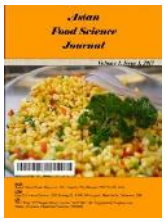

Asian Food Science Journal

2(1): 1-11, 2018; Article no.AFSJ.40468

Influence of *Moringa oleiferea* Seed Meal and Yam Blend in Body Weight and Glucose Level of Alloxan Induced Diabetes Mellitus Male Albino Rats

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Authors' contributions

This work was carried out in collaboration between all authors. Authors JSA, MOE and ATG designed the study. Author ANK performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author ANK managed the analyses of the study. Authors ANK and CVE managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2018/40468
Editor(s):
(1) Aneta Popova, Chief assistant Professor, Department of Catering and tourism, University of food technologies, Bulgaria.
Reviewers:
(1) Juan Carlos Troiano, University of Buenos Aires, Argentina.
(2) Haris Ja'afar Bello, National Mathematical Centre, Nigeria.
(3) Keagile Bati, University of Botswana, Botswana.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/24192

Original Research Article

Received 27th January 2018
Accepted 8th April 2018
Published 17th April 2018

ABSTRACT

The aim of this work was to evaluate the influence of *Moringa oleifrea* seed meal and yam blend in body weight and glucose level of alloxan - induced diabetes mellitus in male albino rats. The animal study was carried out at the animal house of [5] Department of physiology, biochemistry and pharmacology of the College of Veterinary Medicine Federal University of Agriculture Makurdi Benue State. Three yam varieties namely *Dioscorea alata*, *cayennesis, rotundata* and *Moringa oleifera* were sourced at Wurukum Market Makurdi Benue State Nigeria. *Moringa oleifera* seed was deposited at the herbarium for identification. The yam varieties were processed into flour and *Moringa oleifera* seeds were processed into seed meal. The *moringa* seed meal and yam flour were formulated into animal feed at 90% (yam / moringa seed meal blend) and 10% (rat chow); to

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produce *Dioscorea alata* control (100%) at 90% + 10% commercial feed , DA90%MRGA10% at (90%) +10%commercial feed, *Dioscorea rotundata* control (100%) at 90+10% commercial feed, DR 90% MRGA10%, at (90%) +10%commercial feed, *Dioscorea cyennesis* control (100%) at 90% + 10% commercial. DC 90% MRGA10% at (90%) +10%commercial feed, Moringa seed meal (100%) at 90% + 10% commercial feed, and 100% commercial feed. Both GRP8 (non -diabetic group) and GRP 9 (diabetic untreated group), were feed with rat Chow.
This was used for the treatment of 45 male albino rats that were acclimatized for two weeks. The animals were grouped into nine groups and each group contains 5 rats. They were later induced with diabetic with alloxan monohydrate, at 60 mg/kg body weight in 0.05M citrate, pH 4.5. The result generated illustrated that there was a significant increase (p≥0, 05) in the body weight of the animals in GRP1 to GRP8 which are diabetic treated animal. Animals in GRP8 were not diabetic. The glucose level of the animals in GRP1 to GRP7 increases from 48 hrs having been confirmed diabetic with blood glucose level of 197.00±12.44 to 205.50±81.37. However, the animals in Grp9 which are the diabetic untreated animals has a constant significant decreased in the body weight from the period under investigation which value decreases from 103.80^{a}±9.12 to 78.40^{e}±4.6 at the end of the study. The glucose level increased significantly from baseline to wk 4 (105.20±6.4 to 244.40±54.

Keywords: Alloxan –induced; diabetes mellitus; Moringa oleifera; Dioscorea spp.

1. INTRODUCTION

Diabetes mellitus (DM) is a dysfunction of the endocrine system that gives rise to the chronic metabolic disorder as described by world health organization (WHO)which leads to hyperglycemia (elevated blood glucose) and dyslipidemia [1]. Hyperglycemia as an abnormal condition has blood glucose level above the normal condition which is estimated over 120mg/dL on fasting condition and over 200mg/ dL two hours after eating. Retinopathy, nephropathy, and neuropathy are the major complication in diabetes as a result of elevated blood glucose [2,3].

