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# Effects of the combination of red dragon fruit, kiwi, and young coconut water on blood pressure through ACE inhibition and antioxidant mechanisms in pre-elderly women: A quasi-experimental study

*Efek kombinasi buah naga merah, kiwi, dan air kelapa muda terhadap tekanan darah melalui mekanisme hambatan ACE dan antioksidan pada wanita pra-lansia: Studi kuasi-eksperimen*

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## Abstract

Hypertension is a major health concern among pre-elderly women, particularly those aged ≥45 years, as the hormonal changes associated with menopause exacerbate susceptibility. This study aimed to evaluate the effects of combined red dragon fruit (Hylocereus polyrhizus), green kiwi (Actinidia deliciosa), and young coconut water (Cocos nucifera) juice on blood pressure among women aged 45–59 years with prehypertension at the Sawah Lebar Primary Health Center in Bengkulu. A quasi-experimental pretest–posttest design was used with 30 participants in this study. Participants were assigned to the intervention (n=15; 230 mL juice twice daily for 7 days combined with exercise and nutrition counseling) or control (n = 15; counseling only) groups. Blood pressure was measured at baseline and post-intervention. Statistical analyses were performed using paired and independent t-tests ($p<0.05$) and ANCOVA. The intervention group showed a significant reduction in systolic (137.0±1.81 to 122.47±2.32 mmHg) and diastolic pressures (87.07±1.43 to 81.87±1.50 mmHg) compared with the control group (systolic: 135.87±2.29 to 132.40±2.77 mmHg; diastolic: 87.27±1.22 to 84.87±1.55 mmHg). The high potassium content (1,041.5 mg/serving) may enhance vasodilation, inhibit angiotensin-converting enzyme activity, and reduce sodium retention. Confounders (BMI, sodium intake, and physical activity) contributed <25% of the variance. This functional juice effectively reduced blood pressure, supporting its role in non-pharmacological strategies for hypertension management. Larger and longer trials are required to confirm the long-term benefits.

**Keywords:** Blood Pressure, Cocos nucifera, Functional Foods, Hypertension.

## Abstrak

Hipertensi merupakan masalah kesehatan utama pada wanita pra-lansia, khususnya pada usia ≥45 tahun, karena perubahan hormonal terkait menopause meningkatkan kerentanan terhadap penyakit ini. Penelitian ini bertujuan mengevaluasi efek kombinasi jus buah naga merah (Hylocereus polyrhizus), kiwi hijau (Actinidia deliciosa), dan air kelapa muda (Cocos nucifera) terhadap tekanan darah pada wanita usia 45–59 tahun dengan pra-hipertensi di Puskesmas Sawah Lebar, Bengkulu. Penelitian menggunakan desain kuasi-eksperimen dengan rancangan pretest–posttest melibatkan 30 partisipan. Mereka dibagi menjadi dua kelompok, yaitu kelompok intervensi (n=15; mengonsumsi 230 mL jus dua kali sehari selama 7 hari, disertai olahraga dan konseling gizi) serta kelompok kontrol (n=15; hanya konseling). Tekanan darah diukur sebelum dan sesudah intervensi. Analisis statistik dilakukan menggunakan uji t berpasangan, uji t independen ($p<0,05$), dan ANCOVA.

Hasil menunjukkan kelompok intervensi mengalami penurunan signifikan tekanan darah sistolik (137,0±1,81 menjadi 122,47±2,32 mmHg) dan diastolik (87,07±1,43 menjadi 81,87±1,50 mmHg), dibandingkan dengan kelompok kontrol (sistolik: 135,87±2,29 menjadi 132,40±2,77 mmHg; diastolik: 87,27±1,22 menjadi 84,87±1,55 mmHg). Kandungan kalium tinggi (1.041,5 mg/sajian) diduga berperan dalam meningkatkan pelebaran pembuluh darah, menghambat aktivitas enzim pengubah angiotensin, serta menurunkan retensi natrium. Faktor pengganggu seperti indeks massa tubuh, asupan natrium, dan aktivitas fisik hanya berkontribusi <25% terhadap variabilitas hasil. Kombinasi jus ini terbukti efektif menurunkan tekanan darah, sehingga berpotensi sebagai strategi nonfarmakologis. Penelitian dengan jumlah sampel lebih besar dan periode lebih panjang diperlukan untuk mengonfirmasi manfaat jangka panjangnya.

