Disease and Diagnosis

Dis Diagn. 2024; 13(2):52-57

doi 10.34172/ddj.539

Original Article

Tamarind Intake and Hypertension: An Alarming Association Found in the Bandar Kong Cohort Study

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Abstract

Background: Hypertension (HTN) is a significant global public health concern and can elevate the risk of cardiovascular and kidney diseases. Tamarind (*Tamarindus indica*, Fabaceae), a tropical fruit highly valued for its pulp, offers many health benefits, including a reduction in oxidative stress and inflammation. Nonetheless, emerging uncertainties surround Tamarind's efficacy in certain health aspects. This study examined its potential negative impact on HTN within the Bandar Kong cohort.

Materials and Methods: The current study included 2823 participants of the Bandar Kong cohort study, of whom 693 individuals (24.5%) had HTN, with 288 men (25.3%) and 405 women (24.0%) being affected. Binary logistic regression analysis was used to investigate the connections between variables and the likelihood of HTN in both men and women. Moreover, multivariable binary logistic regression analysis and multivariable linear regression were utilized to determine the correlation between Tamarind consumption and the risk of HTN.

Results: After adjusting for covariates, the odds of HTN in males with moderate consumption of Tamarind were 0.55 higher than in males with low consumption of Tamarind. Tamarind consumption was significantly associated with the risk of HTN in both genders, with males and females who consumed moderate to high amounts having a higher risk. The findings revealed that high consumption of Tamarind was associated with higher diastolic blood pressure (BP) in females.

Conclusion: The study suggests that moderate to high consumption of Tamarind may have a negative impact on HTN among both males and females. Although Tamarind is highly valued for its pulp and offers some health benefits, its potential negative impact on HTN should be taken into consideration.

Keywords: Tamarind, Hypertension, Blood pressure, Cohort study

Received: July 18, 2023, **Accepted:** August 27, 2023, **ePublished:** January 15, 2024

Introduction

Hypertension (HTN) is a condition characterized by high blood pressure (BP), which is generally diagnosed when the BP reading is 140/90 mm Hg or higher. However, the diagnosis threshold may vary depending on several factors, such as age, underlying health conditions, and individual risk factors. HTN is a long-term health condition that may develop over time and can be influenced by various factors, including genetics, lifestyle choices, and underlying medical conditions. It usually does not show any symptoms until it has reached an advanced stage and causes damage to organs, such as the heart, kidneys, brain, or blood vessels (1-3). The World Health Organization (WHO) states that HTN is the primary reason for cardiovascular disease (CVD) and early death on a global scale. Risk factors for HTN that can be altered include unhealthy diets, physical inactivity, tobacco and alcohol use, and overweight or obesity (1, 3).

Tamarind (*Tamarindus indica*, Fabaceae) is a tropical plant species that has been traditionally utilized for various remedies. Its diverse components, including leaves, bark, seeds, and fruit pulp, have demonstrated antimicrobial and antifungal characteristics, as well as antioxidant and anti-inflammatory effects (4-7). Several in vivo and in vitro studies have reported the beneficial effects of Tamarind on various conditions, such as hypercholesterolemia (8), along with moderate inhibitory effects on cholinesterases and thrombolytic activities (9). While several studies have indicated that the consumption of Tamarind can lead to a significant

decrease in BP, especially in individuals with HTN (4, 10), recent research has cast doubt on the utility of Tamarind in certain aspects of health. For example, a randomized controlled clinical trial (RCT) conducted in Iran on a small group of obese and overweight patients did not identify any significant effects of Tamarind fruit pulp on BP, serum lipid profile, blood glucose levels, or anthropometric measurements (11). Moreover, the quality of evidence is currently constrained due to the limited number of investigations on the effect of Tamarind on BP. Therefore, this article has evaluated the association of Tamarind consumption with HTN among participants in the Bandar Kong cohort study to provide further insight into the effects of Tamarind on health. Bandar Kong County is situated in the southernmost part of Iran (12). Tamarind is widely utilized in diverse culinary traditions worldwide, including Iranian cuisine (4,13).