Diabetes affects the endogenous antioxidants such as the superoxide dismutase, catalase, and the glutathione which are the antioxidative defence system. This generates more free radicals in the body that distort the pancreatic B cells. The onset of diabetes leads to loss of body weight and hyperglycemia [4,5].

Alloxan is a chemical compound produced by the oxidation of urea with uric acid or the production of the monohydrate type by the oxidation of barbituric acid by chromium trioxide. Alloxan is widely used for the diabetogenic investigation which causes Type 1 diabetes by the selective necrosis from the β- cells of pancreatic islets Islam [6]. Alloxan injection is used to induce chemical diabetes. The chemical diabetes-induced is the Type 1 diabetes which causes a destruction of pancreatic β-cells. The pancreatic β-cells store the hormone insulin which is responsible for the use of glucose in the body. When pancreatic β-cells is damaged this leads to insulin deficiency and resulting in hyperglycemia [7].

Diabetes mellitus (DM) can be managed with intramuscular administration of insulin to individuals with diabetes in addition to several synthetic antidiabetic medicines used as a glycemic control. However, from toxicology point of view, herbal formulation or use of a natural plant with phytochemical property is preferred as a better alternative to synthetic antidiabetic drugs due to it none or minimal side effects.

Moringa oleifera Lam. (Family: Moringaceae) (M. oleifera) is a medium-sized tree, found in Asia, Africa and tropical areas of the world and has received a natural nutrition of the tropics as a valuable food source, locally it is esteemed as a vegetable [8].

Muhammad et al. [9] reported that *Moringa oleifera* has pharmacological and nutritive such as antiulcer, analgesic, antifertility, anticonvulsant antimicrobial, anticancer, anti-hyperlipidemic, antidiabetic, hepatoprotective potential. The leave, flowers, seed, steam, root are known to possess anti-diabetic properties. The hypoglycemia and anti hyperglycemia can amylase to the presence of some phytochemicals such as alkaloids, flavonoids, glycosides, tannins and steroids.

Yam (*Dioscorea* spp.) is a perennial herb, which is mainly cultivated in the tropical and subtropical

regions of the world. Among the over 150 species of yam grown in the world only six species such; D. rotundata (white yam), *D. esculenta* (Chinese yam), *D. alata* (water yam), *D. bulbifera* (aerial yam), and *D. dumenterum* (trifoliate yam) are among the economically important species [10]. Dioscoreacea posses physicochemical and phytochemical properties namely; the organic acid and Phenolic compounds. Phenolic compounds of which have minimal side effects and toxicity. The phenolic compounds have demonstrated antioxidant activity, antitumor, antimutagenic and antibacterial properties [11,12]. Several reports show the hypoglycemic effect of diosgenin which is one of the phytochemical (saponin) in normal and diseased states. Diosgenin as one of phytochemical found in yam was reported by McAnuff, et al. [13] to have reduced the blood glucose and therefore increased the body weight of Wistar rat fed with diosgenin extract when compared with other Streptozotocin-induced diabetic rats fed with commercial rat feed and saponin extracts. Therefore the work is aimed at evaluating the influence of *Moringa oleifera* seed meal and yam blend in body weight and glucose level of alloxan-induced diabetes mellitus male albino rat.

