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Research Article

Assessment of Groundnut Milk Intake on Nutritional Status and some Biochemical Indices of Normal Rats

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ABSTRACT

Groundnut milk also known as peanut milk, is an increasingly popular based beverage that serves as a potential alternative to cow's milk. It is rich in essential nutrients such as proteins, healthy fats, vitamins, and minerals but limited research has explored its effect on nutritional status and biochemical indices. Therefore, this study assessed the effect of groundnut milk intake on nutritional status and some biochemical indices of Wistar rats. The Wistar rats (n=20), with body weight ≤50g were randomly divided into four groups of five rats each: Group 1 served as control. Groups 2, 3, and 4 were administered groundnut milk at daily doses of 247.2, 494.3, and 988.6 mg/kg respectively for eight weeks. Significant increase in abdominal circumference ($P<0.005$) between groups was observed. However, increase in the BMI and thoracic circumference between groups were insignificant ($P>0.05$). The levels of TC, TG and LDL-c were decreased significantly ($P<0.005$). However, HDL-c showed no significant difference. The decrease in atherogenic index, atherogenic coefficient and cardiac risk ratio indices were insignificant ($P>0.05$). The groundnut milk had no effect on serum total protein, adiponectin, and albumin while it increased serum leptin level significantly ($P<0.005$). The blood glucose levels of group 2, 3 and 4 were lowered dose-dependently ($P<0.005$) compared to the control. Groundnut milk showed no effect on liver and kidney-to-body weight ratio ($P>0.05$), but showed effect on heart-to-body weight ratio ($P<0.005$). The ratio of food and water intake of groups 2, 3, and 4 decreased significantly ($P<0.005$) compared to the control group. The results revealed that groundnut milk could play a positive role nutritionally and positively influence lipid profile, glucose, and leptin levels in a dose-related manner.

Keywords: *Groundnut milk, Biochemical parameters, Organogenic indices*

INTRODUCTION

Nigeria accounts for 51% of groundnut production in West Africa, making it the largest producing country in the region (Ajeigbe *et al*., 2014). Groundnuts have been developed into a variety of products like roasted groundnut, groundnut butter, groundnut oil, groundnut paste, groundnut sauce and groundnut flour. The major components of groundnut (Protein, fats, and fiber) are present in their most beneficial forms. The protein is plant based, the fat is unsaturated, and the fiber is complex carbohydrate which are all proved to be the best for human nutrition (Shalini et al., 2016). Nuts are naturally high in energy and essential nutrients. Groundnuts possess many important bioactive compounds such as resveratrol, phytosterols, p-coumaric acid etc., these nutrients and bioactive compounds are not readily accessible to humans (Sze-Yen *et al*., 2018; Bhat *et al*., 2019). To address the issues of lower nutrient and bioactive compound accessibility from nuts, studies have demonstrated that food processing increase concentration of the nutrient and bioactive compounds (Gebaueret al., 2016; Ho et al., 2010). Several studies reported that groundnut has got significant effect on improvement of lipid profile as HDL-cholesterol increased significantly, and total cholesterol, LDL-cholesterol and TAG concentrations decreased significantly in individuals who consumed groundnut (Fiona et al., 2010; Phoebe et al., 2007; Hasina et al., 2015). Several studies revealed that processing methods greatly affect the nutritive content of groundnut seeds (Tobin and Baraka, 2018; Peruguet al., 2018). Groundnut processing may neither compromise the lipid-lowering effects associated with peanuts, nor impact negatively on body weight (Fiona et al., 2010).

The utilization of simple and processed groundnuts has appeared to be helpful for human wellbeing and various researches have discovered that utilization of groundnut is related with lessened cardiovascular diseases and may enhance serum lipid profiles (Bhat et al., 2019). Research studies have demonstrated that dietary inclusion of groundnuts and tree nuts has been linked to reduced heart disease (Jones et al., 2014), certain types of cancers (Gonzalez and Salas-Salvado, 2006), and improved weight management (Moreno et al., 2013). Eating nuts daily can reduce death from heart disease by 29%, and even eating groundnuts just twice a week can reduce risk by 24% (Bao et al., 2013). Other studies have shown that regular groundnut consumption helps to decrease blood pressure among hypertensive individuals with significant reduction in diastolic blood pressure (Jones et al., 2014).

Therefore, this study aimed to assess whether groundnut milk intake has an effect on nutritional status and some biochemical indices of normal wistar rats. Milk is consumed by all categories of age, information on the effect may encourage the consumption or otherwise of groundnut milk.

MATERIALS AND METHODS

Chemicals and Reagents

All chemicals and reagents used in the study were of analytical grade

Groundnut sample

Groundnut (Arachis hypogea) was purchased at Rimi Market Kano. The seeds were identified, authenticated and verified by the Herbarium unit, Department of Biological Sciences, Bayero University Kano, Nigeria. The Herbarium accession number is BUKHAN 405.

Preparation of groundnut milk

A hundred gram (100g) of groundnuts were soaked in water in a ratio of 1:3 (kernel: water) for 18 hours and they were dehusked. The dehusked kernels were washed with water and ground with hot water in a ratio of 1:6 (kernels to water) in the grinder. The slurry formed was sieved with muslin cloth and groundnut milk was collected (Perugu et al., 2018).

Concentration of the milk

Exactly 5 ml of milk sample was placed in a weighed petri dish. The samples were kept at 102 ºC in a hot air oven overnight. Then, the dried samples were taken out of the oven and placed in a desiccator, then weighed finally (O'connor, 1994).

Dosage: Based on verbal discussion with the herbal medicine practitioners in Gada, district of Bungudu L.G.A Zamfara State, Nigeria, we measured the daily dose for an average 70kg individual consumes.

