Nutrición Hospitalaria

SENPE

Efecto del consumo de galletas a base de harina de anacardo (Anacardium occidentale l.) en niños con sobrepeso: un ensayo clínico piloto aleatorizado

Effect of the consumption of cashew nut (Anacardium occidentale l.) flour-based biscuits in overweight children: a pilot randomized clinical trial

10.20960/nh.05241

12/13/2024

OR 5241

Effect of the consumption of cashew nut (*Anacardium occidentale l.*) flour-based biscuits in overweight children: a pilot randomized clinical trial

*Efecto del consumo de galletas a base de harina de anacardo (*Anacardium occidentale l.*) en niños con sobrepeso: un ensayo clínico piloto aleatorizado*

Letícia Bezerra Brito[1], Brenna Oliveira Leal[2], Janaína Ribeiro da Silva[2], Kelly Maria Pereira Barbosa[2], Vinícius Teixeira da Silva[2], Andressa Silva Costa[3], Yroan Paula Landim[4], Lívia Maia Pascoal[2], Marcelino Santos Neto[5], Ana Lúcia Fernandes Pereira[6], Virgínia Kelly Gonçalves Abreu[6], Virlane Kelly Lima Hunaldo[6], José de Ribamar Macedo Costa[7], Ana Cristina Pereira de Jesus Costa[2], Márcio Flávio Moura de Araújo[8]

[1]Neonatal and Pediatric Intensive Care; [2]Nursing; [3]Health and Technology; [4]Primary Health Care; [5]Public Health Nursing; [6]Food Science and Technology; [7]Physical Chemistry. Universidade Federal do Maranhão. Imperatriz, Maranhão. Brazil. [8]Nursing. Oswaldo Cruz Foundation. Eusébio, Ceará. Brazil

Received: 25/03/2024
Accepted: 06/10/2024

Correspondence: Letícia Bezerra Brito. Neonatal and Pediatric Intensive Care. Universidade Federal do Maranhão. Avenida da Universidade, s/*n*. Residencial Dom Afonso Felipe Gregory. Imperatriz CEP: 65915-060, Maranhão. Brazil
e-mail: brito.leticia@discente.ufma.br

Acknowledgments: this study was funded by the Foundation for Research and Scientific and Technological Development of Maranhão *and the Coordination for the Improvement of Higher Education Personnel (CAPES, Brazil) under process code 001.*

Conflicts of interest: the authors declare that they have no conflict of interest.

Artificial intelligence: the authors declare not to have used artificial intelligence (AI) or any tool that uses AI to write the article.

ABSTRACT

Background: cashew nut is an almond known for its cardiovascular benefits in adults and weight gain effects in malnourished children, as supported by research. However, its impact on overweight children remains unexplored.

Objective: to analyze the effect of consuming biscuits made with cashew nut flour on the blood glucose and serum triglyceride levels of children with overweight/obesity over four weeks.

Methods: a pilot, randomized, open-label clinical study was conducted with 19 overweight children (11 in intervention group 1 [G1] and 8 in group 2 [G2], aged between 7 and 15 years. Over four consecutive weeks, they consumed, daily, three biscuits with 50 % cashew nut flour composition (G1) and six biscuits with 50 % cashew nut flour composition (G2). The biomarkers analyzed were glycated hemoglobin (HbA1c), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and total cholesterol (TC) at baseline and seven days post-biscuit consumption.

Results: post-experiment, the TG (p = 0.153), HDL-C (p = 0.895), and TC (p = 0.122) biomarkers showed no significant changes. LDL-C levels experienced a slight but statistically significant increase of 0.52 % across all participants (p = 0.031). In contrast, non-HDL cholesterol levels saw a minor yet significant reduction of -1.7 % in serum concentration ($p = 0.014$). Independent of group allocation, the participants' HbA1c and average blood glucose levels significantly decreased by 12.1 % ($p < 0.001$) and 17.9 % ($p < 0.001$), respectively (Cohen’s Δ = 1, in both instances).

Conclusion: consumption of biscuits containing cashew nut flour by overweight/obese children positively affected the reduction of blood glucose and non-HDL cholesterol biomarkers in both groups, regardless of the formulations used.

Keywords: Overweight. *Anacardium*. Nutritional supplements. Child. Clinical trial.

RESUMEN

Antecedentes: el anacardo es un fruto seco conocido por sus beneficios cardiovasculares en los adultos y sus efectos de aumento de peso en los niños desnutridos, según lo respaldan las investigaciones. Sin embargo, su impacto en los niños con sobrepeso sigue sin explorarse.

Objetivo: analizar el efecto del consumo de galletas elaboradas con harina de anacardo sobre los niveles de glucosa en sangre y triglicéridos séricos de niños con sobrepeso/obesidad durante cuatro semanas.