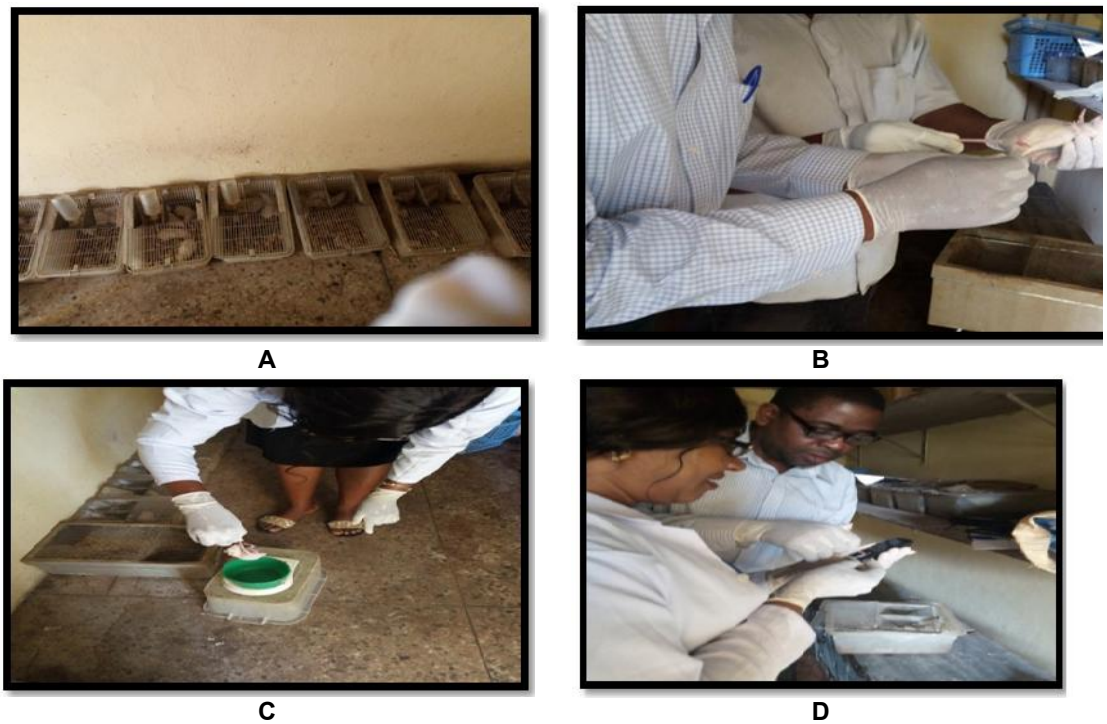
2. MATERIALS AND METHODS

2.1 Preparation of Yam Flour

Three yam varieties *namely; Dioscorea alata*, (DA) *Dioscorea rotundata* (DR) and *Dioscorea cayennensis* (DC) were purchased from Wurukum Market Benue State Makurdi. The yams were washed, peeled, washed and sliced into 5mm size diameter. This was blanched with 5% sodium metabisulphate at 80ºC and was oven dried at the temperature of 60ºC for 24 hrs. The dried yam was ground into flour.

2.2 *Moringa oleifera* Seed Meal

A sample of the plant (*Moringa oleifera* seed) was deposited at the herbarium of the Department of Pharmacology College of Veterinary Medicine (CVM) Michael Okpara University of Agriculture Umudike Umuahia Abia State Nigeria. A voucher number MOUAU/VPP/17/021 was assigned.



Picture A shows the cages containing the male albino rats during the two weeks acclimatization in the animal house receiving water and rat chow ad libtum, Picture B is the intraperitoneal injection of alloxan, picture C is the measuring of the blood glucose level with Glucometer and strips of an Acute check. And picture D is the weighing of the body weight of the animal

The *Moringa oleifera* seed was oven dried at 40ºC for 12 hrs. After which it was milled into fine particles. The milled samples were added in a corked bottle and 600ml of n-hexane was added. The bottle is then placed in a rotator shaker for 48hrs. The oil was observed to have moved to the top. The mixture of oil and hexane was then decanted. The meal was collected and dried in the oven at 40ºC until all the hexane was evaporated from the cake. The dried cake was milled to get a fine powder and was stored in an airtight container until further used.

2.3 Feed Formulation

The yam flour was used to form a blend with Moringa (MRGA) seed meal at 10% inclusion. The flour blend was named thus;

(a) *Dioscorea* alata control (DAC) at 100%, (b) *Dioscorea* alata 90% and Moringa seed meal 10% (DA 90% MRGA 10%), (c) *Dioscorea* rotundata control (DRC) at 100%, (d) *Dioscorea* rotundata 90% and moringa meal 10% (DR 90% MRGA 10%) (e) *Dioscorea* cyennesis control (DCC) at 100%, (f) *Dioscorea* cyennesis 90% and moringa meal 10%, (DC 90% MRGA 10%), (g) Moringa seed meal (MRGASM) at 100%. The samples were kept in a safe place and used as animal feed at 90% (yam, moringa seed meal blend) with an addition of 10% rat chow (commercial feed).