Objectives

The present study aimed to examine the potential impact of Tamarind consumption on HTN among participants in the Bandar Kong cohort study during October 2016-April 2021.

Materials and Methods

This study received ethical approval from Hormozgan University of Medical Sciences, identified by the reference number IR.HUMS.REC.1399.409. The primary dataset was drawn from the Bandar Kong cohort study, which encompassed 4063 participants aged 35–70. Regarding HTN prevalence among the total participants, the rates were 14.6% for men and 21% for women. From the pool, 2823 eligible participants were included after the application of the exclusion criteria, while those who were pregnant, had a history of CVD, diabetes, or cancer, and those with extremely low (< 800 kcal/d) or high (> 4200 kcal/d) calorie intake were excluded from the investigation. The study defined HTN as a consistent BP reading of 140/90 mm Hg or higher or the use of anti-hypertensive medications. In cases where the readings were elevated (≥ 140/90 mm Hg), they were verified on a different day (14).

The collection of demographic, health, and lifestyle data, along with annual follow-ups and re-surveys, had been meticulously described in previous publications (12,15). In summary, participants underwent re-evaluation every five years, accompanied by additional annual follow-ups. To ensure methodological rigor and research integrity, local recruits underwent training in cohort principles and interview techniques. This comprehensive training was facilitated by a team of professionals, including physicians, interviewers, nurses, and other designated roles. The original data collection was executed using a validated electronic questionnaire spanning the period from October 2016 to April 2021. This encompassing questionnaire addressed a wide spectrum of aspects, incorporating elements related to general health, medical conditions, and nutritional factors (12,15). Comprehensive dietary intake information of participants was gathered through the utilization of a food frequency questionnaire. Each food item inquired about the frequency of consumption (daily, weekly, or monthly) over the past year and the typical portion size. Subsequently, the data relating to Tamarind consumption was transformed into grams per day using common household measurements (16). Daily energy and nutrient intakes for participants were estimated by referencing the United States Department of Agriculture (USDA) food composition database (17,18).

Statistical Analysis

The study presented quantitative and categorical variables as means ± standard deviations (SD) or standard error means, as well as frequencies and percentages. Independent samples *t* test and χ^2 test were employed to compare variables between men and women. Daily Tamarind consumption (grams per day) was categorized based on quartiles into low, moderate, and high groups. Physical activity was assessed by calculating the metabolic equivalent of the task (MET) score for 24 hours using a continuous score system. The score was determined by assigning MET values to different activities, and participants were classified into low, moderate, and high physical activity groups based on their MET score quartile. The study employed binary logistic regression analysis to investigate the relationship between variables and the probability of HTN in both men and women. The crude odds ratio (OR) and 95% confidence interval (CI) were calculated, and multivariable binary logistic regression analysis was utilized to establish the correlation between Tamarind consumption and HTN risk. The adjusted OR and 95% CI were computed using three models.

In Model 1, the analysis was adjusted for daily energy intake. Daily energy intake and age were controlled in Model 2. In Model 3, the analysis was adjusted for daily energy intake, age, education, body mass index (BMI, all continuous), residence (urban/rural), occupation (yes/no), marital status (single/married/widowed or divorced), hookah use (yes/no), socio-economic status (low/medium/high), physical activity (low/medium/high), and family history of HTN (yes/no). Additionally, multivariable linear regression was utilized to determine the average difference in systolic and diastolic BP (SBP and DBP) between different groups. All statistical analyses were performed using SPSS (version 19), with a significance level of $P < 0.05$.

Results

Overall, 2823 individuals participated in this research,

including 59.7% females with an average age of 46.62 ± 8.78 years. For the male participants (40.3%), the average age was 47.27 ± 9.15 years.

