



***Ipomoea batatas* L. Extract Reduces Food Intake, Fasting Blood Glucose Levels and Body Weight**

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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 coordination. Author IEE statistical analysis and interpretation of data. Author AUB experimental design and supervision. Author ADE managed the literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aim: Obesity is a global epidemic and increased awareness of the association between chronic disease and excess body weight has motivated consumers to seek weight loss and management aids that are safe and effective. *Ipomoea batatas* L. (Sweet potato) is among the most nutritious subtropical and tropical vegetables, it is believed to contain substances that can help maintain body weight without side effects. It is also used in traditional medicine for type 2 diabetes mellitus. This study was therefore conducted to determine the effect of the aqueous extract of *Ipomoea batatas* L. (IB) on food intake, fasting blood glucose and body weight in male wistar rats.

Materials and Methods: Twenty four in-bred male wistar rats weighing 170g-180g were used for this study. The potato tubers were chopped into small pieces and homogenized in distilled water for 30seconds. Homogenate was filtered through muslin cloth into centrifuge tubes and then centrifuged at 120rpm for 20 minutes. The residue was

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evaporated to dryness; the dried extract was reconstituted in freshly prepared normal saline for administration to test animals. The animals were randomly assigned into four groups of six rats each. Group 1 served as the control and was fed with 0.3ml of normal saline; Group 2-4 was fed with IB extract at 100, 200 and 300mg/kg body weight respectively.

Results: The results showed that in the extract-treated groups, the food intake, blood glucose level and body weight were significantly reduced at $p < 0.05$ when compared with the control group.

Conclusion: Consumption of *Ipomoea batatas* L. caused a reduction in food intake probably by increasing satiety and reduction in weight gain by using up the body's reserve of fat as a result of the low blood glucose.

Keywords: Ipomoea batatas L.; sweet potato; food intake; overweight; obesity.

1. INTRODUCTION

Excessive body weight gain could ultimately lead to overweight or obesity. Obesity in its gross manifestation poses a real threat to health. The etiology of obesity is multifactorial but can be abridged to accommodate two dominant categories: physiological and environmental elements [1]. The physiological aspects of obesity include body metabolism, hormones and the neurological components of appetite regulation. Environmental causes include the abundance of high calorie foods in the Western diet, as well as the prevalence of increasingly sedentary lifestyles due to technological advances [1].

Obesity is associated with the development of life-threatening chronic conditions and an increased risk for cardiovascular disease, metabolic syndrome, hypertension, stroke, diabetes, osteoarthritis, sleep apnea, depression, gallbladder disease, type 2 diabetes, and certain types of cancer [2,3].

Increased awareness of association between excess body weight and chronic disease has motivated consumers to seek weight loss and management aids that are safe and effective without side effects. Pharmacological agents and over the counter supplements designed to suppress hunger or decrease appetite, block fat absorption, or reduce stomach volume have had limited success and are often accompanied by numerous side effects such as dizziness, increased blood pressure or heart rate, chest pain, heart attack, stroke and seizure [4]. Certain appetite suppressants interact adversely with certain medications [5]. Therefore, there is a large and continuously growing market for other dietary regimen for appetite control.

Ipomoea batatas L. (Sweet potato) is among the most nutritious subtropical and tropical vegetables. It is a starchy tuberous crop which is common in our environment, it is best known for its carbohydrate content (approximately 26 grams in a medium potato). The predominant form of this carbohydrate is starch [6] and this starch is said to be resistant to digestion in the intestine. A small but significant portion of this starch is resistant to digestion by enzymes in the stomach and small intestine, and so reaches the large intestine essentially intact. This resistant starch is considered to have similar physiological effects and health benefits as fibre: It provides bulk, offers protection against colon cancer [7], improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly even reduces fat storage [8].

Protease inhibitor-2 derived from potato (PI-2) is claimed to reduce appetite and food intake, stimulate the satiety hormone cholecystokinin (CCK) and lower postprandial glucose peaks when taken before a meal [9]. The presence of PI-2 in the intestine could result in increase in the level of CCK [10] naturally released in response to a meal [11]. Following consumption of a meal, CCK, a well-characterized gut peptide hormone is secreted into the bloodstream by endocrine cells [12]. This hormone then acts on various tissues including the gastrointestinal tract, where it stimulates enzyme secretion and delays gastric emptying, creating a feeling of fullness [13]. CCK also acts on the brain leading to feelings of satiety [14]. Loxiglumide, a CCK receptor antagonist, stimulates hunger in humans [13].

