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Baru nuts reduce abdominal adiposity in type 2 diabetic adults: a randomized, placebo-controlled, crossover trial

Amêndoa de baru reduz a adiposidade abdominal de adultos com diabetes Mellitus tipo 2: um estudo randomizado, placebo-controlado, crossover

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ABSTRACT

Objective
This study aimed to evaluate the effect of baru nuts supplementation on body composition and metabolic profile in adults with type 2 diabetes.

Methods
This is a randomized, placebo-controlled, crossover trial with 30 adults with type 2 diabetes. The assay had two periods of 12 weeks each, with a washout period of 12 weeks between treatments. The subjects were randomized and received the two treatments in alternate periods: supplementation of 30g baru nuts or placebo. Anthropometry, body composition, blood pressure, blood sampling, food intake, and physical activity data were analyzed.

Results
Baru nut intake reduced waist circumference (p=0.032), compared to placebo group. In the intra-group analysis, baru nut intake reduced total cholesterol (p=0.012) and LDL-c (p=0.017).

Conclusion
The daily intake of baru nuts improved abdominal adiposity. Therefore, these nuts should be included in the diet to improve the health status of adults with type 2 diabetes.

Keywords: Body composition. Diabetes Mellitus, Type 2. Dietary modification. Nuts. Obesity managements.

RESUMO

Objetivo

Avaliar o efeito da suplementação com amêndoa de baru sobre a composição corporal e perfil metabólico de adultos com diabetes Mellitus tipo 2.

Métodos

Este é um estudo randomizado, placebo-controlado, crossover com 30 adultos com diabetes Mellitus tipo 2. O ensaio clínico foi dividido em dois períodos de 12 semanas cada, com um washout de 12 semanas entre os tratamentos. Os sujeitos foram randomizados e receberam dois tratamentos em períodos alternativos: suplementação com 30 g de amêndoa de baru ou placebo. Foram coletados dados referentes à antropometria, composição corporal, pressão arterial, amostras de sangue, ingestão de alimentos e práticas de atividade física.

Resultados

A ingestão de amêndoa de baru reduziu a circunferência da cintura (p=0,032), em comparação com o grupo placebo. Na análise intragrupo, a ingestão de amêndoa de baru também reduziu o colesterol total (p=0,012) e LDL-c (p=0,017).

Conclusão

A ingestão diária de amêndoa de baru melhorou a adiposidade abdominal, portanto, deve ser incluída na dieta para a melhora do estado de saúde de adultos com diabetes Mellitus tipo 2.

Palavras-chave: *Composição corporal. Diabetes Mellitus Tipo 2. Intervenção dietética. Nozes. Manejo da obesidade.*

INTRODUCTION

According to the International Diabetes Federation, in 2021, 536.6 million (10.5%) people aged 20-79 were diabetic. This number is estimated to grow to 783.2 million diabetics worldwide by 2045. In 2021, the health care of diabetics generated a cost of 966 billion dollars, 316% more than in 2007. In addition, 6.7 million people in this age group died due to type 2 diabetes *Mellitus* (T2D), which represents 12.2% of all causes of mortality [1]. In this sense, seeking prevention and treatment strategies for this public health problem is necessary.

The T2D is a multifactorial disease. Initially, it was characterized by hyperglycemia caused by insulin resistance in muscle and liver cells, associated with a failure in β-cell insulin production [2]. However, more recent studies have shown that diabetes does not include only dysfunctions in the muscle, liver, and β cells of the pancreas but also in fat cells, the gastrointestinal tract, pancreatic, kidney, and brain cells [2].

The T2D, in general, is caused by unhealthy dietary patterns, sedentary lifestyles, and genetic predisposition [3]. To provide better control of the glycemic profile of diabetic individuals and to reduce the risk of complications in T2D, it is important to control the Body Mass (BM). It is known that abdominal obesity generates a state of inflammation in the body through the production of cytokines and chemokines, which is harmful to several organs, such as the pancreas, kidney, and liver, worsening glycemic control [4,5].

