ORIGINAL ARTICLE

Effect of Tomato and Cucumber Juice on Blood Pressure in Hypertensive Patients: a Quasi-Experimental Study

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ABSTRACT

Background. Hypertension is associated with the improvement of cardiovascular disease and all-cause mortality. A healthy diet based on consuming natural foods can prevent and control hypertension.

Objective. The aim of this study was to analyze the effectiveness of tomato and cucumber juice in reducing the blood pressure of hypertensive patients.

Methods. The study used a quasi-experiment pretest-posttest control group design. The target population are people with hypertension Stage 1, people living in urban area - Cibiru Health Centre Work Area. Purposive sampling was used and the sample size was calculated using the average comparison formula with effect size=0.9, α=0.05, β =0.2. Forty-five subjects involved in the study were divided into three groups (15 subjects were given tomato juice, 15 subjects were given cucumber juice, and 15 subjects were given treatment with mineral water (control group)., This research used 100 grams of ripe red tomatoes, 100 grams of fresh cucumber, and 200 ml of water. The data collected were patient characteristics and blood pressure. The ANOVA analysis test and the Bonferroni Post Hoc test were used to analyze the data.

Results. The results of the study showed a difference in blood pressure reduction in each group. The decrease in systolic blood pressure in the tomato juice group was 7.3±3.1, the cucumber juice group was 4.2±3.3, and the control group was -0.0±2.5 (p=0.0001). The decrease in diastolic blood pressure in the group given tomato juice was 9.2±3.1, the group given cucumber juice was 7.6±3.4, and the control group was 0.4±2.1 (p=0.0001).

Conclusion. There is a difference in blood pressure reduction between the group given tomato juice and the control group, and there is a difference in blood pressure between the group given cucumber juice and the control group.

Keywords: hypertensive, blood pressure, tomato juice, cucumber juice

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INTRODUCTION

High blood pressure, also known as hypertension, is one of the most prevalent disorders in the world.[1] It raises the risk of cardiovascular disease, including stroke, coronary heart disease, heart failure, chronic renal failure, and central

and peripheral vascular disease, as well as all-cause mortality.[2] The doctors advise lifestyle change as the initial treatment strategy even if there are several ways to lower blood pressure (for example, pharmaceutical treatment).[3] According to the World Health Organization (WHO) statistics, 22% of the world's population has hypertension; however, when it comes to regional differences, Africa has the highest prevalence of hypertension with a percentage of 27%, followed by the Eastern Mediterranean with a percentage of 26%, and Southeast Asia with a percentage of 25%.[4] In Indonesia, 34.11% of people have hypertension, an increase of 8.31% from 2013. The morbidity of hypertension increases while the patients are getting older. The prevalence of hypertension based on the highest age group is adult and elderly. The prevalence of hypertension in Bandung City is 36.79%.[5]

In 2020, the International Society of Hypertension (ISH) developed and reported practice guidelines for the management of hypertension around the world, including salt reduction, healthy diet, healthy beverages, moderation of alcohol consumption, weight reduction, smoking cessation, regular physical activity, stress reduction, mindfulness, and reducing exposure to air pollution and cold temperatures.[6] Among these lifestyle modifications, the Dietary Approaches to Stop Hypertension (DASH) is a dietary pattern promoted by the National Heart, Lung, and Blood Institute (NHLBI) of the United States-based National Institutes of Health (NIH) to prevent and control hypertension.[7]

Due to increased incidence of hypertension and increased incidence of complications because of hypertension, there is new interest in finding new strategies in the control of hypertensive disease. The focus of control is strategies such as a healthy lifestyle, doing physical activity, regulating diet, controlling blood pressure regularly, and taking anti-hypertensive drugs. Because of the focus of hypertension control on patient behavior, the use of natural remedies is quite rarely in demand, although some studies help focus the search for treatment naturally in blood pressure control in hypertensive patients. Reported blood pressure control includes using tomato and cucumber extracts.

