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Phytochemical Properties and Hypoglycemic Effect of Finger Millet Malt Drinks Supplemented with Cucumber and Carrot Juice on Alloxan-Induced Diabetic Rats

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The study evaluated the phytochemical content and effect of supplementation of finger millet malt drinks with 25% carrot and cucumber juice on diabetes management.
Sample: Finger millet malt, cucumber juice, carrot juice, Albino rats.
Study Design: Completely Randomized Design was used.

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Place and Duration of Study: Department of Food Science and Technology and Department of Animal Health and production, Faculty of veterinary Medicine, University of Nigeria, Nsukka (between January 2021 and June, 2021.

Methodology: Finger millet grain was malted for 48 h, dried for 5 days, and subsequently divided into two portions. A portion was roasted while the other was not. Roasted and unroasted finger millet malt drinks were prepared and blended in different ratio with processed mixture of carrot and cucumber juice. The finger millet malt drink and the supplemented malt were evaluated for phytochemical and microbial properties using standard methods. Thirty albino rats separated into four test groups and one control group initially tested for fasting blood glucose were induced diabetes using Alloxan monohydrate (dose=150 mg/kg body weight). The test animals were fed malt drinks and measured amount of rat chow for 28 days, their blood samples were subjected to serum lipid profile, fasting blood sugar and weight measurement.

Results: The results revealed that the total phenols and flavonoids increased with supplementation with cucumber and carrot juice. Total viable counts of the malt drinks ranged from 1.13 -2.93 x 102Cfu/100ml and no mould growth was detected. Rats fed sample prepared from 50% unroasted finger millet malt drink, 25% of cucumber and 25% carrot juice) had the highest reduction in fasting blood sugar level (87% and also most effective in weight regain(15.30%) while rats fed 100% roasted finger malt drink had the least decrease in fasting blood sugar (44.2%). High density lipoprotein increased and the values ranged from 26.00 -50.34 mg/dl while cholesterol, very low-density lipoprotein, low-density lipoprotein, and triglyceride levels reduced and the values ranged from 16.17 to 42.28, 8.17 -9.16, 13.35 – 21.44 and 40.84 – 46.64 mg/dl, respectively in the rats fed experimental malt drink.

Conclusion: Rats fed samples containing 50% unroasted finger millet malt, 25% of cucumber and 25% carrot drink had more weight gain (15.30%) and fasting blood glucose reduction (87%). Malted drinks from unroasted finger millet enriched with cucumber and carrot juice can be used in diabetes management.

Keywords: Carrot juice; cucumber juice; fasting blood sugar; finger millet malt; diabetes; lipid profile.

1. INTRODUCTION

Nigeria is one of the countries in sub-Saharan Africa (SSA) that are currently groaning under a rising prevalence of diabetes mellitus (DM) [1]. Apart from complications of DM which are a serious global issue, diabetic patients also suffer food monotony and hunger due to restriction imposed on them from consuming major staples. Food monotony experienced by DM patients sometimes culminates into consumption of little food than needed or outright rejection of food provided by caregiver, hence they experience hunger. Beverages such as conventional malt drinks are among foods diabetic patients are advised to avoid. Malt beverages are easily accessible foods for providing the body with the right nutrients. These drinks are consumed principally because of thirst quenching characteristics [2]. It may be consumed together with liquid or powdered milk or without whole milk among others. Malted drinks are manufactured by mixing malt with other cereal and legume flour. The use of raw materials rich in phytochemicals such as polyphenols in the production of malt drinks can confer beneficial health properties on the end products [3]. Several researchers have reported that consumption of polyphenol-rich foods reduces postprandial hyperglycemia [4].

Finger millet (*Eleusine coracana*), one of the lesser-known cereals that has potent health benefits which was attributable to polyphenol and dietary fibre contents [3,5]. The grain form part of food for low-income groups in India and some Africa countries [2]. The potential of this grain to grow under adverse climatic conditions makes it play an important role in food and nutritional security in some developing countries [6]; in addition to other cultivating advantages. Finger millet has better balanced protein and contains more lysine, threonine, and valine than other millets [7]. Millet is rich in calcium (0.38%), dietary fibre (18%), and phenolic compounds (0.3–3%) and is a good source of micronutrients, which could alleviate the widespread micronutrient malnutrition [8]. The high antioxidant activities and phenolic acids in finger millet protect regular finger millet consumers from chronic diet-related diseases [9]. As a rich source of nutrients, finger millet can be used in large-scale in the manufacture of baby foods, snack foods, dietary foods among others in grain and flour form [10]. The worldwide burden of disease is increased by an inadequate consumption of fruits and vegetables, In the Danish diet, eating more vegetables is linked to a lower incidence of type 2 diabetes [11,12]. According to a 4-year longitudinal study of Swedish individuals, eating fruits and vegetables can help prevent the development of type 2 diabetes [12]. Spinach, broccoli, celery, green beans, and chickpea plant juice are said to reduce blood postprandial glucose levels. Pratik *et al.* also demonstrated that higher intake of green leafy and cruciferous vegetables from a study was associated with a lower risk of T2D [13].