Although it is hypothesized that potatoes yield a relatively high glycemic response, the potato may have other properties which could counteract the effects related to the glycemic response, with regard to hunger and food intake. One such property could be the fibre content; Potatoes contain a considerable amount of fibre [15]. Dietary fibres are said to have different physiological effects and provide a variety of health benefits, including satiety; adding fibre to low-calorie/low-fat foods may enhance satiety [16]. Food and Nutrition Board have also reported that potato contains dietary fibre which has been shown to increase satiety, which may help with weight loss [17]. Therefore, *Ipomoea batatas L.* may lead to the development of a dietary regimen which could serve as an ingestible supplement in reducing excessive body weight gain so as to control overweight and obesity. This present study was carried out to determine the effect of the aqueous extract of *Ipomoea batatas L.* (IB) on food intake, fasting blood glucose and body weight in normal male wistar rats.

2. MATERIALS AND METHODS

2.1 Plant Materials and Preparation of Extract

Fresh *Ipomoea batatas L.* (Kona B: Orange Skin, Orange Flesh) weighing between 50-60g were purchased locally from the Ogbette main market, Enugu State, Nigeria. The plants were subsequently identified and authenticated by a Botanist of the Botany Department of the University of Nigeria, Nsukka, Nigeria. The tubers were chopped into small pieces and homogenized in distilled water (0.25g tissues/mL of water) for 30seconds using a fisher scientific tissuemiser portable homogenizer (Healthcare, Lab & Life Science San Diego, California, United States). Homogenate was filtered through muslin cloth with a mesh size of 2 mm into centrifuge tubes and then centrifuged at 120rpm for 20 minutes. For use, the residue was evaporated to dryness. The dried extract was reconstituted in freshly prepared normal saline (1g of extract in 10ml of normal saline) for administration to test animals. Extract was stored in capped tubes and refrigerated until when required for use. Plant extraction was carried out according by the method of Al- Salkhan et al. [18] but with some modifications.

The phytochemical constituents of *Ipomoea batatas L.* showed that it contains dietary fibers, vitamins and minerals [19], carotenoids and natural phenols [19, 20, 21, and 22]. Chlorogenic acid constitutes up to 90% of the potato tuber natural phenols. Others found in potatoes are 4-O-caffeoylquinic acid (crypto-chlorogenic acid), 5-O-caffeoylquinic (neo-chlorogenic acid), 3, 4-dicaffeoylquinic and 3,5-dicaffeoylquinic acids [23]. The USDA [24] stated that nutritional value per 100g (3.5oz) of sweet potato contains the following:

1. Carbohydrates -20.1 g
Starch- 12.7 g

Sugars- 4.2 g

Dietary fiber- 3 g (The fiber content of a potato with skin (2 g) is equivalent to that of many whole grain breads, pastas, and cereals (19).

2. Fat -0.1 g
3. Protein -1.6 g
4. Water- 77g
5. Vitamins and minerals: The Vitamins are: Vitamin A equiv. 709 µg (89%) - beta-carotene 8509 µg (79%), Thiamine (vit. B₁)- 0.078 mg (7%), Riboflavin (vit. B₂)-0.061 mg (5%), Niacin (vit. B₃)- 0.557 mg (4%), Pantothenic acid (B₅)- 0.8 mg (16%), Vitamin B₆- 0.209 mg (16%), Folate (vit. B₉)-11 µg (3%), Vitamin C- 2.4 mg (3%), Vitamin E- 0.26 mg (2%).

The minerals are: Calcium- 30 mg (3%), Iron- 0.61 mg (5%), Magnesium- 25 mg (7%), Manganese- 0.258 mg (12%), Phosphorus- 47 mg (7%), Potassium- 337 mg (7%), Sodium- 55 mg (4%), Zinc- 0.3 mg (3%).

2.2 Animals Preparation, Experimental Groupings and Treatment

Twenty four in-bred male wistar rats weighing 170g-180g were used for this study. They were obtained from the Enugu campus Animal House, University of Nigeria. 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 (supplex 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. An acute oral toxicity test was carried out before administration of the extract according to Lorke's method [25] and it was found to be non toxic at 2000mg/kg body weight. The animals were randomly assigned into 4 groups of 6 rats each; each rat in a group was individually caged in a cubicle in a larger cage. Group 1 served as the control and were fed with 0.3ml of normal saline, Group 2-4 were fed with IB extract at 100, 200 and 300mg/kg body weight (bwt) respectively.

Administration of the aqueous extract was done before feeding by means of calibrated syringe with attached rubber cannula (1g of extract in 10ml of normal saline) by oral gavage. The experimental procedures involving the animals and their care were in line with the approved guidelines by the local research and ethical committee.