Animals and treatments

Weaned wistar rats (n=20) of <50g were procured from animal house, Department of Life Sciences, Bayero University, Kano. They were grouped into four groups (five animals per group), a control group 1 and treatment groups 2, 3 and 4. The animals were kept in the animal house cages for one week to acclimatize with the environment (Okafor et al., 2018).

Experimental Design

Group 1: Fed with basal diet for eight (8) weeks.

Group 2: Administered daily 247.2 mg/kg body weight of the milk for eight (8) weeks.

Group 3: Administered daily 494.3 mg/kg body weight of the milk for eight (8) weeks

Group 4: Administered daily 988.6mg/kg body weight of the milk for eight (8) weeks.

During this period, the animals were closely monitored and standard environmental conditions were maintained and 12L: 12D were maintained. The animals were properly fed with growers feed from Vital Feed Nigeria Limited, housed in plastic cages with stainless steel mesh covers, the floors were covered with saw dust which suck away the urine of the rats and was changed on daily basis. There was cross ventilation in the Animal House and was kept clean throughout the study; plain water was provided for the rats to drink in plastic bottle with stainless steel nozzles while the feed was provided in plastic bowls. Blood glucose level and the anthropometrical measurements were taken at 7-day intervals throughout the experimental period.

Animal sacrifice, serum and organ sample collection

The rats were sacrificed through cervical dislocation by dangling their necks and pulling on their tails until a cracking sound indicative of antoaxial joint dislocation was heard (Aguwa et al., 2020). The blood sample collected from the orbital plexus of the rat in plane tube, and serum was separated at 4000 rpm for 15min for biochemical analysis. The liver and kidney were harvested, and weighed.

Proximate analysis of the raw groundnut and groundnut milk

The proximate compositions of the raw groundnut and groundnut milk were determined using conventional methods of the Association of Official Analytical Chemists, AOAC (2000).

Administration of the milk to the animals

The animal's weight, blood glucose level, length, abdominal circumference, and thoracic circumference were measured before the commencement of the milk administration. The administration of the milk was done for the period of eight (8) weeks.

Route of administration

The milk is water soluble and was administered by oral route. Robber-caped needles were used to administer the milk after vigorous shaking, to facilitate dissolution of the milk. The period of extract administration took eight (8) weeks and was done at a fixed time daily 9:00 am (Atama and Idu ,2007).

Anthropometric parameters

Body length, weight, body mass index, thoracic circumference and abdominal circumference were measured using method described by Novelli *et al*. (2007).

Biochemical parameters

Determination of blood glucose concentration

Blood glucose concentration was measured by tail tapping using healthy Q glucometer (Healthy –Q MGD-1002A, MiCoBioMed Co., Ltd. 116 Gongdan 1-ro, Anseong-si, gyeongggi-do, Korea)

Determination of serum lipid profile

Concentration of Total Cholesterol, HDL Cholesterol, Triacylglycerol, LDL Cholesterol, were measured using CardioCheck PA analyser (Ibrahim *et al*., 2016).

Atherogenic indices

The atherogenic indices were calculated as decribed by Okafor *et al*. (2015).

Cardiac Risk Ratio (CRR) = TC/HDLC--------------------- 1

Atherogenic Coefficient (AC) = (TC– HDLC)/HDLC-----2

Atherogenic Index (AI) = log (TG/HDLC) -----3

Determination of serum albumin, total protein, leptin and adiponectin concentration

Serum albumin concentration was estimated by the method described by Harding and Keyser (1968) while total protein concentration was estimated by the method described by Gornall *et al*. (1949). Serum leptin and adiponectin concentration was determined using Elisa kit (Sunlong Biotech. CO. LTD).

Statistical analysis

SPSS version 23.0 was used in analyzing the data. The mean and standard deviation of the triplicate analyses were calculated. Repeated measure of analysis of variance (ANOVA) was performed to determine significant differences between the means at p<0.05.

RESULTS

Proximate compositions of raw groundnut and groundnut milk

The percentage of carbohydrate, protein, fat, ash, moisture and crude fiber contents of raw groundnut were found to be 23.38±3.53%, 26.36±0.3%, 37.79±3.3%, 2.26±0.7%, 3.71±0.1% and 6.5±0.3% respectively (Figure 1), while in groundnut milk they were found to be 6.54±3.4, 10.73±0.7, 19.47±3.3%, 0.96±0.3%, 61.55±3.8% and 0.75±0.2% respectively. The percentage of carbohydrate, protein, fat, ash and crude fiber contents in groundnut milk decreased significantly (P<0.05) when compared to the raw groundnut while the moisture contents increased significantly (P<0.05).

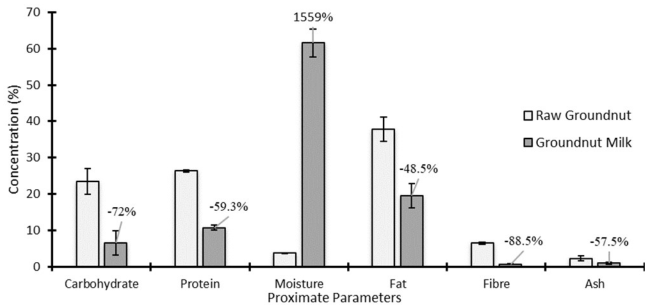

Figure 1. Raw Groundnut and Groundnut Milk Proximate Composition.

Data are presented as mean ± standard deviation. Significant difference was determined statistically (P < 0.05) using unpaired t test. Values on the groundnut milk error bars are percentage difference between groundnut milk and raw groundnut.