Concerning food intake, a healthy diet and the consumption of foods such as nuts and oilseeds should be encouraged [6]. Baru nuts, an edible native seed from the Cerrado biome, are rich in good-quality proteins, mono and polyunsaturated fats, dietary fibers, and micronutrients, such as zinc [7], which have important effects on glycemic control [2,6,8]. The antioxidant action of phytic acid and other phenolic compounds [9], and a reduction in total cholesterol and LDL-cholesterol [10] can be mentioned among the benefits of this seed already described in the literature.

Given the possible effects of baru nuts on the improvement of clinical and biochemical manifestations of T2D and, to date, no publications evaluating their action on this disease have been found, the objective of this study was to evaluate the effect of baru nut supplementation on the body composition and metabolic profile in adults with T2D.

MATERIALS AND METHODS

This is a randomized, placebo-controlled, crossover trial carried out between August 2017 and June 2018 in Brazabrantes and Santo Antônio de Goiás, cities in the state of Goiás, Brazil. This study was approved by the Research Ethics Committee of the Universidade Federal de Goiás (protocol n° 784.446/2014 and Certificate of Presentation for Ethical Appreciation n° 32847014.2.0000.5083) and registered in the Brazilian Registry of Clinical Trials (Registration Number: RBR-8zmmgm). All participants gave informed consent before participating in the study and signed the Terms of Free and Informed Consent.

The sample size calculation was performed in G*Power 3.1, considering the values of waist circumference (WC) of adult women supplemented with baru nuts [11]. A paired Student's *t*-test and type of power analysis "a priori: compute required sample size – given α, power, and effect size" was performed, which resulted in a required sample of 13 individuals, with a power of 0.80 and effect size of 0.48. However, 37 adults were randomized and 30 were analyzed, with a power of 0.80 and an effect size of 0.31.

In total, 52 adults were recruited, all aged 20-59, with a diagnosis of T2D, attended by the public health service of the cities. The eligibility criteria included (1) adults; (2) not receiving insulin therapy; (3) with no clinical history of cardiovascular disease (heart attacks in the last six months, unstable angina, cardiac arrhythmia, and stroke), cancer, chronic lung disease, musculoskeletal disorders, and neurological deficit; (4) nuts intake < twice a month; (5) not participating in food education and/or a physical exercise programs; (6) individuals not allergic to nuts and/or edible seeds; (7) not pregnant and lactating; and (8) not taking hormone replacement therapy. Adults with some physical or cognitive disability that would compromise the data collection were excluded.

Of the 52 individuals assessed for eligibility, 37 were randomized into two groups (baru nuts group and placebo group), and 30 were analyzed (Figure 1).

Stratified randomization was performed by a volunteer researcher aiming to eliminate potential biases that could confuse the two groups [sex, age, Body Mass Index (BMI), WC, and fasting glucose]. The study was performed in two periods of 12 weeks each. Between the two periods, there was a 12-week washout to eliminate possible carryover effects of the first phase. In the first period of the study, the baru nuts group consumed a daily serving of 30 g of baru nuts with skin, and the placebo group consumed one capsule/day of placebo (containing 300 mg microcrystalline cellulose) for 12 weeks. In the second period, there was an inversion of the treatments. The duration of 12 weeks was considered given that it was a longer intervention compared to other studies that evaluated baru nut supplementation's effects on the health parameters of adults [10,11].

The proportion of baru nuts supplied was determined from a meta-analysis, which showed that the daily intake of 28 g or more of nuts is sufficient to reduce individuals' fasting glycemia [6]. The offered baru nuts were roasted at 140 ºC for 30 minutes [12] to inactivate antinutritional factors [13]. The portions of baru nuts were offered to the patients in packages containing 30 g of the almond, vacuum-packed (the portions were weighed and packed at the Laboratório de Nutrição Experimental / Universidade Federal de Goiás (Experimental Nutrition Laboratory / Federal University of Goiás/Brazil). Every 21 days, meetings were held with the participants to deliver baru nuts or placebo capsules and to assess their consumption during the period.