The study findings revealed that 693 individuals (24.5%) had HTN, with 288 men (25.3%) and 405 women (24.0%) being affected. The characteristics of the study population are provided in , section A of Table 1. The number of Tamarind consumers by gender is provided in section A. Among the total sample size of 2823 individuals, 271 men (23.8%) and 384 women (22.8%), as well as 565 men (49.6%) and 828 women (49.1%), were categorized as low and medium Tamarind consumers, respectively. In addition, 302 men (26.5%) and 473 women (28.1%) were categorized as high Tamarind consumers (additional information is presented in Table S1 of Supplementary file 1). Tamarind consumption, measured in grams per day, is provided in Table 1, Section B, categorized by gender and HTN status. Among men, those without high BP consumed 0.95 ± 0.04 g/day (n = 850), while those with high BP consumed 1.22 ± 0.10 g/d (n = 288). For women, Tamarind consumption was 1.05 ± 0.04 g/d (n = 1280) and 1.33 ± 0.09 g/d (n = 405) without and with high BP, respectively.

There was a significant difference in the mean consumption of Tamarind ($P = 0.010$) between men with HTN and those without HTN. Moreover, the mean consumption of Tamarind was higher for women with HTN than those without HTN ($P = 0.003$).

According to the results of univariable binary logistic regression and the crude ORs (Table 1, Section C), males who consumed moderate and high amounts of Tamarind had a 0.68 and 0.80 higher risk of HTN, respectively, compared to males who consumed a low amount of Tamarind. Females who consumed a high amount of Tamarind had a 0.75 higher risk of HTN than females who consumed a low amount of Tamarind. Additionally, there was a strong association between the risk of HTN and age, energy intake, occupation, BMI, socio-economic status, and family history of HTN in both genders (Table S2).

According to the results of multivariable binary logistic regression in Model 1 (Table 1, section D), it was found that Tamarind consumption was significantly associated with the risk of HTN in both genders after controlling for daily energy intake. Males who consumed moderate and high amounts of Tamarind had a 0.70 and 0.83 higher risk of HTN, respectively, in comparison to males who consumed a low amount of Tamarind. Females who consumed a high amount of Tamarind had a 0.88 higher risk of HTN than females who consumed a low amount of Tamarind. In Model 2 (Table 1, section D), after adjusting for daily energy intake and age, it was observed that Tamarind affected HTN, and the OR of HTN in males with moderate consumption of Tamarind was 0.50 higher than in males with low consumption of Tamarind.

In Model 3 (Table 1, section D), after adjusting for covariates, such as daily energy intake, age, education, BMI, residence, job, marital status, hookah use, socio-economic status, physical activity, and family history of HTN, the odds of HTN in males with moderate consumption of Tamarind were 0.55 higher than males with low consumption of Tamarind. Furthermore, based on the results of multivariable linear regression (Table 1, section E), after adjusting for covariates, including daily energy intake, age, education, BMI, residence, job, marital status, hookah use, socio-economic status, physical activity, and family history of HTN, the average DBP in females who consumed high amounts of Tamarind was 1.44 mmHg higher than those who consumed low amounts of this food.

Discussion

Our study aimed to explore the potential impact of Tamarind intake on BP. Given that HTN is associated with various health conditions, including CVD, this study sought to determine if Tamarind consumption correlated with an increased risk of HTN in both genders. Tamarind's conflicting effects on health led us to investigate its relationship with BP, with the goal of providing insights for dietary recommendations to mitigate HTN-related complications and other health concerns.