Carrot is a root vegetable rich in carotenoids, flavonoids, vitamins, and minerals which are of nutritional and health benefits [14]. An orange-fleshed carrot has been recognized for its high provitamin A content which functions as an antioxidant (beta-carotene) [15] and other health benefits include reducing cholesterol, detoxifying the body, and improving vision among others. Carrot is rich in dietary fibre, molybdenum and magnesium. Molybdenum is rarely found in many vegetables and plays role in fats and carbohydrates metabolism and aid iron absorption. Magnesium performs numerous functions such as bone, protein and new cells synthesis, activating B vitamins, and clotting blood among others [16]. Vegetables such as cucumber have numerous health benefits due to their high content of vitamins and phytochemicals and it lowers blood sugar level. Cucumber is a member of the *Cucurbitaceae* family and rich source of B vitamins, pro-vitamin A, and antioxidants which include a type known as lignans but is low in calories, fat and sodium [17]. Antioxidants help to remove substances from the body known as free radicals. Researchers have reported that the lignans in cucumber and other foods may help lower the risk of cardiovascular disease and several types of cancer [18]. Cucumbers have been used for food and medicinal purposes since ancient times in Indian and also been part of the Mediterranean diet. Combination of vegetable and cereal or legume juice formula also lowers postprandial blood sugar by delaying stomach emptying, slowing down carbohydrate digestion, and delaying glucose absorption [19] The study evaluated the effects supplementation of finger millet malt drinks with 25% carrot and cucumber juice on diabetes management.

2. MATERIALS AND METHODS

Finger millet (*Eleusine coracana*) was purchased from Jos, Plateau state, Nigeria. Cucumber (*Cucumis sativus*), Carrot (*Daucus carota*) were purchased from Ogige marke, Nsukka, Enugu State, Nigeria.

2.1 Processing of Finger Millet Malt Drinks

Finger millet grains were cleaned by winnowing and 400 g weighed into each malting bag (25 cm x 45cm), steeped in water (1:3 w/v ratio) for 24 h at room temperature with a constant change of water at 6 h intervals. The water was drained off after 24 h, and the steeped grain was then kept in a malting room and allowed to germinate for 48 h at an average temperature of 26 ± 0.25^{o}C. During germination, the grain was moistened by the sprinkling of water at 6 h intervals and mixed gently. The green malt was sun-dried at a temperature of 31±0.12^{o}C for 5 days. After drying, the rootlets were removed manually by rubbing in-between palms, and the malts were winnowed with a stainless steel tray. The dried malt was packed in airtight low-density polyethylene bags and kept inside a plastic container. Finger millet malt (1.8 kg) was roasted in a grain roaster with constant stirring at the temperature of 100 °C for 20 min to obtain roasted finger millet malt.

Processed finger millet malt (roasted and unroasted) was ground in a hammer mill and sieved to obtain flour. Mashing was carried out in a stainless steel pot using flour to water ratio of 1:5 (w/v). For the protein rest period, the mash was held at 45 °C for 45 min in a water bath while the mash temperature was increased from 45 to 60 °C and held for 18 min for a sugar rest period. The mash temperature was then increased to 65 °C and held for 30 min for dextrinizing rest period (saccharification rest) and further raised to 77 °C and held for 8 min for the mashing off period. The wort obtained after mashing was separated from the spent grain using muslin cloth (2 folds) and then boiled for 10 min. The boiled wort was filtered through a clean muslin cloth (4 folds) and left for 12 h to settle the suspended particles. Racking was done and the supernatant was boiled for 45 min.

2.2 Processing of Cucumber Juice, Carrot Juice and Enriched Malt Drinks

Mature fresh cucumber and carrot were sorted and washed thoroughly with clean water. Carrot fruits were scrapped and cut with a stainless steel knife, and the juice was extracted using an electric blender (QASA, Model QBL-18L40). The extracted juice was filtered using a muslin cloth while cucumbers were peeled and cut into cubes with a stainless steel knife and the juice was extracted using an electric blender (QASA, Model QBL-18L40). The extracted juice was filtered using a muslin cloth (sieve size, 60 mm).

Finger millet malt drinks (400 mL roasted and unroasted) were blended with juice from cucumber, carrot, or their mixture at different proportion to generate 4 samples coded as:

R100=malt drink produced from roasted finger millet malt only

R50:25:25=malt drink containing 50% roasted finger millet malt,25% cucumber juice and 25% carrot juice

U100 = malt drink produced from unroasted finger millet malt only

U50:25:25 = malt drink containing 50% roasted finger millet malt,25% cucumber juice and 25% carrot juice

The formulated malt drinks were pasteurized at 80^{o}C for 3 min, hot filled into clean sterilized bottles, and corked. The bottles were allowed to cool to 25^{o}C and stored at refrigeration (< 10°C).