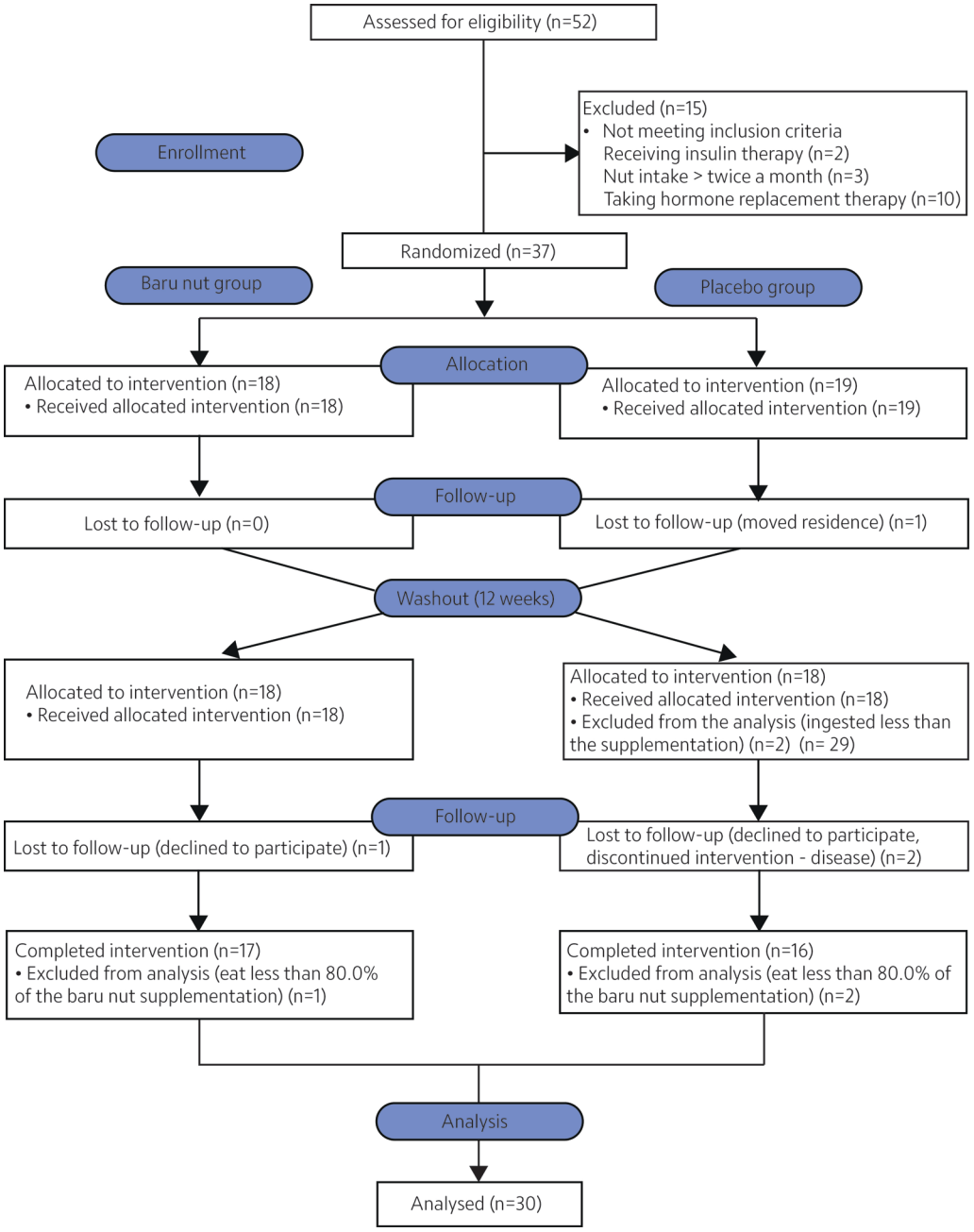

Figure 1 – CONSORT flow diagram of participants throughout the study.

Adherence to supplementation was monitored fortnightly by the researchers. During the intervention period, participants were advised not to modify their eating habits and physical activity. At the beginning and end of each 12-week intervention, a collection of data, including anthropometry, body composition, blood pressure, blood sampling, food intake, and physical activity was performed.

