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Blood glucose lowering effect of *Solanum melongena* (garden egg), *Solanum lycopersicum* (tomatoes), *Daucus carota subsp. Sativus* (carrot) extracts on lead induced toxicity in albino wistar rats

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Abstract

Lead is one of the heavy metal humans are often expose to either through food, cosmetics or environment. This study is aimed at investigating the positive effect of *Solanum melongena (garden egg), Solanum lycopersicum (tomatoes) and Daucus carrots subsp.sativus* (carrot) on blood glucose concentration, body weight, and feeding habits of albino rats on lead toxicity. In this study 35 albino rats weighing 80-120g were grouped into five. Group 1 served as normal control, group 2 negative control. The remaining three groups served as treatment groups 1, 2 and 3. All groups except group 1 (normal control) were administered 50mg/kg of lead acetate. Treatment groups were administered 200mg/kg of *Solanum melongena (garden egg), Solanum lycopersicum (tomatoes) and Daucus carrots subsp.sativus* (carrot). Group 3 was administered *Solanum malongen* and *Daucus carrots subsp.sativus* while group 4 was given *Daucus carrots subsp.sativus* and *solanum lycopersicon*. Group 5 was administered *Solanum malongen, Daucus carrots subsp.sativus* and *Solanum lycopersicon*. Changes in blood glucose concentration, body weight, feed and water consumption recorded at intervals. The result showed a significant decrease ($P<0.05$ and $P<0.01$) in blood glucose concentration in treatment groups compared to negative control. There was also significant increase ($P>0.05$, $P>0.01$ and $P>0.001$) in body weight and feed consumed in treatment groups compared to negative control. Combined therapy of any two of *Solanum malongen, Daucus carrots subsp.sativus* and *Solanum lycopersicon* juice can help in the management of hyperglycemia and reverse internal abnormality or injury resulting in weight loss in lead induced toxicity.

Keywords: Lead toxicity; Hyperglycemia; Body weight; Glucose concentration fresh juice

1. Introduction

Lead poisoning accounts for almost 0.6% of the world disease, diabetes being one of them (WHO, 2009). A common route of lead exposure in humans occurs early in childhood by ingestion of lead-contaminated household dust (Lanphear *et al,.* 2002). Over the millennia lead as been used in production of diverse products like; pipes, glazes, vinyl products, storage batteries, pigments and paints, cable covers, radiation shielding, weights shot and ammunition (Bener, et al 2001).

Analytical results in an epidemiological study demonstrated that basal body lead burdens and blood lead levels, even when at low levels, were major risk factors in diabetic nephropathy progression in type II diabetic patients (L-Lin *et al* 2006). In a study with factory workers in the United Arab Emirates, some significant positive correlations between blood lead levels and fasting blood glucose were observed. This finding suggests a possible link between lead toxicity and diabetes (Bener, et al 2014).

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Carbohydrates are complex polysaccharides (example is starch and glycogen of plant and animal source respectively) in diets, they also exist to a minor extent, as disaccharides (sucrose and lactose), especially in processed food. Carbohydrates are hydrolyzed (degraded) to monosaccharide units in the gastrointestinal tract (Vishram et al, 2014). Monosaccharides are absorbable forms of carbohydrate by the intestine and the rate of absorption is maximum for galactose, moderate for glucose, and minimum for fructose. Glucose is the preferred source of energy for most body tissues. Brain cells derive the energy mainly from glucose, when glucose metabolism is deranged, life threatening conditions may occur. A minimum amount of glucose is always required for normal functioning cellular activities**,** Normal fasting plasma glucose level is 70 to 110 mg/dl. After having a carbohydrate rich meal, glucose level rises; but in a normal healthy person, this rise level is below 150mg/dl.

Due to the versatile nature of medicinal plant and their application in treating a large number of diseases, it is obviously a good approach to consider plant extracts in the fight against conditions such as hyperglycemia. Plants such as *Solanum melongena (garden egg), Solanum lycopersicum (tomatoes) and Daucus carrots subsp.sativus* should be considered as one of the best options if they show positive result as they serve as both food and medicine making them easily accessible and affordable for patients.

Solanum species (eggplants) belong to the family of Solanaceae and genus *Solanum*. The plant is an economically important vegetable widely cultivated in the tropical regions of the world (Agoreyo, *et al* 2012). *Solanaceae* are family of flowering plants with over 75 genera covering 2000 species. This includes herbaceous plants, but *Solanum* species fruit is berry and seeds have enlarged endosperm and are grown mostly as food and medicinal purposes (Das, *et al* 2013). The low soluble carbohydrate in *Solanum melongena* has the ability to reduce the absorption of glucose into the blood thereby controlling blood sugar levels, making it is a great dietary option for diabetes patients (nutrifactsblog, 2020).