2.3 Analysis

2.3.1 Determination of flavonoids

Flavonoid was determined by the method described by Boham and Kocipai [20]. Ten (10 mL) of the malt drink was extracted repeatedly with 100 mL of 80% aqueous methanol at 25^{o}C. The whole solution was filtered through Whatman filter paper No. 42 (125 mm). The filtrate was transferred to a crucible and evaporated to dryness over a water bath and weighed until a constant weight was obtained. The percentage flavonoid was calculated as:

$$\text{Percent flavonoid} = \frac{\text{weight of flavonoid}}{\text{weight of sample used}} \times \frac{100}{1}$$

2.3.2 Determination of total phenol

Total phenolics were determined colorimetrically using folin-ciocalteau reagents according to method of Velioglu *et al.* [21]. The sample (1 mL) was mixed with 0.5 mL Folin-ciocalteu reagent previously diluted with 7 mL dionized water. It was allowed to stand for 3 min at 25^{o}C. Saturated sodium carbonate solution (0.2 mL) was added. The mixture was allowed to stand for another 120 min and absorbance was read at 725 nm. Gallic acid was used as standard and for the calibration curve. The total phenolic content was calculated in form of Gallic acid equivalent.

$$C = C \times V/M$$

Where C= total phenolic compounds in mg/g of the sample.
V= volume of the sample
M= weight of sample in g

$$\text{Total phenol (mg/100g)} = \frac{\text{absorbance of sample} \times \text{concentration}}{\text{absorbance of standard}}$$

2.4 Animals Housing and Diet

Thirty male albino rats of the wistar strain (supplied by the Department of Veterinary Medicine University of Nigeria Nsukka) of average weight (95 – 360g) were grouped into five randomized groups (n=6). The rats were handled in accordance with the care and use of laboratory animals guidelines. All rat groups were fed commercial rat chow (UAC vital feed consisting of 17% crude protein, 10% fat, and 15% crude fiber) for 6 days for acclimatization before the experiment, after which their weights were taken using a weighing scale (NBT-A200). The experimental diets consist of 2 mL processed malt drinks from malted finger millet, cucumber and carrot juice and 20 g of rat chow daily. The initial blood glucose levels of the rats were taken using an Accu-Check glucometer. The value was digitally read off on the screen of the glucometer and represents the 0-day value. This was done by tail snip of the rats and allowing blood to drop on the Glucometer strip. Diabetes was induced in rats using the method described by Venugopal *et al.* [22]. Alloxan monohydrate (dose=150 mg/kg body weight) was dissolved in distilled water and then intraperitoneally given to the rats, after overnight fasting (18 h). Assessment of blood glucose status was carried out on the 3rd day and at 3-day intervals throughout the feeding period using a blood glucose monitoring system. ACCU-CHEK test strips were used for the assay. Blood glucose values >7 mMol/L (126 mg/dL) were considered diabetic [23]. Clear serum was aspirated for serum biochemical analysis after blood samples were centrifuged (3000 rpm) for 5min. Serum triglycerides, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very LDL levels were estimated using the Liebermann Burchard reaction method [24].

2.4.1 Animal grouping and experimental diets for bioassay

The formulated malt drinks was given to the animals according to their group (i.e the sample specified for the group). The various rat groups were:

Group 1 : Diabetic rats fed sample R100 and normal rat chow
Group 2 : Diabetic rats fed sample R50:25:25 and normal rat chow
Group 3 : Diabetic fed sample U100 and normal rats chow.
Group 4 : Diabetic rats fed sample U50:25:25 and normal rat chow
Group 5 : Diabetic rats fed only normal rat chow

2.5 Microbial Analysis

Microbial analysis was carried out on the beverage to determine total viable count TVC) and mould count using the pour plate method as described by Prescott *et al.* [25]. The malt drink (1 mL) was added with 9 mL of Ringer's solution in a test tube and mixed thoroughly by shaking. This was 10^{-1} dilution, where one milliliter of the sample mixture was pipette into another 9 mL Ringer solution. Petri dishes were prepared in triplicate for each sample, and in each plate, 15 mL of sterile nutrient agar (NA) medium was added, and 1 mL of each sample dilution was pipette into each medium-containing plate. This was followed by shaking by circular movement carefully for about 10 sec to enhance mixing. The plates were allowed to set and incubated (inverted) for 48 h at 37 ℃. The colonies formed were counted and recorded as Colony Forming Units (cfu).