Data on age and sex were collected in a self-administered questionnaire. The BM (kg) was measured in a digital scale (Plenna, São Paulo, Brazil); the height (m) in a portable stadiometer (Sanny, São Paulo, Brazil); the waist circumference with an inextensible tape (Cescorf, Rio Grande do Sul, Brazil) at the midpoint between the lower portion of the last rib and the iliac crest [14]; and

the body composition by a tetrapolar bioimpedance model Quantum II (RJL Systems, Michigan, United States of America).

The metabolic profile was characterized by the biochemical parameters and blood pressure. The systolic blood pressure and diastolic blood pressure were measured in a semiautomatic validated equipment (OMRON brand - HEM 705CP, Kyoto, Japan), following the protocol of the VII Brazilian Hypertension Guidelines of the Brazilian Society of Cardiology [15].

The subjects' blood, in a 12-hour fast, was drawn and analyzed for fasting glucose by enzymatic method (LABTEST® kit, Labmax® Plenno automatic analyzer); fasting insulin by chemiluminescence (Architect i1000 analyzer, Abbott Diagnostics®); total cholesterol and triglycerides by enzyme system (endpoint reaction); HDL per system for direct homogeneous determination (LABTEST® kit, Labmax® Plenno automatic analyzer); and C-Reactive Protein (CRP) (LABTEST® kit, Labmax® Plenno automatic analyzer) by the immunoturbidimetry method. The HOMA-IR was obtained by the equation [fasting glucose (nmol/L) x fasting insulin(μ U/L)]/22.5, and LDL-c was calculated using the Friedewald equation [16,17].

The intake of energy, carbohydrates, proteins, and lipids was estimated using three 24-hour dietary recalls on non-consecutive days, including one during the weekend, estimated in DietBox® software. The physical activity was evaluated through the International Physical Activity Questionnaire – Short Version, computed in continuous scores and expressed in metabolic equivalents (METS) (minutes/week) [18], to monitor consumption and energy expenditure.

The data collection regarding food intake, anthropometry, body composition, blood pressure, and blood sampling occurred at the beginning and end of each of the two 12-week intervention periods.

Data were typed in double entry and analyzed in the R 3.5.2 and RStudio 1.1.463 programs. The discrepant values were excluded, and a Lilliefors test was performed to evaluate the normality of the data. The carryover evaluation was performed for all variables, and the means comparison test was by analysis of variance (factorial ANOVA). For data on anthropometry, body composition, blood pressure, biochemical parameters, food intake, and physical activity (METS), a factorial ANOVA test was performed. In addition, a paired Student's *t*-test was performed to assess whether there were differences between the initial and final time for the two interventions (intra-group). The significance level of 5% was adopted for all tests.

RESULTS

Of the 30 adults who were analyzed, 18 were female and 12 were male. The mean age of participants was 49±7.24 years. The washout time was sufficient since no carryover effect was found between the two periods for all variables, and there were no initial differences between the two groups ($p \geq 0.050$). The 30 g intake of baru nuts resulted in a reduction in WC ($p=0.032$) in the baru nut group when compared to the placebo group, with no difference in blood pressure, glycemic profile, serum lipids, and CRP concentration ($p \geq 0.050$) (Tables 1,2). In the intra-group evaluation, a reduction of total cholesterol ($p=0.012$) and LDL-cholesterol ($p=0.017$) was observed at the end of the baru nuts treatment (Table 2). Energy and macronutrients intake and physical activity, expressed in METS, did not differ between groups during the intervention, identified by factorial ANOVA ($p \geq 0.050$) (Table 2).

Table 1 – Anthropometry, body composition, and blood pressure of participants at baseline and after 12 weeks of treatment with baru nuts and placebo (n=30).