2.4 Animals and Feed

Forty- five male albino rats were got at 6 weeks old from the Veterinary Department of the school of Health Benue State University Makurdi. The animals were kept at the animal house of the Veterinary Clinic, University of Agriculture Makurdi. Rats were housed in stainless steel cages in a room kept on a 12-hour light-dark cycle. They were fed a normal chow diet (Vita FEED of UAC Nigeria plc) and water was given ad libitum for a 2-week acclimatization period prior to the dietary manipulation. After the two weeks acclimatization period the animals were allocated into 9 groups with 5 rats making up a group.

2.4.1 Induction of experimental Type 1 diabetes mellitus

Eight groups of the animals received a single injection of alloxan (Sigma) 60 mg/Kg-body weight in 0.05 Mcitrate buffer, pH 4.5) intraperitoneally (ip). They were found to be down with diabetes after 48hours of the injection. On the onset of diabetes the rats were treated with the different feeds:

Group 1 received DAC *Dioscorea* alata control (100%) at 90% + 10% commercial feed,

GRP 2 DA90%MRGA10% at (90%) +10% commercial feed,

GRP 3 DRC *Dioscorea* rotundata control (100%) at 90+10% commercial feed,

GRP 4 DR90%MRGA10%, at (90%) +10% commercial feed

GRP 5 DCC *Dioscorea* cayennesis control (100%) at 90% + 10% commercial

GRP 6 DC90%MRGA10% at (90%) +10% commercial feed

GRP 7 MRG Moringa seed meal (100%) at 90% + 10% commercial feed

GRP 8 received 100% commercial feed (non - diabetic group)

GRP 9 received 100% commercial feed (diabetic untreated)

The alloxan - induced diabetic male albino rats were allowed to have access to their feed according to their body weight and water ad libitum; except during the fasting blood sugar test. The body weight of the animals and fasting blood glucose was done on weekly bases. Blood samples were collected from the distal end of the tail; and analyzed immediately with a Glucometer and the corresponding glucose test strips (Accu-Check Active®).while their body weight were taken using a weighing scale. The study lasted for 28 days. The animal experiments were carried out in accordance with the Nigeria Institute of Health guideline for Care and use of Laboratory Animals. The ethical approval down the page attests to the claims.

2.5 Statistical Analyses

Results were expressed as means ± SEM. Analysis of variance (ANOVA) was used to test for differences among the groups. Post Hoc analysis was carried out using the least significance difference (LSD) multiple range tests to test for significant difference among the means ($P < 0.05$). All statistical analyses were done using the IBM SPSS statistical Programme version.

4. RESULTS AND DISCUSSION

The result in Table 1 shows the blood glucose level of the animals from the baseline to the wk 4 (28 days). The baseline blood glucose level, of all the animals in GRP1 through GRP 9 ranges from75 to 117. This indicated that the animals were not diabetic at the time of the experiment. This can be supported by the work of Ebuehi et al. [14] who reported that at a normal condition that the blood glucose level really exceed 120 mg/dl.

There was a decrease in the blood glucose level, (70 – 118 mg/dl) of the animals at 24hrs. However, at this stage the animals were still not down with diabetes, rather the injection reduced their glucose level. This can be as a result of the destruction of the pancreatic bête cell by alloxan monohydrate.

Insulin functions as the blood sugar regulator and it is stored in the pancreatic beta cell. The presence of alloxan monohydrate into the body of the animal inhibits the function of glucokinase which is a glucose sensor. The inhibition causes excessive release of insulin which triggers the absorption of glucose by muscles, livers and fat cells, thereby lowering the sugar level [15].

