concentration of Diabetic control groups were significantly ($P<0.05$) higher, compared to the other test groups. At day 7, it was observed that the FBG and 2hrs post-prandial diabetic rats fed with irish potato flour diet showed significant decrease ($P<0.05$) when compared with diabetic rats, which reduced the FBS and 2hrs post-prandial levels from 297.2 ± 10.50 to 133.6 ± 18.55 and 399.4 ± 42.32 to 144.4 ± 19.79 mmol/L. The FBG and 2hrs post-prandial normal rats fed with sweet potato flour showed significant difference ($P<0.05$) when compared with the normal control which reduced the FBS and 2hrs post-prandial levels from 100.8±5.12 to 76.4 ± 3.67 mmol/L and 101.8 ± 4.56 to 99 ± 18.67 mmol/L, respectively. At day 14 the FBS and 2hrs post-prandial levels reduced from 133.6 ± 18.55 to 123 ± 12.41 mmol/L and 132.2 ± 12.88 to 144.4 ± 19.79, respectively. At day 21, the FBS and 2hrs post-prandial levels significantly decreased ($P<0.05$) from 123.0 ± 12.41to 121.0 ± 2.45 and 132.2 ± 12.88 to 159.0 ± 3.03 mmol/L. On the other hand, the group fed with irish potato and glucophage showed marked significant decrease ($P<0.05$) when compared with the diabetic control.

DISCUSSION

The finding that *Ipomea batatas* demonstrated a significant decrease ($P<0.05$) in hyperglycemia in alloxan induced diabetic rats. The feeding of diabetic rats with sweet potato flour diet for 21 days reduced fasting blood glucose and 2hrs blood glucose from 273.6 ± 20.60 to 157.4 ± 10.57 mmol/L which was similar to the work of (Okon and Ofeni, 2013) who showed that bitter yam reduced fasting blood glucose from 280.2 ± 10.2 to 145.4 ± 12.5 mmol/L. This also corroborate with the findings of Zeinab *et al*. (2020) who reported that raw and cooked sweet potato induced anti-diabetic effects and decreased glucose in blood serum The work also agreed with Ramchander *et al.* (2012) who showed that rats treated with aqueous extract of Indian date leaf extract reduced blood glucose from 176 ± 7.75 to 107 ± 4.09 mmol/L. The observed hypoglycemic effects of the tuber could be due to alkaloids, proteins and glycosides present in the tuber. The finding agreed with the earlier reports of Okon and Ofeni, (2013), on the roles some phytochemicals compounds inherent in such plants. These constituents may be responsible for the observed significant activity in the tuber. In this study, continuous feeding of the diabetic rats for a period of 21 days caused a significant decrease in blood glucose level from 270.4 ± 19.52 to 131.4 ± 7.89 compared to untreated diabetic ones. Some plants have been reported to exert hypoglycemic action by potentiating the insulin effect, either by increasing the pancreatic secretion from the cells of islet of Langerhans or corrections of insulin resistance (Kim *et al*., 2014). Another possible mechanism of glucose reduction by sweet potato may be due to the action of the tuber through extra pancreatic mechanism by inhibition of hepatic gluconeogenesis or reducing post prandial absorption of glucose due to low glycemic index (Nagarchi *et al*., 2015), Soy and Brand-Miller (1999)

The treatment of streptzotocin induced diabetic rats with *nauclea latifolia* (Pin cushion tree) ethanoic leaf extract reduced blood glucose from 262.0 ± 7.50 to 82.50 ± 6.43 (Gidado *et al.,* 2009) which was better than that of Irish and sweet potato as observed in this study.

The observed hypoglycemic effect of the tuber might be due to presence of protease inhibitor-2 which delays gastric emptying rate hence reducing post prandial glucose absorption (Trout *et al*., 1993). It may also be due to high percentage of total dietary fiber which impedes digestion of sugars and their absorption (Astawan and Widuwati, 2011).

Conclusion

The results of the presented study showed that sweet potato and Irish potato when administered to alloxan- induced diabetic rats had hypoglycemic effects. However, all the groups treated with different diet/drugs over time, have demonstrated an appreciable hypoglycaemic property, with the group administered a combination of sweet potatoes and glucophgage was the best among the other groups.