Tomato and cucumber extracts have been shown in many trials to be beneficial in treating a number of non-communicable diseases, including diabetes,[8] high cholesterol,[9] heart disease,[10] and hypertension[11]. Tomato (Lycopersicon esculentum L) is one of the most popular and widely consumed vegetable crops worldwide.[12] Tomatoes contain a complex mix of carotenoids, including lycopene (35–96% of total lycopene, mainly in all forms of trans-isomers, and 1–22% cis-lycopene), β-carotene, and lutein, all of which support cardiovascular health. Regular consumption of tomatoes and tomato-based products has been correlated with a reduced risk of contracting cardiovascular diseases that provide cardiovascular benefits.[13] Some research supports the idea that tombok-based food intake increases serum lipids and reduces cardiovascular risk better than lycopene supplementation.[14,15]

In both fresh and ripe tomatoes, the lycopene isoform is the predominant form and accounts for about 90%.[16] Lycopene is able to quench free radicals due to its apparent anti-oxidant function which can improve blood vessel function and further reduce the chance of cardiovascular complications.[17] Previous research stated that lycopene supplementation found no changes in blood pressure.[18] Recent research revealed that standardized tomato nutrient complex treatment with 15 or 30 mg of lycopene is associated with a significant reduction in systolic blood pressure.[16]

Cucumbers have a hypotensive effect in blood pressure and a diuretic effect that lowers the amount of fluid circulating in the bloodstream, which can ultimately reduce the workload of the heart. It can be said that the way therapy with cucumber extract works is similar to blood pressure-lowering antihypertensive diuretic drugs.[19] It contains 147 mg of potassium per 100 grams of cucumber and contains no sodium and many other nutrients. Potassium content in cucumber can reduce systolic and diastolic blood pressure by inhibiting renin release, increasing sodium and water excretion. Renin circulates in the blood and works by catalyzing the decomposition of angiotensin into angiotensin I. Angiotensin I converts to the active form angiotensin II with the help of Angiotensin-Converting Enzyme (ACE). Sodium and water retention are reduced in the presence of potassium, resulting in decreased plasma volume, cardiac output, peripheral pressure, and blood pressure. Potassium is a good electrolyte producer for the liver and helps reduce high blood pressure and regulate the rhythm of the heartbeat by doing the bad effects of sodium, the potassium content in cucumber is effective in treating hypertension.[20]

The hypertension control program in Indonesia has supported a continuous campaign of public education through the media about the symptoms of hypertension, the causes of hypertension, the importance of conducting health checks as early as possible, and carrying out regular health controls. To further enhance the struggle, the government has made many efforts to ensure that non-communicable disease services reach every region in Indonesia. However, current efforts to routinely control blood pressure are not enough.

There is an increasing tendency to develop complications of non-communicable diseases mainly due to hypertension, especially affecting developing countries. The focus of previous research was to test extracts of tomato and cucumber content in cardiovascular diseases. This study aims to evaluate how well tomato and cucumber juice lowers blood pressure in hypertensive patients. The specific objectives of this study were 1) to analyze blood pressure in patients with hypertension; 2) to analyze the difference in the mean reduction of systolic and diastolic blood pressure in the intervention groups (given tomato juice and cucumber juice) and the control group; 3) to analyze the magnitude of the difference in systolic and diastolic blood pressure reduction between groups. The findings of this study will help improve hypertension control policies in Indonesia.

MATERIALS AND METHODS

Research Design

In conducting this study, the researchers used quasi-experiment pretest-posttest control group design: This study was conducted in Primary Health Care (Cibiru Health Center), Bandung Regency, Indonesia. Enrolment period was conducted in April 2022, allocation and follow-up was conducted in May-July 2022, and analysis was conducted in August 2022 (Figure 1).

Study Subjects

The target population are Sundanese living in the area Primary Health Care (Cibiru Health Center), Bandung Regency, Indonesia, with Stage 1 hypertension, both men and women, and not currently undergoing treatment. The sample was taken using purposive sampling. Forty-five subjects were divided into three groups (15 subjects in the group given tomato juice, 15 subjects in the group given cucumber juice, and 15 subjects in the control group). The control group was drawn and matched to the characteristics of the intervention group. All subjects were in an enclosed facility and did not limit their activities during the treatment. The sample size was calculated using the average comparison formula with effect size=0.9, α=0.05, β=0.2, performed three times and the optimum number of subjects was 15 for each group. All participants of this study have signed the informed consent.

Eligibility Criteria

(1) hypertension Stage 1 (Systolic blood pressure 140-159 mmHg and diastolic 90-99 mmHg), (2) ≥40 y/old, (3) open to both sexes (man and woman), (4) absence of other non-communicable diseases such as stroke, coronary heart disease, cancer, diabetes mellitus, and obesity, and (5) not taking antihypertensive medications.