Effect of groundnut milk on anthropometric parameters

The AC was compared within group 1 per week, from week 0 to week 8, all were found to increase significantly (p < 0.05). The AC was compared within group 2 per week, from week 0 to week 8, all were found to increase significantly (p < 0.05). The AC was compared within group 3 per week, from week 0 to week 8, all were found to increase significantly (p < 0.05). The AC was compared within group 4 per week, from week 0 to week 8, all were found to increase significantly (p < 0.05).

The AC was compared between groups per week, all were found to increase significantly (p < 0.05) (Figure 2).

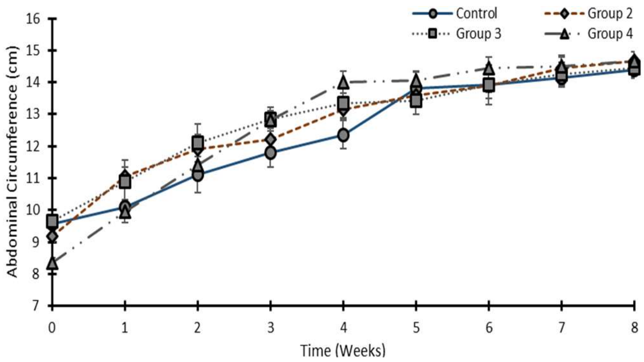

Figure 2. Effect of Groundnut Milk on Abdominal Circumference of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using repeated measures analysis of variance.

The thoracic circumference was compared within group 1 per week, from week 0 to week 8, all were found to increase significantly ($p < 0.05$). The thoracic circumference was compared within group 2 per week, from week 0 to week 8, all were found to increase significantly ($p < 0.05$). The thoracic circumference was compared within group 3 per week, from week 0 to week 8, all were found to increase significantly ($p < 0.05$). The thoracic circumference was compared within group 4 per week, from week 0 to week 8, all were found to increase significantly ($p < 0.05$).

The Thoracic circumference was compared between groups per week, all were found not to increase significantly ($p > 0.05$) (Figure 3).

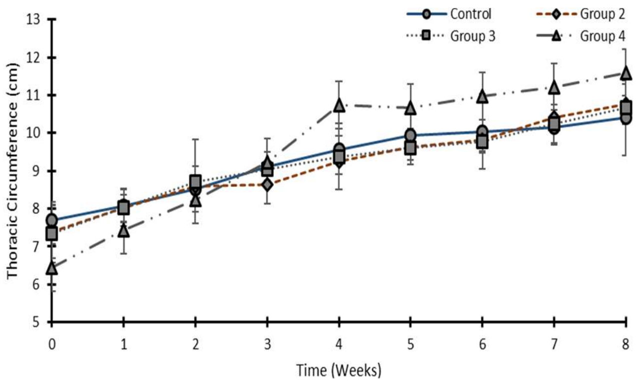

Figure 3. Effect of Groundnut Milk on Thoracic Circumference of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using repeated measures analysis of variance.

The BMI was compared within group 1 per week, from week 0 to week 8, all were found not to increase significantly ($P > 0.05$). The BMI was compared within group 2 per week, from week 0 to week 8, all were found not to increase significantly ($P > 0.05$). The BMI was compared within group 2 per week, from week 0 to week 8, all were found not to increase significantly ($P > 0.05$). The BMI was compared within group 2 per week, from week 0 to week 8, all were found not to increase significantly ($P > 0.05$) The BMI was compared between groups per week, all were found not to increase significantly ($P > 0.05$) (Figure 4).

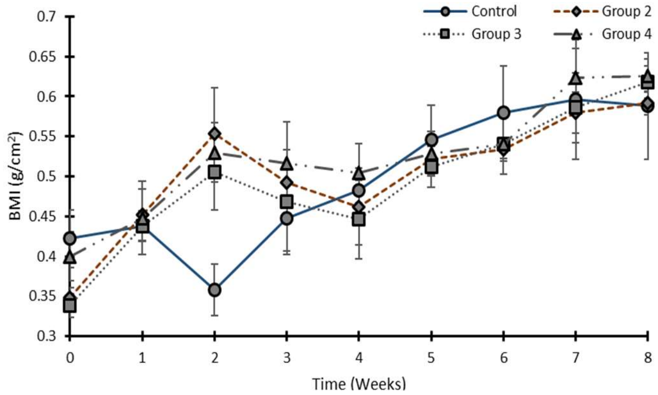

Figure 4. Effect of Groundnut Milk on Body Mass Index of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using repeated measures analysis of variance.

Effect of groundnut milk on some biochemical parameters of the wistar rats

Serum cholesterol of group 1 (control) was found to be 134.6±11.80 mg/dl, group 2 was 116±7.51 mg/dl, group 3 was 109.4±8.82 mg/dl and group 4 was 99.2±6.20 mg/dl. When all the groups were compared to the control group they all showed a significant decrease ($P < 0.05$), when group 2 was compared to group 3 there was no any significant decrease ($P > 0.05$), while group 2 compared to group 4 showed a significant decrease ($P < 0.05$), and when group 3 was compared to group 4 there was no any significant decrease ($P > 0.05$) (Figure 5).

Serum triglyceride level of group 1 (control), 2, 3 and 4 were found to be 108.8±21.7 mg/dl, 63.6±9.3 mg/dl, 59.6±11.1 mg/dl and 48.4±6.1 mg/dl respectively. All the groups revealed a significant decrease when compared to the control group ($P < 0.05$). When group 2 was compared to group 3 and 4 it showed no significant decrease ($P > 0.05$), also group 3 compared to group 4 showed no significant decrease ($P > 0.05$) (Figure 5).