No of colonies (cfu/mL) = Average count × Dilution factor (Df)

The method of dilution used was similar to that of the TVC determination. However, the dilution factor used here was 10^{-3} signifying three dilutions; and the agar used was the Sabourand Dextrose Agar (SDA) to prepare the medium. Incubation period was set for 48 h at 25 ℃.

2.6 Experimental Design and Statistical Analysis

Experimental design was based on completely randomized design (CRD). Analysis of Variance (ANOVA) using SPSS (Statistical Package for the Social Sciences) version [26] was use to analyze the data. Means were separated using Ducan's Multiple Range Test (DMRT). Significance was accepted at $p<0.05$.

3. RESULTS AND DISCUSSION

The results of the total phenolic and flavonoid contents of roasted /unroasted finger millet malt drink incorporated cucumber and carrot juice are presented in Table 1.The phenol content of finger millet malt drinks varied from 1.65 – 1.79 mg/100 mL and 1.75-1.86 mg/100 mL, for samples containing roasted finger millet malt and unroasted finger millet malt, respectively. Roasted finger millet malt drink had low phenolic contents compared to those formulated with unroasted finger millet malt and the value was increased when supplemented with cucumber and carrot juice mixture. Roasting may have contributed to a loss of phenolic compound in roasted finger millet malt drink compared to the unroasted as earlier observed by some authors [27,28]. This may be caused by the degradation of phenolic compounds upon heat treatment thus making total phenols less extractable. Towo et al. reported that finger millet subjected to a temperature above 100°C for 15 min reduces the total extractable phenolics by forty percent [25]. Auto oxidation of unsaturated lipids is averted by phenolic compound, hence the formation of oxidized low-density lipoprotein that induces cardiovascular diseases are prevented [29].

Table 1. Phenolic compound and flavonoid and contents of finger millet malt-vegetable composite drink

Samples FM: Cu: Ca	Phenolic compound (mg/100ml)	Flavonoids (mg/100ml)
R100	$1.65^{a}\pm0.00$	$3.45^{e}\pm0.05$
R50:25:25	$1.79^{b}\pm0.00$	$1.45^{b}\pm0.15$
U100	$1.75^{b}\pm0.01$	$6.15^{d}\pm0.50$
U50:25:25	$1.86^{c}\pm0.01$	$1.65^{bc}\pm0.15$

Values are mean of three replications ± standard deviation. Values on the same column with different superscripts are significantly (p<0.05) different

Key: R100=malt drink produced from roasted finger millet malt only;R50:25:25=malt drink containing 50% roasted finger millet malt,25% cucumber juice and 25% carrot juice; U100= malt drink produced from unroasted finger millet malt only; U50:25:25 = malt drink containing 50% roasted finger millet malt,25% cucumber juice and 25% carrot juice, FM=finger millet, Cu=Cucumber juice, Ca= carrot juice, R=roasted finger millet malt, U=unroasted finger millet malt

Malt drink from roasted finger millet malt contain significantly ($p<0.05$) lower flavonoids content(3.45 mg/100mL) than the one formulated with unroasted malt drink(6.15 mg/100 mL) which further decreased on supplementation with vegetable juice (Table 1). The reduction of flavonoids may be attributable to heat treatment applied [25,28]. Flavonoids can scavenge hydroxyl radicals, superoxide anions, and lipid peroxy radicals and possess antibacterial, anti-inflammatory antiallergic, antiviral, anti-thrombotic, and vasodilatory activity [30]. Flavonoids (quercetin) cause rejuvenation of pancreatic islets and possibly increase insulin release in streptozotocin-induced diabetic rats [31]. As a potent free radical scavenger, flavonoids recently attract great attention as potential therapeutics against free radical-mediated diseases, principally diabetes mellitus.

Lipid profile of the diabetes induced rats fed malt drinks from roasted and unroasted finger millet malt enriched with cucumber-carrot juice are presented in Fig. 1. The results revealed cholesterol levels between the values of 53.32 mg/dL in the control and 110.60 mg/dL in rat group fed sample containing 50% roasted finger millet malt, 25% cucumber and 25% carrot juice (R50:25:25) prior to the feeding trial. After the feeding trial, cholesterol levels varied from 56.81 to 70.95 mg/dL in the experimental rats. Rats fed only normal rat chow (control group) had an increase in cholesterol level (33.1% increase) than unroasted malt drink (6.15 mg/100 mL) which further decreased on supplementation.

It was revealed that cholesterol level of all the rats fed formulated malt drink reduced and more reduction was observed in rat group fed finger millet incorporated carrot and cucumber juice. The reduction in cholesterol was more with sample prepared with roasted finger millet malt. Variation existed in cholesterol levels of the rats at initial stage of experiment probably due to differences in the physiological state of the animals. The combined effect of cholesterol reduction in experimental rats fed formulated samples may be due to the raw material used. Presence of cucumber and carrot juice in the samples may have caused more cholesterol reduction effect [32,33]. Rats fed carrot seeds have been reported to show a reduction in serum cholesterol compared with the control group [34].