Parameters	Baru almond			Placebo			
	Baseline	12 weeks	p^a	Baseline	12 weeks	p^a	p^b
	M±SE	M±SE		M±SE	M±SE		
Body Mass (kg)	84.68±2.88	84.97±2.87	0.947	85.28±2.78	84.59±2.94	0.787	0.350
Body Mass Index (kg/m^2)	32.78±1.23	32.64±1.18	0.948	33.02±1.19	32.51±1.22	0.822	0.422
Waist Circumference (cm)	106.28±3.15	101.76±2.68	0.328	105.71±2.91	103.77±2.78	0.731	0.032
Fatty Mass (%)	39.30±1.64	40.28±1.50	0.567	40.41±1.56	39.72±1.62	0.936	0.098
Fat Free Mass (%)	60.70±1.64	59.62±1.50	0.567	59.59±1.56	60.28±1.62	0.936	0.098
Systolic Blood Pressure (mmHg)	126.31±2.92	125.16±2.99	0.956	127.43±3.43	121.02±2.51	0.199	0.121
Diastolic Blood Pressure (mmHg)	80.67±1.82	80.50±2.01	0.880	81.98±2.18	79.86±1.62	0.721	0.700

Note: [a]*p*-value for intra-group comparison (paired Student's t-test); [b]*p*-value for comparison between groups (factorial ANOVA). M: Mean; SE: Standard Error.

Table 2 – Biochemical parameters, food intake, and physical activity of participants at baseline and after 12 weeks of treatment with baru nuts and placebo (n=30).

Parameters	Baru nuts			Placebo			
	Baseline	12 weeks	p^a	Baseline	12 weeks	p^a	p^b
	M±SE	M±SE		M±SE	M±SE		
Glucose (mg/dL)	132.29±8.60	130.11±7.25	0.272	135.54±9.13	127.93±7.00	0.223	0.704
Insulin (μU/mL)	14.03±1.21	12.56±0.91	0.783	11.80±1.23	12.56±0.95	0.462	0.965
HOMA-IR	5.48±0.63	4.67±0.44	0.284	4.83±0.61	4.44±0.40	0.902	0.454
Total Cholesterol (mg/dL)	198.03±8.26	174.77±5.51	0.012	193.48±8.30	180.77±8.88	0.199	0.429
HDL cholesterol (mg/dL)	42.10±1.91	42.37±1.98	0.923	42.37±1.94	41.73±1.89	0.816	0.574
LDL cholesterol (mg/dL)	109.29±4.74	96.04±4.48	0.017	106.73±5.57	97.41±5.87	0.145	0.674
Triglycerides (mg/dL)	211.43±23.40	190.83±18.80	0.221	201.57±19.55	201.72±8.48	0.792	0.514
C-Reactive Protein (mg/L)	9.20±1.17	8.77±1.08	0.434	9.24±0.85	8.32±0.86	0.288	0.308
Energy (kcal)	1657.1±151.6	1582.5±105.0	0.875	1713.9±113.8	1607.6±113.2	0.752	0.763
Carbohydrate (g)	203.7±17.7	199.0±13.7	0.926	222.7±14.1	195.5±11.4	0.709	0.695
Protein (g)	80.5±8.7	74.9±5.9	0.875	71.8±4.1	82.7±7.7	0.419	0.209
Lipid (g)	53.9±6.0	56.6±5.3	0.842	56.8±4.7	58.6±6.0	0.948	0.650
Metabolic Equivalents (min/wk)	161.2±44.8	136.0±45.4	0.949	256.1±72.3	177.8±60.0	0.915	0.538

Note: [a]*p*-value for intra-group comparison (paired Student's t-test); [b]*p*-value for comparison between groups (factorial ANOVA). M: Mean; SE: Standard Error.

DISCUSSION

This is the first study that investigated the effect of baru nut supplementation in T2D adults. The present study showed that the daily ingestion of 30 g of baru nuts for 12 weeks reduced abdominal adiposity when compared to the placebo group.