Serum HDL level of group 1 (control), 2, 3 and 4 were found to be 65±8.50 mg/dl, 62±11.30 mg/dl, 63.2±11.70 mg/dl and 65±5.10 mg/dl respectively. All the groups showed no significant difference compared with the control group and between the groups ($P > 0.05$) (Figure 5).

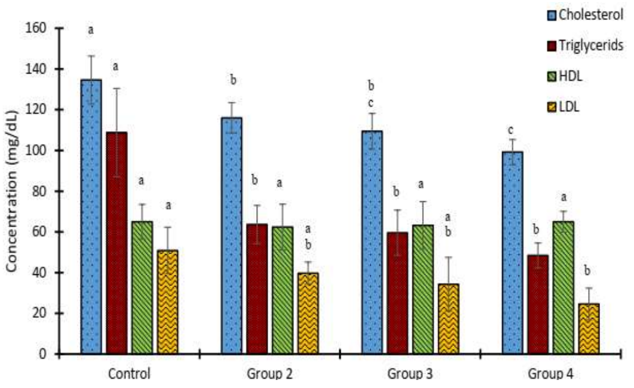

Figure 5. Effect of Groundnut Milk On Cholesterol, Triglyceride, HDL (High Density Lipoprotein Cholesterol and LDL (Low Density Lipoprotein Cholesterol) The Wistar Rats.

Data are presented as mean ± standard deviation. Error bars bearing different superscript are statistically significant (P< 0.05) using one-way analysis of variance.

Serum LDL level of group 1, 2, 3 and 4 was found to be 50.84 ± 11.40 mg/dl, 39.6 ± 5.50 mg/dl, 34.28 ± 13.19 mg/dl and 24.6 ± 7.80 mg/dl respectively. All the groups showed no significant difference (P > 0.05) when compared to the control group except group 4 which showed a significant decrease (P < 0.05), while between the groups there was no any significant decrease (P > 0.05) (Figure 5).

Atherogenic indices

Cardiac risk ratio of group 2, 3 and 4 were found to be 1.9 ± 0.30, 1.76 ± 0.44 and 1.5 ± 0.15 respectively. Group 2, 3 and 4 revealed no significant difference (P> 0.05) when compared with the control group (2.09 ± 0.30). Variation among group means is considered not significant (P > 0.05) but there is dose dependent insignificant decrease (Figure 6).

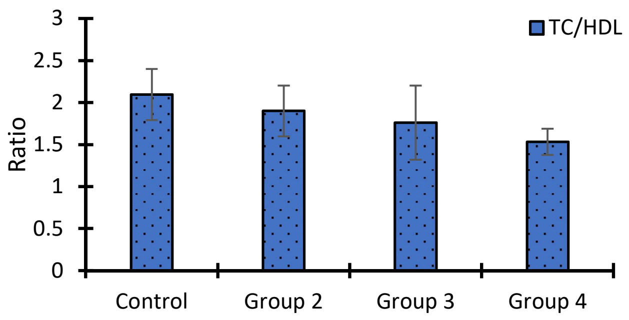

Figure 6. Effect of Groundnut Milk nn Cardiac Risk Ratio of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically (P < 0.05) using one-way analysis of variance.

Atherogenic coefficient of groups 2, 3 and 4 were found to be 0.9 ± 0.31, 0.79 ± 0.42 and 0.53 ± 0.16 respectively. Group 2, 3 and 4 revealed no significant difference (P>0.05) when compared with the control group (1.09 ± 0.31). Variation among group means was considered not significant (P>0.05). In general, it showed dose dependent insignificant decrease (P<0.05) of atherogenic coefficient (Figure 7).

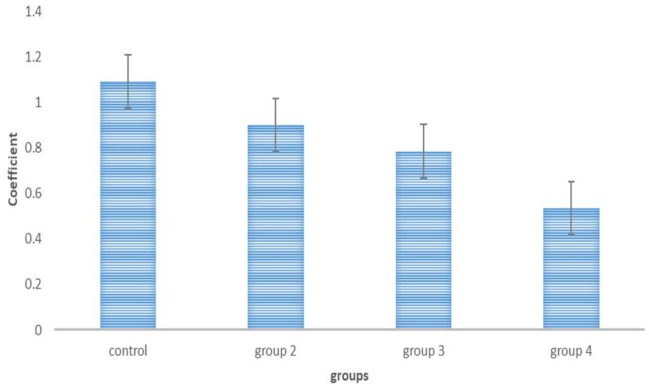

Figure 7. Effect of Groundnut Milk on Atherogenic Coefficient of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically (P < 0.05) using one-way analysis of variance.

Atherogenic index of group 2, 3 and 4 were found to be 0.28 ± 0.06, 0.24 ± 0.09 and 0.18 ± 0.04g respectively. Group 2 and 3 revealed no significant difference (P< 0.05) when compared with the control group (0.32 ± 0.06), while group 4 showed a significant difference (P>0.05) when compared to the control group. Variation between group 2 and 3, group 2 and 4, and group 3 and 4 means were considered not significant (P<0.05). Therefore, it shows dose dependent insignificant decrease (P< 0.05) of atherogenic index (Figure 8).

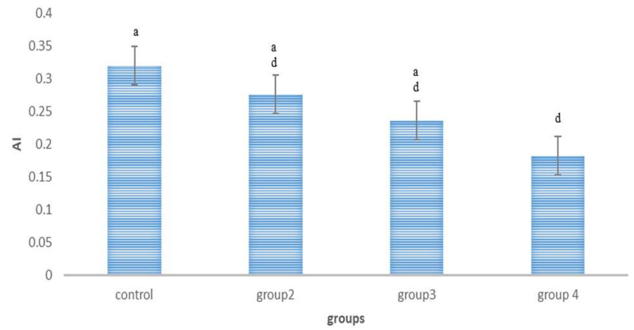

Figure 8. Effect of Groundnut Milk on Atherogenic Index of the Wistar Rats.