Our findings demonstrated a significant connection between Tamarind intake and the risk of HTN, even after adjusting for daily energy intake. Both males and females exhibited a higher risk of HTN with moderate to high Tamarind consumption. This contrasts with studies suggesting the potential BP-lowering effects of Tamarind, especially in hypertensive individuals. For instance, Iftekhar et al (10) and De Caluwé et al (4) reported the positive effects of Tamarind consumption, attributing reductions in total cholesterol, low-density lipoprotein-cholesterol levels, and DBP to its intake. However, a direct comparison to other remedies for reducing BP remains lacking. Conversely, a small Iranian clinical trial on obese patients indicated the lack of significant effects of Tamarind fruit pulp on BP, serum lipid profiles, blood glucose, or anthropometric measurements. This RCT was conducted on a small group of only 40 individuals. In the case group, the individuals consumed a daily dose of 20 g of tamarind fruit pulp (11). Our study differs from the previous RCT in that we specifically focused on assessing tamarind usage based on self-reported data provided by the participants. The average daily tamarind consumption in our investigation was 1.08 ± 0.03 g/d. Notably, we did not differentiate between various forms of tamarind consumption (e.g., fruit, paste, or other forms) within our study population. Furthermore, our study encompassed a substantial population consisting of both hypertensive and non-hypertensive individuals,

Table 1. Tamarind and Blood Pressure

A. Age/gender and Total Energy Intake[a] (kcal/day)					
		Total (n=2823)	**Men (n=1138; 40.3%)**	**Women (n=1685; 59.7%)**	***P* Value**
Age (y); Mean (SD)		46.88 (8.94)	47.27 (9.15)	46.62 (8.78)	0.062[a]
Total energy intake (kcal/d); Mean (SD)		2741.29 (665.08)	3024.02 (613.99)	2550.34 (629.45)	<0.001[a]
Tamarind	Low	655 (23.2)	271 (23.8)	384 (22.8)	
	Medium	1393 (49.3)	565 (49.6)	828 (49.1)	0.630[b]
	High	775 (27.5)	302 (26.5)	473 (28.1)	

B. The comparison of Tamarind Consumption (g/d) in Both Genders With and Without Hypertension							
Comparison (g/d)	**Total (n=2823)**	**Men (n=1138)**			**Women (n=1685)**		
		Without BP (n=850)	**With BP (n=288)**	***P* Value**	**Without BP (n=1280)**	**With BP (n=405)**	***P* Value**
	1.08±0.03	0.95±0.04	1.22±0.10	0.010[a]	1.05±0.04	1.33±0.09	0.003[a]
Tamarind	Low	222 (19.5)	49 (4.3)		309 (18.3)	75 (4.5)	
	Medium	412 (36.2)	153 (13.4)	0.007[b]	639 (37.9)	189 (11.2)	0.001[b]
	High	216 (19.0)	86 (7.6)		332 (19.7)	141 (8.4)	

C. The Associations Between High Blood Pressure and Tamarind Consumption by Univariable Logistic Regression Analysis							
		Men (n=1138; 40.3%)			**Women (n=1685; 59.7%)**		
		Crude OR	**95% CI***	***P* Value**	**Crude OR**	**95% CI***	***P* Value**
Age (y)		1.08	1.07-1.10	<0.001	1.1	1.08-1.11	<0.001
Total energy intake (megajoule)		0.91	0.86-0.96	<0.001	0.93	0.89-0.97	<0.001
Tamarind	Low	Reference					
	Medium	1.68	1.17-2.41	0.005	1.22	0.90-1.64	0.196
	High	1.8	1.21-2.68	0.004	1.75	1.27-2.41	0.001

D. Multivariable Logistic Regression Analysis							
Characteristic		**Model 1[c]**		**Model 2[d]**		**Model 3[e]**	
		Adjusted OR (95% CI*)	***P* Value**	**Adjusted OR (95% CI)**	***P* Value**	**Adjusted OR (95% CI)**	***P* Value**
Men							
	Low	Reference					
Tamarind	Medium	1.70 (1.18-2.44)	0.004	1.50 (1.03-2.19)	0.035	1.55 (1.04-2.30)	0.031
	High	1.83 (1.23-2.73)	0.003	1.27 (0.83-1.94)	0.275	1.21 (0.77-1.90)	0.397
Women							
	Low	Reference					
Tamarind	Medium	1.26 (0.93-1.70)	0.136	1.03 (0.75-1.42)	0.859	0.99 (0.70-1.40)	0.963
	High	1.88 (1.36-2.60)	<0.001	1.32 (0.93-1.87)	0.115	1.11 (0.76-1.60)	0.595