Also, Saleem et al. [16] reported that the administration of alloxan causes disruption of the pancreatic beta cell (beta-cytolysis) which in turn lead to the excess release of insulin (hyperinsulinaemia) thus inducing severe hypoglycaemia as show in 24hrs after induction in GRP 1 GRP 7.

On Normal condition excess glucose in the body is taken up by the liver as glycogen by the influence of insulin. The administration of alloxan monohydrate to induce diabetes causes the fall of blood glucose at the first instant below normal, as a result, destruction of beta cell giving rise to the excess release of insulin. At this stage of blood glucose level, glucagon is secreted and glycogen is (stored excess glucose) depolymerised from the liver and glucose is released. This is responsible for high hypyperglycemia as seen in 48hrs. Elevated blood glucose level; at 48hrs alloxan monohydrate induction which is above normal shows the presence of diabetes. This could also be as a result of the destruction of the beta cell of the islet of langerham by alloxan monohydrate thereby causing insulin depletion and on set of hyperglycemic condition [14].

On a similar issue Qaid & Abdelrahman, [17] reported that insulin absence causes decrease in glucose uptake by liver and muscles, insulin no longer performs its function of regulating and sending blood glucose to the liver. So if there is a decrease of glucose uptake by the tissue then blood glucose level is likely to be elevated (hyperglycemia).

Similarly Helal, et al. [18] that administration of alloxan causes hyposecretion of insulin by pancreatic β-cells initially. Gradually there will be a massive reduction or deceased of insulin by the damage of the b-cells of the islets of langerhans, thereby inducing hyperglycaemia. However after hypoglycaemia, whole brain glycogen stores markedly increase above baseline levels, this is known as super-compensation. This can account for the rise of the blood glucose level at 48hrs alloxan-induction.

At wk 1 there was a decrease of the blood glucose level of all the aimal, this shows that the yam/moringa seed meal blend has anti - diabetic property and this increases with repeated doses. Mohammed1 et al. [19] reported that aqueous seed extract of moringa, when administered to Wistar rat, caused significant decreases in the blood glucose level. The oral administration of aqueous seed extract of *Moringa oleifera* experimentally produced significant decrease in blood glucose level in Wistar albino rats, 6 to 18 h post administration, however, the diabetic untreated animals in GRP9 has an increase of blood glucose level, this is true as no treatment was given to them.

At wk 2 of the alloxan induction and treatment of the diabetic male albino rats; it was discovered that there was an increase in the blood glucose level in all groups of the animal administered with alloxan. This is in line with the work of Lin, et al. [20] who reported that alloxan injection causes type 1 diabetes. There is insulin resistance and at such more insulin is produced which leads to hypoglycemia. It will get to a stage where the insulin produced is insufficient and blood glucose in diabetics is much higher than the ordinary level (baseline).

Also, the elevated blood glucose level could be attributed to the failure of the active principle in the feed; to reach the target site and so needs sufficient concentration to have a pronounced effect [21].

Table 1. Effect of yam/moringa seed meal blend on the glucose level of the alloxan induced diabetic albino rats

Samples	Treatment	Baseline	24 hrs	48 hrs	Wk 1	Wk 2	Wk 3	Wk 4
Grp1	Diabetic (DAC)	103.00±4.6	98.80±18.86	180.00±85.50	74.75±6.07	173.50±89.34	107.00±28.68	85.67±15.27
Grp2	Diabetic (DA90M10)	102.80±11.2	70.00±9.34	197.00±12.44	127.00±0.00	130.00±0.00	125.00±0.00	98.00±0.00
Grp3	Diabetic (DCC)	114.40±15.8	118.00±13.58	178.25±9.83	73.67±32.12	109.00±16.37	100.66±4.16	81.33±6.51
Grp4	Diabetic (DC90M10)	117.40±7.09	105.60±9.91	179.50±59.12	98.33±21.77	237.00±23.52	140.00±12.49	131.00±10.81
Grp5	Diabetic (DRC)	102.60±13.99	84.50±12.05	205.50±81.37	79.00±11.31	200.50±99.70	131.50±6.36	78.00±24.04
Grp6	Diabetic (DR90M10)	112.20±8.89	88.80±8.40	141.20±56.50	96.50±38.89	185.00±56.57	109.00±12.72	99.00±1.41
Grp7	Diabetic (MRGA)	107.00±6.04	112.20±2.48	166.25±28.9	98.00±17.19	173.25±68.27	121.25±22.23	111.25±24.48
Grp8	Non - Diabetic	75.00±9.75	101.20±4.86	101.20±4.89	74.50±10.25	93.12±6.50	118.38±18.91	104.00±9.85
Grp9	Diabetic untreated	105.20±6.4	96.00±4.5	199.00±6.37	215±6.4	223.00±61.3	229.54±58.2	244.40±54