The high density lipoprotein (HDL) levels of experimental rats varied from 16.17 to 42.20 mg/dL prior to feeding trial and 26.00 to 50.34 mg/dL after the feeding trial. All rats groups fed formulated malt drink exhibit an increase in HDL levels while rats fed only normal rat chow (control group) had significant ($p<0.05$) decrease (26.5.%) in HDL level. HDL level increase was observed in rat group fed malt drink prepared from roasted finger millet malt (R100). Malt drink prepared from roasted finger millet malt supplemented with cucumber and carrot juice (R50:25:25) had higher HDL increase (17.33 mg/dl) of diabetic induced rats compared to un-supplemented sample (8.14 mg/dl). HDL increase (18.19 mg/dl) of rat fed malt drink from unroasted finger millet supplemented with cucumber and carrot juice (U50:25:25) was highest compared to other groups. Group 4 (rats fed sample U50:25:25) exhibited highest percent increase (112%) in HDL indicating that roasted finger millet malt may have negative impact on the ability of the malt drink to increase the high density lipoprotein (HDL) level. The observed increase in HDL in samples containing cucumber juice and carrot juice compared to unsupplemented counterpart shows the positive effect of these materials on HDL improvement. Consumption of cucumber has been reported to cause increase in HDL by some authors [32,33].

The values of very low density lipoprotein (VLDL) varied from 10.26 mg/dl in rats fed normal rat chow (Group 5) 18.70 mg/dL in rats fed malt drink from unroasted finger millet supplemented with cucumber and carrot juice (U50:25:25) prior to feeding trial. After the feeding trial, the VLDL level of rat groups fed formulated malt drinks dropped and the values ranged from 8.17 to 9.61 mg/dL. Malt drink prepared with roasted finger millet malt decreased the VLDL from 16.09 to 17.17 mg/dl. More reduction (from 17.91 to 9.61 mg/dl) was observed when cucumber and carrot juice was added to the juice. Rat group fed malt drink prepared with unroasted finger millet malt and supplemented with cucumber and carrot juice (U50:25:25) exhibited highest reduction in VLDL level. Increase in VLDL level (from 10.26 to 32.41 mg/dl) was observed in rats fed normal rat chow and the value was significantly ($p<0.05$) high in comparison to other rat groups.

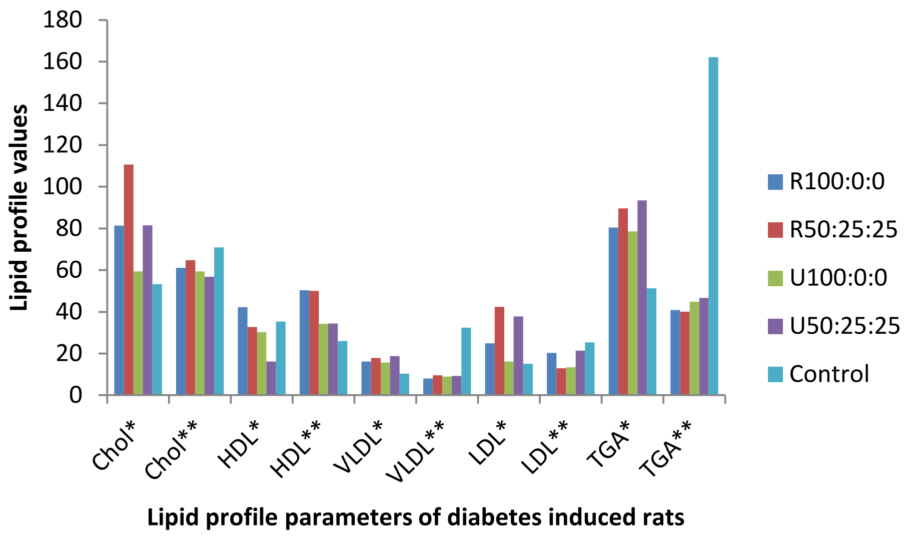

Fig. 1. Effect of roasted and unroasted finger millet malt supplemented with vegetable juice on lipid profile of diabetes induced rats

*Key: Rat groups- 1. = diabetes induced rat fed 100% roasted finger millet malt drink R100; 2. = diabetes induced rat fed 50% roasted finger millet malt, 25% of cucumber and 25% carrot drink R50:25:25; 3. = diabetes induced rat fed 100% unroasted finger millet malt drink U100; 4. = diabetes induced rat fed 100% unroasted finger millet malt drink, 25% of cucumber and 25% carrot drink U50:25:25 ; 5.Control= diabetes induced rats fed normal rat chow as control; Chol- Cholesterol; HDL- High Density Lipoprotein; VLDL- Very Low Density Lipoprotein; LDL-Low Density Lipoprotein; TGA-Triglyceride; *-parameter level before treatment; **-parameter level after treatment*

