British Journal of Medicine & Medical Research
3(4): 1871-1880, 2013

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Dioscorea alata L. Reduces Body Weight by Reducing Food Intake and Fasting Blood Glucose Level

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Authors' contributions

This work was carried out in collaboration between all authors. Author OTH conception and design, experimentation and acquisition of data. Author AEO preparation of draft manuscript and managed the literature searches. Author IEE statistical analysis, interpretation of data & coordination. Author AUB experimental procedure and supervision. All authors read and approved the final manuscript.

Research Article

Received 16th March 2013
Accepted 12th May 2013
Published 16th June 2013

ABSTRACT

Aims: The prevalence of type 2 diabetes may be most likely linked to obesity and its prevalence appears to have increased as the prevalence of obesity increased. *Dioscorea alata* L. has been observed to possess flavonoids which induce antidiabetic effect and phenolic compounds which could help in weight management. It has been postulated that any therapeutic regimes that can limit weight gain while simultaneously controlling blood glucose levels will be effective in managing diabetes. This study was conducted to determine the effect of this rich plant on food intake, blood glucose and body weight in a normal non- diabetic state.
Materials and Methods: The tuber was washed and the edible portion was dried at 50ºC, powdered, passed through 60 mesh sieve (BS), the powder was extracted with hot (70ºC) distilled water in a mechanical shaker for 24 h, filtered and freeze dried to yield aqueous extract. Twenty male wistar rats were used for this study; the rats were randomly assigned into five groups of five rats per group. Rats in group 1 served as

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control and were administered 0.3ml of 0.9% sodium chloride while Group 2, 3 and 4 received *Dioscorea alata L. (DA)* extract at 100mg/kg, 200mg/kg and 300mg/kg of body weight respectively for a period of 21 days. Food intake, Fasting blood glucose and body weight were measured.
Results: The results showed that food intake, fasting blood glucose level and body weight were significantly (P=.05) reduced when compared with the control group.
Conclusion: Therefore, we recommend that with further research into the extraction of the active constituent of *Dioscorea alata* L. that caused the reduced food intake, this plant could serve as a great therapeutic diet in the management of diabetes.

Keywords: Dioscorea alata L.; diabetes; food intake; body weight; blood glucose.

1. INTRODUCTION

The prevalence of type 2 diabetes may be most likely linked to obesity and its prevalence appears to have increased as the prevalence of obesity increased [1]. It has been estimated that the proportion of diabetes mellitus among adults between the ages of 20 and 79 was 6.4% in the year 2010 and will increase to 7.7% in 2030 worldwide [2]. Weight gain is a major risk factor in the development of the disease [3, 4] with a 9% relative increase in prevalence being reported for every 1kg gain in body weight [4]. Obesity and type 2 diabetes are occurring at epidemic rates in the United States and in the 8-year period from 1990 to 1998, there was a 33% increase [5]. As many as 80–90% of patients with type 2 diabetes are overweight, and this negatively influences the existing physiological and metabolic disorders associated with the disease. In particular, hyperglycaemia, hyperlipidaemia and hypertension [3, 6] can greatly increase the risk of early death [7].

Intervention studies have shown that a structured lifestyle intervention including dietary change, weight loss and increased physical activity can reduce the risk of progressing to diabetes mellitus from impaired glucose tolerance [8, 9].

Food intake is regulated by the complex interaction of psychological and physiological events associated with ingestion. Many different factors including biological, behavioural and environmental, have an influence on appetite. Abstinence from food is not a good approach to weight loss; it leads to “hunger” which is the biological drive that forces one to search for food. It determines when one eats and how much to eat [10], sometimes leading to eating more than one used to or need. It was thought that energy restriction might be the most effective way for individuals with insulin resistance, obesity and/or non-insulin dependent diabetes mellitus to improve their glucose control and plasma lipid profile and lose weight [11]. However, weight loss by this method also reduces satiety and increases appetite, which makes adherence to an energy- restricted diet difficult [12]. Stabilization of blood sugar, hunger control, and preservation of lean body mass and metabolism is important.

