

ORIGINAL

Collective Health

Editor

Luciana Bertoldi Nucci

Conflict of interest

The authors declare that there is no conflicts of interest.

Received

June 12, 2024

Final version








October 17, 2024

Approved

December 19, 2024

Association between bean consumption and metabolic syndrome in adults: Home Health Survey in Piauí

Associação entre consumo de feijão e a síndrome metabólica em adultos: Inquérito de Saúde Domiciliar no Piauí

Lays Arnaud Rosal Lopes Rodrigues¹ , Bruna Grazielle Mendes Rodrigues¹ , Layanne Cristina de Carvalho Lavôr² , Jany de Moura Crisóstomo¹ , Paulo Víctor de Lima Sousa² , Larisse Monteles de Nascimento¹ , Karoline de Macêdo Gonçalves Frota³ 

¹ Universidade Federal do Piauí, Centro de Ciências da Saúde, Programa de Pós-Graduação em Alimentos e Nutrição. Teresina, PI, Brasil.

² Universidade Federal do Piauí, Curso de Nutrição. Picos, PI, Brasil.

³ Universidade Federal do Piauí, Centro de Ciências da Saúde, Departamento de Nutrição. Teresina, PI, Brasil. Correspondence to: KGM FROTA. E-mail: <karolfrota@ufpi.edu.br>.

Article based on the dissertation by LARL RODRIGUES, entitled "Inquérito de saúde domiciliar no Piauí (ISAD-PI): aspectos metodológicos e o consumo de feijão como fator protetor para doenças crônicas não transmissíveis". Universidade Federal do Piauí; 2022.

How to cite this article: Rodrigues LARL, Rodrigues BGM, Lavôr LCC, Crisóstomo JM, Sousa PVL, Nascimento LM, Frota KMG. Association between bean consumption and metabolic syndrome in adults: Home Health Survey in Piauí. Rev Nutr. 2025;38:e240097. <https://doi.org/10.1590/1678-9865202538e240097>

ABSTRACT

Objective

To verify the association between bean consumption and components of Metabolic Syndrome, as well as with the presence of Metabolic Syndrome diagnosed in adults.

Methods

Cross-sectional, population-based and household study, with data from the Home Health Survey in Piauí. 192 adults, both sexes, from Teresina in the state of Piauí participated. Demographic, socioeconomic and lifestyle data were investigated, using structured questionnaires, and anthropometric, biochemical and blood pressure data. The diagnosis of Metabolic Syndrome was in accordance with the National Cholesterol Education Program Adult Treatment Panel III criteria. The Chi-square test and Poisson regression were used to verify associations. The study was approved by the Research Ethics Committee (Opinion no. 2.552.426).

Results

The prevalence of Metabolic Syndrome was 31.2% (95% CI: 23.5-40.3) and was associated with education, being more predominant in individuals with a lower educational level (36.4%; $p=0.0211$). No associations were observed between Metabolic Syndrome and other demographic, socioeconomic and lifestyle variables. Bean consumption was not associated with Metabolic Syndrome components. However, individuals who consumed more than 110 kcal of beans/day had a prevalence ratio of Metabolic Syndrome 48% lower (PR: 0.52; 95% CI: 0.29-0.91) compared to individuals who consumed less than 55 kcal of beans/day.

Conclusion

There was a high prevalence of Metabolic Syndrome in the population, with a higher proportion of individuals with a lower educational level. The greater share of bean consumption in the diet was inversely associated with the prevalence of Metabolic Syndrome, constituting a protective factor.

Keywords: Adult. Food Consumption. Metabolic syndrome. Minimally processed foods.

RESUMO

Objetivo

Verificar a associação entre o consumo de feijão com componentes da Síndrome Metabólica, bem como com a presença de Síndrome Metabólica diagnosticada em adultos.

Métodos

Estudo transversal, de base populacional e domiciliar, com dados do Inquérito de Saúde Domiciliar no Piauí – ISAD-PI. Participaram 192 adultos, ambos os sexos, de Teresina (PI). Investigou-se dados demográficos, socioeconômicos e de estilo de vida, por meio de questionários estruturados, e dados antropométricos, bioquímicos e de pressão arterial. O diagnóstico de Síndrome Metabólica foi de acordo os critérios do National Cholesterol Education Program Adult Treatment Panel III. O teste do qui-quadrado e a regressão de Poisson foram utilizados para verificar as associações. O estudo foi aprovado pelo Comitê de Ética em Pesquisa (Parecer nº 2.552.426).

Resultados

A prevalência de Síndrome Metabólica foi de 31,2% (IC 95%: 23,5-40,3) e esteve associada à escolaridade, sendo mais predominante em indivíduos com menor nível educacional (36,4%; $p=0.0211$). Não foram observadas associações entre a Síndrome Metabólica com as demais variáveis demográficas, socioeconômicas e de estilo de vida. O consumo de feijão não esteve associado aos componentes da Síndrome Metabólica. Entretanto, os indivíduos que consumiam mais de 110 kcal de feijão/dia apresentaram razão de prevalência de Síndrome Metabólica 48% menor (RP: 0,52; IC 95%:0,29-0,91) comparados aos indivíduos que consumiam menos de 55 kcal de feijão/dia.

Conclusão

Verificou-se elevada prevalência de Síndrome Metabólica na população, com maior proporção em indivíduos de menor nível educacional. A maior participação do consumo de feijão na dieta esteve inversamente associada à prevalência de Síndrome Metabólica, constituindo um fator de proteção.