Exclusion Criteria

Patients who do not consume juice at all in a day, or consume juice after the schedule, or are sick at the time of the study.

Intervention

Tomato juice group

Standard operating procedures for making tomato juice were applied, including materials and tools. This research used 100 grams of ripe red tomatoes, 200 ml of water, a blender, a knife, and a filter.[21] The procedure of making tomato juice begins with washing the tomatoes thoroughly using running water, then cutting them into pieces. After that, blend it

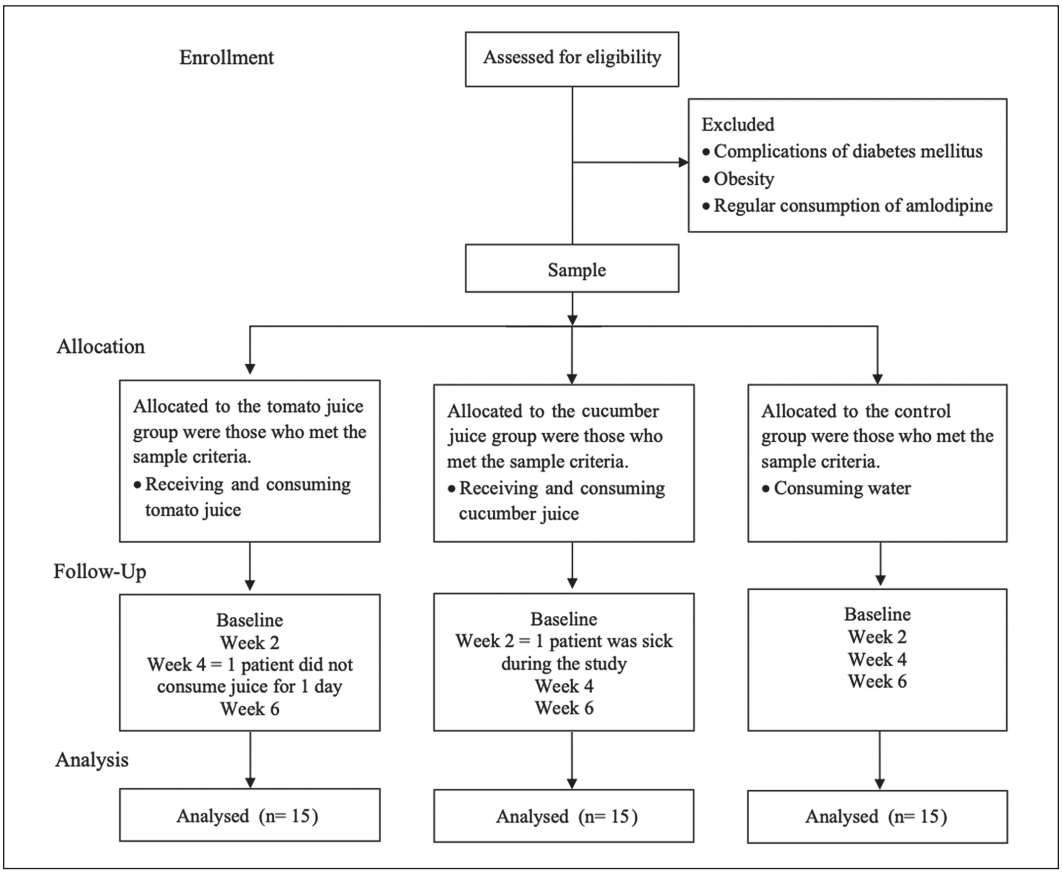

Figure 1. Research Flowchart.

until well combined, then filter and serve in a glass cup. Subjects were given time to consume tomato juice for 15 minutes. During the intervention, subjects were not allowed to consume any type of food other than the juice given. The tomato juice was administered orally to the subjects. During the intervention, direct monitoring was conducted by the researcher. The first blood pressure measurement (baseline) was conducted before the intervention. The second measurement (week 2) was conducted after 14 days of intervention. The third measurement (week 4) was conducted after 28 days of intervention. The fourth measurement (week 6) was done after 42 days of intervention. Tomato juice was given in the morning, between 7:00 am - 8:00 am.