Métodos: se realizó un estudio clínico piloto, aleatorizado y abierto con 19 niños con sobrepeso (11 en el grupo de intervención 1 [G1] y 8 en el grupo 2 [G2], con edades entre 7 y 15 años. Durante cuatro semanas consecutivas, consumieron diariamente tres galletas con composición de harina de anacardo al 50 % (G1) y seis galletas con composición de harina de anacardo 50 % (G2). Los biomarcadores analizados fueron: hemoglobina glicosilada (HbA1c), triglicéridos (TG), colesterol de lipoproteínas de baja densidad (LDL- C), colesterol de lipoproteínas de alta densidad (HDL-C) y colesterol total (CT) al inicio y siete días después del consumo de las galletas.

Resultados: tras el experimento, los biomarcadores TG (p = 0,153), HDL-C (p = 0,895) y TC (p = 0,122) no mostraron cambios significativos. Los niveles de LDL-C experimentaron un aumento ligero, pero estadísticamente significativo del 0,52 % en todos los participantes (p = 0,031). Por el contrario, los niveles de colesterol no HDL experimentaron una reducción menor pero significativa del -1,7 % en la concentración sérica (p = 0,014). Independientemente de la asignación de grupo, los niveles promedio de HbA1c y glucosa en sangre de los participantes disminuyeron significativamente en un 12,1 % (p < 0,001) y un 17,9 % (p < 0,001), respectivamente (Δ de Cohen = 1 en ambos casos).

Conclusiones: el consumo de galletas que contienen harina de anacardo por parte de niños con sobrepeso/obesidad afectó positivamente a la reducción de los biomarcadores de glucosa en sangre y colesterol no HDL en ambos grupos, independientemente de las formulaciones utilizadas.

Palabras clave: Sobrepeso. Anacardo. Suplementos nutricionales. Niño. Ensayo clínico.

INTRODUCTION

The prevalence of overweight among children aged 5 to 19 years escalated from 4 % to 18 % between the years 1975 and 2016, amounting to 124 million individuals within this age group classified as overweight and/or obese (1). In Brazil, over three decades (1990, 2000, 2010), the prevalence of pediatric overweight/obesity has seen a significant rise (1990: 6.5 %; 2000: 8.4 %; 2010: 12.0 %). An epidemiological study highlighted a considerable prevalence in the Northeast region (9.67 %), only surpassed by the South (11.52 %) and Southeast (10.41 %) regions, thus emphasizing that excess weight is not solely linked to more developed urban centers (2,3).

In the school environment, children are exposed to a myriad of dietary stimuli, both through interaction with peers from diverse socio-economic backgrounds and the composition and quality of the school meals. The habitual offer and consumption of nutritionally deficient, carbohydrate-rich school snacks may contribute to pediatric obesity, accounting for 12 to 13 % of their daily energy intake, the physiological and metabolic effects of which appear to provide a justification for the observed increase in body weight during this phase (4). Furthermore, an appropriate dietary approach in this setting could foster healthy eating behaviors.

The composition of school meals has also evolved, featuring foods high in carbohydrates and sugars, a concerning development since this consumption pattern has been associated with a range of metabolic harms, including systemic arterial hypertension (SAH), type 2 diabetes mellitus (DM2), fatty liver disease, obstructive sleep apnea syndrome, chronic inflammation, and psychological issues (5,6). In this context, focusing on the substitution/addition of foods and nutrients that aid in weight reduction represents a potentially more suitable nutritional intervention strategy in this population (7-9).

However, the relationship between the consumption of nutraceutical products and body weight in children remains unclear. There is evidence that dietary intake of cashew nuts (*Anacardium occidentale* L.), an oleaginous seed with high protein and lipid content, can serve as an energy source and reduce the risk of developing SAH and stroke (10-12). Research findings have shown that cashew nuts have effects on serum levels of high-density lipoprotein (HDL) (13,14).

The mechanisms by which cashew nut intake may exert beneficial effects on metabolic health are numerous but may include the high levels of proteins and fibers, which are associated with reduced appetite, increased satiety, and consequently, weight reduction (14-17). However, these effects have not been studied using products containing cashew nut flour nor specifically in children. Therefore, the aim of this study was to investigate the effect of consuming biscuits containing cashew nut flour on children aged 7 to 15 years with overweight/obesity in terms of blood glucose and triglyceride regulation. Our hypothesis is that the consumption of biscuits containing cashew nut flour during school snack times would reduce subjective appetite to a greater extent than the conventionally offered ultra-processed snacks, thereby being more effective in lowering glycemic and triglyceride levels.

MATERIALS AND METHODS

Study design

We conducted an open-label, randomized clinical trial with repeated measures before and after intervention. Participating children engaged in a 4-week study, during which they consumed biscuits containing cashew nut flour and other healthful ingredients, such as brown sugar, rice flour, and palm fat.