2.3 Measurement of Parameters

Food intake was determined everyday by giving 100g of feed to each animal in a group and the remaining quantity was measured the following day to determine the quantity eaten by each animal and the average was determined for each group [26]. Fasting blood glucose was determined after an overnight fasting and was measured using a glucometer (Life Scan Inc. milano, Italy). Thereafter, body weight was measured just before feeding the extract 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.

2.4 Statistical Analysis

Data obtained were subjected to descriptive statistics and the results presented as means±standard error of mean (Mean±SEM). 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 $p \leq 0.05$. Data analysis was done using the statistical software package SPSS for windows version 17.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSION

3.1 Comparison of Food Intake in the Different Experimental Groups

Table 1 showed the effect of IB extract on the food intake of the various groups at the different concentrations. The result showed that the food intake of the test groups was significantly ($p < 0.05$) lower than those of the control group.

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
IB 1 (100mg/kg)	79.71±2.18*	74.86±2.69*	74.86±2.25*
IB 2 (200mg/kg)	78.43±1.80*	71.43±1.46*	70.43±1.04*
IB 3 (300mg/kg)	77.86±2.14*	70.86±2.53*	69.29±1.70*

*= $p = 0.05$ vs control; a= $p = 0.05$ vs IB 1

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

Table 2 showed the effect of IB extract on the fasting blood glucose profile level. The initial glucose level was not significantly different from the control but after administration of the extract, the blood glucose level of test groups became lower significantly ($p < 0.05$) at 200mg/kg but having more significance at 300mg/kg.

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
IB 1 (100mg/kg)	64.20±2.15	66.20±4.66	66.80±5.43	71.80±4.47*
IB 2 (200mg/kg)	70.40±1.63	67.40±2.87*	60.20±1.39*	54.40±2.42*
IB 3 (300mg/kg)	66.40±3.64	57.00±2.17*	53.60±2.06*	51.20±1.32 ^a

*= $p = 0.05$ vs control; ^a= $p = 0.05$ vs IB 1
IB 1- *Ipomoea batatas* L. at 100mg/kg

3.3 Comparison of Body Weight Changes in the Different Experimental Groups

Table 3 showed the mean body weight and weight changes of the various treatment groups given IB 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 test groups became significantly ($p < 0.05$) lower than the control group. In the IB extract group, there was more

significant weight loss at 200mg /kg and 300mg/kg probably because of the reduced food intake at both concentrations.

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
IB1 (100mg/kg)	179.00±0.63	185.40±0.51*	195.40±0.67*	210.40±1.20*
IB 2 (200mg/kg)	180.00±0.32	175.60±0.37*	178.20±1.15*	185.60±1.21*
IB 3 (300mg/kg)	180.00±0.49	170.80±0.52*	175.60±0.32*	180.00±1.42 ^a

*=p=.05 vs control; a= p=.05 vs IB 1
IB 1- *Ipomoea batatas* L. at 100mg/kg

4. DISCUSSION

Significance of appetite control in weight management cannot be overemphasized; appetite control plays a vital role between energy intake and energy expenditure (27). Sustained increases in energy intake without an accompanying increase in energy expenditure can lead to increased body weight. Also, a sustained increase in energy expenditure without an accompanying increase in energy intake will lead to weight loss. Body weight will be maintained when energy intake matches energy expenditure.

In the present study, it was observed that in the extract-treated groups that there was a reduction in energy intake which resulted in the weight loss observed. The food intake, blood glucose level and body weight were significantly reduced at $p < 0.05$ when compared with the control group. The weight loss observed in the extract-treated groups might be due to reduced food intake which occurs probably by increasing satiety and also, the reduction in the fasting blood glucose level; a reduced blood glucose level may help the body to use stored reserves from fat or muscle, gradually leading to weight loss.

4.1 The effect of IB Extract on Food Intake

Table 1 showed that IB extract was able to cause a significant reduction in food intake in the treated groups than the baseline control.

Hu et al. [28] observed that oral administration of PI-2 was able to significantly decrease hunger in overweight and healthy subjects in their study. These findings are also consistent with the report of Slavko et al. [29] who also reported that PI-2 was effective in reducing food intake and body weight gain in healthy rats when administered orally by increasing circulating CCK levels probably through a trypsin-dependent mechanism. Our report supports the study by Tamir and Tsega [30] who supplemented animal feed with dried leaves of *Ipomoea batatas* L. and observed that inclusion of dried leaves of *Ipomoea batatas* L. up to 200 g/kg DM significantly reduced food intake. Our study has shown that the tubers of *Ipomoea batatas* L. also possess food intake reducing capability as the leaves.