Values are expressed as Mean ± SEM

The constant treatment of the animal (GRP1-GRP7) with yam and moringa blend caused a persistent decrease in the blood glucose level. According to Adeeyo et al. [22] hypoglycemic activity of *Moringa oleifera* is linked to the presence of α-glucosidase and pancreatic amylase enzyme inhibitors. These enzymes make glucose to be in an absorbable state and thus, the blood glucose level cannot increase after glucose intake. Since the glucose is prevented to be in an absorbable state by the enzymes [23]. The hypoglycemic activity of moringa leaf extract may be due to the presence of antioxidants namely; flavonoids, phenol, and vitamins C and E. Pharmacologically active ingredient found in *Dioscorea* species and other plant have hypoglycemic properties. They function by enhancing the secretion of insulin from the pancreatic β-cells of Islets of Langerhan [24].

(*Cymodocea nodosa* sulphated polysaccharide (CNSP) also exhibits hypoglycemic effect. Kolsl et al. [23] reported that the oral treatment of diabetic rats with CNSP(*Cymodocea nodosa* sulphated polysaccharide (CNSP) caused b-cells regeneration in the pancreas, which led to an increase insulin secretion , this induced a decrease in the blood glucose level as can be seen in the diabetic untreated groups (GRP9).

Fast conversion of carbohydrate to glucose leads to high glucose absorption rate and thus the high level of blood glucose level which is evident in the GRP 9 (diabetic untreated group). However, the treating of other groups of animals with yam and moringa blend which are rich with a lot of phytochemical must have caused a decrease in the carbohydrate conversion to glucose and thus a decrease in the blood glucose level [25].

There was a rapid reduction in the blood glucose level in 3 and 4 weeks progressively this is an indication that repeated administration of the feed in the different group of the animal from 1 through 7 brought about hypoglycemia. Kumar et al. [26] reported that *E. indica* possesses glucose reducing activity and this was observed on repeated administration in alloxan - induced diabetic rats, which lowered the blood glucose to 4th day with 400 mg/kg and on the 7th day with 200 mgkg.

Also, the fail of the glucose level of the animal in group 1 to group 7 can be as a result of the phytochemical present in the yam flour and Moringa. This can be supported by Ojiako et al. 2016 who reported that the low blood glucose level in repeated dose is as a result of the chemical interaction of the phytochemical constituent which ameliorates hyperglycemia. Furthermore, flavonoids are a-amylase inhibitors and according to Najafia et al. [27] can exhibit glycemic control in STZ induced rat model of type 1 Diabetes mellitus.

In another study by Winarsi et al. [28], blood glucose level of treated rats were found to decrease continuously when; Ethanol Cardamom Leaves Extract(ECLE) was administered to them for a longer time (14 days) of 201.7 to 102. 8 mg/dl (P = 0,017) when compared to those of diabetic group rat given feed only.

The presence of flavonoid cannot be ruled out since Flavonoid is proven to be able to stimulate the immune system. Flavonoid is known to posse antioxidant character which was able to recover the beta-pancreatic cells damage by alloxan. The flavonoid glycosidic component acts as the suppressor of the hydroxyl radicals, and therefore, was capable to block subsequent development of diabetic.