Relationship exists between food intake and body weight, lesions in the lateral hypothalamus (hunger center) leads to anorexia and loss of body weight while lesions in the ventromedial hypothalamus (satiety center) leads to overeating and obesity, therefore the amount and type of food eaten affect body weight.

The fasting blood glucose level is the most commonly used indication of overall glucose homeostasis, largely because disturbing events such as food intake are avoided. The mean normal blood glucose level in humans is about 4 mM (4 mmol/L or 72 mg/dL, i.e.

milligrams/deciliter) [13] however, this level fluctuates throughout the day. Glucose levels are usually lowest in the morning, before the first meal of the day (termed "the fasting level"), and rise after meals for an hour or two by a few millimolar. The normal blood glucose level (tested while fasting) for non-diabetics, should be between 70 and 100 milligrams per deciliter (mg/dL). Blood sugar levels for those without diabetes and who are not fasting should be below 125 mg/dL. [14]. The American Diabetes Association recommends a fasting plasma glucose level of 70–130 mg/dL (3.9-7.2 mmol/L) and after meals less than 180 mg/dL (10 mmol/L) for diabetics [15].

Consumption of both simple and complex carbohydrates raises blood glucose levels, which in turn stimulate insulin release by the pancreas, hypersecretion of insulin leads to a rapid drop in blood glucose level, prompt onset of hunger, and the desire to eat soon after the initial meal. This cycle leads to more frequent meals, overall increase in caloric intake and obesity [16], but long term animal models have shown that diets high in simple carbohydrates are more rapidly absorbed into the blood stream than complex carbohydrates causing hyperglycemia and hypersecretion of insulin which promote the growth of fat tissue, visceral fat stores and higher concentrations of lipogenic enzymes and can promote weight gain than do moderate calorie, complex carbohydrate diets [17].

Dioscorea alata L (DA) is a species of yam, a tuberous root vegetable that is bright lavender in color. It is wide spread in distribution being grown in tropics and subtropics of Africa, America, Asia and Caribbean [18]. In Indian traditional medicine, the tuber is used as a diuretic, aphrodisiac, anthelminitic and antidiabetic [19]. Researchers have shown that *Dioscorea alata* L. contain most notably carotenoids and anthocyanins like potato [20].

Dioscoreaceae (D. alata, D. batatas, D. bulbilfera, D. opposita) has health beneficial compounds such as dioscorin [21, 22, 23] diosgenin [24, 25, 26] and water soluble polysaccharides (WSP) [27]. Dioscorin is the major storage protein in yam and functions against angiotensin, which converts enzyme to cause hypertension [28]. Diosgenin is used in making progesterone and other steroid drugs [29]. Some studies showed that WSP had hypoglycemic effect [30].

Maithili et al. [31] reported on the “antidiabetic activity of ethanolic extract of *Dioscorea alata* L. in glucose loaded and alloxan induced diabetic rats”. Phytochemical analysis of the plant showed that it contains flavonoids and phenolic compounds. Hydro-Q chromene, gamma-tocopherol-9, alpha-tocopherol, coenzyme Q, 1-feruloylglycerol, cyanidine-3-glucoside, peonidin-3-gentiobioside, alatanins A, B and C have also been discovered in the tubers of the plant, any of which could induce hypoglycemic effect [32,33] and phenolic compounds that possess potent antioxidant effect which could induce weight loss and aid metabolism [34]. However, it has also been reported that flavonoids constitute active biological principles of most medicinal plants with hypoglycemic and antidiabetic properties [32]. Therefore the antidiabetic and hypoglycemic activity of *Dioscorea alata* L. could be also closely linked to its flavonoids constituents.

It was postulated by David- Russell Jones [35] that any therapeutic regimes that can limit weight gain, or even reduce weight, while simultaneously controlling blood glucose levels will be welcomed in the management of diabetes.

