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Research Article

Tomato Juice (*Lycopersicum commune*) Reduces Blood Pressure in Elderly Hypertensive Indonesians in Kulisusu, North Buton

¹Yusuf Sabilu, ¹Nuziyati, ¹Andi Faisal Fachlevi, ¹Syawal Kamiluddin Saptaputra and ²Healthy Hidayanty

¹Faculty of Public Health, Universitas Halu Oleo, Kendari, Southeast Sulawesi, Indonesia

²Faculty of Public Health, Universitas Hasanuddin, Makassar, Indonesia

Abstract

Background and Objective: Hypertension is the third leading cause of death in Indonesia, accounting for 6.7% of all age deaths. Hypertension is closely linked to the risk of various complications. Serious hypertension related complications require appropriate treatments. This study investigated the effects of tomato juice (*Lycopersicum commune*) consumption on systolic blood pressure and diastolic blood pressure in elderly hypertension patients at the Kulisusu Public Health Center of North Buton, Indonesia.

Materials and Methods: This randomised controlled feeding study enrolled 28 elderly hypertension (systolic blood pressure ≥ 140 mmHg and diastolic blood pressure ≥ 90 mmHg) patients, who were randomly assigned to intervention and control groups. The treatment group received tomato juice (prepared by blending 150 g of tomatoes with 50 mL of water and 2 g of dietary sugar) for 7 days, while the control group received nutritional education on a balanced diet. An independent sample t-test was performed to test between group differences. Analysis of covariance and SPSS was used to analyze the data. **Results:** The median age of the participants was 67 years (64.3% women) and most participants had a normal nutritional status, as demonstrated by the median BMI value (18.91 kg m^{-2}). These characteristics were comparable between groups at baseline. In the treatment group, the systolic and diastolic blood pressure (BP) measurements were significantly different after the intervention ($p < 0.05$). Compared with the control group, the treatment group showed a higher reduction in systolic blood pressure (8.59 mmHg, $p < 0.05$) and diastolic blood pressure (6.19 mmHg, $p < 0.05$) following the 7 day intervention with tomato juice. **Conclusion:** The findings indicate that tomato juice treatment effectively reduced systolic and diastolic blood pressure levels in elderly Indonesians with hypertension.

Key words: Hypertension, *Lycopersicum commune*, epidemiology, systolic blood pressure, diastolic blood pressure

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Corresponding Author: Yusuf Sabilu, Faculty of Public Health, Universitas Halu Oleo, Kendari, Southeast Sulawesi, Indonesia Tel: +62-85241826752

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The elderly are one of the most rapidly growing populations worldwide. Data collected over a 30 years period have demonstrated the increasing prevalence of hypertension with age¹. Hypertension is a non-communicable disease that has become a serious health problem, it is often referred to as "the silent killer". The incidence of hypertension is high, with approximately 1 in 3 adults with this condition, approximately 1 billion people worldwide have hypertension. Hypertension is estimated to cause the deaths of 17 million people every year. Deaths due to complications of hypertension are estimated at 9.4 million every year². Hypertension is also responsible for 45% of deaths due to heart problems and 55% of deaths due to stroke². Intraindividual blood pressure (BP) dynamically fluctuates over time³. In routine clinical practice, a systolic BP of >120 mmHg and a diastolic BP of >70 mmHg were each associated with adverse cardiovascular outcomes, including mortality in patients with hypertension and CAD.⁴

The prevalence of hypertension in adults in Southeast Asia was 36% in 2013 and the incidence of hypertension is projected to increase by 7.3% in 2030². Hypertension is the third leading cause of death in Indonesia after stroke and tuberculosis, accounting for 6.7% of total all age deaths in Indonesia⁵.

In 2011, the Indonesian Health Department recorded 48.8% cases of mild and moderate hypertension and 20% cases of severe hypertension. The prevalence of hypertension increases with age, affecting 1 of 10 people 20-30 years of age and 5 of 10 people 50 years of age⁶. According to epidemiological data, the number of patients with hypertension will potentially increase because of the growing elderly population. Moreover, systolic hypertension or a combination of systolic and diastolic hypertension often occurs in people older than 65 years of age¹. Hypertension is significantly associated with increased morbidity and mortality rates from cerebrovascular disease, myocardial infarction, congestive heart failure and renal insufficiency. Arterial hypertension is highly prevalent in the elderly age⁷. Systolic BP variability is emerging as a new risk factor for CVD, diabetic nephropathy and other atherosclerotic conditions⁸.