Participants

Children aged 7 to 15 years, assessed as overweight/obese according to international standards for measuring body mass index (BMI), were recruited from a public school in Imperatriz, Maranhão, Brazil (18). The study adhered to the Brazilian Registry of Clinical Trials and all ethical components were reviewed and approved by the Research Ethics Committee of the Federal University of Maranhão. Children were excluded if they had a history of cashew nut allergy, had started a nutritional intervention for overweight/obesity, or had a diagnosis of severe neurodevelopmental disorders.

Children meeting the inclusion criteria provided written consent, and their parents provided written authorization for participation in the study. Biomarkers including TG, HDL-C, LDL-C, CT, and HbA1c were obtained using a blood sample equivalent to 9 ml, divided into a 4 ml tube with ethylenediaminetetraacetic acid (EDTA) (purple tube) serving as an anticoagulant, and 5 ml of blood in a non-anticoagulant tube with separator gel (rede tube).

This is the first experiment assessing the effect of cashew nut flour-containing biscuit consumption in overweight/obese children, making it impossible to use data from similar studies to detect a percentage difference in post-intervention biomarkers and the minimum number of participants.

Protocol

The experiment was conducted in a municipal public school, consisting of 30 consecutive daily sessions over 4 weeks. After a 12-hour overnight fast, children had blood samples collected at the school, before and seven days after the intervention ended. Upon arrival, the children's parents filled out an initial questionnaire to provide socioeconomic information and ensure adherence to the study protocol in the 12 hours preceding the blood collection. Children were assigned a sequence number to consume varying amounts of cashew nut flour-containing biscuits on each study session day. The biscuit consumption timing was designed to replicate the natural school snack time.

Cashew nut-flour biscuits

The biscuits used in this experiment consisted of cashew nut flour (32 g), rice flour (32 g), brown sugar (14 g), palm fat (15 g), and other ingredients. The biscuits were produced in the food engineering laboratories of the Federal University of Maranhão, where they underwent physicochemical and microbiological analysis before being distributed for consumption during the intervention. Children were invited to consume the biscuits during school snack time, within the class break.

Two different intervention protocols were applied for biscuit consumption. In Intervention Group 1 (GI 1), children followed intervention protocol 1, receiving three biscuits containing 50 %

cashew nut flour in composition in replacement of rice flour for 30 days. After the intervention ended, a seven-day break was observed before post-protocol 1 reassessment. In Intervention Group 2 (GI 2), children followed intervention protocol 2, receiving six biscuits with 50% cashew nut flour in composition also replacing rice flour for 30 days. After the intervention ended, a seven-day break was observed for post-protocol 2 reassessment.

Measurements

Blood samples for biomarker measurements were collected using commercial kits from Labtest Diagnóstica S/A® with standardized techniques based on enzymatic and colorimetric methods through spectrophotometry according to the manufacturer's recommendations. Concentrations were determined using an automatic biochemical analyzer, while LDL-C determinations were calculated using the Friedewald formula (19).

A blood sample equivalent to 9 ml was collected from each child, divided into a 4 ml tube with EDTA, serving as an anticoagulant, and 5 ml of blood in a non-anticoagulant tube with separator gel. The tubes with blood samples were labeled with the child's name and identification number, collection date, and stored in a properly sealed styrofoam box, immediately transported to the clinical analysis laboratory on the same day. Biomarker measurements of HbA1c, CT, TG, HDL-C, and LDL-C were taken at the beginning of the study (before the experiment) and seven days after the experiment.

Statistical analysis

The Statistical Package for Social Sciences (SPSS), Chicago, version 11.5 for Windows, using a p-value ≤ 0.05 as significant, was utilized for all statistical analyses with data reported as means, standard deviation. To determine the effect of the biscuits, comparison analyses between groups were performed using the Student's t-test for paired samples, the Wilcoxon test for combined group analysis, and the Mann-Whitney test for within-group comparison.

RESULTS

A total of 19 children completed this study. It can be seen that the Intervention Group 1 (GI 1) and Intervention Group 2 (GI 2) were homogeneous regarding the sociodemographic variables under study. The majority of participants were male (GI 1 = 6 and GI 2 = 7), mixed race (GI 1 = 6 and GI 2 = 5) and had an income above two minimum wages (GI 1 = 6 and GI 2 = 5). Concerning age, participants in Intervention Group 2 (GI 2) were older compared to those in Intervention Group 1 (GI 1) (mean = 11.0 and 12.9 years; median = 12.0 and 13.0 years; standard deviation = 2.05 and 2.02 years, respectively) ($p = 0.027$).

Children in both groups exhibited homogeneity regarding the nutritional and/or metabolic biomarkers under study prior to the initiation of the research. It is also important to highlight the presence of hypertriglyceridemia and hyperglycemia observed at this baseline stage in both groups (Table I).