Palavras-chave: Adulto. Ingestão de alimentos. Síndrome metabólica. Alimentos minimamente processados.

INTRODUCTION

Metabolic Syndrome (MetS) is characterized by the coexistence of metabolic risk factors for type 2 diabetes mellitus and cardiovascular diseases, including insulin resistance, dyslipidemia, central obesity, and hypertension [1,2]. Furthermore, it has shown an increasing prevalence and affects about a quarter of the world's population [3]. In Brazil, data from the 2013 *Pesquisa Nacional de Saúde* (PNS, National Health Survey) revealed a prevalence of 38.4% in the adult population [4].

Weight gain is one of the major risk factors for MetS. Data from the National Health and Nutrition Examination Survey in the United States show that MetS was present in 5% of those with normal weight, 22% of those overweight, and 60% of those with obesity [5]. In this sense, lifestyle modifications, especially related to dietary changes and physical activity, are the main recommended interventions for the management of MetS [1,6].

It has been shown that legume consumption exerts beneficial effects on the prevention and as an adjunct in the treatment of metabolic disorders. In a study with Canadian adults, regular consumption of legumes such as peas, chickpeas, beans, and lentils promoted beneficial changes in risk factors for MetS, such as waist circumference, insulin resistance, glycated hemoglobin, HDL-cholesterol, peptide-C, and fasting insulin [7].

Beans are widely consumed in Brazil [8] and can be highlighted for their nutritional profile, representing an important source of nutrients, especially proteins, dietary fiber, complex carbohydrates, and micronutrients such as vitamins, minerals, and phytochemicals [9,10].

Due to its nutritional characteristics, bean consumption has been attributed to various health benefits, including reduced cardiovascular risk [11], serum cholesterol [12], blood glucose [13,14], serum triglycerides [15], weight [16,17], and waist circumference [18]. Despite this, studies relating to bean consumption and MetS are still scarce. In view of the above, the present study was conducted with the objective of verifying the association between bean consumption and components of MetS, as well as with the presence of diagnosed MetS in adults.

METHODS

The data for this study were obtained from the *Inquérito de Saúde Domiciliar no Piauí* (ISAD-PI, Household Health Survey in Piauí) from 2018–2019 [19], a population-based and household-based cross-sectional study, referring to a representative sample of the municipalities of Teresina and Picos, to analyze the living conditions and health status of the urban population, through visits to private households.

For this investigation, adult individuals of both sexes, residing in the municipality of Teresina in the state of Piauí, with collected data on food consumption and biochemical analyzes were included.

The study sampling plan was carried out by a cluster sampling process, in two stages: Primary Sampling Units (PSU), composed of census sectors, and in the second stage, households, based on the Instituto Brasileiro de Geografia e Estatística (IBGE, The Brazilian Institute of Geography and Statistics) census data for the year 2010 [20].

For the sample size calculation, the population size and the number of private households in Teresina (767,557 inhabitants; 210,093 households) were considered. From this data, the average number of individuals of both sexes per household was calculated in each of the following age groups: children under 2 years old; children aged 3 to 4 years; children aged 5 to 9 years; adolescents aged 10 to 14 years; adolescents aged 15 to 19 years; adults aged 20 to 59 years and the elderly over 60 years. A total of 578 households was then estimated. The final sample size for this study was adjusted using $n = n_0 / 0.90$, assuming a response rate of 90%, resulting in $n \cong 642$ households. All residents of the selected households were invited to participate upon signing the Free and Informed Consent Form.

The overall sampling fraction used in this study was $f = aM_i \sum M_i \times M' i$ where: f = overall sampling fraction; a = total number of PSUs to be selected in the first stage; $M' i$ = number of households in the PSU "i"; M_i = number of households to be drawn from each selected PSU. In this way, all regions of the urban area of the municipality were covered, so that it was possible to have an actual picture of the city of Teresina, considering that all data represent the socioeconomic and health situation of the municipality.

Following the same sampling plan, 50% of the households were selected, forming a subsample for the collection of food consumption data, through the application of 24-hour dietary recalls, as well as for blood analysis. Thus, the number of individuals in the final sample was considered adequate for public health studies, allowing adequate precision, in general, with a Coefficient of Variation (CV) for proportions below 20% [19]. Further details about the sample size and sampling plan of the ISAD-PI have been published in the study by Rodrigues et al. [19].

After the conclusion of the research, the final sample included 497 households in Teresina, and the subsample consisted of 248 households. In the end, data on food consumption and blood tests

were obtained from 365 and 242 adult individuals, respectively. Of these, a total of 192 individuals were included in this study because they had both data collected (Figure 1). In the present study, most estimates had a CV below 20% and, in more than 90% of them, the design effect was less than 1.5, indicating precision in the estimated parameters and that the sampling design was successful [9].