According to a report from the Southeast Sulawesi Provincial Health Department, hypertension most often appears in the list of 10 diseases in Southeast Sulawesi. A total of 10,953 and 37,036 hypertension cases were reported in 2011 and 2012, respectively. In 2013, the incidence of hypertension decreased to 24,419 cases and it remained unchanged in 2014. According to a report from the North Buton District Health Office, hypertension most often appears

in the list of top 10 diseases in North Buton. A total of 1,072, 1,023 and 2,053 hypertension cases were reported in 2013, 2014 and 2015, respectively. Moreover, in 2015, the Kulisusu Public Health Center recorded hypertension as the second most prevalent disease, after acute respiratory infection, with up to 417 hypertension cases. Of these 417 cases, 220 were elderly patients.

Effective hypertension treatment can reduce the risk of stroke, heart attack, congestive heart failure, hypertensive retinopathy and nephropathy⁹. Effective treatment is necessary to prevent the complications caused by hypertension. Generally, hypertension is treated using pharmacological and non-pharmacological approaches. However, because of the adverse side effects of pharmacological treatment, some people prefer herbal treatments as an alternative approach. Herbal treatments for hypertension are widely used in Indonesia. Many plants are believed to be effective in lowering BP, including tomato (*Lycopersicon commune*), banana, cucumber, watermelon, strawberry, apple, star fruit and potato. Tomato fruit is inexpensive, easily obtained, easily processed and delicate, as well as a rich source of nutrients, including bioflavonoids, potassium, calcium and fibre. Just 100 g of tomatoes contains 245 mg of potassium. Potassium in tomatoes can lower BP by reducing the sodium content in urine and water, similar to a diuretic¹⁰. Elderly people are categorised as a vulnerable group for malnutrition because of the aging process, which results in the impairment of physiological functions. In elderly people, consumption of nutritious food is necessary to maintain their health and prevent disease or disease complications. Previous studies using tomatoes have shown positive effects in reducing blood pressure levels in hypertensive elderly patients. A study conducted in Semarang examined BP in postmenopausal women and reported an SBP reduction of 11.76 mmHg and diastolic BP reduction of 8.82 mmHg after using tomato juice as an intervention. In that study, tomato juice was made from 150 g of tomatoes and 5 g of sugar and 50 mL of water were added to the juice, the participants received this juice for 7 days. Another study of elderly patients reported reduced systolic blood pressure levels in elderly patient given tomato juice with and without skin, but there was no difference in the reduction of systolic blood pressure levels between the two treatment group¹¹. Many elderly people with hypertension in the Kulisusu Public Health Center working area of North Buton require comprehensive treatment, along with pharmacological and non-pharmacological action, to reduce BP levels and the number of patients with hypertension. Tomato juice consumption is one of the herbal treatments used to reduce

BP. The current study investigated whether the consumption of tomato juice (*L. Commune*) reduces systolic and diastolic BP levels in elderly patients with hypertension at the Kulisusu Public Health Center, North Buton.

MATERIALS AND METHODS

Study design and intervention: The study used a randomised controlled feeding design. Twenty-eight elderly hypertension patients residing in the Kulisusu Public Health Center working area of North Buton, one regency in the Southeast Sulawesi Province of Indonesia, were enrolled in the study. Data were collected over a 2 month period from 1 May, 2016 to June 30, 2016.

The sample size was calculated using the formula for group comparison, based on the study hypothesis, in which the estimated standard deviation was assumed to be equal for each group¹². The sample size was estimated at 28 elderly patients, which provided 80% power to detect a 9 unit difference in the mean change of systolic blood pressure from prior to the intervention to 7 days after the intervention and it accommodated a 17% drop out rate. Of these 28 patients, 14 were assigned to the treatment group and 14 to the control group. The groups were matched based on age and sex. All participants received information regarding the study objectives and were asked to provide informed consent. This study was approved by the Research Institute and Community Research Ethics Committee of the Universitas Halu Oleo (clearance number: 834/UN29.20/PPM/2016).