Cucumber juice group

For cucumber juice, this research used 100 grams of fresh cucumber, 200 ml of water, a blender, a knife, and a filter.[21] However, the procedure for making cucumber juice starts with washing the cucumber thoroughly using running water, then cutting into pieces, and putting them into a blender until they are smooth and filtered, and served in a glass. Subjects were given time to consume cucumber juice for 15 minutes. During the intervention, subjects were not allowed to consume any type of food other than the juice given. The cucumber juice was given orally to the subject. During the intervention, direct monitoring was conducted by the researcher. The first blood pressure measurement (baseline) was conducted before the intervention. The second measurement (week 2) was conducted after 14 days of intervention. The third measurement (week 4) was conducted after 28 days of intervention. The fourth measurement (week 6) was done after 42 days of intervention. Cucumber juice were given in the morning, between 7:00 am - 8:00 am.

Tomato juice and cucumber juice were given once daily for six weeks. Giving intervention for 2-6 weeks can reduce blood pressure. This is due to the lycopene and potassium contained in tomatoes and cucumbers.[22] Potassium in tomato juice can reduce systolic and diastolic blood pressure by inhibiting the release of renin resulting in increased excretion of sodium and water.[23]

Control Group

The control group was given mineral water as much as 200 ml. The first blood pressure measurement (baseline) was conducted before the intervention. The second measurement (week 2) was conducted after 14 days of intervention. The third measurement (week 4) was conducted after 28 days of intervention. The fourth measurement (week 6) was done after 42 days of intervention. Mineral water was given in the morning, between 7:00 am - 8:00 am.

Measurements

During the study, blood pressure readings were collected, both systolic and diastolic. In addition, respondent characteristics, such as age, gender, education, and occupation were also collected at the time of the first blood pressure measurement.

Statistical Analysis

Test normality using Shapiro Wilk test was done. The General Linear Model-Repeated Measures (GLM-RM) test was used to analyze systolic and diastolic blood pressure drops. Furthermore, 1) The paired t test was used for the analysis of the post-intervention period which aimed to analyze the mean differences before and after the intervention in the group given tomato juice, the group given cucumber juice, and in the control group (using a significance level of 5%). 2) ANOVA test is used to compare each group, in this case comparing the group given tomato juice, the group given cucumber juice, and the control group (using a significance level of 5%). 3) The problem of multiple comparisons of each intervention group was handled using the Bonferroni post hoc test (using a significance level of 5%).

Ethical Clearance

This study had been approved by the Immanuel School of Health Sciences Bandung (No.130/KEPK/STIKI/VII/2022).

RESULTS

There were 45 subjects included in the study. However, two subjects dropped out for the following reasons: one subject missed a day in consuming the tomato juice, and one subject experienced pain during the study. (Figure 1).

The characteristics of the subjects are described in Table 1. All participants included in this study were hypertensive patients who were not undergoing treatment. The characteristics of the subjects of the study did not differ significantly between the groups given tomato juice, cucumber juice, and control. The subjects of this study are in the age range of 40-70 years. Demographic characteristics include age, gender, education, and occupation in all three homogeneous groups.

The average blood pressure in the group given tomato juice before the intervention was 151.9±5.5, 94.6±2.8 and after the intervention was 147.6±4.0, 91.5±2.4. The average blood pressure in the group given cucumber juice before intervention was 151.4±6.3, 94.4±2.7 and after intervention was 148.4±4.6, 89.6±2.6). While the average blood pressure in the control group before the intervention (151.1±5.5, 95.2±3.1) and after the intervention (151.6±4.7, 94.5±2.9) (Table 2).

The average decrease in systolic blood pressure is shown in Figure 2. After intervention, the systolic blood pressure in the group given tomato juice has a greater blood pressure drop than in the group given cucumber juice or the control group.

The average decrease in diastolic blood pressure is shown in Figure 3. After intervention, that the diastolic blood

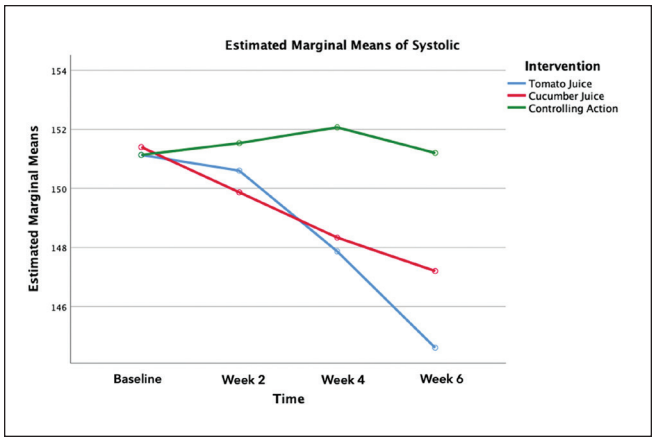

Figure 2. Plot general linear model-repeated measures (GLM-RM) systolic blood pressure (n=45).