Tomato (*Solanum lycopersicum L.*) is the second most important available vegetable crop in the world after potatoes. The world production and consumption of tomato has grown rapidly over the past 25years. Like other *Solanum* species, *Solanum lycopersicum* is rich in many vitamins and minerals for the protection of the eyes and vision enhancement. Its rich lycopene, lutein, and beta carotene contents (antioxidants) have shown to be able to protect the eyes from light damage, prevent development of cataracts, and age-related macular degeneration (Thies et al., 2012).

Daucus carrots subsp. sativus are root plants containing valuable phytochemicals. The presence of phytochemicals is considered as crucial nutritional important food in the prevention of chronic diseases, such as cancer, cardiovascular disease, and diabetes (Jamuna *et al*. 2011).

2. Plant preparation of juice extract

Fresh *Solanum melongena, Solanum lycopersicum and Daucus subsp. sativus* fruits were obtained from by purchase from Bwari market, federal capital territory, Abuja and were identified by a botanist in the department of Biological sciences, Veritas University Abuja, Nigeria. The samples were washed with deionized water, sliced into pieces with sterile knife and introduced to a juice extractor. The fresh juice was obtained from the extractor. The extract was then transferred into a clean storage container for use.

3. Material and methods

All chemicals and reagents used were of analytical grade.

3.1. Collection and Preparation of fruit extracts

Fresh Garden Egg, Tomatoes, and Carrot were purchased from Bwari market, Federal Capital Territory, Abuja. The fruits were identified by a botanist from the department of Biological Sciences, Veritas University, Abuja. The samples were washed with deionized water, sliced into pieces with sterile knife. The samples juice was extracted individually using juice extractor. The extracts were then transferred into three separate containers and stored in a refrigerator at 2-5^{o}C.

3.2. Animals

Thirty- five healthy male albino Wistar rats with an average weight of (150g) were obtained from the animal house of the department of Biochemistry, Veritas University, Abuja. They were acclimatized for seven days in the Animal house in Veritas University Abuja during which they had access to food and water *ad libitum*.

3.3. Rat group, body weight and treatment

Rat groups	Mean body weight(g)	Treatment administered
1	100.0 ±13	Normal rat chow and water
2	102.3 ±12	50mg/kg body weight of Lead acetate + Normal rat chow + water
3	120.3 ±11	50mg/kg body weight of Lead acetate + 200mg/kg of Garden Egg + Carrot +Normal rat chow + water
4	104.4 ±11	50mg/kg body weight of Lead acetate + 200mg/kg of Carrot + Tomato +Normal rat chow + water
5	88.3 ±13	50mg/kg body weight of Lead acetate + 200mg/kg of Garden Egg + Carrot + Tomato + Normal rat chow + water

These treatments were conducted daily and observations/body weight (3days interval) recorded for the 14days.

3.4. Sample collection

All animals were euthanized under chloroform vapor and sacrificed. Whole blood was collected via cardiac puncture using sterile syringes and needle, dispensed into a set of plain tube and allowed to clot for two hours. The clotted blood samples were centrifuged for 10 minutes at 3000 rpm to recover serum from clotted cells. The serum obtained was stored in a refrigerator for biochemical analysis. Biochemical analyses were carried out including blood glucose concentration using Randox test kits.

3.5. Data Analysis

The results obtained from the laboratory investigation were expressed as Mean ±SD. Statistical significance between the groups were compared by using one-way analysis of variance (ANOVA) and least significant test (LSD) procedure using the statistical package for the social sciences software (SPSS). Statistical significance was considered at $p<0.05$, $p<0.01$, and $p<0.001$

4. Results

Table 1 results for body weight shows a significant increase of $P<0.01$ in body weight of groups 3 towards the end of study compared to group 2, where body weight for group 3 was 154.0 ± 11, the body weight of group 2 was 137.2 ± 09. Group 4 and 5 had body weight 126g and 122g respectively compared to group 2 with 137.2 ± 09.