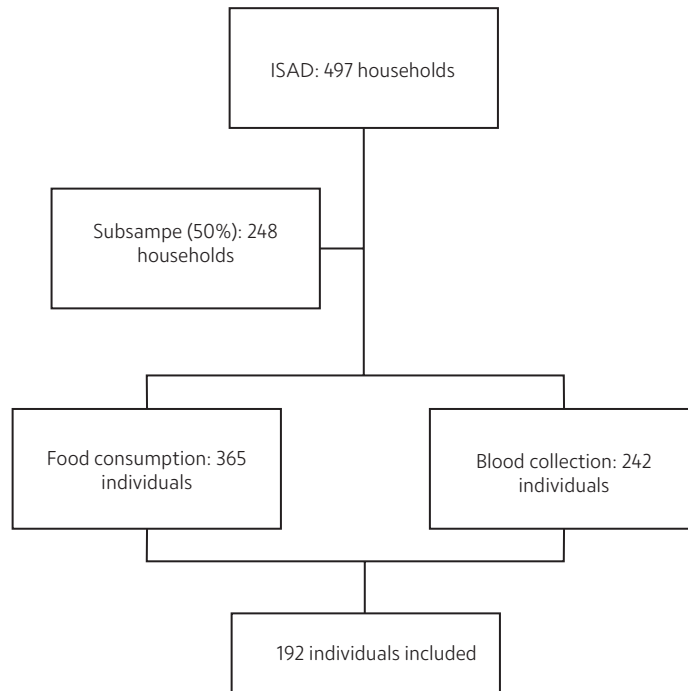


Figure 1 – Flowchart of the ISAD-PI sample. Teresina, Piauí, 2018/2019 (n=192).

Note: ISAD-PI: *Inquérito de Saúde Domiciliar no Piauí* (Household Health Survey in Piauí).

Demographic data (age, sex, skin color, and marital status), socioeconomic (education and income), lifestyle (alcohol consumption, smoking status, and physical activity) and use of medications were collected through the application of structured questionnaires, applied by trained interviewers, using mobile devices, using the Epicollect 5[®] application (Imperial College London) [21]. Anthropometric data (weight, height, and waist circumference), blood pressure, and food consumption data (24-hour dietary recall) were also measured. In addition, blood was collected for biochemical analysis (fasting glucose, triglycerides, and HDL-c - High-Density Lipoprotein).

Weight (kilograms) and height (meters) data were collected according to the recommendations of Cameron [22] and Jelliffe, Jelliffe [23]. Waist circumference – WC (centimeters) was measured according to the World Health Organization – WHO recommendation [24]. Blood pressure was measured using an aneroid sphygmomanometer (Durashock Welch AllynTycos[®], NY, USA, Model DS-44) following the recommendations of the Brazilian Society of Cardiology [25].

Food consumption data were obtained through the application of a 24-hour dietary recall, using the Multiple Pass Method [26]. The household measures reported by the interviewees were transformed into grams (g) or milliliters (mL) using the Table for Assessment of Food Intake in Household Measures, based on the study by Pinheiro et al. [27]. Energy intake was estimated based

on the *Tabela Brasileira de Composição de Alimentos* (TACO, Brazilian Food Composition Table) [28], the *Tabela de Composição Nutricional dos Alimentos Consumidos no Brasil* (TBCA, Table of Nutritional Composition of Foods Consumed in Brazil) [29] and the Food Composition Table – Support to Decision Nutrition [30].

Bean consumption was categorized based on the energy value equivalent to a serving size, defined as one medium shallow ladle, approximately 80g (50% grain and 50% broth) corresponds to approximately 55 kcal [27,28]. The groups were categorized as follows: <55 kcal – less than one medium shallow ladle; 55 to 100 kcal – one to two medium shallow ladles; >110 kcal – two or more medium shallow ladles.

Blood was collected after a 12-hour overnight fast. To obtain the serum, the samples were centrifuged (3000 rpm – 5 minutes) within 4 hours after blood collection, the concentrations of glucose, serum triglycerides, and serum HDL-cholesterol (High-Density Lipoprotein) were quantified using the colorimetric-enzymatic method, using Labtest[®] reagent kits.

For the diagnosis of MetS, the NCEP ATP III criteria (National Cholesterol Education Program Adult Treatment Panel III) [31] were used. It was defined by the combination of at least three of the following criteria: 1) abdominal obesity, defined by waist circumference in men >102 cm and in women >88 cm; 2) serum triglycerides ≥ 150 mg/dL; 3) serum HDL-cholesterol (HDL-c) <40 mg/dL in men and <50 mg/dL in women; 4) Systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg; 5) Fasting glucose ≥ 110 mg/dL.

The study was submitted to the Ethics Committee of the Universidade Federal do Piauí (UFPI, Federal University of Piauí) and approved under opinion number 2.552.426. After clarification, all individuals participated in the research by signing the Free and Informed Consent Form.

For variables with missing values, imputation was performed using the Predictive Mean Matching method, not exceeding 20%.

Imputation for missing data was performed for the following variables analyzed in this study: income, education level, alcohol consumption, and smoking status. Predictor variables included geographic location of the household, sex, age, employment status, and marital status.

All analyzes were performed using the survey module of the Stata version 14 program, which considers the sampling design (equiprobabilistic) in the estimation of the results. The normality of the distribution of the variables was assessed using the Kolmogorov-Smirnov test. A 95% Confidence Interval (95% CI) was assumed, and a p -value <0.05 was considered significant.

The Chi-square test was used to verify the association between the frequency of bean consumption and the explanatory variables in the bivariate analysis. The multiple analysis of the association between MetS and bean consumption was performed using the Prevalence Ratio (PR), obtained through Poisson regression, with robust variance adjustment (95% CI).

The selection of confounding variables was guided by a theoretical model involving exposure, outcome, and confounding variables, designed using Directed Acyclic Graphs (DAGs) in the Dagitty software version 3.2. After the elaboration of the DAG, a minimum set of confounding variables was indicated, established by the backdoor criterion, which were age, sex, education level, income, alcohol consumption, smoking status, physical activity, and medication use [32].