Fig. 2 shows the body weight of male alloxan - induced diabetic albino rats. In all the study animals, the result shows that their body weight remained the same in the Baseline, 24hrs and 48hrs under investigation because at this stage they were yet to get acclimatized with the feed treatment.

The weight of animals in GRP 1 at one wk 1 through wk 4 of the study increased when compared to other animals in other groups (GRP 2, 3, 5 and 6,) This can be associated with the hypoglycemic property of water-soluble polysaccharides found in *Dioscorea* alata which reduces blood glucose level [29]. Diabetes is known to be associated with hyperglycemia (elevated blood glucose) and causes loss of body weight. However, GRP 1 animal received 100% *Dioscorea* alata, *Dioscorea* alata possess anti- diabetic property; this brought a healing process thus causing a reduction in blood glucose and a resultant increase in body weight. The animals in GRP 7 have a similar increase in body weight like the non diabetic animals in GRP8. This group (GRP7) was feed with 100% moringa (at 90%) and rat chow (10%). The anti diabetic property in moringa was able to restore the normal condition in the animal. This can be linked to the Flavonoids, sterols/triterpenoids,

alkaloids and phenolics which are bioactive antidiabetic principles. Flavonoids and Phenolics must have regenerated the damaged β cells in the alloxan diabetic rats to normal condition [2,30].

Furthermore, Yassa and Tohamy [31] reported that Phytochemical such as; glucosinolates, flavonoids (quercetin and kaempferol), and phenolic acids (chlorogenic acid) found in Moringa seed possess antioxidant and antidiabetic activity, this is responsible in normalizing the disease condition, thereby improving the animals appetite and body weight.

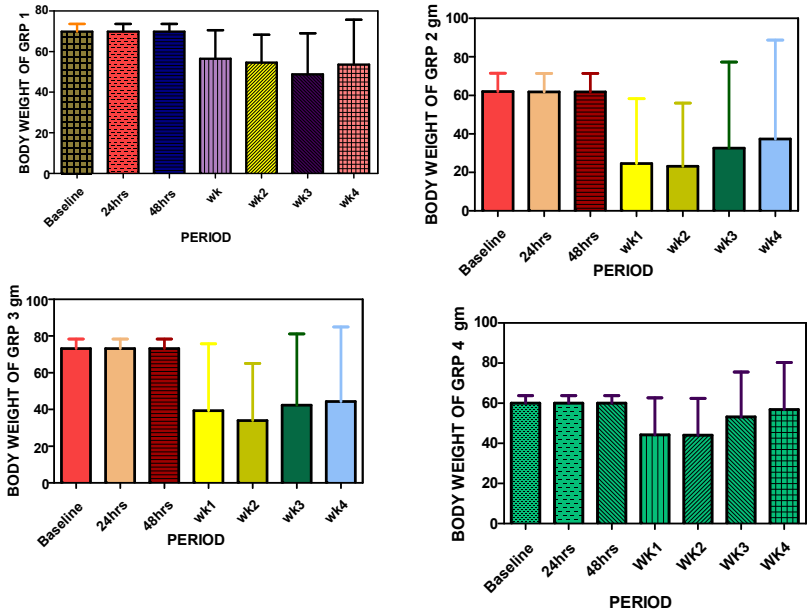


Fig. 1. Effect of yam moringa seed meal on the body weight of alloxan induced diabetic albino rats