Data are presented as mean ± standard deviation. Error bars bearing different superscript are statistically significant (P< 0.05) using one-way analysis of variance.

Effect of groundnut milk on serum leptin and adiponectin level of the wistar rats

Serum leptin level of group 2 and 3 were found to be 6.62 ± 1.71 and 7.53 ± 2.83 ng/ml respectively. Group 2 and 3 revealed no significant difference (P> 0.05) when compared with the control group (3.81 ± 0.60 ng/ml), while group 4

(10.20 ± 0.60 ng/ml) showed a significant increase (P< 0.05) when compared with the control group. In general, it revealed dose dependent increase in serum leptin (Figure 9).

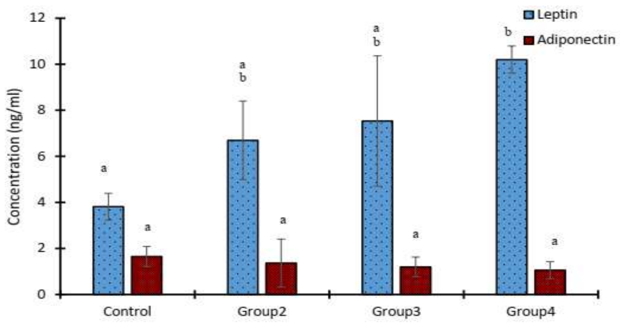

Figure 9. Effect of Groundnut Milk on Leptin and Adiponectin of the Wistar Rats.

Data are presented as mean ± standard deviation. Error bars bearing different superscript are statistically significant (P< 0.05) using one-way analysis of variance.

Effect of groundnut milk on serum albumin and total protein level of the wistar rats

The serum total protein and albumin level of group 2, 3, 4 were found to have no significant difference (P > 0.05) when compared to their respective control groups. Variation among group means of serum albumin level and total protein level were considered not significant (p > 0.05). Despite irregular pattern of serum total protein, the result depict dose dependent insignificant increase in serum albumin (Figure 10).

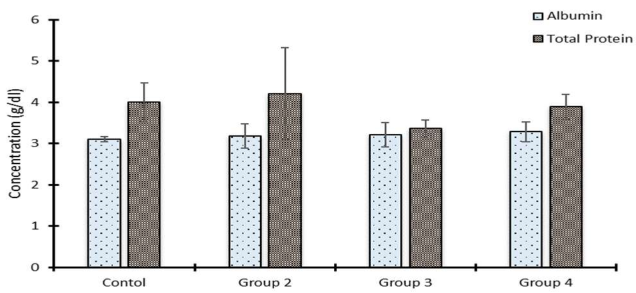

Figure 10. Effect of Groundnut Milk on Serum Albumin and Total Protein Level of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically (P < 0.05) using one-way analysis of variance.

Effect of groundnut milk on blood glucose level of the wistar rats

The blood glucose level was compared within group 1 per week, from week 0 to week 8, all were found to decrease insignificantly (P > 0.05). The blood glucose level was compared within group 2 per week, from week 0 to week 8, all were found to decrease significantly (p < 0.05). The blood glucose level was compared within group 3 per week, from week 0 to week 8, all were found to decrease significantly (p < 0.05). The blood glucose level was compared within group 4 per week, from week 0 to week 8, all were found to decrease significantly (p < 0.05). The blood glucose level was compared between groups per week, all were found to decrease significantly (p < 0.05) (Figure 11).

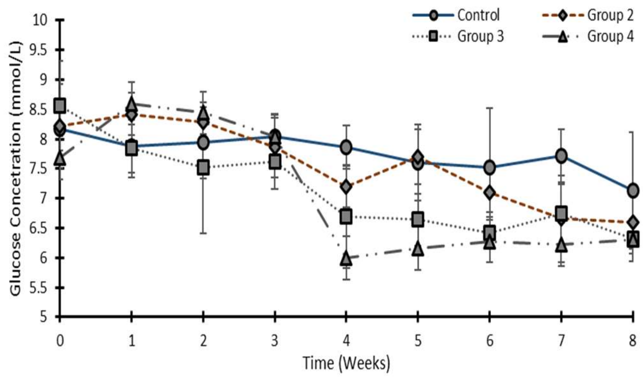

Figure 11. Effect of Groundnut Milk on Blood Glucose Level of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically (P < 0.05) using repeated measures analysis deviation

Effect of groundnut milk on heart, liver and kidney to body weight ratio of the wistar rats.

Heart to body weight ratio of group 2 (0.0032 ± 0.0) and 4 (0.0032 ± 0.0) showed no significant difference when compared to the control, while group 3 (0.0025 ± 0.0) was significantly different from the control (0.003 ± 0.0). Also there was significant variation between group 3 and 4, and between group 3 and 2 (P< 0.05) (Figure 12).

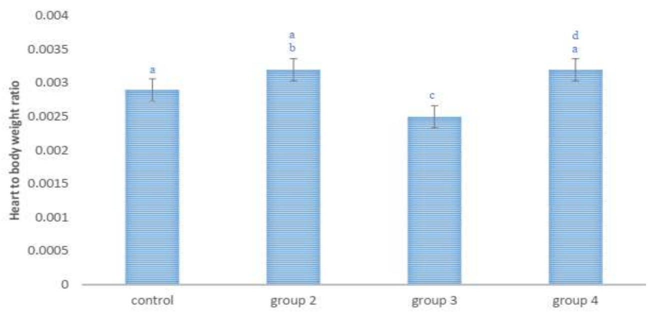

Figure 12. Effect of Groundnut Milk on Heart to Body Weight Ratio of the Wistar Rats.