Concerning the reduction of WC, regardless of the type of nut and edible seed, studies have related the ingestion of these foods with the decrease of adiposity in humans. Observational studies, such as cross-sectional research carried out with 34831 European women, observed that individuals with higher nut intake had a BMI of 2.4 kg/m2 and a WC 2.6 cm smaller compared to lower-consumption groups [19]. In addition, a cohort of European countries, which evaluated 14535 people, found that individuals who consumed more than a 30 g portion of nuts per week for five years had a 10% lower BM gain when compared to those who ingested oilseeds with lower frequency [20]. Clinical trials also presented similar results, as a study that offered 50 g of nuts for three months, associated with a hypocaloric diet, and observed a reduction in BMI and WC [21]. Another example is the study with 214 women who ingested 42 g of nuts for a year and observed an 8.2% BM loss, while the group that had a restricted diet lost 6.5% [22].

Several mechanisms have been proposed to justify the effect of nut intake on abdominal adiposity. One of them is associated with the low bioavailability of the nuts' energy content. To access the nutrients of the nuts, the walls of their cells must be broken, which happens in the

mechanical chewing process or enzymatic or microbial degradation. However, studies have revealed that this degradation is not completely efficient, since the cells of the nuts are not totally ruptured, and, consequently, their content is not absorbed but eliminated, which is evidenced by studies that show that, when consuming this food, a 10-15% increase of fat occurs in the fecal content [23-25]. Thus, the metabolizable energy of nuts is 5-21% lower than expected by the Atwater factors, which generically determine the metabolizable energy values from the consumption of carbohydrates, proteins, and lipids from food [26].

Another mechanism is related to satiety after the ingestion of nuts, from the stimulation of secretion of the intestinal hormone glucagon like-peptide 1, cholecystokinin [22], and peptide YY [27]. This effect seems to be induced by the high content of proteins and fats in nuts, and therefore, more satiety may be generated after a meal containing oleaginous foods [27,28]. Yet another mechanism proposed the synergistic effect between nutrients and phytochemicals of nuts that generate satiety, and it is estimated that 55-75% of the energy supplied by this food is offset by a subsequent lower energy intake [25]. Furthermore, the dietary fiber content present in the nuts also generates satiety and reduces energy intake, as it delays gastric emptying and the intestines' transit time [29,30].

Finally, like other nuts, the baru contains polyphenols such as tannins, which reduce oxidative stress, a condition observed in obese individuals and related to excess adiposity, which seems to exert a suppressing effect on energy intake [31,32]. Thus, the significant reduction in individuals' WC in this study can be justified by the synergistic effect of baru nuts' nutrients, directly or indirectly, on food intake and adiposity.

The present study did not find an effect of baru nut supplementation on the glycemic profile. However, the literature has shown a correlation between the reduction of abdominal adiposity and the prevention of T2D, such as the results reported in Chinese cohort studies which observed an association between the incidence of T2D and visceral and central obesity [33,34]. Another cohort study with adults aged 35-79 years in the United States found that the increase in adiposity led to a rise in the diabetes rate in that population in the period between 1988-2014 [35].

The mechanisms by which overweight, especially abdominal adiposity, contributes to the development of T2D seem to be related to the chronic state of low-grade inflammation [36]. The generation of inflammation can occur from high energy intake, which promotes the expansion of adipose tissue, generating adipocyte dysfunction. With this dysfunction, adipocytes release adipokines such as tumor necrosis factor- α (TNF-α), interleukin-6 (IL-6), resistin, leptin, and monocyte chemoattractant protein-1 (MCP-1), which contribute to insulin resistance [36-38].

Therefore, the reduction of WC in subjects who consumed baru nuts in this study may be considered an important factor in attenuating inflammation and insulin resistance, although an effect of baru nut supplementation was not observed on CRP, glucose, insulin, and HOMA-IR. The intervention period and/or the amount of baru nuts offered may not have been enough for an effect on these parameters. Moreover, further studies are needed to evaluate other biomarkers, such as glycated hemoglobin (HbA1c), TNF-α, IL-1, and IL-6, which is a limitation of this study. Another limitation of the study was the non-evaluation of the drugs used by the participants. However, the sample size, the length of intervention, and the study design can be considered a strength of this research.

CONCLUSION

In the present study, baru nut supplementation reduced the abdominal adiposity of adults with T2D without difference in blood pressure and biochemical parameters. Although it did not improve the glycemic profile, its consumption can contribute to a reduced cardiometabolic risk.

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