The occurrence of diabetes has been observed to increase due to excessive weight gain which might be due to increased food intake and blood glucose level. *Dioscorea alata* L. has been observed to possess anti-diabetic properties which could help in managing body

weight. Therefore the study of the effect of this rich plant on food intake, `blood glucose and body weight in a normal non- diabetic state became expedient.

2. MATERIALS AND METHODS

2.1 Plant Material and Preparation of Extracts

Dioscorea alata L. tubers were purchased locally from the Ogbette main market, Enugu and subsequently identified and authenticated by a Botanist of the Botany Department of the University of Nigeria, Nsukka. The tubers were washed and the non edible portion (peel) discarded. The edible portion was dried at 50ºC, grinded, passed through 60 mesh sieve (BS) and stored in an air tight container at 4ºC till further use. To obtain the aqueous extract of *Dioscorea alata* L., the powder was extracted with hot (70ºC) distilled water in a mechanical shaker for 24 h, filtered and freeze dried. The acute oral toxicity test was carried out by Lorke's method, [36]. There were no mortality or any toxic reactions found at the maximum tested dose of 2000mg/kg. Therefore, the extract was administered at 100, 200 and 300mg/kg body weight.

2.2 Animals Preparation, Experimental Groupings and Treatment

Twenty male Wistar rats were used for this study. The animals are inbred healthy male rats were obtained from the University of Nigeria, Enugu campus Animal House. The animals were kept in a conducive, healthy environment for the period of the experiment in clean steel-gauzed cages. They were fed on standardized animal pellets (suppex starter fedR) and tap water ad libitum for two weeks for acclimatization to standard laboratory conditions before the experiment. Before the commencement of the experiment, the rats weighed averagely between 170 and 180g. The rats were acclimatized for two weeks and were randomly assigned into five groups of five rats per group. Rats in group 1 served as control and were administered 0.3ml of 0.9% sodium chloride while Group 2, 3 and 4 received *Dioscorea alata* L. (DA) extract at 100mg/kg, 200mg/kg and 300mg/kg of body weight respectively for a period of 21 days.

Administration of the aqueous extract was done orally 10 minutes before feeding (to allow the animals stabilize) by means of calibrated syringe with attached rubber cannula. The experimental procedures involving the animals and their care were in line with the approved guidelines by the local research and ethical committee.

Fasting blood glucose was determined after an overnight fasting and body weight was measured before the commencement of extract administration and further readings were taken every 7 days. Fasting blood glucose level and changes in body weight were measured on days 0 (initial reading), 7, 14 and 21.Fasting blood glucose level was measured using a glucometer (Life Scan Inc. milano, Italy), and the body weight was measured with a spring balance. Thereafter, food intake was determined everyday by giving 100g of feed to all groups and the remaining quantity was been measured the following day to determine the quantity eaten by each group [37].

2.3 Statistical Analysis

Data gotten from the study were subjected to descriptive statistics and the results presented as means ± standard error of mean. Differences between means were separated by one-

way analysis of variance (ANOVA), followed by post hoc multiple comparisons (Gabriel), with the least significant threshold employed at p=.05. Data analysis was done using the statistical software package SPSS for windows version 17.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS

3.1 Comparison of Food Intake in the Different Experimental Groups

Table 1 showed the effect of *Dioscorea alata* L. (DA) extract on the food intake of the various groups at the different concentrations. The result showed that the food intake of the treated groups were significantly lower than those of the control group. At 100mg/kg, the food intake was not significantly different from the control group but a more significant reduction was observed at 300mg/kg. There was an inverse relationship between the extract doses and food intake. The food intake decreased as the extract dose increased.