RESULTS

Table 1 presents the characterization of the sample according to demographic, socioeconomic, lifestyle aspects, and prevalence of MetS. It was observed that most of the studied population is female (72.9%), with black, brown, or indigenous skin color (77.1%), studied up to high school or less (68.7%), has no partner (55.7%), has a family income less than or equal to two minimum salaries (75.5%) and works (58.9%). Regarding lifestyle habits, the majority does not consume alcoholic beverages (53.1%), does not smoke (90.6%), and is sufficiently active (94.3%).

Table 1 – Sample distribution and prevalence of metabolic syndrome, according to demographic, socioeconomic and lifestyle characteristics in adults. Teresina/PI, 2018/2019. (n=192).

Bean kcal / day	Total Sample		Has Metabolic Syndrome		Does not have Metabolic Syndrome		p ^a
	n (%)	95% CI*	n (%)	95% CI*	n (%)	95% CI*	
Total			60 (31.2)	23.5-40.3	132 (68.8)	59.7-76.5	
Sex							
Male	52 (27.1)	22.0-32.8	19 (36.5)	22.2-53.7	33 (63.5)	46.3-77.8	0.2788
Female	140 (72.9)	67.2-78.0	41 (29.3)	22.5-37.1	99 (70.7)	62.9-77.5	
Skin color							
White, yellow or other	44 (22.9)	16.7-30.4	14 (31.8)	19.4-47.6	30 (68.2)	58.3-77.8	0.9295
Black, brown or indigenous	148 (77.1)	69.5-83.2	46 (31.1)	22.2-41.7	102 (68.9)	58.3-77.8	
Education							
High school or less	132 (68.7)	58.1-77.7	48 (36.4)	27.0-46.9	84 (63.6)	53.1-73.0	0.0211
Higher education or more	60 (31.3)	22.3-41.8	12 (20.0)	11.6-32.4	48 (80.0)	67.6-88.4	
Marital status							
Has a partner	107 (44.3)	36.8-52.0	39 (36.4)	26.8-47.3	68 (63.6)	52.7-76.5	0.0599
Does not have a partner	85 (55.7)	48.0-63.2	21 (24.7)	15.7-36.6	64 (75.3)	63.4-84.3	
Family income**							
≤2 MS	145 (75.5)	64.2-84.1	49 (33.8)	24.2-44.9	96 (66.2)	55.1-75.8	0.3414
>2 MS	47 (24.5)	15.9-35.8	11 (23.4)	10.9-43.2	36 (76.6)	56.8-89.1	
Working status							
Works	113 (58.9)	53.0-64.5	33 (29.2)	19.2-41.8	80 (70.8)	58.2-80.8	0.3900
Does not work	79 (41.1)	35.5-64.5	27 (34.2)	26.7-42.5	52 (65.8)	57.5-73.3	
Alcohol consumption							
Drinks	90 (46.9)	39.0-55.0	25 (27.8)	18.9-38.9	65 (72.2)	61.1-81.1	0.2663
Does not drink	102 (53.1)	45.0-38.0	35 (34.3)	24.6-45.6	67 (65.7)	54.4-75.4	
Smoking status							
Smokes	18 (9.6)	83.6-94.8	6 (33.3)	13.9-60.7	12 (66.7)	39.3-86.1	0.8527
Does not smoke	174 (9.4)	5.1-16.3	54 (31.0)	23.1-40.3	120 (69.0)	59.7-76.9	
Physical activity							
Sufficient	11 (5.7)	2.9-10.7	1 (9.0)	1.3-43.1	10 (90.9)	56.9-98.7	0.1089
Insufficient	181 (94.3)	89.3-97.0	59 (32.6)	24.2-42.3	122 (67.4)	57.7-75.8	

Note: *Corrected for the sample design; **Reference minimum salary based on the year 2019 (R\$998.00). ^aPearson's Chi-square test. CI: Confidence Interval. MS: Minimum salary.

The prevalence of MetS was found to be 31.2% (95% CI: 23.5-40.3). Moreover, an association with education level was observed, being more prevalent in individuals with lower education (up to high school or less) (36.4%; $p=0.0211$) compared to individuals with higher education (higher education or more) (20.0%).

Table 2 shows the bean consumption data according to demographic, socioeconomic, and lifestyle aspects. No associations were observed in the analyzed variables.

Table 2 – Bean consumption, according to demographic, socioeconomic and lifestyle characteristics, in adults. Teresina/PI, 2018/2019. (n=192).

Bean kcal / day	<55 kcal		55-110 kcal		>110 kcal		p ^a
	n	%	n	%	n	%	
Sex							
Male	32	61.5	10	19.2	10	19.2	0.1305
Female	110	78.6	19	13.6	11	7.8	
Skin color							
White, yellow or other	35	79.6	6	13.6	3	6.8	0.4735
Black, brown or indigenous	107	72.3	23	15.5	18	12.2	
Education							
High school or less	99	75.0	18	13.6	15	11.4	0.7390
Higher education or more	43	71.7	11	18.3	6	10	
Marital Status							
Has a partner	84	78.5	15	14.0	8	7.5	0.2268
Does not have a partner	58	68.2	14	16.5	13	15.3	
Family income^{**}							
≤2 MS	108	74.5	22	15.2	15	10.3	0.8872
>2 MS	34	72.3	7	14.9	6	12.8	
Working status							
Works	59	74.7	11	13.9	9	11.4	0.9098
Does not work	83	73.5	18	15.9	12	10.6	
Alcohol consumption							
Drinks	66	73.3	12	13.3	12	13.3	0.4693
Does not drink	76	74.5	17	16.7	9	8.8	
Smoking status							
Smokes	14	77.8	1	5.6	3	16.7	0.5109
Does not smoke	128	73.6	28	16.1	18	10.3	
Physical activity							
Sufficient	132	72.9	28	15.5	21	11.6	0.4587
Insufficient	10	90.9	1	9.1	0	0.0	

Note: ^{*}Corrected for the sample design; ^{**}Reference minimum salary based on the year 2019 (R\$998.00). ^aPearson's Chi-square test. CI: Confidence Interval; HDL-c: High-Density Lipoprotein Cholesterol; MS: Minimum salary..