Conflict of interest

The authors have no conflict of interest to declare

Table 2: Hypoglycemic effect of feeding normal/alloxan -induced diabetic rat's sweet potato flour fortified with vitamins

Groups	DURATION							
	0 days		**7 days**		**14 days**		**21 days**	
	FBS	**2HRS**	**FBS**	**2HRS**	**FBS**	**2HRS**	**FBS**	**2HRS**
NC	97.0 ±5.66	139.6 ± 4.71	107.0 ± 5.23	128.6 ±16.34	111.6±10.34	125.8±15.96	106.6±7.83	121.0±9.73
DC	248.6±15.52	346.0±26.32	252.0±19.06^{a}	330.0±54.03^{a}	238.0±15.27^{a}	265.0±20.3^{a}	223.6±9.31^{a}	270.4±19.52
D+SP	273.6±20.60	412.6±43.53	157.4±10.57^{b}	177.2±18.5^{b}	140.4±8.81^{b}	154.2±9.08^{b}	119.6±5.59^{b}	131.4±7.89
D+G	269.0±25.42	296.6±33.78	117.0±9.81^{b}	190.8±6.89^{b}	111.6±7.79^{b}	121.4±9.09^{b}	102±4.23^{b}	124.2±5.60
N+SP	101.4±4.85	116.2±8.83	85.6±3.28^{c}	103.5±5.35^{a}	87.0±2.62^{a}	104.2±1.84^{a}	85.2±1.40^{a}	163.6±10.25
D+SP+G	299.4±18.79	340.0±15.28	85.6±8.41^{b}	115.4±5.95^{b}	102.0±6.36^{b}	167.0±17.9^{b}	96.8±1.63^{b}	114.0±3.61

Values are recorded as mean ± SEM of three determinants. Values in the same row with different superscripts are significantly different.
KEY: FBS= Fasting blood sugar, SP=Sweet Potato, D=Diabetic, NC=Normal control, G=Glucophage, DC=Diabetic Control a=highly significant b=moderately significant.

Table 3: Hypoglycemic effect of feeding normal/alloxan induced diabetic rats with Irish potato flour fortified with vitamin

	DURATION							
	0 days		**7 days**		**14 days**		**21 days**	
Groups	FBS	2HRS	FBS	2HRS	FBS	2HRS	FBS	2HRS
NC	97.0±5.66	139.6±14.71	107.0±5.23	128.6±16.34	111.6±10.34	125.8±15.96	106.6±7.83	121.0±9.73
DC	248.6±15.52	346±26.32	252.0±19.06^{a}	330.0±54.03^{a}	238.0±15.27^{a}	265.0±20.3^{a}	223.6±9.31^{a}	270.4±19.52^{a}
D+IP	297.2±10.50	399.4±42.32	133.6±18.55	144.4±19.79^{b}	123.0±12.41^{b}	132.2±12.88^{b}	133.0±2.45^{b}	159.0±3.03^{b}
D+G	269.0±25.42	296.6±33.78	117.0±9.81^{b}	190.8±6.89^{b}	111.6±7.79^{b}	121.4±9.09^{b}	102.0±4.23^{b}	124.2±5.60^{b}
N+IP	100.8±5.12	101.8±4.56	76.4±3.67^{b}	99.0±18.67^{b}	73.2±3.17^{b}	104.2±1.80^{b}	114.0±11.55^{b}	157.6±16.53^{b}
D+IP+G	292.8±8.87	292.8±8.87	106.2±5.05^{b}	179.4±44.30^{b}	110.0±4.33^{b}	150.0±9.5^{b}	102.2±2.52^{b}	112.4±2.65^{b}

Values are recorded as mean ± SEM of three determinants. Values in the same row with difference superscripts are significantly different
KEY: FBS= Fasting blood sugar, IP=Irish Potato, D=Diabetic, NC=Normal control, G=Glucophage, DC=Diabetic Control a=Highly significant b=moderately significant

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Authors' Contribution

SM, PBB and SFA designed the work. AA and CG did the laboratory experiment and analysed the experimental results. CG and PBB wrote the manuscript. SM, BM and SFA proof read the manuscript. All authors have read and approved the final manuscript.

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