From the perspective of the selected glycemic and lipid biomarkers, at the end of the intervention, both Intervention Group 1 (GI 1) and Intervention Group 2 (GI 2) did not exhibit statistically significant differences or magnitude in their values (Table II).

The biomarkers for triglycerides, HDL, and total cholesterol did not undergo significant changes throughout the experiment (Table III).

Within the lipid profile, it's noteworthy that LDL-cholesterol levels exhibited a slight but statistically significant increase of 0.52 % (Wilcoxon signed-rank test, $p = 0.031$) across all participants in the sample. Conversely, for the non-HDL-cholesterol biomarker, an opposite trend was observed: a minor yet significant decrease of -1.7 % in serum concentration (Wilcoxon signed-rank test, $p = 0.014$) (Fig. 1 and 2).

HbA1c and the estimated average glucose (EAG) of the experiment participants significantly decreased by 12.1 % ($p < 0.001$) and 17.9 % ($p < 0.001$), respectively, with a Cohen's delta (Δ) of 1 in both instances, regardless of the allocation group (Fig. 3 and 4).

DISCUSSION

The principal finding of this study was that the consumption of biscuits containing cashew nut flour for 30 days resulted in beneficial effects on the glycemic and lipid profile of overweight children. It's noteworthy that there are no similar studies in the literature regarding the use of food products with this flour in this audience, making this the first randomized clinical trial to analyze such an effect.

In this research, participants exhibited baseline average GME values indicating a predisposition to diabetes, which, after the experiment, showed a significant reduction in both average GME and HbA1C values in both groups. These results align with the fact that the chemical and nutritional composition of cashew nuts has a low amount of available carbohydrates, meaning it does not significantly contribute to postprandial blood glucose. Furthermore, it is a source of dietary fiber, capable of increasing the viscosity of intestinal content and delaying nutrient absorption in the gastrointestinal tract, thereby prolonging the sensation of satiety (15,16).

Research reports demonstrate that the dietary fiber present in cashew nuts appears to be resistant to digestion by enzymes in the small intestine, becoming susceptible to fermentation by bacteria in the colon with consequent production of short-chain fatty acids (SCFAs). SCFAs have been shown to reduce hepatic glucose production and stimulate the secretion of the incretin hormone glucagon-like peptide 1 (GLP-1) (20). GLP-1, along with other incretins, acts as a gastric inhibitory polypeptide (GIP), promoting the proliferation of beta cells and their insulin secretion, thus favoring the maintenance of blood glucose levels (21).

Another study shows that regular consumption of this nut may slow carbohydrate absorption and stimulate incretin secretion, positively impacting glucose homeostasis when consumption is ≥ 5 servings/week (where 1 serving = 15 g) compared to < 1 serving/month was associated with a lower HOMA-IR (22).

Therefore, it is likely that, in addition to these characteristics present in cashew nut flour, the hypoglycemic effect was potentiated in our study by replacing refined sugar with brown sugar in the biscuit formula.

This discovery supports the fact that brown sugar differs from refined sugar in not undergoing refinement processes, such as color removal through activated carbon adsorption, thus maintaining its original color. Accordingly, this sugar has a lower percentage of sucrose and retains micronutrients like potassium, phosphorus, calcium, magnesium and sodium, as well as polyphenols and policosanol, originally present in sugarcane juice, which are important for metabolism and physiological regulatory processes (23).

A study published in the Journal of Obesity & Metabolic Syndrome, after evaluating the effects of high concentrations of white sugar and brown sugar on insulin resistance and body weight in albino rats, showed a significant increase in insulin resistance in both groups, related to high exposure. However, in rats treated with refined sugar, the amount of changes in insulin resistance and body weight was greater compared to rats treated with brown sugar ($p < 0.05$) (24).

The presence of brown sugar polyphenols along with anthocyanins present in rice flour, another ingredient used in the formulation of the research biscuits, may have exerted antioxidant effects on the glycemic indexes of the researched children. Rice flour is produced from the residue called "broken rice," located in the outer layers of the grain (23). Thus, it differs from other flours due to its hypoallergenic properties, easily digestible carbohydrates, low sodium levels, and the vast composition of anthocyanins, mainly cyanidin-3-glucoside and peonidin-3-glucoside (21).

Another report found that anthocyanins possess high antioxidant power, demonstrating effective action in combating oxidative stress in human metabolism, acting preventively in chronic non-degenerative diseases such as diabetes and cardiovascular diseases. Therefore, given its nutraceutical properties, rice flour has been used to replace wheat flour in preparations such as bread, cakes, and biscuits (25).