Table 3 shows the prevalence ratio of MetS and MetS components according to bean consumption in adult individuals. Bean consumption was not associated with MetS components; however, it was observed that individuals who consumed more than 110 kcal of beans/day had a 48% lower prevalence ratio of MetS (PR: 0.52; 95% CI: 0.29-0.91) compared to individuals who consumed less than 55 kcal of beans/day.

Table 3 – Prevalence ratio of metabolic syndrome and metabolic syndrome components according to bean consumption in adults. Teresina/PI, 2018/2019. (n=192).

Bean kcal / day	Metabolic Syndrome			
	Crude analysis [*]		Adjusted analysis ^{**}	
	PR [95% CI]	p	PR [95% CI]	p
Bean kcal / day				
<55 kcal	1		1	
55-110 kcal	1.08 [0.52-2.26]	0.815	1.05 [0.44-2.50]	0.907
>110 kcal	0.75 [0.29-1.8]	0.532	0.52 [0.29-0.91]	0.024

Table 3 – Prevalence ratio of metabolic syndrome and metabolic syndrome components according to bean consumption in adults. Teresina/PI, 2018/2019. (n=192).

2 of 2

Bean kcal / day	Metabolic Syndrome			
	Crude analysis*		Adjusted analysis**	
	PR [95% CI]	p	PR [95% CI]	p
Abdominal Obesity				
<55 kcal	1		1	
55-110 kcal	1.04 [0.62-1.75]	0.859	1.24 [0.80-1.91]	0.314
>110 kcal	0.67 [0.41-1.10]	0.114	0.77 [0.48-1.23]	0.272
High triglycerides				
<55 kcal	1		1	
55-110 kcal	1.17 [0.78-1.78]	0.418	1.19 [0.77-1.83]	0.401
>110 kcal	1.03 [0.56-1.89]	0.902	0.92 [0.52-1.62]	0.773
Low HDL-c				
<55 kcal	1		1	
55-110 kcal	1.26 [0.95-1.67]	0.098	1.10 [0.86-1.40]	0.417
>110 kcal	1.04 [0.76-1.42]	0.761	0.83 [0.60-1.15]	0.267
High blood pressure				
<55 kcal	1		1	
55-110 kcal	0.98 [62.4-1.53]	0.929	1.04 [0.70-1.56]	0.805
>110 kcal	0.93 [61.4-1.41]	0.727	0.81 [0.60-1.10]	0.179
High fasting blood glucose				
<55 kcal	1		1	
55-110 kcal	2.44 [0.68-8.69]	0.159	0.17 [0.03-8.03]	0.356
>110 kcal	2.25 [0.49-10.29]	0.282	0.93 [0.12-6.9]	0.946

Note: *Poisson regression, crude analysis. **Poisson regression, adjusted analysis for age, sex, education, income, alcohol consumption, smoking status, physical activity, consumption of raw fruits and vegetables and use of medication. CI: Confidence Interval; PR: Prevalence Ratio.

DISCUSSION

The present study showed a high prevalence of MetS in the studied population. Santos et al. [33], similarly to this study, identified a prevalence of 30.9% of MetS in adult individuals from Florianópolis, Santa Catarina. Likewise, a study conducted with individuals from Pará showed a prevalence of 29.9% in adults [34].

Individuals with lower education levels showed a higher prevalence of MetS. This result was also identified in a study conducted with data from the 2013 *Pesquisa Nacional de Saúde* (PNS, Brazilian National Health Survey), in which the prevalence of MetS was almost double in individuals with 0 to 8 years of education, compared to those with more years of education [4]. Similarly, in a study conducted by Ramires et al. [35], the lowest level of education was associated with a higher prevalence of MetS in women.

Education is one of the major determinant factors of an individual's lifestyle, as people with higher levels of education are less likely to have unhealthy lifestyle habits associated with the risk of developing MetS. In addition, educational level is also associated with access to health services [36].

Furthermore, bean consumption was associated with a lower prevalence of MetS in adults. The protective effect of bean consumption on the presence of MetS was also verified by Chang et al. [37], in a 6.5-year longitudinal study conducted in Taiwan, in which it was observed that a bean-free diet was associated with an increased chance of developing MetS by up to 83% in men and 45% in women.

Several studies have shown that bean consumption improves metabolic aspects, such as reduced waist circumference [16,38,39], reduced body fat percentage [38], reduced blood pressure [7,39], and improved postprandial glycemic control [40]. In a randomized crossover study with adults, it was demonstrated that the consumption of brown beans compared to the consumption of white bread provided a significant reduction in glycemia and insulinemia [13].

In the present study, although no associations were observed between bean consumption and the components of MetS individually, an association was observed between bean consumption and the presence of these components when present simultaneously in the diagnosis of MetS. Thus, the protective effect of bean consumption was demonstrated, moreover, it should be considered that the risk of negative health outcomes related to MetS is synergistically greater than the estimate of its factors separately [4].