Data are presented as mean ± standard deviation. Error bars bearing different superscript are statistically significant (P< 0.05) using one-way analysis of variance.

Liver to body weight ratio of group 2, 3 and 4 were found to be 0.034 ± 0.0, 0.035 ± 0.0 and 0.0 ± 0.003 respectively. All of these revealed no significant difference (P< 0.05) when compared with the control group (0.034 ± 0.0). Variation among group means were considered not significant (p > 0.05) (Figure 13).

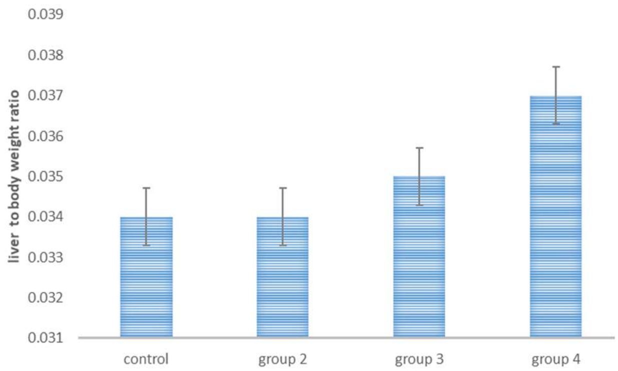

Figure 13. Effect of Groundnut Milk on Liver to Body Weight Ratio of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using one-way analysis of variance.

Kidney to body weight ratio of group 2, 3 and 4 were found to be 0.0065 ± 0.0, 0.0051 ± 0.0 and 0.0067 ± 0.0 respectively. All of these revealed no significant difference ($P < 0.05$) when compared with the control group (0.006 ± 0.0). Variation among group means was considered insignificant ($P > 0.05$) (Figure 14).

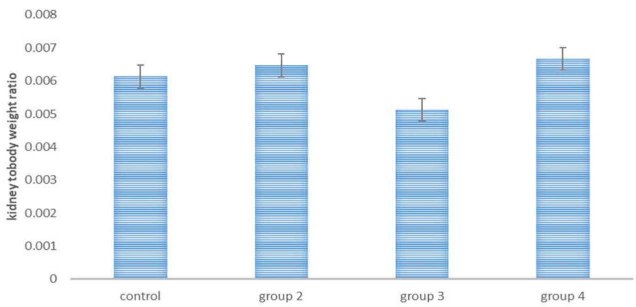

Figure 14. Effect of Groundnut Milk on Kidney to Body Weight Ratio of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using one way analysis of variance.

Effect of groundnut milk on food consumption and water intake of the wistar rats

The food intake was compared within group 1 per week, from week 1 to week 8, all were found to increase significantly ($p < 0.05$). The food intake was compared within group 2 per week, from week 1 to week 8, all were found to increase significantly ($p < 0.05$). The food intake was compared within group 3 per week, from week 1 to week 8, all were found to increase significantly ($p < 0.05$). The food intake was compared within group 4 per week, from week 1 to week 8, all were found to increase significantly ($p < 0.05$). The food intake was compared between groups per week, all were found to decrease significantly at ($p < 0.05$). Rate of food intake per week decreased among group significantly ($P < 0.05$) when all the groups were compared to the control (345.09 ± 11.36 g/week), but when compared between group 2(331.89 ± 11.43g/week) and 3(327. 79 ± 7.0g/week), between group 2 and 4(320.93 ± 6.39), and between group 3 and 4 there was no significant decrease ($P > 0.05$)

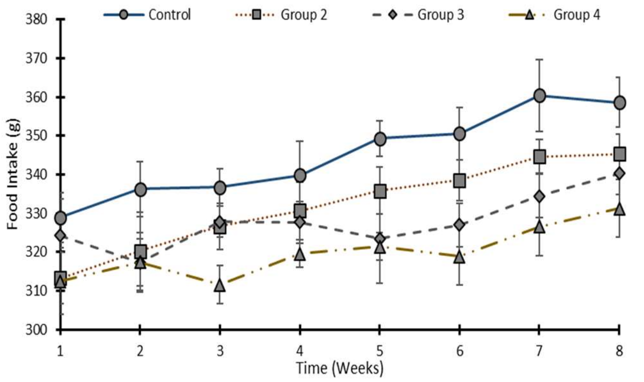

Figure 15. Effect of Groundnut Milk on Food Intake of the Wistar Rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using repeated measures analysis of variance.

The water intake was compared within group 1 per week, from week 1 to week 8, all were found not to decrease significantly ($P > 0.05$). The water intake was compared within group 2 per week, from week 1 to week 8, all were found to decrease significantly ($p < 0.05$). The water intake was compared within group 3 per week, from week 1 to week 8, all were found to decrease significantly ($p < 0.05$). The water intake was compared within group 4 per week, from week 1 to week 8, all were found to decrease significantly ($p < 0.05$).

Rate of water intake per week decreased among group significantly ($P < 0.05$) when all the groups were compared to the control (156.61 ± 5.21 mL/week), but when compared between group 2 (124.77 ± 10.18 mL/week) and 3 (112.32 ± 7.41 mL/week) there was no significant decrease ($P > 0.05$). While between group 2 and 4(102.45 ± 7.51 mL/week), and between group 3 and 4 showed significant decrease. The water intake was compared between groups per week, all were found to decrease significantly ($p < 0.05$).