Inclusion criteria: The following inclusion were applied: (1) Elderly hypertension patients 60 years of age and older, (2) With a systolic BP ≥ 140 mmHg or a diastolic BP \geq mmHg, (3) Who were not receiving any antihypertensive drugs, (4) Resided in the Kulisusu Public Health Center working area at the time of the study, (5) Were willing to participate in the study by providing informed consent and (6) Had no co morbidities.

Description of the intervention: The treatment group received one glass of tomato juice, which was prepared by blending 150 g of red tomatoes with 50 mL of water and 2 g of dietary sugar. The juice was given to the participants every morning at 8 am in their home for 7 days and balanced diet education was provided. Blood pressure levels were measured again after the intervention, 30 min after the patients consumed tomato juice on the 7th day. The elderly patients in the control group receive nutrition education on balanced

diet. The information provided was based on the general guidelines for balanced nutrition in Indonesia and was delivered daily to the elderly patients over the 7 days.

This study was a home-based setting study of the elderly in their own homes and the participants did not know one another.

Baseline variables: At baseline, variables (e.g., sex, age, physical activity habit, smoking habit and coffee consumption) were collected using a questionnaire. Furthermore, the nutritional status of elderly was determined through anthropometry measurements. Trained field staff members measured elderly anthropometrics using standard procedures and calibrated instruments. Body weight was measured with a portable flat scale (Seca Deutschland, Hamburg, Germany) to the nearest 0.1 kg, with shoes and heavy clothing removed. Standing height was measured to the nearest 0.1 cm using a microtoise. The BMI (kg m^{-2}) was calculated as weight in kilograms divided by the square of height, in meters.

Outcomes: The study outcomes were changes in systolic and diastolic blood pressure levels. BP was measured using sphygmomanometer (Riester, Jungingen, Germany). These data were collected by a trained field staff member prior to and 7 days after the intervention.

Statistical analysis: The SPSS software (version 19.0; IBM Corp., New York, USA) was used to analyse all quantitative data. The Shapiro-Wilk test of normality was used to evaluate all continuous data for normal distribution non-normally distributed data were transformed for normality, or nonparametric techniques were used. Independent sample t-tests (continuous variables) and the chi-squared tests (categorical variables) were used to assess changes in the outcome measures for normally distributed data (two group t-test, $p < 0.05$ one-tailed significance). Analysis of covariance¹² was used to test the effect of intervention material on groups and adjustments to the analyses were made for the variables of baseline characteristics data.

RESULTS

Baseline characteristics: Baseline characteristics of the study participants are listed in Table 1. Overall, no significant differences in the patient characteristics were observed between the intervention and control groups. The mean participant age was 67 years and most were women. Additionally, there were no significant differences in BMI

Table 1: Baseline characteristic of the intervention and control groups in the Kulisusu Public Health Center of North Buton

Variables	Intervention group (n = 14)	Control group (n = 14)	Total (n = 28)	p-value**,#,#
Age (Median, IQR*)	65.0 (62.0, 70.5)	69.0 (63.8, 71.0)	67.0 (63.0, 70.0)	NS**
Sex (n, %)				
Men	5 (35.7)	5 (35.7)	10 (25.7)	
Women	9 (64.3)	9 (64.3)	18 (64.30)	NS##
Weight (Median, IQR)	42.00 (37.75, 56.50)	46.00 (43.50, 54.00)	45.00 (41.25, 54.00)	NS**
Height (Mean ± SD)	150.57 ± 9.89	155.07 ± 8.83	152.82 ± 9.48	NS#
BMI (Median, IQR)	18.82 (18.29, 21.89)	18.91 (16.71, 21.91)	18.91 (17.46, 21.82)	NS**
Physical Activity (n, %)				
No	12 (85.7)	11 (78.6)	23 (82.51)	
Yes	2 (14.3)	3 (21.4)	5 (17.59)	NS##
Smoking Habit (n, %)				
Yes	5 (35.7)	5 (35.7)	10 (35.7)	
No	9 (64.3)	9 (64.3)	18 (64.3)	NS##
Coffee drinking habit (n, %)				
Yes	3 (21.4)	4 (28.6)	7 (25.0)	
No	11 (78.6)	10 (71.4)	21 (75.0)	NS##