The protective effect of beans can be explained by their high content of dietary fiber and complex carbohydrates with slow digestion, which delay gastric emptying and, consequently, help reduce the release of postprandial glucose, favoring glycemic control. Beans are also characterized by being a low-energy-density food and having a low-fat content, which can favor weight control. In addition [41], beans are also rich in saponins, substances associated with improved insulin sensitivity and reduced cholesterol concentrations [42,43].

In a randomized crossover clinical trial, Reverri et al. [44], demonstrated that the inclusion of black beans in a typical Western-style meal promotes the attenuation of postprandial insulin and moderately improves the antioxidant capacity of adults with MetS, which may be partially explained by the fiber content and antioxidant properties of beans. A large part of the antioxidant properties of beans comes from its high content of phenolic compounds, whose antioxidant action can contribute to the prevention of oxidative events that can trigger the onset of metabolic complications [10].

Bean consumption can also lead to the production of bioactive peptides through proteolytic hydrolysis during gastrointestinal digestion. Bioactive peptides from beans can promote antioxidant, antithrombotic, and antihypertensive effects. Some of these beneficial effects of bioactive peptides from beans can be explained by the ability of bioactive peptides to inhibit certain enzymes related to the onset of chronic non-communicable diseases, such as dipeptidyl peptidase IV, alpha-amylase, and alpha-glucosidase, associated with type 2 Diabetes Mellitus, as well as the inhibition of the angiotensin-converting enzyme, related to the development of hypertension [10].

Approximately 58.6% of the Brazilian population consumes beans five or more days a week, mostly men and those with lower education levels [45]. However, research on the acquisition of food items for household consumption in Brazil points to a reduction in minimally processed or unprocessed foods, such as beans, to the detriment of increased consumption of ultra-processed foods [46,47].

Thus, a change in the population's dietary consumption profile is perceptible, since Cruz et al. [48], when evaluating the consumption of dietary fiber in the Brazilian population and its relationship with the intake of ultra-processed foods, observed that the highest quintile of consumption of ultra-processed foods was inversely associated with insufficient consumption of fiber, unprocessed or minimally processed foods.

It is known that ultra-processed foods have some particularities in their composition, such as high amounts of sugar, sodium, saturated fat, as well as high caloric content and low or absent content of dietary fiber and micronutrients. This composition, in turn, increases the risk of mortality and development of chronic non-communicable diseases, such as obesity [49-51].

This study presents limitations, as there were losses in the sample size. However, studies evaluating the association between bean consumption in the diet and the presence of MetS are still scarce, as most studies evaluate the consumption of legumes in general or only isolated nutrients and compounds from beans or other health outcomes other than the diagnosis of MetS per se. Thus, the findings of the present study can serve as a basis for the development of more studies on the topic.

CONCLUSION

A high prevalence of MetS was observed in the adult population of Teresina, with a higher proportion in individuals with lower educational levels. Additionally, a higher participation of bean consumption in the diet was inversely associated with the prevalence of MetS, constituting a protective factor for the study population.

Given the scarcity of studies evaluating the effects of bean consumption on the diagnosis of MetS, there is still a need for more research to elucidate the topic, and the present work can serve as a basis for the development of future research.

REFERENCES

1. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. *Lancet*. 2005;365(9468):1415-28.
2. Fahed G, Aoun L, Bou Zerdan MB, Allam S, Zerdan MB, Bouferraa Y, et al. Metabolic syndrome: Updates on pathophysiology and management in 2021. *Int J Mol Sci*. 2022;23(2):786-24.
3. Saklayen MG. The global epidemic of the metabolic syndrome. *Curr Hypertens Rep*. 2018;20(2):1-8.
4. Oliveira LVA, Santos BNS, Machado ÍE, Malta DC, Velasquez-Melendez G, Felisbino-Mendes MS. Prevalência da Síndrome Metabólica e seus componentes na população adulta brasileira. *Cien Saúde Coletiva*. 2020;25:4269-80.
5. Park Y-W, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med*. 2003;163(4):427-36.
6. McGrath L, Fernandez M-L. Plant-based diets and metabolic syndrome: Evaluating the influence of diet quality. *J Agric Food Res*. 2022;9:100322. doi: <https://doi.org/10.1016/j.jafr.2022.100322>
7. Mollard RC, Luhovyy BL, Panahi S, Nunez M, Hanley A, Anderson GH. Regular consumption of pulses for 8 weeks reduces metabolic syndrome risk factors in overweight and obese adults. *Br J Nutr*. 2012;108(S1):S111-S22.
8. Souza AM, Pereira RA, Yokoo EM, Levy RB, Sichieri R. Alimentos mais consumidos no Brasil: Inquérito nacional de alimentação 2008-2009. *Rev Saúde Pública*. 2013;47:190s-9s.
9. Frota K de MG, Soares RAM, Arêas JAG. Composição química do feijão caupi (*Vigna unguiculata* L. Walp), cultivar BRS-Milênio. *Food Sci Technol*. 2008;28:470-6.
10. Los FGB, Zielinski AAF, Wojeicchowski JP, Nogueira A, Demiate IM. Beans (*Phaseolus vulgaris* L.): whole seeds with complex chemical composition. *Curr Opin Food Sci*. 2018;19:63-71.
11. Bazzano LA, He J, Ogden LG, Loria C, Vupputuri S, Myers L, et al. Legume consumption and risk of coronary heart disease in US men and women: NHANES I Epidemiologic Follow-up Study. *Arch Intern Med*. 2001;161(21):2573-8. doi: <https://doi.org/10.1001/archinte.161.21.2573>
12. Winham DM, Hutchins AM, Johnston CS. Pinto bean consumption reduces biomarkers for heart disease risk. *J Am Coll Nutr*. 2007;26(3):243-9.
13. Nilsson A, Johansson E, Ekström L, Björck I. Effects of a brown beans evening meal on metabolic risk markers and appetite regulating hormones at a subsequent standardized breakfast: a randomized cross-over study. *Plos One*. 2013;8(4):e59985.
14. Spadafranca A, Rinelli S, Riva A, Morazzoni P, Magni P, Bertoli S, et al. *Phaseolus vulgaris* extract affects glycometabolic and appetite control in healthy human subjects. *Br J Nutr*. 2013;109(10):1789-95.