In this study, the consumption of biscuits containing cashew nut flour also impacted the triglyceridemia of the researched children. Similar results to our study estimated the effects of different nuts consumption on the blood lipid profile of overweight children, with findings indicating a strong association between cashew nut consumption and an increase in HDL-cholesterol (26).

A clinical trial conducted at the Beltsville Human Nutrition Research Center, Maryland, identified that the consumption of 42 g/day of cashew nuts did not show effects on blood lipids, lipoproteins, nor on central or peripheral blood pressure, these being considered risk factors for cardiovascular diseases (CVD), in healthy adults (27). Also, a systematic review that included four RCTs, evaluated the effect of nut consumption on health and diet quality in children with appropriate weight, found no association between nut supplementation and changes in the lipid profile of these children. However, in both studies, the authors clarify that the scarcity and lack of data consistency limit conclusions about a possible association, as well as the use of multiple nuts in the experiment (28).

The fact that cashew nuts are a source of proteins, carbohydrates, amino acids, mono- and polyunsaturated fatty acids, phytosterols, omega-6, B-complex vitamins, vitamins E and A, iron, zinc, phosphorus, magnesium, selenium, copper, and potassium, reaffirms their nutraceutical properties (29). Thus, they can exert positive effects, directly and indirectly on cells, such as maintaining their normal functions, since fatty acids participate in the process of transferring oxygen to the bloodstream, cell division, and hemoglobin synthesis, and have anti-inflammatory and antioxidant functions (30,31).

Given the vast amount of nutrients in this product used in the biscuit formulation, it's worth noting that previous studies using cashew nut flour in malnourished children and those living with human immunodeficiency virus (HIV) demonstrated positive effects of this use in increasing nutritional status, evidencing improvement in glycated hemoglobin and hematocrit, elevation of HDL-C, and reduction of LDL-C (14,32).

The study's results must be viewed within the limits of its limitations, including the difficulty of ensuring that adherence to the consumption of biscuits containing cashew nut flour was high (≥ 70 %) until the end of the experiment, as it was not possible to monitor the complete intake of the product, as some children saved biscuits to consume after school snack time and also took them home to consume on weekends and holidays.

Furthermore, the interaction between nutrients from the intervention biscuits and food substances from the diet was not investigated. For future investigations, it is important to consider the aspects of bioavailability. A final limitation is that, although overweight children were recruited for this study, the total number of overweight children in the school used in the experiment (n = 19) was relatively low. Thus, it is suggested to conduct more studies with a broader, more representative sample of other socioeconomic realities.

CONCLUSION

In conclusion, the study sample demonstrated that the consumption of biscuits containing cashew nut flour by overweight children and adolescents over a period of four weeks led to a reduction in blood glucose and non-HDL cholesterol levels in both groups. Therefore, such consumption may benefit glycemic parameters and lipid profiles in overweight/obese children.

REFERENCES

1. World Health Organization (WHO). Obesity and overweight; 2021. Available in: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. Ferreira CM, Reis ND, Castro AO, Hofelmann DA, Kodaira K, Silva MY, et al. Prevalence of childhood obesity in Brazil: systematic review and meta-analysis. J Pediatr 2021;97(5):490-9. DOI: 10.1016/j.jped.2020.12.003
3. Brazil. Ministry of Health. Overweight and obesity as public health problems; 2022. Available in: https://www.gov.br/saude/pt-br/assuntos/saude-brasil/eu-quero-ter-peso-saudavel/noticias/2022/sobrepeso-e-obesidade-como-problemas-de-saude-publica
4. Luiggi M, Rey O, Travert M, Griffet J. Overweight and obesity by school socioeconomic composition and adolescent socioeconomic status: a school-based study. BMC Public Health 2021;21(1):1837. DOI: 10.1186/s12889-021-11752-2
5. Freitas AS, Silveira MF, Santana JJF, D'Ângelo MFSV, Haikal DS, Monteiro-Junior RS. New reference parameters for body mass index in children aged six to ten year. Rev Paul Pediatr 2021;39:e2019129. DOI: 10.1590/1984-0462/2021/39/2019129
6. Lee J. Influences of exercise interventions on overweight and obesity in children and adolescents. Public Health Nurs 2021;38(3):502-16. DOI: 10.1111/phn.12862
7. Sutherland ME. Prevalence of overweight and obesity among african american children and adolescents: risk factors, health outcomes, and prevention/intervention strategies. J Racial Ethn Health Disparities 2021;8(5):1281-92. DOI: 10.1007/s40615-020-00890-9
8. Kelley GA, Kelley KS, Pate RR. How many us children and adolescents with overweight and obesity could improve their