*IQR: Interquartile range (percentiles, 25th and 75th), **,#,#Between groups differences were analysed using independent t-tests, Mann-Whitney U-test (for continuous data) or Pearson's chi-squared test (for categorical data)

Table 2: Effect of tomato juice on systolic and diastolic blood pressure among intervention and control groups at the Kulisusu Public Health Center of North Buton

Variables**	Intervention group mmHg (n = 14)	Control group mmHg (n = 14)	Unadjusted p-value#	Adjusted p-value##
Systolic				
Baseline (0 days)	160.71 ± 11.95	153.06 ± 4.62	<0.05*	
Endline (7 days)	152.11 ± 11.87	152.34 ± 4.81	NS	
Change (Δ)	8.59 ± 1.38	0.72 ± 1.09	<0.05*	<0.05*
Diastolic				
Baseline (0 days)	98.58 ± 2.86	96.73 ± 3.19	NS	
Endline (7 days)	92.38 ± 3.59	96.33 ± 3.26	<0.05*	
Change (Δ)	6.19 ± 2.55	0.20 ± 0.52	<0.05*	<0.05*

**Expressed as the Mean ± SD, #Between groups differences were analysed using an independent t-test. *Significant at a p-value of <0.05, ##Further analysis to investigate the effect of tomato juice on the intervention and control groups (as reference), adjustments were made for the variables of sex, age, BMI and baseline data of systolic and diastolic data. Analysis used ANCOVA

between the intervention and control groups, on average the participants had a normal nutritional status, as demonstrated by BMI (18.91). Furthermore, no significant between group differences were observed, in terms of physical activity, smoking habit and coffee consumption. Most participants were physically inactive. Compared to the control group, the number of patients in the treatment group, who performed physical activity was slightly higher. However, statistically the value was not significantly different.

Among the 14 participants in the treatment and control groups, 5 (35.7%) were smokers, whereas the remaining 9 (64.3%) were non-smokers. Of the 14 participants in the treatment group, 3 (21.4%) drank coffee, whereas the remaining 11 (78.6%) did not drink coffee. Of the 14 participants in the control group, 4 (28.6%) drank coffee, whereas the remaining 10 (71.4%) did not drink coffee.

Result for research hypothesis: Data are presented in Table 2. Within 7 days, the tomato juice intervention demonstrated a positive effect on the blood pressure levels of elderly hypertension patients in Kulisusu of North Buton.

The mean decreases in systolic and diastolic blood pressure levels in the intervention group was significantly (p<0.05) higher than those in the control group.

After the 7 day intervention, systolic pressure decreased by a mean difference (Δ) of 8.59 in the intervention group compared and 0.72 in the control group, diastolic blood pressure decreased by Δ of 6.19 points in the intervention group, compared with a decrease of 0.20 point in the control group.

The intervention remained significantly effective even after adjusting for some baseline characteristics, such as age, sex, BMI and baseline systolic and diastolic blood pressure data.

DISCUSSION

This study evaluated whether tomato juice consumption reduces SBP and diastolic BP in elderly hypertension patients. A total of 14 patients were assigned to the treatment group and 14 patients were assigned to the control group. The study results demonstrated reductions in SBP and diastolic BP in the

treatment group after the intervention. The BP reduction in the treatment group after tomato juice consumption was caused by potassium and other substances, which play a crucial role in BP reduction.

Potassium acts as a vasodilator in blood vessels. Vasodilation in blood vessels can reduce peripheral resistance and increase cardiac output, which can help in normalising BP. In addition, potassium can inhibit the release of renin, which alters the activity of the renin-angiotensin system. Potassium can also control BP by acting on the peripheral and central nervous systems.

High potassium consumption may protect against hypertension. Increasing potassium intake can lower SBP and diastolic BP. Consuming potassium increases its concentration in the intracellular fluid, which tends to draw fluid from extracellular compartments, thereby reducing BP.

A clinical study investigating the effectiveness of potassium in lowering BP demonstrated that potassium significantly reduced SBP by 4.4 mmHg and reduced diastolic BP by 2.5 mmHg in the hypertensive group, compared with an SBP reduction of 1.8 mmHg and diastolic BP reduction of 1.0 mmHg in the normotensive group.