Table 1 Body weight (gram)

	DAY 1	DAY 4	DAY 7	DAY 11	DAY 14
Group 1	100.0 ± 11	113.3 ± 12(11.7%)	138.3 ± 12 (18.1%)	145.9 ± 11 (5.2%)	151.7 ± 10(3.8%)
Group 2	102.3 ± 12	116.0 ± 10(11.8%)	124.8 ± 08 (7.1%)	145.0 ± 07(13.9%)	137.2 ± 09(-5.4%)
Group 3	120.3 ± 11	131.0 ± 14(8.4%)	151.9 ± 07 (13.8%)	161.0 ± 10(5.7%)	154.0 ± 11(-4.3%)
Group 4	100.4 ± 11	97.0 ± 12(-3.4%)	121.8 ± 10 (20.4%)	130.3 ± 11(6.3%)	126.3 ± 14(-3.1%)
Group 5	88.8 ±1 3	90.0 ± 12 (1.3%)	106.2 ± 11 (15.3%)	122.0 ± 09(13.0%)	122.3 ± 10(0.2%)

Significant increase of $P>0.01$ in body weight of group 3; Significant decrease of $P<0.01$ in body weight of group 4; Significant decrease of $p<0.001$ in body weight of group 5; Significant increase of $P>0.01$ in body weight of group 1

Table 2 shows results of feed consumption where group 1, 2 and 5 recorded 88±00,91±00 and 86±00 on Day four respectively compared to 120±00, 7120±00 and 98±00 on Day eleven.

Table 3 show a non-significant change in water consumption in all the groups.

Table 2 Daily feed consumption (grams)

	DAY 1	**DAY 4**	**DAY 7**	**DAY 11**	**DAY 14**
Group 1	30 ± 00	88 ± 00(65.9%)	120 ± 00(26.7%)	120 ± 00(0%)	93 ± 0(-22.5%)
Group 2	31 ± 00	91 ± 00(63.9%)	90 ± 00(-1.1%)	120 ± 00(25.0%)	74 ± 0(-38.3%)
Group 3	23 ± 00	84 ± 00(72.6%)	119 ± 00(29.4%)	120 ± 00(0.8.7%)	73 ± 0(-39.2%)
Group 4	19 ± 00	73 ± 00(73.9%)	100 ± 00(27.0%)	119 ± 00(16.0%)	72 ± 0(-39.5%)
Group 5	60 ± 00	86 ± 00(30.2%)	80 ± 00(-7.0%)	98 ± 00(18.4%)	80 ± 0(-18.4%)

Significant increase of P>0.05 in feed consumption of group 3; Significant decrease of p<0.01 in feed consumption of group 4; Significant P<0.001 decrease in feed consumption of group 5; Significant increase of P>0.05 in feed consumption of group 1

Table 3 Daily water consumption (ml)

	DAY 1	**DAY 4**	**DAY 7**	**DAY 11**	**DAY 14**
Group 1	139 ± 00	104 ± 00(-25.2%)	130 ± 00 (20%)	148 ± 00(12.2%)	115 ± 00(-22.3%)
Group 2	125 ± 00	61 ± 00(-51.2%)	102 ± 00 (40.2%)	135 ± 00(24.4%)	116 ± 00(-14.1%)
Group 3	149 ± 00	99 ± 00(-33.6%)	125 ± 00 (20.8%)	130 ± 00(3.8%)	88 ± 00(-32.3%)
Group 4	180 ± 00	79 ± 00(-56.1%)	102 ± 00 (22.5%)	129 ± 00(20.9%)	85 ± 00(-34.1%)
Group 5	120 ± 00	95 ± 00(-20.8%)	177 ± 00 (46.3%)	113 ± 00(-36.2%)	68 ± 00(-39.8%)

No significant change in water consumption in all groups

Table 4 results of blood glucose concentration showed a significant increase of P>0.05 in blood glucose concentration of group 2 compared to normal control at the end of the experiment, this increase in blood glucose was above the standard range of blood glucose level which is between 75-115mg/dl. On comparing group 2 to the groups 3 and 4, a statistically significant decrease of P<0.01 was observed. Where group 2 had a blood glucose concentration of 120.8±3.0mg/dl at the end of the study, group 3 and 4 had 94.80±2.2mg/dl and 96.9±1.4mg/dl respectively. Group 5 with 120.1 ±3.6 showed a blood glucose concentration similar to those of group 2 with 120.8±3.0.

Table 4 Blood glucose concentration (mg/dl)

	DAY 1	DAY4	DAY7	DAY11	DAY14
Group 1	94.1 ± 3.6	71.9 ± .1.3(-23.5%)	74.4 ±2.2 (3.4%)	76.6 ± 6.2(3.0%)	93.1 ± 3.3 (17.7%)
Group 2	91.1 ± 3.2	48.4 ± 1.0(-46.9%)	60.9 ± 1.7(25.8%)	68.7 ± 4.2(11.4%)	120.8 ± 3.0(42.8%)
Group 3	72.9 ± 2.9	54.9 ± 1.7(-24.7%)	56.9 ± 2.1(3.64%)	72.1 ± 2.3(26.7%)	94.80 ± 2.2(23.9)
Group 4	87.7 ± 2.0	58.6 ± 1.1(-31.2%)	65.4 ± 2.5(11.6%)	59.4 ± 3.2(-9.2%)	96.9 ± 1.4(38.7%)
Group 5	115.7 ± 3.8	52.0 ± 2.9(-55.1%)	60.9 ± 1.3(17.1%)	38.4 ± 5.6(-37%)	120.1 ± 3.6(68.0%)