Table 1. Comparison of food intake in the different experimental groups

Groups	Food intake (grams)		
	Week 1	Week 2	Week 3
Control	88.57±2.10	89.86±1.65	92.14±1.84
DA 1 (100mg/kg)	87.86±1.91	86.14±1.82	87.00±0.82*
DA 2 (200mg/kg)	77.86±3.24*	74.29±2.54*	79.29±1.30*
DA 3 (300mg/kg)	76.42±2.37*	73.57±4.19*	75.71±2.97*[a]

**=p=.05 vs control; a= p=.05 vs DA 1*
DA 1- Dioscorea alata L. at 100mg/kg

3.2 Comparison of Fasting Blood Glucose Level in the Different Experimental Groups

Table 2 showed the effect of DA extract on the fasting blood glucose level. The initial blood glucose levels of all treated groups were not significantly different from the control at the onset of the experiment. The extract caused a reduction in the fasting blood glucose level of test groups in a dose dependent manner.

Table 2. Comparison of fasting blood glucose level in the different experimental groups

Groups	Initial	Fasting blood glucose level (mg/dl)		
		Week 1	Week 2	Week 3
Control	61.00±3.38	79.60±2.53	89.20±4.86	97.40±5.94
DA 1 (100mg/kg)	65.20±2.91	67.20±1.65*	63.80±2.18*	61.00±1.72*
DA 2 (200mg/kg)	65.20±2.75	68.80±1.84*	61.00±2.58*	58.40±1.55*
DA 3 (300mg/kg)	67.80±3.98	65.60±5.85*	55.40±4.95*	49.80±2.58*[a]

**=p=.05 vs control; a= p=.05 vs DA 1*
DA 1- Dioscorea alata L. at 100mg/kg

3.3 Comparison of Body Weight Changes in the Different Experimental Groups

Table 3 showed the mean body weight changes of the various treatment groups given DA extract and those of the baseline control. The initial body weight of all the groups was not significantly different but over the weeks, the body weight of the treated groups became significantly lower than the control group. At 100 and 200mg/kg, there was an increase in body weight, but at 300mg/kg, it was observed that more reduction in body weight was observed in the group where the food intake and fasting blood glucose (FBG) was observed to be more reduced therefore the more weight loss observed at this concentration might be due to the more reduction in food intake and fasting blood glucose.

Table 3. Comparison of body weight changes in the different experimental groups

Groups	Initial	Body weight (grams)		
		Week 1	Week 2	Week 3
Control	180.00±0.63	195.00±2.74	220.00±1.58	255.00±1.48
DA 1 (100mg/kg)	179.00±0.44	190.00±1.87	217.00±1.55*	235.00±0.89*
DA 2 (200mg/kg)	180.00±0.55	188.20±0.84*	200.60±1.87*	215.40±0.81*
DA 3 (300mg/kg)	180.00±0.63	178.60±0.50*	182.60±1.33*	190.80±0.86*[a]

**=p=.05 vs control; a= p=.05 vs DA 1*
DA 1- Dioscorea alata L. at 100mg/kg

4. DISCUSSION

Significance of appetite control in weight management cannot be overemphasized; appetite control plays a vital role between energy consumption and energy expenditure [38]. Sustained increases in energy intake can lead to increased body weight and an accompanying increase in energy expenditure. Body weight will stabilize and energy balance will be achieved when energy expenditure is increased to the level of energy intake. Conversely, a decrease in energy intake will disrupt energy balance and produce a loss of body weight accompanied by a reduction in energy expenditure. Body weight will stabilize when energy expenditure declines to the level of energy intake [38].

In the present study, it was observed that in the extract-treated groups there was a reduction in food intake which probably resulted in the weight loss observed. The food intake, blood glucose level and body weight were significantly (p=.05) reduced in a dose dependent manner when compared with the control group. The weight loss observed in the extract-treated groups might be due to reduced food intake which probably increased satiety or the reduction in the fasting blood glucose level because a reduced glucose level may help the body to use stored reserves from fat or muscle, gradually leading to weight loss.