**Kata Kunci:** Air Kelapa Muda, Hipertensi, Makanan Fungsional, Tekanan Darah

## Introduction

Hypertension is a leading modifiable risk factor for cardiovascular diseases (CVDs). In the Sustainable Development Goals (SDGs), hypertension is included in Goal 3: Good Health and Well-being, especially in targets related to non-communicable diseases (NCDs), with a specific target of 3.4: "By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being." It affects approximately 1.28 billion adults globally, with two-thirds of cases concentrated in low- and middle-income countries (WHO, 2023). In Indonesia, the prevalence of hypertension surged from 25.8% in 2013 to 34.1% in 2018, disproportionately affecting women over 45 years of age, where hormonal shifts during menopause exacerbate susceptibility (Kemenkes RI, 2021; Riskesdas, 2018). Women have a higher risk of hypertension, especially after the age of 45 years, due to the natural decline in estrogen levels during menopause. Before menopause, estrogen helps raise HDL levels, offering protection against atherosclerosis and reducing cardiovascular risk (Simbolon et al., 2020). The latest data on the prevalence of hypertension according to SKI 2023 in Indonesia is 30.8%, with women (34.7%) being higher than men (26.9%). Despite pharmacological advancements, long-term antihypertensive drug use is often associated with adverse effects, non-adherence, and financial burdens, particularly in resource-limited settings (Li'wuliyya, 2024). Consequently, non-pharmacological interventions, including dietary modifications rich in bioactive compounds, have gained traction as sustainable strategies for blood pressure (BP) management (Filippini et al., 2020).

Emerging evidence highlights the antihypertensive potential of potassium-rich fruits, such as red dragon fruit (Hylocereus polyrhizus), green kiwifruit (Actinidia deliciosa), and young coconut water (Cocos nucifera), which synergistically target multiple pathways in BP regulation. Red dragon fruit contains anthocyanins (38.3 mg/100 g) and flavonoids (7.21 mg/100 g), which inhibit angiotensin-converting enzyme (ACE) activity, a key enzyme in the renin-angiotensin-aldosterone system (RAAS) that is responsible for vasoconstriction (Aprianti et al., 2021; Hanura et al., 2021). Similarly, green kiwifruit provides 332 mg/100 g of potassium and 100 mg/100 g of vitamin C, which enhances nitric oxide (NO)-mediated vasodilation and reduces oxidative stress (Guan et al., 2020; Zuraini et al., 2021). Young coconut water, with 299 mg/100 ml potassium, promotes natriuresis and counterbalances sodium-induced fluid retention (Cembun et al., 2020; Zulaikhah, 2020). While the individual effects of these fruits have been documented (Aulia & Achirman, 2021; Fadlilah et al., 2021; Prasad et al., 2020), their combined efficacy remains unexplored, representing a critical research gap in the management of nutritional hypertension in nutritional hypertension.

The current literature underscores the limitations of single-nutrient approaches in addressing multifactorial hypertension. For instance, isolated potassium supplementation reduces systolic BP by 4–5 mmHg but fails to address endothelial dysfunction or oxidative stress (Filippini et al., 2020). Conversely,

polyphenol-rich diets improve vascular reactivity but may lack sufficient electrolyte modulation (Wu, 2024). A blended fruit intervention could theoretically bridge these gaps by integrating ACE inhibition, antioxidant activity and electrolyte balance. Mechanistically, anthocyanins in red dragon fruit block angiotensin II formation (Hanura et al., 2021), whereas kiwifruit-derived vitamin C enhances NO bioavailability and mitigates endothelial dysfunction (Guan et al., 2020). Concurrently, the high potassium content of coconut water suppresses RAAS activation and reduces sodium reabsorption (Zulaikhah, 2020). This triad of actions aligns with the "multi-target" paradigm advocated for complex chronic conditions, such as hypertension (Sriperumbuduri et al., 2024).