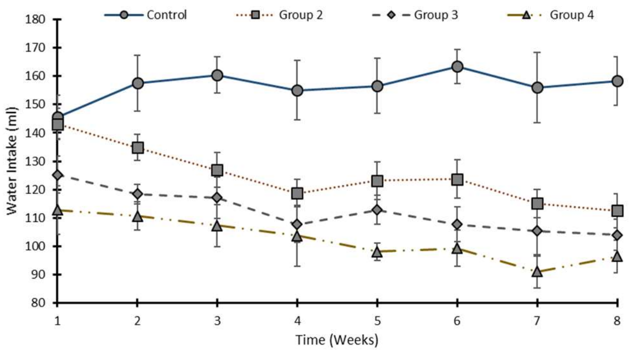

Figure 16. Effect of groundnut milk on water intake of the wistar rats.

Data are presented as mean ± standard deviation. Significant difference was determined statistically ($P < 0.05$) using repeated measures analysis of variance

DISCUSSION

The significant decrease in carbohydrate and fat content of groundnut milk when compared to raw groundnut doesn't render it an insufficient source of energy; the fat and carbohydrate content of groundnut milk is higher than that of cow milk (3.90% and 5.0% respectively) (Omole and Ighodaro, 2012). The low-fat content in groundnut milk makes it a healthy food because high-fat diets lead to increased blood cholesterol, fat levels, and heart attack (Hession*et al*., 2009). Although the protein content decreased significantly in groundnut milk, the amino acid composition is more important than the quantity of protein in milk (Omole and Ighodaro, 2012). The ash content is generally recognized as a measure of quality for the assessment of the functional properties of foods, it signifies the presence of minerals in food (Hofman *et al*., 2002). The significant increase in moisture content in the milk was due to soaking and the addition of water during the milk preparation. The concentration of other nutrients present in milk were affected by its moisture content as lower moisture content increases the concentration of the nutrient (Omole and Ighodaro, 2012). The percentage of crude fiber in groundnut milk was found to decrease significantly due to sieving in the preparation of the milk.

Anthropometric parameters

In this study, the anthropometric measurements showed that the abdominal circumference (AC), thoracic circumference, and body mass index (BMI) of rats in all the groups increased progressively and significantly when compared within groups per week throughout the experimental period. The increase in thoracic circumference between the group means per week was considered insignificant. The increase in AC between group means per week was considered significant which showed that the groundnut affects the AC. The body mass index of all the groups for 8 weeks was at the normal range but the 8th week of group 3 (0.618 g/cm^2) and 4 (0.626 g/cm^2), and 7th week of group 4 (0.624g/cm^2) were on the high side of the average reference range; male (0.45 – 0.68 g/cm^2), female (0.4504–0.5044 g/cm^2) (Rabiu *et al*., 2017). The average BMI of the male and female was (0.4502 – 0.5922). This study is suggesting that consumption of groundnut milk has no obesity-causing potential within the study period (weaning to the 7th week). These results conform to a work done by Joan *et al.* (2010) who concluded that nut consumption improves blood lipid levels in a dose-related manner, particularly among subjects with higher low-density lipoprotein cholesterol or with lower BMI.

Lipid profile

This result is consistent with several literatures that reported the effect of nuts and groundnut on lipid profile improvement (Phoebe *et al*., 2007; Kris-Etherton *et al*., 1999). The current study showed a significant decrease in total cholesterol, triacylglycerol, and LDL-cholesterol levels in the rats administered the groundnut milk, possibly due to its high monounsaturated fatty acid (Regiane *et al*., 2008). Oleic acid as the predominant monounsaturated fatty acid exerts antihypertensive effects, prevents LDL oxidation, reduces platelet aggregation, and enhances fibrinolysis, thereby reducing the risk of cardiovascular diseases (Hasina *et al*., 2015). Some bioactive compounds in groundnut inhibit the absorption of dietary cholesterol (Hu *et al*., 1998; Awad*et al*., 2000), resveratrol, a polyphenol phytoalexin of groundnut decreases serum total cholesterol and triglyceride levels (Zhu *et al*., 2008). The fiber content of groundnut also reduces total and LDL-cholesterol levels and reduces insulin resistance (Kirkmeyer and Mattes, 2000). Elevated LDL-cholesterol is thought to be the best indicator of atherosclerosis risk (Amit *et al*., 2011). The observed dose-dependent decrease in LDL-cholesterol could be due to vitamin E in groundnut as reported by Kris-Etherton*et al.* (1999). Regular consumption of small amounts of groundnut contributes daily requirement for Mg^{+2} and dietary Mg^{+2} decreases serum cholesterol and triglycerides levels (Altura *et al*., 1990). Low serum Mg^{+2} concentrations can reduce lipoprotein lipase and lecithin -cholesterol acyltransferase (LCAT) activity which results in hyperlipidemia (Zhu *et al*., 2008). However, HDL-cholesterol showed no significant difference between the groups. Groundnut milk intake could be used therapeutically to reduce blood total cholesterol, LDL-cholesterol, and triglyceride and thus prevent or manage atherosclerosis and diabetes mellitus. A high content of mg^{2+} and other active components may result in the lipid-lowering effect of groundnut (Hasina *et al*., 2015).

Atherogenic indices are one of the powerful indicators of the risk of heart disease, the higher the value, the higher the risk of developing cardiovascular disease and *vice versa* (Okafor *et al*.,2015). In this study, it was observed that groundnut milk reduced atherogenic indices, there was a slight decrease in the atherogenic coefficient and cardiac risk ratio indices of the rat administered with the groundnut milk when compared to the control, but it was not significantly different among the groups. The atherogenic index of plasma of only group 4 decreased significantly when compared to the control. A lower atherogenic index is an indication of potential protection against coronary heart disease (Usoro *et al*., 2006).