The study indicated that DA was able to significantly decrease food intake when compared with the control group. There is paucity of data on the effect of DA on food intake therefore the mechanism for the reduction in food intake is probably unknown but it might be due to increased satiety level, some components of the plants might act by increasing the level of some enzyme or hormone (e.g. Cholecystokinnin) known to increase satiety thereby decreasing appetite and hunger ratings which led to the reduced food intake observed. The

higher dose of 200mg/kg and 300mg/kg might stimulate these enzymes more, therefore increasing satiety and causing a more reduced food intake at these doses.

Also, flavonoids and phenolic compounds [32, 33, and 34] which are believed to be present in the tubers of this plant which helps maintain blood sugar level might also stimulate some enzymes in the synthetic pathway of DA digestion which might also enhance satiety thereby reducing the intake of food.

All rats used for these study have a normal fasting blood glucose level because as with all fasted mammals, the blood glucose level decreases significantly over time since no sugar is consumed. Fasting blood glucose for rats ranges from 50 to 109 mg/dl [39] and the fasting blood glucose level of rats used for the study ranges from 50 to 97 mg/dl, therefore the fasting blood glucose level of all the different study groups all still fall within the normal range. Initially, the glucose level of all the extract-treated group were not significantly different from the control group but at the end of the study, the fasting blood glucose level of the various treatment groups became significantly lower than the control group, though they all still fall within the normal range for a fasted rat.

In Table 2, DA was observed to cause a significant reduction in glucose level when compared with the control. According to our study, the higher dose of *Dioscorea alata* L. at 300mg/kg was observed to have a more hypoglycemic effect which could mean that *Dioscorea alata* L. in high dose could cause slight hypoglycemic effect and our data are in line with the results from the study by Maithili et al. [31] who reported that in glucose loaded normal rats, the treatment with the extract of *Dioscorea alata* L. showed a highly significant reduction ($p=.001$) in blood glucose levels at the doses of 100 and 200 mg/kg respectively, therefore the higher dose of 300mg/kg might be responsible for the slight hypoglycemia and probably because the rats were normal models and not diabetic. This could imply that excess intake of *Dioscorea alata* L. in normal individuals might not be beneficial.

Our study also supports the report by Teti Estiasih et al [30] who observed that WSP from Dioscorea hispida has hypoglycemic polysaccharides that are able to reduce blood glucose level in hyperglycemia condition; the mechanisms of blood glucose level decline were glucose absorption inhibition and short chain fatty acids (SCFA) formation. WSP has also been found in the tubers of *Dioscorea alata* L. [27]. Odetola et al. [32] reported that flavonoids constitute active biological principles of most medicinal plants with hypoglycemic and antidiabetic properties. Therefore, the hypoglycemic effects of the DA plant in this study might be as a result of a synergistic effect between flavonoids and WSP in potentiating each other's effect thereby reducing blood glucose level.

Restraint from food is not the best way in the control of weight gain, it is believed to lead to hunger sometimes leading to eating more than one used to or need, this could result from a rapid fall in the blood glucose level which reduces satiety and increases appetite and willingness to eat more, but a successful and healthy weight loss could be achieved if the blood glucose level is maintained within the normal fasting levels.

In this study, it was observed that though there was reduced food intake in the treated rats, a reduced fasting blood glucose level and a healthy weight loss was observed because the fasting blood glucose level was reduced but maintained which might lead to the inhibition of insulin secretion because there is no excess glucose in circulation thereby increasing the mobilization and degradation of fat from body's stored reserve. The reduction in body weight might also be due to the phenolic compounds which are believed to be present in the tubers

of the plant [34] which have been observed to have antioxidant effect which could help in weight management and may help prevent diabetes and obesity as well.

5. CONCLUSION

As it has been suggested that any therapy that could reduce food intake thereby limiting weight gain, or even reduce weight, while simultaneously controlling blood glucose levels will be very efficient in managing diabetes. According to our study, *Dioscorea alata* L. extract has met these criteria to a large extent; therefore, we recommend that with further research into the extraction of the active constituent of *Dioscorea alata* L. that caused the reduced food intake and body weight, this plant could serve as a great therapeutic diet in the management of diabetes.

CONSENT

Not applicable.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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