The low density lipoprotein (LDL) levels of experimental rats varied from 16.23 to 42.35 mg/dL prior to feeding trial and 12.93 to 25.34 mg/dL after the feeding trial. Rat group fed only normal rat chow (control group) had an increase in LDL concentration (67.93%) while rat groups fed processed malt drinks in addition to rat chow had reduced low density lipoprotein (LDL) and the values ranged between 12.93 and 21.44 mg /dL. Rat group fed malt drink prepared with roasted or unroasted finger millet malt and supplemented with cucumber and carrot juice (R50:25:25 and U50:25:25) showed more reduction in LDL compared to groups fed unsupplemented samples (R100 and U100, respectively). The reduction in LDL in experimental animals may be attributed to the raw materials used in the formulation. Finger millet, cucumber and carrot have been reported to decrease LDL level in the body [31,32]. This report corroborate with Lee *et al.* [33] who reported a reduction in LDL concentration in rats fed whole grains of foxtail millet and proso millet for a period of 5 weeks. Reduction in very low density lipoprotein observed in rats fed sample R100 (group 1) indicates that finger millet malt drink has a positive effect on its reduction which was more in unroasted malt drink. Amino acids lecithin and methionine in finger millet has been noted to decrease bad cholesterol (LDL and VLDL) in the body, and also inhibit lipid oxidation [34,35].

The observed reduction in triglyceride (TGA) was in agreement with Archna's report that amino acids lecithin and methionine in finger millet could also reduce triglycerides [35]. The triglycerides (TGA) concentration in experimental rats fed formulated drinks were observed to reduce and the values ranged from 40.84 and 48.03 mg/dL. Rats group fed only normal rat chow (control group) had significant increase in TGA concentration (from 61.28 to 162.13 mg/dl). Although the lowest reduction in TGA was observed in rats fed sample prepared with unroasted finger millet malt(U100), unroasted finger millet malt drink supplemented with cucumber and carrot juice (U50:25:25) exhibited the highest reduction in TGA level (93.49 t0 46.64 mg/dl).

Results of weight of experimental rats fed malt drinks prepared from roasted and unroasted finger millet malt and those supplemented with cucumber and carrot juice are shown in Table 2. There was a decrease in weight of the experimental rats after diabetes was induced. Rat groups fed samples R50:25:25 and

U50:25:25 (malt drinks containing 50% roasted finger millet malt, 25% of cucumber and 25% carrot juice and 50% unroasted finger millet malt, 25% of cucumber and 25% carrot juice, respectively) experienced an increase in weight (9.8% and 15.30%, respectively) while those fed samples prepared from finger millet malt only(R100 and U100 suffered slight weight loss (-2.28 and -5.54 %) within the feeding period.

The decrease in weight of the experimental rats after diabetes induction agreed with Diabetes UK [34] who asserted that diabetes could lead to weight loss attributable to insufficient insulin in the system. The insufficiency in insulin production in the experimental rats may be caused by the destruction of the beta cells of the pancreas by alloxan as pancreas is the site for insulin synthesis. This condition may lead to the body’s inability to get or mobilize blood glucose into the cells as energy source. When this happens, energy is then generated from fat burned from the body, leading to loss of weight. Also diabetes causes polyuria which increased urination where sugar is lost through the frequent urination at the same time; diabetes keeps the sugar in the diet from reaching the body cells, causing the body to use up stored fat in a bid to get energy for the body functions, leading to loss of weight [35]. The weight loss observed in rat groups fed samples containing only finger millet (U100 and R100) indicated that the presence of cucumber juice samples R50:25:25 and U50:25:25 enhanced the uptake of the blood glucose, reducing the rate in which the body’s stored fat was being used and therefore leading to weight gain.

The fasting blood sugar (FBS) levels of experimental rats fed malt drinks prepared from roasted and unroasted finger millet malt and those supplemented with cucumber and carrot juice are shown in Fig. 2. The fasting blood sugar (FBS) of the experimental rats before alloxan induction ranged between 90 and 98 mg/dL, showing that they were not diabetic prior to alloxan induction (Fig. 2). After induction, the FBS values of between 146 and 381mg/dL were observed in the experimental rats. The fasting blood glucose level of the experimental rats varied from 26 to 331 mg/dL after feeding trial revealing general drop in values. Group 4 rats fed sample U50:25:25 (sample prepared from 50% unroasted finger millet malt drink, 25% of cucumber and 25% carrot juice) had the highest reduction in fasting blood sugar level (87%) and group 1, fed sample R100 (100% roasted finger millet malt drink) had the least drop (44.2%). An increase was observed in FBS of control group (group 5), and the increase was 0.87%.