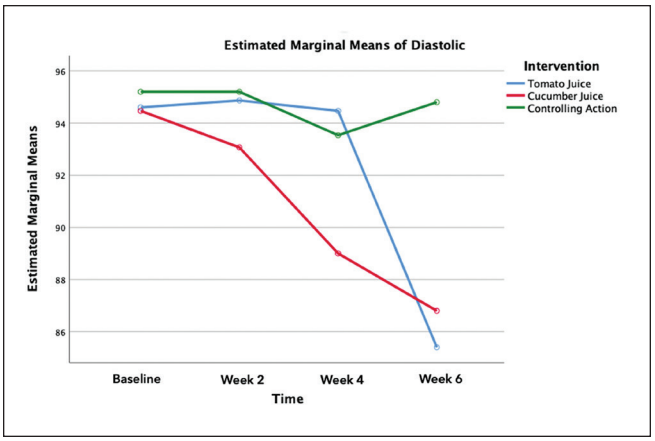

Figure 3. Plot general linear model-repeated measures (GLM-RM) diastolic blood pressure (n=45).

Table 1. Characteristics of the Subjects

Characteristic	Tomato Group	Cucumber Group	Control Group
	Mean±SD (Min-Max)		
Age	52.88±7.839 (40-63)	55.40±7.414 (43-65)	55.80±8.662 (40-70)
	n (%)	n (%)	n (%)
Gender			
Male	7 (46.7%)	7 (46.7%)	8 (53.3%)
Female	8 (53.3%)	8 (53.3%)	7 (46.7%)
Education			
Elementary	3 (20.0%)	3 (20.0%)	3 (20.0%)
Junior High School	7 (46.7%)	6 (40.0%)	6 (40.0%)
Senior High School	4 (26.7%)	4 (26.7%)	4 (26.7%)
University	1 (6.7%)	2 (13.3%)	2 (13.3%)
Occupation			
Civil Servant	1 (6.7%)	0 (0.0%)	0 (0.0%)
Private	3 (20.0%)	3 (20.0%)	3 (20.0%)
Entrepreneur	5 (33.3%)	5 (33.3%)	5 (33.3%)
Housewife	6 (40.0%)	6 (40.0%)	6 (40.0%)
Retired	0 (0.0%)	1 (6.7%)	1 (6.7%)
Total	**15 (100.0%)**	**15 (100.0%)**	**15 (100.0%)**

Table 2. Average Blood Pressure in Hypertensive Patients

Intervention	Baseline blood pressure	Average of 3 measurements for each observation period
Systolic Blood Pressure		
Tomato	151.9±5.5	147.6±4.0
Cucumber	151.4±6.3	148.4±4.6
Control	151.1±5.5	151.6±4.7
Diastolic Blood Pressure		
Tomato	94.6±2.8	91.5±2.4
Cucumber	94.4±2.7	89.6±2.6
Control	95.2±3.1	94.5±2.9

pressure in the group given tomato juice has greater blood pressure drop than in the group given cucumber juice or the control group.

The difference in blood pressure reduction in the groups given tomato juice, cucumber juice, and control is shown in Table 3. The systolic blood pressure in the tomato juice group decreased after treatment (week 6) by 7.3 mmHg (p=0.0001). In the group given cucumber juice, there was a decrease in blood pressure between pre- and post-treatment (week 6) by 4.2 mmHg (p=0.0001). While in the control group, there was an increase in blood pressure after treatment (week 6) by 0.0 mmHg (p=0.921). Diastolic blood pressure that in the tomato juice group decreased after treatment (week 6) by 9.2 mmHg (p=0.0001). In the group given cucumber juice, there was a decrease in blood pressure between before and after treatment (week 6) by 7.6 mmHg (p=0.0001). While in the control group there was an increase in blood pressure after treatment (week 6) by 0.4 mmHg (p=0.486).

The results showed that the greatest decrease in blood pressure was in the group given tomato juice (7.3±3.1 systolic) and (9.2±3.1 diastolic). The mean difference of each group can be seen in Figure 4.