15. Olmedilla-Alonso B, Pedrosa MM, Cuadrado C, Brito M, Asensio-S-Manzanera C, Asensio-Vegas C. Composition of two Spanish common dry beans (*Phaseolus vulgaris*), 'Almonga' and 'Curruquilla', and their postprandial effect in type 2 diabetics. *J Sci Food Agric*. 2013;93(5):1076-82.
16. Wang S, Chen L, Yang H, Gu J, Wang J, Ren F. Regular intake of white kidney beans extract (*Phaseolus vulgaris* L.) induces weight loss compared to placebo in obese human subjects. *Food Sci Nutr*. 2020;8(3):1315-24.
17. Udani J, Singh BB. Blocking carbohydrate absorption and weight loss: a clinical trial using a proprietary fractionated white bean extract. *Altern Ther Health Med*. 2007;13(4):32.
18. Celleno L, Tolaini MV, D'Amore A, Perricone NV, Preuss HG. A dietary supplement containing standardized *Phaseolus vulgaris* extract influences body composition of overweight men and women. *Int J Med Sci*. 2007;4(1):45.
19. Rodrigues LARL, Costa e Silva DM, Oliveira EAR, Lavôr LCC, Sousa RR, Carvalho RBN, et al. Sampling plan and methodological aspects: a household healthcare survey in Piauí. *Rev Saúde Pública*. 2021;55:118-31. doi: <https://doi.org/10.11606/s1518-8787.2021055003441>
20. Instituto Brasileiros de Geografia e Estatística. Censo Demográfico 2010: características gerais da população e dos domicílios, resultados do universo. Rio de Janeiro: IBGE; 2010 [cited 2020 Feb 20]. Available from: <https://censo2010.ibge.gov.br/resultados.html>
21. Aanensen DM, Huntley DM, Feil EJ, Al-Own F, Spratt BG. EpiCollect: linking smartphones to web applications for epidemiology, ecology and community data collection. *Plos One*. 2009;4(9):e6968. doi: <https://doi.org/10.1371/journal.pone.0006968>
22. Cameron N. The measurement of human growth. In: Cameron N, Bogin B, editors. *Human growth and development*. Amsterdam: Elsevier. 2022. p. 317-45.
23. Jelliffe DB, Jelliffe EFP. *Anthropometry: major measurements*. Community Nutr Assess. United Kingdom: Oxford University Press; 1989.
24. World Health Organization. *Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation, Geneva, 8-11 December 2008*. Geneva: World Health Organization; 2008.
25. Barroso WKS, Rodrigues CIS, Bortolotto LA, Mota-Gomes MA. Diretrizes Brasileiras de Hipertensão Arterial-2020. *Arq Bras Cardiol*. 2021;116:516-58.
26. Conway JM, Ingwersen LA, Vinyard BT, Moshfegh AJ. Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women. *Am J Clin Nutr*. 2003;77(5):1171-8. doi: <http://doi.org/doi:10.1093/ajcn/77.5.1171>
27. Pinheiro ABV, Lacerda EM A, Benzecry EH, Gomes MCS, Costa VM. *Tabela para avaliação de consumo alimentar em medidas caseiras*. 5th ed. São Paulo: Editora Atheneu; 2005. p.131.
28. *Tabela Brasileira de Composição de Alimentos*. 4th ed. Campinas: Nepa/Unicamp; 2011.
29. Instituto Brasileiro de Geografia e Estatística. *Pesquisa de Orçamentos Familiares (POF) 2008-2009: tabela de composição nutricional dos alimentos consumidos no Brasil*. Rio de Janeiro: IBGE; 2011.
30. Philippi ST. *Tabela de composição de alimentos: suporte para decisão nutricional*. 6th ed. Manole; 2018.
31. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA*. 2001;285(19):2486-97. doi: <https://doi.org/10.1001/jama.285.19.2486>
32. Textor J, Van der Zander B, Gilthorpe MS, Liśkiewicz M, Ellison GTH. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *Int J Epidemiol*. 2016;45(6):1887-94.
33. Santos FAA, Back IDC, Giehl MWC, Fassula AS, Boing AF, González-Chica DA. Nível de atividade física de lazer e sua associação com a prevalência de síndrome metabólica em adultos: estudo de base populacional. *Rev Bras Epidemiol*. 2020;23:e200070. doi: <https://doi.org/10.1590/1980-549720200070>
34. Monte IP, França SL, Vasconcelos RNO, Santos Vieira JR. Comparação entre quatro diferentes critérios de diagnóstico de síndrome metabólica em indivíduos do Arquipélago do Marajó (Pará, Brasil). *Rev Assoc Bras Nutr*. 2019;10(1):96-102.
35. Ramires EKNM, Menezes RCE, Longo-Silva G, Santos TG dos, Marinho PM, Silveira JAC da. Prevalência e fatores associados com a Síndrome Metabólica na população adulta brasileira: pesquisa nacional de saúde-2013. *Arq Bras Cardiol*. 2018;110:455-66.