Leptin and adiponectin

The study showed no significant change in serum adiponectin levels compared to the control group. Adiponectin is a peptide hormone that diminishes the concentration of blood fatty acids and level of triglycerides (Nam *et al*., 2014), Liver and muscle insulin sensitivity is known to be increased by adiponectin thereby regulating peripheral glucose and fatty acid metabolism (Leticia *et al*., 2019). Maeda *et al*. (2002) reported that a deficiency of adiponectin in mice induces insulin resistance, whereas over-expression of adiponectin in mice improves insulin sensitivity and glucose tolerance. Barnea *et al*. (2008) reported that adiponectin decreased in mice fed with high-fat diets, therefore the high-fat content of the groundnut milk does not affect the serum adiponectin levels. This also further explains the significant decrease of triglyceride, LDL-cholesterol and no significant change in HDL-cholesterol levels, Izadi *et al*. (2003) also reported that adiponectin prevents dyslipidemia and has an inverse relationship with the concentration of LDL-cholesterol, TC, and TG levels and also a positive relationship between circulating adiponectin and HDL-cholesterol levels.

According to this study, groundnut milk was found to affect the serum leptin level, leptin level increases significantly when compared to the control group, and the increase was dose-dependent. Circulating leptin serves to communicate the state of body energy repletion to the central nervous system (CNS) to suppress food intake and permit energy expenditure (Martin *et al*., 2008b). The administration of leptin in humans and mice induces the reduction of excessive eating and obesity (Cowley *et al*., 2001).

Total protein and Albumin

Protein is a nutrient that the body needs to grow and maintain itself (Janice, 2019). According to this study, groundnut milk has does not affect the serum total protein and serum albumin; when groups 2, 3, and 4 were compared to the control group there was no significant difference statistically. This may be as a result of the processing of the groundnut which reduces the protein content by 59.3%. Abnormally elevated protein concentration (Hyperproteinemia) is a high-mortality, metabolic complication associated with severe liver and kidney disease, which includes cirrhosis, multiple myeloma, angiosarcomatosis, metabolic acidosis and nephropathy (Xue-Dong *et al*., 2018). While hypoproteinemia has several causes that all result to oedema by reducing osmotic pressure of the blood, leading to loss of fluid from the intravascular compartment, or the blood vessel, to the interstitial tissue (Semrad, 2012).

Blood glucose

The finding in this study showed a significant decrease in blood glucose levels in the rats administered with groundnut milk as week's progresses when compared within the group per week except for the control (group 1). When the blood glucose levels were compared between the groups per week there was a significant decrease. The high satiety effects of nuts lead to their decreased food intake and subsequently blood glucose level. Generally, nuts have a low Glycemic index and groundnut with a glycemic index of 14, has one of the lowest glycemic index of all nuts (Jennette, 2005). Fibers and proteins in groundnut milk cause sugars to be released more slowly by slowing the process of digestion (Khan *et al*., 2017). Diabetes mellitus disorder is usually associated with hyperglycemia (Alhassan *et al.,* 2012), and it could play a vital role in lowering blood glucose.

Heart, liver, and kidney to body weight ratio

The study also showed no significant increase in heart to body weight ratio of groups 2 and 4 when compared to the control group, while group 3 shows a significance difference when compared to the control group. Comparison between groups 3 and 2, groups 3 and 4 showed significant differences. Therefore, this study is suggesting that a monitored dose of groundnut milk is needed to overcome heart weight increase. The liver and kidney to body weight ratios showed no significant difference when compared to their various control groups. Groundnut milk does not affect liver and kidney weight but affects heart weight.

Food and water consumption

The mean weekly food consumption showed a significant increase in food consumption of all the groups when compared within the group per week probably due to body development and growth phase, but the control group ate more than groups 2, 3, and 4 as the result showed a significant decrease when compared between groups per week. The food quantity consumed was found to be inversely dose-dependent. The serum leptin level increase could decrease the food intake through the upregulation of neuropeptides such as α-melanocyte-stimulating hormone, which is known to be anorexigenic (Facey *et al*., 2017).

The mean weekly water consumption shows a significant increase in water intake of the control when compared within the group per week, while a significant decrease was found in groups 2, 3 and 4 when compared within the group per week as the week progressed. The result showed a significant decrease when compared between groups per week. Water intake decreased also as the dosage increased. This could be as a result of the water content (moisture content) of the milk of 61.6%

CONCLUSION

Findings from this study showed that the decrease in protein, carbohydrate, fat, and fiber composition of the raw groundnut does not invalidate its energy-giving property when compared to the cow milk fat and carbohydrate property. The anthropometric parameters showed no obesity-causing potential. Serum triglycerides, LDL-cholesterol, and total cholesterol decreased, but no effect on HDL-cholesterol and TC/HDL cholesterol ratio. There were no effects on serum adiponectin levels which further explains its positive relationship with HDL-cholesterol. The high serum leptin levels which are known to suppress food intake, lead to lower food intake of the treated groups. The high satiety effect of groundnut, decreased food intake so also blood glucose levels. There was no effect on liver and kidney weight. The decrease in water intake was a result high moisture content of the groundnut milk. Therefore, groundnut milk could play a positive role nutritionally, as it improves serum lipid profile, serum leptin concentration, and blood glucose concentration, hence consumption of groundnut milk should be encouraged.

AUTHORS' CONTRIBUTIONS

Author The author Adamu J. Alhassan conceptualized and designed the study. Author Muazu G. Aliyu carried out the formal analysis, drafted and revised the manuscript. Data analysis was done by author Kamaluddeen Babagana. Investigation was by author Abba Babandi and Methodology was by Abbas sani and Abdullahi M. Umar. All the authors read through the final version and gave approval for its publication.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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