percent body fat by exercising?: Meta-analytic based estimates. Child Obes 2021;17(2):144-50. DOI: 10.1089/chi.2020.0245
9. Janicke DM, Mitchell TB, Basch MC, Ding K, Jones LC, Pinto S, et al. Meta-analysis of lifestyle modification interventions addressing overweight and obesity in preschool-age children. J Health Psychol 2021;40(9):631-41. DOI: 10.1037/hea0001104
10. Rico R, Billó M, Salas-Salvadó J. Nutritional composition of raw fresh cashew (Anacardium occidentale L.) kernels from different origin. Food Sci Nutr 2015;4(2):329-38. DOI: 10.1002/fsn3.294
11. Dias CCQ, Mdruga MS, Pintado MME, Almeida GHO, Alves APV, Dantas FA, et al. Cashew nuts (Anacardium occidentale L.) decrease visceral fat, yet augment glucose in dyslipidemic rats. PLoS One 2019;14(12):e0225736. DOI: 10.1371/journal.pone.0225736
12. Caldas APS, Rocha DMUP, Dionísio AP, Hermsdorff HHM, Bressan J. Brazil and cashew nuts intake improve body composition and endothelial health in women at cardiometabolic risk (Brazilian Nuts Study): a randomized controlled trial. Br J Nutr 2022;128(9):1747-57. DOI: 10.1017/s000711452100475x
13. Mohan V, Gayathri R, Jaacks LM, Lakshmipriya N, Anjana RM, Spiegelman D, et al. Cashew nut consumption increases HDL cholesterol and reduces systolic blood pressure in asian indians with type 2 Diabetes: a 12-week randomized controlled trial. J Nutr 2018;148(1):63-9. DOI: 10.1sx093/jn/nxx001
14. Costa ACPJ, Silva MKS, Oliveira SB, Silva LL, Silva AC, Barroso RB, et al. Effects of Cashew Nut (Anacardium occidentale L.) Seed Flour in Moderately Malnourished Children: Randomized Clinical Trial. J Nutr Metab 2020;2020:6980754. DOI: 10.1155/2020/6980754
15. Atazadegan MA, Heidari-Beni M, Entezari MH, Sharifianjazi F, Kelishadi R. Effects of synbiotic supplementation on anthropometric indices and body composition in overweight or obese children and adolescents: a randomized, double-blind,

placebo-controlled clinical trial. World J Clin Pediatr 2023;19(4):356-65. DOI: 10.1007/s12519-022-00664-9
16. Vrech M, Ferruzzi A, Pietrobelli A. Effects of micronutrient and phytochemical supplementation on cardiovascular health in obese and overweight children: a narrative review. Curr Opin Clin Nutr Metab Care 2022;25(6):430-5. DOI: 10.1097/MCO.0000000000000873
17. Khorshidi M, Hazaveh ZS, Alimohammadi-Kamalabadi M, Jamshidi S, Moghaddam OM, Olang B, et al. Effect of omega-3 supplementation on lipid profile in children and adolescents: a systematic review and meta-analysis of randomized clinical trials. Nutr J 2023;22(1):9. DOI: 10.1186/s12937-022-00826-5
18. Alvarado MGG, Garcia LHR, Lopez JAP. Overweight and obesity in children aged 5-11 years in Mexico - Why is necessary an interdisciplinary approach?. Nutr Hosp 2024;41(4):775-80. DOI: 10.20960/nh.04807
19. Cordova CMM, Portal AS, Cordova MM. Fórmulas de Martin, Friedewald e Cordova comparadas com a dosagem direta do LDL-C no sul do Brasil. Bras Patol Med Lab 2020;56(e1342020):1-6. DOI: 10.5935/1676-2444.20200003
20. Pabón-Rivera S, Flores RR, Frei-Jones M. The complete blood count: a practical tool for the pediatrician. Pediatr Rev 2023;44(7):363-82. DOI: 10.1542/pir.2021-005273
21. Nishi SK, Viguiliouk E, Kendall CWC, Jenkins DJA, Hu FB, Sievenpiper JL, et al. Nuts in the prevention and management of type 2 diabetes. Nutrients 2023;15(4):878. DOI: 10.3390/nu15040878
22. Liu X, Li Y, Guasch-Ferré M, Willett W, Drouin-Chartier JP, Bhupathiraju SN, et al. Changes in nut consumption influence long-term weight change in US men and women. BMJ Nutr Prev Health 2019;2(2):90-9. DOI: 10.1136bmjnph-2019-000034