36. Kim I, Song Y-M, Ko H, Lee E, Shin J-Y, Chang Y, et al. Educational disparities in risk for metabolic syndrome. *Metab Syndr Relat Disord*. 2018;16(8):416-24.
37. Chang W-C, Wahlqvist ML, Chang H-Y, Hsu C-C, Lee M-S. A bean-free diet increases the risk of all-cause mortality among Taiwanese women: the role of the metabolic syndrome. *Public Health Nutr*. 2012;15(4):663-72.
38. Tucker LA. Bean consumption accounts for differences in body fat and waist circumference: a cross-sectional study of 246 women. *J Nutr Metab*. 2020;2020:1-7. doi: <https://doi.org/10.1155/2020/3626047>
39. Papanikolaou Y, Fulgoni III VL. Bean consumption is associated with greater nutrient intake, reduced systolic blood pressure, lower body weight, and a smaller waist circumference in adults: results from the National Health and Nutrition Examination Survey 1999-2002. *J Am Coll Nutr*. 2008;27(5):569-76.
40. Winham DM, Hutchins AM, Thompson S V. Glycemic response to black beans and chickpeas as part of a rice meal: a randomized cross-over trial. *Nutrients*. 2017;9(10):1095.
41. Nchanji EB, Ageyo OC. Do Common Beans (*Phaseolus vulgaris* L.) Promote Good Health in Humans? A systematic review and meta-analysis of clinical and randomized controlled trials. *Nutrients*. 2021;13(11):3701.
42. Calderón Guzmán D, Juárez Olguín H, Veloz Corona Q, Ortiz Herrera M, Osnaya Brizuela N, Barragán Mejía G. Consumption of cooked common beans or saponins could reduce the risk of diabetic complications. *Diabetes Metab Syndr Obes*. 2020;13:3481. doi: <https://doi.org/10.2147/DMSO.S270564>
43. Entezari M, Hashemi D, Taheriazam A, Yazdanpanah S, Khodadadi I, Goodarzi G, et al. AMPK signaling in diabetes mellitus, insulin resistance and diabetic complications: a pre-clinical and clinical investigation. *Biomed Pharmacother*. 2022;146:112563. doi: <https://doi.org/10.1016/j.biopha.2021.112563>
44. Reverri EJ, Randolph JM, Steinberg FM, Kappagoda CT, Edirisinghe I, Burton-Freeman BM. Black beans, fiber, and antioxidant capacity pilot study: examination of whole foods vs. functional components on postprandial metabolic, oxidative stress, and inflammation in adults with metabolic syndrome. *Nutrients*. 2015;7(8):6139-54.
45. Ministério da Saúde, Secretaria de Vigilância em Saúde e Ambiente (Brasil). *Vigitel Brasil 2023: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2023*. Brasília: Ministério da Saúde; 2023.
46. Instituto Brasileiro de Geografia e Estatística. *Pesquisa de Orçamentos Familiares 2008-2009: análise do consumo alimentar pessoal no Brasil*. Rio de Janeiro: IBGE; 2011.
47. Instituto Brasileiro de Geografia e Estatística. *Pesquisa de Orçamentos Familiares 2017-2018: análise do consumo alimentar pessoal no Brasil*. Rio de Janeiro: IBGE; 2020.
48. Cruz GLD, Machado PP, Andrade GC, Louzada MLDC. Alimentos ultraprocessados e o consumo de fibras alimentares no Brasil. *Ciênc Saúde Coletiva*. 2021;26(9): 4153-61. doi: <https://doi.org/10.1590/1413-81232021269.15462020>
49. Gupta S, Hawk T, Aggarwal A, Drewnowski A. Characterizing Ultra-Processed Foods by Energy Density, Nutrient Density, and Cost. *Front Nutr*. 2019;6(70):1-9.
50. Louzada MLDC, Cruz GLD, Silva KAA, Grassi AGF, Andrade GC, et al. Consumo de alimentos ultraprocessados no Brasil: distribuição e evolução temporal 2008-2018. *Revista de Saúde Pública*. 2023;57;1-13. doi: <https://doi.org/10.11606/s1518-8787.2023057004744>
51. Askari M, Heshmati J, Shahinfar H, Tripathi N, Daneshzad E. Ultra-processed food and the risk of overweight and obesity: a systematic review and meta-analysis of observational studies. *Int J Obes*. 2020;44:2080-91. doi: <https://doi.org/10.1038/s41366-020-00650-z>

CONTRIBUTORS

Conceptualization: LARL RODRIGUES, BGM RODRIGUES, LCC LAVÔR, JM CRISÓSTOMO, PVL SOUSA, LM NASCIMENTO, and KMG FROTA. Data curation: LARL RODRIGUES and LCC LAVÔR. Investigation: LARL RODRIGUES, BGM RODRIGUES, LCC LAVÔR, JM CRISÓSTOMO, PVL SOUSA, LM NASCIMENTO, and KMG FROTA. Methodology: LARL RODRIGUES and KMG FROTA. Writing-original draft: LARL RODRIGUES and KMG FROTA. Writing-review and editing: LARL RODRIGUES and KMG FROTA.