Therefore the reduction in food intake observed might be due to presence of PI-2 in the extract which might probably reduce hunger in the rats thereby decreasing food intake.

Potatoes have also been observed to possess dietary fibre which may enhance satiety [15, 17]. Therefore the reduction in food intake observed in the IB group in this study may be due

to the dietary fibre in the *Ipomoea batatas L.*, which reduced food intake probably by increasing satiety. The decrease in food intake might also be due to resistant starch believed to be present in *Ipomoea batatas L.* whose systemic effects include improvements in glucose tolerance and insulin sensitivity, reductions in blood lipid levels, increase in satiety which could be used in weight management [31,32].

4.2 The Effect of IB Extract on Fasting Blood Glucose Level

All rats used for these study had 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. Normal fasting blood glucose for rats' ranges from 50 to 109 mg/dl [33] and the fasting blood glucose level of rats used for the study ranged 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. Baseline glucose levels were the same but at week 1 to 3, the blood glucose of the extract treated groups were all significantly lower than the control.

In Table 2, IB was observed to cause a more significant reduction in fasting blood glucose level. This is consistent with the result of Schwartz et al. [34] which showed that their subjects showed a significant decrease in plasma glucose levels and plasma insulin levels when PI-2 was added to the ingested meal. The significant reduction in the fasting blood glucose by IB supports the study by Spreadbury et al. [35] whose report showed that supplementation with PI-2 modifies the glycemic response to a meal. Their study showed a significant decline in postprandial blood glucose in patients treated with 15 and 30mg doses of PI-2 but no significant decline occurred in the group taking 7.5mg of PI-2.

It has also been reported that viscous, water-soluble fibre such as β -glycans and pectin found in potato can modify or reduce blood glucose response by interfering with digestion and absorption of glycemic carbohydrates [36]. Our research supports the study by Jiang et al. [37] who observed that the fasting blood glucose (FBG) were decreased in diabetic rats fed with *Ipomoea batatas L.* flavonoids. Thus, the reduced blood glucose level might be due to the water-soluble fibre, PI-2 or flavonoids present in *Ipomoea batatas L.*

4.3 The Effect of IB Extracts on Body Weight Changes

The results showed a significant reduction in weight gain in the extract-treated groups when compared with control group. Initially, the mean body weight of the test groups were not significantly different from those of the control group but at the end of the study the mean body weight of the test groups became significantly lower than the control group.

In Table 3, at 100mg/kg, the animals gained more weight but it significantly lower than the control. The extract caused a significant weight loss at 200mg/kg and even more weight loss was observed at 300mg/kg. The weight loss might be due to the reduction in food intake that was observed in these groups because it was discovered that more weight loss occurred at the test groups which had lesser food intake.

This is consistent with the work of Spiegel et al. [38] who also reported an average 2kg weight loss in overweight women when PI-2 was taken daily prior to lunch and dinner for four weeks. This study also agreed with the work by Dana [39] who reported that PI-2 was effective for weight loss and improved body measurements when taken before a meal by reducing appetite ratings and between meals snacking in human subjects. Tamir and Tsega

[30] also observed that supplementation of animal feed with dried leaves of *Ipomoea batatas* L. up to 150 g/kg DM significantly reduced weight gain in the birds used for their study; this also implies that the tubers of *Ipomoea batatas* L. also reduces weight gain by reducing feed intake as the leaves.

It is believed that PI-2 has been shown to induce CCK which then leads to satiety [10] and well documented weight loss. This assumption is that a food that increases short term satiety decreases the amount of energy ingested subsequently and thus could potentially help in weight management in the long run [27].

In this study, it was observed in the extract-treated group that there was reduction in food intake probably by increasing satiety, decreasing hunger or increasing a feeling of fullness in the rats which probably help to lower and control blood glucose level, which may help the body use up stored reserves from fat or muscle, gradually leading to the weight loss observed.

5. CONCLUSION

In conclusion, the aqueous extract of *Ipomoea batatas* L. was found to reduce food intake probably through appetite regulating mechanism, lowering fasting blood glucose level which may help use up the body's fat reserve, thereby reducing body weight gain. The crude aqueous extract of *Ipomoea batatas* L. was used in this study therefore the observed effects might be a synergism between the dietary fibre, resistant starch, flavonoids and PI-2 in *Ipomoea batatas* L. Therefore, we recommended that consumption of *Ipomoea batatas* L. could be incorporated as a diet in reducing excessive body weight gain so as to control overweight and obesity.

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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