23. Miyamoto K, Yasuda T, Akaho T, Ibusuki R, Shimoshikiryo I, Nishimoto D, et al. Association between brown sugar intake and decreased risk of cancer in the Amami islands region, Japan. Asia Pac J Clin Nutr 2023;32(4):426-33. DOI: 10.6133/apjcn.202312_32(4).0007
24. Shamsi-Goushki A, Mortazavi Z, Mirshekar MA, Behrasi F, Moradi-Kor N, Taghvaeefar R. Effects of high white and brown sugar consumption on serum level of brain-derived neurotrophic factor, insulin resistance, and body weight in albino rats. J Obes Metab Syndr 2020;29(4):320-4. DOI: 10.7570/jomes20037
25. Rigolon TCB, Oliveira IRN, Stringheta P. Natural Dyes: from the diversity of nature to applications and benefits. 1th ed. Minas Gerais: Lacbio; 2021.
26. Haga C, Yokomichi H, Tsuji K, Yamagata Z. Adiposity rebound may be a predictive index of body size for adolescents -Based on retrospective cohort data in a Japanese rural area. Obes Res Clin Pract 2022;16(1):50-5. DOI: 10.1016/j.orcp.2021.12.003
27. Baer DJ, Novotny JA. Consumption of cashew nuts does not influence blood lipids or other markers of cardiovascular disease in humans: a randomized controlled trial. AJNC 2019;109(2):269-75. DOI: 10.1093/ajcn/nqy242
28. Rocha DMUP, Caldas APS, Silva ACS, Brssan J, Hermsdorff HHM. Nut-enriched energy restricted diet has potential to decrease hunger in women at cardiometabolic risk: a randomized controlled trial (Brazilian Nuts Study). Nutr Res 2023;109:35-46. DOI: 10.1016/j.nutres.2022.11.003
29. Djuricic I, Calder PC. Beneficial outcomes of omega-6 and omega-3polyunsaturated fatty acids on human health: An update for 2021. Nutrients 2021;13(7):2421. DOI: 10.3390/nu13072421
30. Machado G, Puton BF, Bertol CD. Nutraceuticals: legal and scientifics aspects. Eletr J Pharmacy 2019;16(E):1-9. DOI: 10.5216/ref.v16i0.47950

31. Olawale P, Olatidoye OP, Shittu T, Awonorin SO, Emanuel D, Ajisegiri E. Nutritional profile, protein quality, and biological value of raw and roasted cashew kernels (Anacardium occidentale) grown in southwest Nigeria. Croat J Food Sci Technol 2020;20(1):11-9. DOI: 10.17508/CJFST.2020.12.1.02
32. Barroso RB, Silva AC, Santos FSS, Costa JRM, Santos LH, Pascoal LM, et al. Hematological parameters of malnourished children after nutritional intervention: a randomized clinical trial. Acta Paul Enferm 2022;35:eAPE0010345. DOI: 10.37689/acta-ape/2022AO0010345

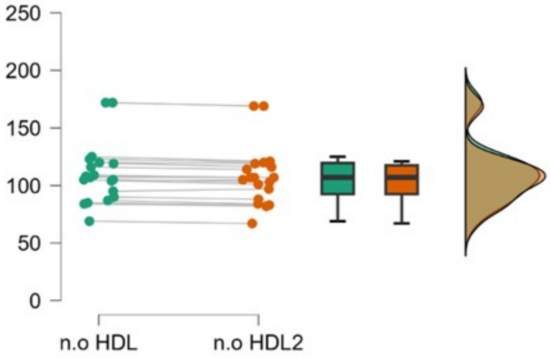

Figure 1. Comparison of non-HDL (mg/dL) values of all experiment participants (*n*.o HDL: non-HDL cholesterol before; *n*.o HDL2: non-HDL cholesterol after).

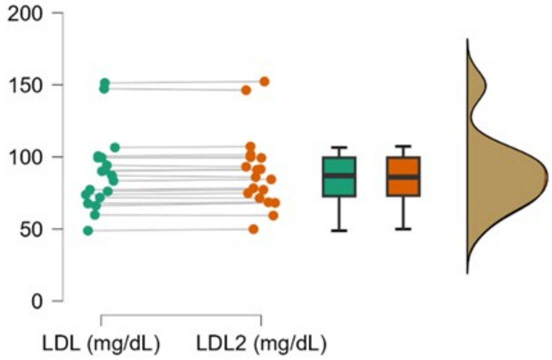

Figure 2. Comparison of LDL (mg/dL) values of all experiment participants (LDL: low-density lipoprotein before; LDL2: low-density lipoprotein after).

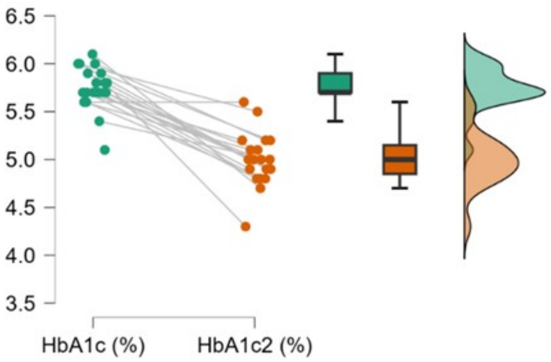

Figure 3. Comparison of HbA1C (%) values before and after nutritional intervention among all participants (HbA1c: glycated hemoglobin before; HbA1c2: glycated hemoglobin after).