Significant decrease of P<0.05 in blood glucose concentration of group 3; Significant decrease of P<0.01 in blood glucose concentration of group 4; Significant decrease of p<0.05 in blood glucose concentration of group 5; Significant decrease of P<0.01 in blood glucose concentration of group 1

5. Discussion

The result of lead acetate induced toxicity obtained from this study showed a decrease body weight in both the treatment and negative control groups. The effect of lead acetate on body weight gain, food intake and feed efficiency were progressively increased during the experimental period of all different five groups. The final body weight of rats intoxicated with lead was significantly lower than that of the normal group. The decrease was noted in all groups exposed to lead intoxication although weight changes did not follow any progressive pattern in the treatment group as some level of fluctuations was noticed in between the experimental days. The loss of body weight might be due to malabsorption and difficulties in the metabolism of essential nutrients for health indicated by an observed concurrent

decrease in feed consumption within concerned groups (Marchlewicz *et al*., 2006). Vallee *et al*., (1972) revealed that inorganic lead selectively binds tissue proteins and disturbs the functions of those proteins (containing-SH group) resulting in growth retardation and body weight loss). Increase in blood glucose concentration observed in this study may be attributed to lead acetate toxicity. The increase in blood glucose concentration may also be attributed to the increased rate of glucose transport from the tissues to blood, glycogenolysis and gluconeogenesis, glycolysis, decreased rate in removal of glucose from the blood to tissues and effect on insulin secretion in pancreas (Nabil *et al*., 2012).

In the experimental groups, the three treatment groups where administered the extract to slow down the development of hyperglycemia (and thus, type 2 diabetes) by identifying the signaling pathways that can be modulated to decrease the amount of oxidative stress in pancreatic islets (Todd *et al*., 2018). Pancreatic beta-cells appear to be exquisitely sensitive to reactive oxygen species (ROS) (Robertson *et al*., 2006). Thus, the mechanism via which lead induces oxidative stress in biological systems (Matović et Al., 2015), explains the hyperglycemic condition (observed in group 2) as several key component of the insulin signaling pathway known to be inhibited by reactive oxygen species (ROS), thus, promoting the development of insulin resistance and hyperglycemia (Type 2 diabetes) (Fridlyand *et al*., 2006).

Tomato (*Solanum lycopersicon*) was considered for this treatment because apart from it improving the oxidative damage and scavenge free radical, it is a low glycemic index food, which makes it a suitable food for diabetic patients (Fajkusova *et al*. 2007).

Carrot (*Daucus carrots subsp.sativus)* juice and *solanum lycopersicon* has a positive effect on experimental diabetic animals when administered individually and not in combination (Kumar *et al*., 2020). Garden egg (*solanum malongena*) aqueous fruit extracts in other researches where the juice was administered individually showed no level of reduction in the mean fasting blood glucose level of experimental animal after administration.

(Wilcox *et al*. 2003) showed that ingestion of *Solanum lycopersicon* upregulates the expression of glucokinase, glycogen synthase 2 genes and downregulates the expression of pyruvate kinase gene, hence the treatment or administration of tomato juice enhances glycogen accumulation, and this explains normal glucose concentration in animal groups administered *Solanum lycopersicon* observed in this study while also explaining the observed increase in body weight in the group administered *solanum lycopersicon* and *Daucus carrots subsp.sativus* sho while maintaining normal blood glucose concentration

6. Conclusion

The study was conducted to determine the possibility of induced hyperglycemia due to lead toxicity exposure. This study suggests that combination of all *solanum malongen, carrots subsp.sativus and solanum lycopersicon* is suspected to properly reverse internal abnormality or injury resulting in weight loss in lead induced toxicity but may not properly normal the blood glucose level. Hence, in case of where hyperglycemia treatment is done using standard drugs, the administration of all three juices extract will help heal internal injuries but where injury is not yet sustained just insulin resistance, *carrots subsp.sativus and solanum lycopersicon* juice extract will be best for regulation of such lead induced hyperglycemia (Sun *et al*., 2017).

Compliance with ethical standards

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Disclosure of conflict of interest

All authors contributed to this article. There is no conflict of interest whatsoever.

Statement of ethical approval

Animals used in this study are experimental animals (Albino Wistar rats). They were properly handled in line with best practices being subjected to 12hours light/dark cycle, provided food/water *ad libitum* and kept in well ventilated clean cages.

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