Rat groups fed experimental malt drink had their fasting blood glucose back to normal ($<$120 mg/dL) while groups 5 rats fed control sample (rat chow alone), remained diabetic with a final fasting blood glucose level of 331.67 mg/dL(0.87% increase in FBS). Generally, the drop in blood glucose level of all the groups fed experimental sample may be attributed to hypoglycermic potentials of finger millet due presence of phytochemicals [36]. Devi *et al.* noted that the polyphenol and dietary fibre contents of finger millet may have contributed to its anti-diabetic effects and antioxidant properties [4]. Synergy between phenolics and dietary fibre may function as a mediating amylase inhibition with the potential to aid type II Diabetes mellitus management [3]. Research has shown that the carbohydrates in finger millet are slowly digested and assimilated than those present in other cereals [37]. The risk of diabetes mellitus can be reduced through consumption of finger millet and cucumber regularly [36,20] attributable to high polyphenols and dietary fibre contents [36]. Millets has been reported to possess valuable health protective properties against diet-related chronic disease due to its rich phenolic antioxidants [37]. Feeding the diabetic animals with finger millet mixed with vegetable juice for 4 weeks regulated the glucose levels and this may be due to the structure and the synergistic effects of different phenolic compounds among others [3]. Consuming vegetables is vital not only for their nutrients but also for their nutraceutical characteristics, as research has shown that eating them is related with a low incidence of non-communicable ailments like cardiovascular disease, diabetes, and cancer [38]. Variations in physiological state of the animals and compositions of the experimental malt drinks could have accounted for the differences in blood glucose lowering effects. Link reported that cucumber had glucose lowering effect in diabetic subjects [18]. This result also corroborate with the report of Roman-Ramos *et al*. [39] and Dixit which stated that cucumber juice consumption could lead to a decrease in fasting blood glucose level [40].

Presence of flavonoids in cucumber and carrot could also account for blood sugar lowering effect witnessed in rat groups fed samples containing these materials. Queretin in carrot, (a type of flavonoids) have been reported to possess antidiabetic activity and also a potent free radical scavengers, hence attracting a tremendous interest as possible therapeutics against free radical mediated diseases, particularly diabetes mellitus [27,41]. The low anti-diabetic activity witnessed in rat group 1 fed sample R100 (100% roasted finger millet malt) compared to group fed malt drink from unroasted finger millet malt could be explained by the reports of some researchers which revealed that roasted finger millet contained lower content of total phenol than unroasted one [28,27]

Table 2. Weight of the diabetes induced rats fed roasted/unroasted finger millet malt-cucumber – carrot drinks

Groups	W0(g)	W1(g)	W2(g)	%Weight gain/loss after feeding trial
1. R100	182.78^{b}±40.72	178.80^{b}±62.85	174.73^{b}±30.35	-2.28
2.R50:25:25	118.66^{a}±47.66	113.47^{a}±4.43	124.60^{a}±6.90	9.91
3. U100	256.06^{c}±55.98	250.20^{c}±70.54	236.33^{c}±47.43	-5.54
4.U50:25:25	172.97^{b}±45.21	166.27^{b}±61.99	191.70^{b}±73.87	15.3
5.Control	264.67^{c}±37.03	258.43^{c}±62.71	241.87^{c}±63.06	-6.41

Values are mean of duplicate determination ± standard deviation. Values on the same column with different superscripts are significantly (p<0.05) different.

Key: Rat groups- 1. = diabetes induced rat fed 100% roasted finger millet malt drink (R100); 2. = diabetes induced rat fed malt drink from 50% roasted finger millet malt, 25% of cucumber and 25% carrot drink (R50:25:25); 3. = diabetes induced rat fed 100% unroasted finger millet malt drink (U100); 4. = diabetes induced rat fed malt drink prepared from 50% unroasted finger millet malt drink, 25% of cucumber and 25% carrot drink (U50:25:25); Control= diabetes induced rats fed normal rat chow ; W0= weight before diabetes was induced, W1= weight after diabetes was induced, W2= weight after treatment