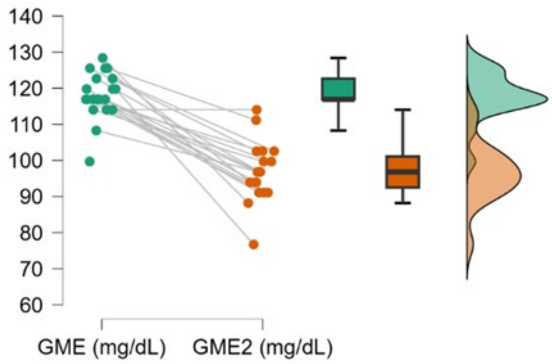

Figure 4. Comparison of GME (mg/dL) values for all experiment participants (GME: estimated average blood glucose before; GME2: estimated average blood glucose after).

Table I. Baseline comparison of experimental groups regarding metabolic and/or nutritional biomarkers

Biomarkers	Group	M	MD	SD	SE	*p*-value*
Glycated hemoglobin (%)	GI 1	5.700	5.700	0.2720	0.0820	0.640
	GI 2	5.780	5.750	0.155	0.0490	
Estimated average glucose (mg/dL)	GI 1	116.890	116.890	7.8072	2.3540	0.640
	GI 2	119.186	118.325	4.446	1.4060	
Triglycerides (mg/dL)	GI 1	115.909	117.000	26.8866	8.1066	0.430
	GI 2	107.818	96.000	51.703	15.5889	
LDL (mg/dL)	GI 1	90.751	77.240	32.4572	9.7862	0.840
	GI 2	86.645	90.390	15.580	5.5084	
Non-HDL	GI 1	111.545	105.000	32.6906	9.8566	0.591
	GI 2	108.500	112.500	16.053	5.6758	
HDL (mg/dL)	GI 1	48.727	48.000	13.6021	4.1012	0.901
	GI 2	48.875	44.500	11.218	3.9661	
Total cholesterol (mg/dL)	GI 1	165.091	177.000	24.1638	7.2857	1.000
	GI 2	167.091	164.000	16.519	4.9808	

*Mann-Whitney test. M: mean; MD: median; SD: standard deviation; SE: standard error.

Table II. Comparison between groups regarding glycemic and lipid metabolism biomarkers after nutritional intervention

Biomarker	**Group**	**N**	**M**	**MD**	**SD**	**SE**	***p*-value***
HbA1c (%) Cohen's Δ = -0.22	GI 1	11	4.97	5.00	0.313	0.0945	0.640
	GI 2	8	5.04	5.00	0.262	0.0925	
Estimated average glucose (mg/dL) Cohen's Δ = -0.22	GI 1	11	96.02	96.80	8.993	2.7114	0.640
	GI 2	8	97.88	96.80	7.506	2.6536	
Total cholesterol (mg/dL) Cohen's Δ = -0.01	GI 1	11	157.36	151.00	28.335	8.5432	0.968
	GI 2	8	156.88	160.50	21.377	7.5580	
HDL (mg/dL) Cohen's Δ = -0.17	GI 1	11	47.45	46.00	14.652	4.4177	0.715
	GI 2	8	49.75	46.00	11.158	3.9449	
LDL (mg/dL) Cohen's Δ = -0.15	GI 1	11	91.24	78.27	32.140	9.6904	0.741
	GI 2	8	87.09	91.28	15.543	5.4952	
Non-HDL Cohen's Δ = 0.13	GI 1	11	109.91	103.00	32.226	9.7164	0.771
	GI 2	8	106.25	110.50	15.545	5.4959	
Triglycerides (mg/dL) Cohen's Δ =	GI 1	11	91.18	93.00	38.345	11.5615	0.698
	GI 2	8	98.0	88.5	35.3	12.48	

0.18	0	0	03	14

*p-value: paired Student's t-test (all variables showed $p > 0.05$ according to the Kolmogorov-Smirnov test); Cohen's Δ: effect size magnitude; M: mean; MD: median; SD: standard deviation; SE: standard error.

Table III. Triglycerides, HDL-cholesterol and total cholesterol biomarkers before and after the experiment

Biomarkers	Time Point	M	MD	SD	SE	*p*-value*
Triglycerides (mg/dL)	Before	94.1	93	36.2	8.31	0.153
	After	105.9	113	38.2	8.76	
HDL (mg/dL)	Before	48.4	46	13.0	2.98	0.895
	After	48.8	46	12.3	2.83	
Total Cholesterol (mg/dL)	Before	157.2	153	25.0	5.73	0.122
	After	163.9	164	21.0	4.81	

*Wilcoxon's test; M: mean; MD: median; SD: standard deviation; SE: standard error.