Based on the findings of the Post Hoc Bonferroni analysis, Table 4 shows that there is a significant difference in systolic blood pressure between the tomato and control groups (p=0.000), which means that the administration of tomato juice is more effective in reducing systolic blood pressure than in the control group. The same with cucumber

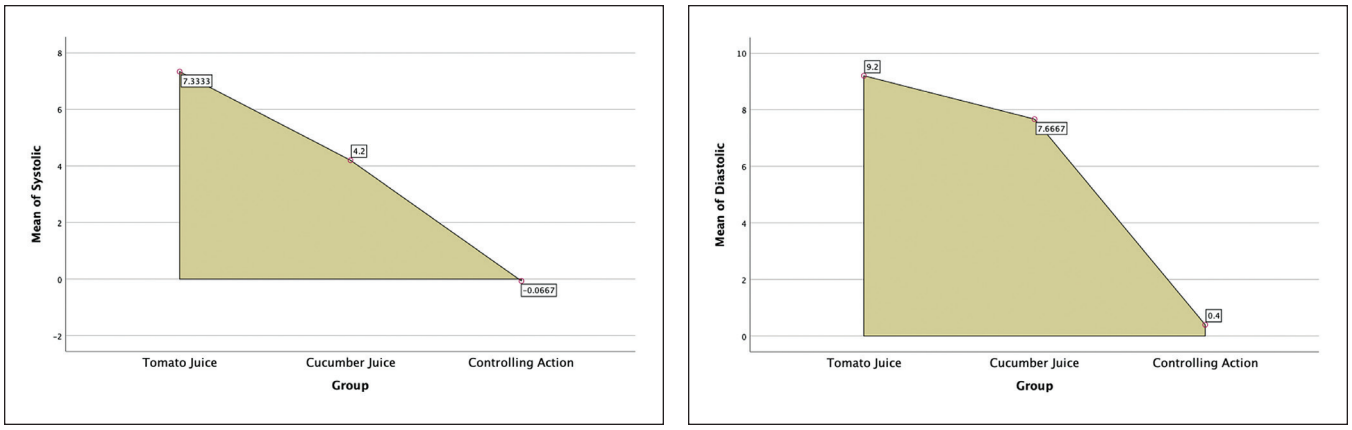

Figure 4. Mean difference of each Intervention group.

Table 3. The Differences Average of Decreasing Blood Pressure Systolic and Diastolic on Intervention Group Given Tomato Juice, Cucumber Juice, and Control Group

Intervention	Mean Pre-test	Mean Post-test (week 6)	Mean Differences	*P*-value (Paired t test)	*P*-value (ANOVA)
Systolic Blood Pressure					
Tomato Juice	151.9±5.5	144.6±3.2	7.3+3.1	0.0001	0.0001
Cucumber Juice	151.4±6.3	147.2±4.0	4.2+3.3	0.0001	
Controlling Action	151.1±5.5	151.2±6.2	-0.0+2.5	0.921	
Diastolic Blood Pressure					
Tomato Juice	94.6±2.8	85.4±3.1	9.2+3.1	0.0001	0.0001
Cucumber Juice	94.4±2.7	86.8±3.9	7.6+3.4	0.0001	
Controlling Action	95.2±3.1	94.8±3.0	0.4+2.1	0.486	

Table 4. Post Hoc Bonferroni Test of Systolic and Diastolic Blood Pressure on Hypertension Patient

Blood Pressure	Group	*P*-value
Systolic	Tomato and Cucumber	0.023
	Tomato and Control	0.0001
	Cucumber and Control	0.001
Diastolic	Tomato and cucumber	0.492
	Tomato and control	0.0001
	Cucumber and control	0.0001

and control (p=0.001), which means that giving cucumber juice is more effective in reducing systolic blood pressure than in the control. There is also a difference in diastolic blood pressure between the group given tomato juice and the control group (p=0.0001), which means that giving tomato juice is more effective in reducing diastolic blood pressure than in the control. And there is a significant difference between the group that received cucumber juice and the control group (0.0001), which means that giving cucumber juice is more effective in reducing diastolic blood pressure than in the control.