E. Multivariable Linear Regression Analysis					
Characteristic		**Dependent Variable: Diastolic blood pressure**		**Dependent Variable: Systolic blood pressure**	
		B (95% CI*)	***P* Value**	**B (95% CI*)**	***P* Value**
Men					
	Low	Reference			
Tamarind	Medium	0.55 (-0.76,1.87)	0.41	-0.94 (-3.42,1.54)	0.458
	High	1.05 (0.02,2.63)	0.19	1.37 (-0.70,3.45)	0.195
Women					
	Low	Reference			
Tamarind	Medium	0.99 (-2.07,1.07)	0.069	1.28 (-2.96,1.39)	0.134
	High	1.44 (0.14,2.75)	0.03	1.75 (-3.79,1.82)	0.092

Abbreviations: SD, Standard deviation; CI, Confidence interval; OR, Odds ratio; BP, Blood pressure.
Note: Data are means ± standard error mean for quantitative variables or frequencies (percentage) for categorical variables.
[a] Independent samples *t* test; [b] $\chi 2$ test; [c] Model 1: Adjusted for daily energy intake; [d] Model 2: Adjusted for daily energy intake and age; [e] Model 3: Adjusted for daily energy intake, age, education, body mass index, residence, job, marital status, hookah use, socio-economic status, physical activity, and family history of hypertension.
*95% confidence interval for the odds ratio. Adjusted for daily energy intake, age, education, body mass index, residence, job, marital status, hookah use, socio-economic status, physical activity, and family history of hypertension.

totaling 2823 participants.

Despite these discrepancies, only a limited number of studies have examined Tamarind's effects on BP (4, 10, 11).

In conclusion, our study contributes to the discussion on dietary factors and HTN. In spite of the potential benefits suggested by other studies (4, 9, 10), our results confirm the potential association between Tamarind consumption and an increased risk of HTN. This study emphasizes the importance of considering Tamarind's effects on overall health, warranting further research to understand its intricate impact. The current study has a few limitations, including the possibility of unadjusted confounding variables, which is common in observational studies. Overall, this study contributes to the existing literature on the relationship between dietary factors and HTN by providing valuable insights into the potential health risks associated with Tamarind consumption.

Conclusion

The findings suggest that Tamarind intake is significantly associated with an increased risk of HTN in both males and females. The results demonstrated that higher levels of Tamarind consumption are related to a greater risk of HTN, and this association was observed even after adjusting for daily energy intake and other covariates. These findings could have important implications for dietary recommendations aimed at preventing HTN-related complications. It is recommended that individuals who are at risk of HTN limit their intake of Tamarind or avoid it altogether. Further research is needed to explore the potential mechanisms underlying the association between Tamarind consumption and HTN risk.

Acknowledgments

The Bandar Kong cohort study is part of the PERSIAN national cohort. The authors extend their gratitude to Professor Reza Malekzadeh, director of the PERSIAN cohort. They also appreciate Dr. Hossein Poustchi, executive director of the PERSIAN cohort.

Authors' Contribution

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Competing Interests

The authors have not declared any conflict of interests. They are solely responsible for the content presented in this article.

Data Availability Statement

The study's supporting data can be accessed through http://persiancohort.com/access or by contacting the director of the Bandar Kong cohort study via email at azimnejate@yahoo.com.

Disclaimer

The viewpoints presented in this article are those of the authors and do not reflect the stance of the Ministry of Health and Medical Education.

Ethical Approval

This study received approval from the Ethical Review Board of Hormozgan University of Medical Sciences (IR.HUMS.REC.1399.409). The corresponding author can provide access to the data generated or analyzed during the study upon reasonable request.

Funding

There is no funding/support for this article.

Informed Consent

The present study employed baseline data from the ongoing Bandar Kong cohort study between October 2016 and April 2021, and all participants provided informed consent.

Supplementary Files

Supplementary file 1 contains Table S1 and Table S2.

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