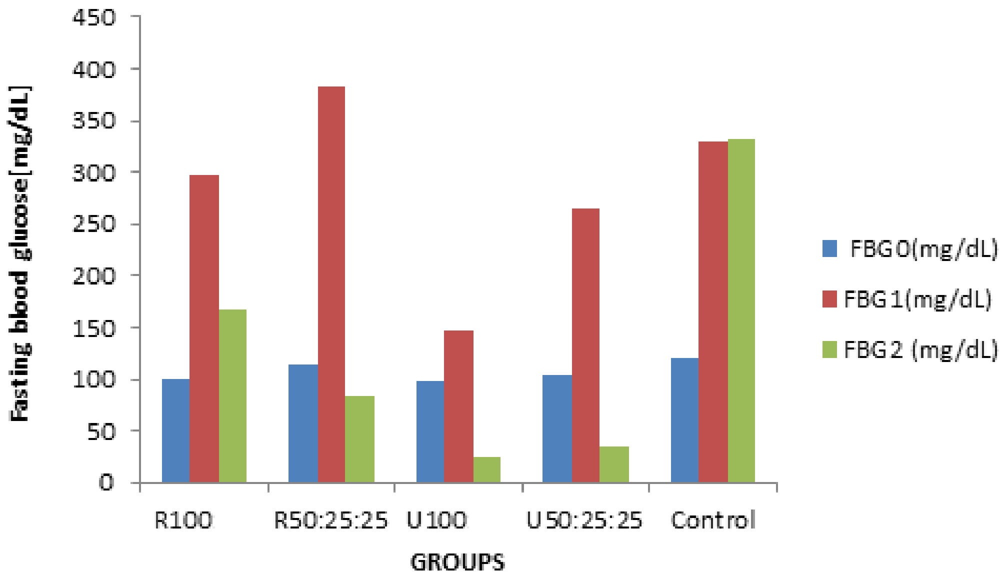

Fig. 2. Effect of roasted/unroasted finger millet malt drink supplemented with carrot and cucumber juice on the fasting blood glucose of the diabetes induced rats

Key: Rat groups- Rat groups- 1. = diabetes induced rats fed 100% roasted finger millet malt drink (R100); 2. = diabetes induced rat fed malt drink prepared from 50% roasted finger millet malt, 25% of cucumber and 25% carrot drink (R50:25:25); 3. = diabetes induced rats fed 100% unroasted finger millet malt drink (U100); 4. = diabetes induced rats fed malt drink prepared from 50% unroasted finger millet malt drink, 25% of cucumber and 25% carrot drink (U50:25:25); 5Control= diabetes induced rats fed normal rat chow; FBG0= Fasting blood glucose before diabetes was induced, FBG1=Fasting blood glucose after diabetes was induced, FBG2=Fasting blood glucose after treatment

*.*FBS below 100 mg/dL = normal. FBS between 100 and 120 mg/dL = pre-diabetes, FBS above 125 mg/dL = diabetic; Source: Mayo clinic [39]*

Table 3. Microbial load of roasted /unroasted finger millet malt-cucumber-carrot juice drinks

Samples F:Cu:Ca	Total viable count (cfu/100mL)	Mould(cfu/100mL)
R100	$1.13 \times 10^{2a} \pm 1.00$	ND
R50:25:25	$2.55 \times 10^{2c} \pm 1.00$	ND
U100	$2.93 \times 10^{2d} \pm 1.00$	ND
U50:25:25	$1.34 \times 10^{2b} \pm 0.00$	ND

Values are mean of three replications ± standard deviation. Values on the same column with different superscripts are significantly (p<0.05) different, Key: R100=100% roasted finger millet malt drink sample; R50:25:25:= Sample with 50% roasted finger millet malt, 25% of cucumber and 25% carrot drink; U100 = 100% unroasted finger millet malt drink sample; U50:25:25. = sample with 50% unroasted finger millet malt drink, 25% of cucumber and 25% carrot drink

The results of the microbial load of roasted /unroasted finger millet malt-cucumber-carrot juice drinks are presented in Table 3.Total viable counts of the malt drinks ranged from 1.13 -2.93 x 10^2Cfu/100ml. The total viable count of the processed malt drinks were below the maximum allowable limit (10^3/ mL of Cfu/g) [42] indicating the effectiveness of the sterilization and pasteurization steps adopted in processing of the fortified malt drink in reducing the microbial load of the product. There were no records of mould counts in the samples and all the samples recorded no distinct colony counts attributable to hygienic condition that was maintained during formulation and processing.

4. CONCLUSION

The study shows that nutritious malt drinks can be produced from finger millet malt, cucumber and carrot juice for diabetic patients. The malt drink was rich in flavonoids and phenolic compound which were more in cucumber and carrot juice supplemented drink. The bioassay analysis showed that the formulated malt drinks caused a reduction in the fasting blood sugar of the diabetic rats. Sample containing 50% unroasted finger millet, 25% cucumber juice and 25% carrot juice was most effective in reducing fasting blood sugar level, increased high density lipoprotein levels and resulted to more weight regain after the initial loss in weight due to effect of diabetes. Based on the study, unroasted finger millet malt drink should be formulated by 50% unroasted finger millet malt, 25% cucumber juice and 25% carrot juice and the finger millet malt and use for effective management of diabetes.

ETHICAL APPROVAL

Animal Ethic committee approval has been collected and preserved by the author(s)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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