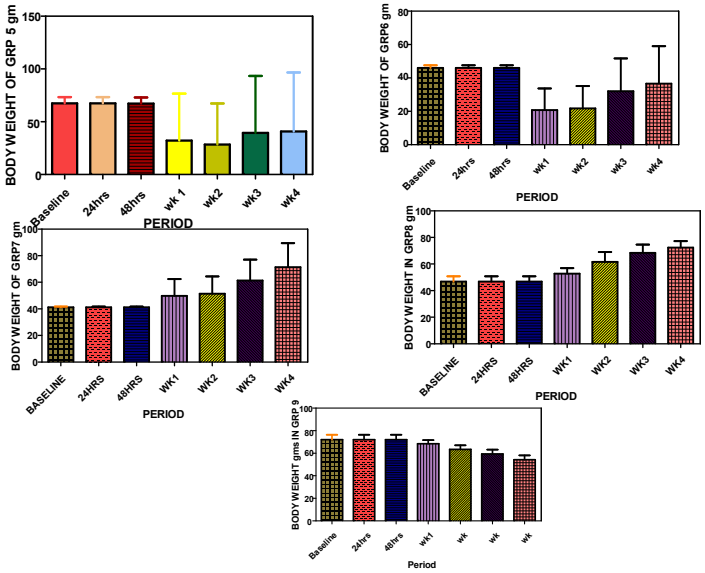


Fig. 2. Effect of yam moringa seed meal on the body weight of alloxan induced diabetic albino rats

The animals in GRP 8 increased in weight progressively during the period under investigation. This group was not induced with diabetes, they received normal rat feed. However, GRP 7 was responding to the feed and had a fast increase in weight than group 8 because of the high protein content of the group 7 feed.

There was a decrease in body weight of the animals, (GRP 1 down to group 6) at wk 2 after being confirmed diabetic with alloxan injection. On Table 2 below the animal were down with diabetes and were not responding to the feed treatment. They were recorded to have high blood glucose (173-237 mg/dl) level at wk 2.

The fall in body weight in week 2 can be attributed to the presence of diabetes which increased their blood sugar. Thus causing a loss of appetite in the animals (GRP 1 –GRP6).This in turn caused a reduction in body weight. A similar observation was made by Aja et al. [4] who reported a loss of body weight of alloxan induced diabetic rats after one week of induction. This could be due to the fact that when there is insulin deficiency, glucose does not enter the cell, rather lipid and protein is used as the source of energy instead of glucose thereby causing a reduction of animal body weight [28].

There was a reduction of body weight of the animals in GRP1- GRP6 at wk 2.This is so because at this stage the animals were recorded to be hyperglycemic as reported in tables 1 above and had lost of appetite. The progressive increase in the body weight from wk 3 to wk 4 was observed in animals in GRP1 – GRP6 6. At these stages it was found that the blood glucose level was decreasing progressively and they were responding to the yam moringa blend treatment and hence the progressive increase in weight. The presence of phytochemicals in moringa meal and yam feed must have initiated positive effect on the animal, after constant administration. The animals were all responding to the feed treatment.

This can be supported by work of Lin, et al. [20]. Who reported that polyphenol especially flavanoid, phenolic acid and tannin have the property of inhibiting α glucosidase and α amylase. These enzymes are responsible for digestion of carbohydrate into glucose. Glucoside and amylase are known to break down Dietary carbohydrate into glucose. However, the presence of polyphenol (polyphenolic acid and tannin) in some plant inhibits their action and attenuate hyperglycemia effect caused by Diabetes. Therefore is it justifiable that the phytochemicals found in the feed must have contributed in normalizing their condition and thereby improving their weight.

The GRP9 animals show a constant decrease in body weight from 48hrs through wk 4. This can be linked to the elevated BGL as recorded in Table 1 above. Diabetes Mellitus cause hyperglycemia which gives loss of appetite and emaciation and loss of body weight. This constant loss of body weight observed in this group is because diabetes causes non-proper metabolization of glucose from amino acid and body protein by the cells. This will eventually lead to tissue wasting and breakdown.

5. CONCLUSION

Alloxan monohydrate is a diabetogenic agent sued to induce experimental Type 1 diabetes. The administration of the chemical, caused diabetes in the male albino rats. However, the phytochemical found in *Moringa oleifera* seed and *Dioscorea* species possess hypoglycemic property. This was evident in the reduction of the elevated blood glucose and the improvement of body weight of male albino rat that was induced with alloxan monohydrate. Furthermore, the result indicated that yam moringa seed meal blend as reported in this work may be used for the production of therapeutic and pharmaceutical formulation in the control and treatment of diabetes and it associated complication. More study can be carried out on the extraction of the individual bioactive components in the yam species to evaluate their anti-diabetic property.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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