Tomatoes are rich in potassium. A cup of tomato juice contains 534 mg of potassium and ½ cup tomato sauce has 454 mg¹³. Therefore, the high potassium content in tomatoes, along with calcium, is crucial for lowering BP, particularly SBP. Low calcium intake reinforces the effect of NaCl intake of elevating BP of people, who are at a high risk of hypertension because calcium exerts a natriuretic effect. Calcium regulates BP by lowering the activity of the renin-angiotensin system, improving the balance of sodium, potassium and inhibiting the constriction of blood vessels. Calcium is also associated with thickening of the blood vessels in the heart. Inadequate calcium intake forces the body to maintain the balance of calcium in blood by producing parathyroid hormone, which stimulates the expenditure of calcium from bones into blood. The calcium present in blood then binds to free fatty acids, resulting in the thickening and hardening of blood vessels, reducing the elasticity of the heart and, consequently, increasing BP.

Tomatoes are a rich source of lycopene¹⁴. Lycopene supplements can decrease blood pressure levels¹⁵. In addition, tomatoes contain bioflavonoids, which increase the level of endothelial nitric oxide synthase (eNOS). The eNOS plays a crucial role in the formation of nitric oxide (NO), therefore, increased eNOS levels can increase NO levels. The NO is released from endothelial cells into vascular smooth muscle cells to reduce the tension caused by circulating blood or receptor substances, such as acetylcholine, bradykinin and serotonin. When emerged, NO can increase the concentration

of intracellular cyclic guanosine monophosphate and induce vascular smooth muscle relaxation, causing vasodilation of the capillaries that reduces total peripheral resistance and, ultimately, BP. Tomato juice provides antioxidant compounds, such as phenolics and lycopene, as well as a small amount of folate¹⁶. Lycopene is a carotene and phytochemical that protects against metabolic diseases. It is found in red fruits and vegetables, predominantly tomatoes¹⁷. Tomatoes also contain natural antioxidants, which can reduce BP after 6 weeks of tomato extract supplementation¹⁸.

Tomato-based food products have health-promoting and disease-preventing effects. Some tomato juice ingredients may have health benefits in middle-aged women, including women with menopausal symptoms and CVD¹⁹. Tomato juice reduces oxidative stress in overweight (and possibly obese) women and may, therefore, prevent obesity related diseases and promote health²⁰.

Chocolate reduces BP. Chocolate, particularly dark chocolate, has a high flavonoid content. A study has shown that chocolate intake significantly affects BP reduction. The average SBP of participants, who consumed a high amount of chocolate was 3.8 mmHg lower than that of participants, who consumed a low amount of chocolate²¹.

Another study evaluating the effect of tomato juice (*L. commune*) on BP included 34 postmenopausal women with hypertension, 17 of whom were assigned to the treatment group and 17 to the control group. This study showed that SBP decreased by 11.76 mmHg, with a standard deviation of 7.726 and diastolic BP decreased by 8.82 mmHg, with a standard deviation of 3.321, in the treatment group¹¹.

Another study has investigated the effect of tomato juice (*L. commune*) on SBP and diastolic BP in hypertensive men between 40 and 45 years of age. The study revealed that SBP decreased by 4.4 mmHg and diastolic BP decreased by 3.1 mmHg in the treatment group, whereas SBP decreased by 1.4 mmHg and diastolic BP decreased by 1.4 mmHg in the control group²². Furthermore, one study has indicated that the intake of tomatoes/tomato-based products may have a potentially beneficial effect on the prevention of depressive symptoms and BP reduction²³.

A similar study of the benefits of tomato juice has been performed by Yamamoto *et al.*²⁴, who investigated the effect on male infertility, regular consumption of tomato juice seems to improve sperm motility in infertile patients²⁴.

This study was a home-based intervention, which used foodstuff that was readily available and easily obtained. The limitation of this study was the absence of information on dietary intake among the participants to control for the effect of the intervention.

CONCLUSION

It was concluded that food-based treatment with tomato juice was effective in reducing systolic and diastolic blood pressure levels in elderly Indonesians with hypertension.

SIGNIFICANCE STATEMENTS

This study investigated the positive effect of tomato juice, which can be beneficial in reducing systolic and diastolic blood pressure in elderly people with hypertension. This study help researchers further investigate a critical area of hypertension that many have been unable to explore.

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