DISCUSSION

This study found that giving tomato juice was more effective in reducing systolic and diastolic blood pressure than giving cucumber juice or the control group. The average decrease in systolic blood pressure in the group given tomato juice was 7.33, while the decrease in diastolic blood pressure was 9.20. These results are in line with other studies which state that tomato juice can reduce blood pressure, both systolic and diastolic.[24–26]

Tomatoes can lower blood pressure because they contain potassium.[27] Potassium is a mineral element that is good for lowering or controlling tension. Potassium is a strong diuretic that helps maintain water balance, blood pressure, acid-base balance, and smooth urine output while dissolving stones in the urinary tract, bladder, and kidneys.[28]

In order to prevent a rise in blood pressure, potassium also prevents the conversion of released renin into renin angiotensin.[29] Potassium works as a natriuretic, increasing the body's need for sodium and fluids. In other words, potassium content of fruits has a big impact on lowering both systolic and diastolic blood pressure.[30] This has to do with how potassium works to lower blood pressure since it produces vasodilation, which can widen blood vessels and improve blood flow.[31]

Tomato extract has been shown to lower blood pressure; a similar impact was seen in both the cucumber juice group and the control group receiving a placebo. Compared to the groups receiving cucumber juice and a placebo, the group receiving tomato juice for six weeks demonstrated a greater decrease in blood pressure. A Poland-based research confirms this; the research revealed that the systolic and diastolic blood pressure of hypertensive patients who took tomato extract for six weeks decreased by ten millimeters of mercury (mmHg) and five millimeters of mercury, respectively.[32] While another study demonstrated that people with grade-1 hypertension

can lower their blood pressure with a brief course of treatment using tomato extract high in antioxidants. They found that when individuals took tomato extract for two months, their systolic and diastolic blood pressures decreased by 10 and 4 mmHg, respectively.[33] This study also proved that cucumber juice can reduce systolic and diastolic blood pressure in patients with hypertension. These results are in line with other studies which state that cucumber juice can significantly reduce blood pressure in patients with hypertension.[34,35] Giving cucumber juice can reduce blood pressure in adults, with a significant percentage of blood pressure reduction.[36]

The decrease in blood pressure occurs because cucumbers have potassium content that can reduce renin secretion, which causes inhibition of the Renin-Angiotensin System and also causes a decrease in aldosterone secretion, resulting in a decrease in sodium and water reabsorption in the renal tubules. As a result of this mechanism, there is an increase in diuresis, which causes a decrease in blood volume, resulting in a drop in blood pressure. In addition, potassium also causes vasodilation of peripheral blood vessels, resulting in a decrease in peripheral resistance and blood pressure.[36] This happens because of the potassium, magnesium, and phosphorus content in cucumbers, which is effective in reducing high blood pressure. Cucumber is also useful as a detoxifier because of its very high water content, up to 90%, which makes cucumbers have a diuretic effect. The rich minerals in cucumber are able to bind salt and excrete it through urine.[37]

Cucumber juice helps lower both systolic and diastolic blood pressure in hypertensive patients, according to one study.[38] These findings are consistent with those of earlier studies showing that cucumber juice can dramatically lower blood pressure in hypertension sufferers. Adults who are given cucumber juice can have a considerable percentage reduction in blood pressure.[38,39]

Having a small sample size is a limitation of this study so it is difficult to generalize the results. Dietary control was not carried out during the intervention, but researchers were able to ensure respondents did not take antihypertensive drugs during the intervention. We did not control for specific levels of stress that could increase respondents blood pressure, we only clarified through interviews, to ensure that respondents were not under severe stress. Additional variables such as exercise, sleep, smoking, and alcoholic beverages were not investigated in this study. These variables may have contributed as confounding factors. In addition, this study did not examine the side effects that may appear in patients.

It is necessary to conduct further research on controlling the diet and measuring the stress level of the research subjects to ensure the effect of tomato and cucumber extract in lowering blood pressure. Further studies may also be done on exercise exposure, sleeping hours, smoking, and alcoholic beverages to ensure that no confounding factors affect the results of the study.

CONCLUSION

The findings of this study showed that there was a difference in the mean decrease in blood pressure in the group given tomato juice, the group given cucumber juice, and the control group. The results can open up various efforts in reducing blood pressure in hypertensive patients such as teaching the public about healthy lifestyle and encouraging them to consume tomato juice every morning.

Consumption of tomato juice is recommended to control blood pressure in hypertensive patients, and can be done as a traditional treatment.

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Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

All authors declared no conflicts of interest.

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