Indonesia's high burden of hypertension, coupled with cultural familiarity with these fruits, provides a unique context for testing this intervention. Pre-elderly women (45–59 years) are particularly vulnerable owing to age-related arterial stiffness and postmenopausal estrogen decline, which diminish vaso-protective effects, and hormonal shifts during menopause exacerbate this susceptibility (Kusumawaty et al., 2016). Prior studies in this demographic have focused on isolated lifestyle modifications (e.g., sodium restriction or exercise), often neglecting synergistic dietary strategies (Bangun, 2016; Yeni et al., 2022). Furthermore, existing trials on fruit-based interventions in Southeast Asia are limited by short durations (<7 days) or inadequate control of for confounding variables such as physical activity and body mass index (BMI) (Mufida, 2019; Sari et al., 2022). A rigorous quasi-experimental design with prolonged intervention (7 days) and multivariate variable adjustment could yield more definitive insights.

This study addresses these gaps by evaluating the efficacy of a 7-day intervention with a novel blended fruit on BP reduction in pre-elderly Indonesian women with prehypertension or stage I hypertension. The secondary objective was to elucidate the intervention's impact on RAAS modulation (via ACE inhibition) and oxidative stress markers, thereby providing mechanistic insights. The quasi-experimental approach, incorporating a control group receiving standard dietary counseling, enhances internal validity while reflecting real-world applicability. By integrating biochemical, clinical, and dietary data, this study advances the understanding of multi-component fruit interventions as feasible and culturally relevant strategies for hypertension management in resource-limited settings.

## Methods

This quasi-experimental study employed a pretest-posttest design with a control group to evaluate the efficacy of a 7-day dietary intervention involving a blend of red dragon fruit (*Hylocereus polyrhizus*), green kiwifruit (*Actinidia deliciosa*), and young coconut water (*Cocos nucifera*) in reducing blood pressure (BP). The study was conducted in Sawah Lebar, Bengkulu City, Indonesia, from February to March 2025, targeting pre-elderly women aged 45–59 years who were diagnosed with prehypertension (systolic BP: 130–139 mmHg; diastolic BP: 85–89 mmHg) (PERHI, 2021). Participants were excluded if they had secondary hypertension, allergies to the fruits, or were undergoing pharmacological antihypertensive therapy (Li'wuliyya, 2024).

A minimum sample size of 30 participants (15 per group) was calculated using Lemeshow's formula (1997), assuming a standard deviation of 9.13 mmHg (Rosanty et al., 2023), a 95% confidence interval, an 80% power. Participants were recruited via purposive sampling from community health center registries and randomized into intervention and control groups using stratified randomization based on baseline BP and BMI (Kemenkes RI, 2021).

Blood Pressure was measured using a validated automated oscillometric monitor (Omron HEM-7320 made in China 2017 and calibrated) after 10 minutes of rest, following WHO (2023) protocols. Triplicate measurements were averaged at baseline (Day 0) and post-intervention (Day 8). Dietary intake was assessed using a 24-hour dietary recall administered daily to assess sodium and potassium intakes, which were analyzed using Nutrisurvey software (Fitri et al., 2023). Physical activity was quantified in metabolic equivalent (MET)-minutes/week using The Global Physical Activity Questionnaire (GPAQ). Anthropometrics: Weight and height were measured using a digital scale (SECA 803) and stadiometer (SECA 213) to calculate BMI (Kemenkes RI, 2018).

Data were analyzed using SPSS version 26. Normality was assessed using the Shapiro-Wilk test. Within-group changes were evaluated using

paired t-tests, and between-group differences were analyzed using independent t-tests. Analysis of covariance (ANCOVA) was adjusted for confounding variables (BMI, sodium intake, and physical activity) with blood pressure. Effect sizes were reported as Cohen's d. Statistical significance was set at $p < 0.05$. Ethical approval: STIKes Sapta Bakti Bengkulu Ethics Committee (No.130/FB/KEPKSTIKesSaptaBakti/2025)

## Result and Discussion

The study involved 30 pre-elderly women (45–59 years) with prehypertension (systolic blood pressure [SBP]: 130–139 mmHg; diastolic blood pressure [DBP]: 85–89 mmHg) from the Sawah Lebar Community Health Center in Bengkulu, Indonesia. Participants were divided into intervention (n=15) and control (n=15) groups.

**Table 1.** Blood Pressure Picture Before and After Intervention

| Variable | Mean | ± | SD | Mean Difference | p Value |
|---|---|---|---|---|---|
| Intervention Group | | | | | |
| Systolic Blood Pressure (mmHg) | | | | | |
| Before | 137.00 | ± | 1.81 | 14.53 | <0.001 |
| After | 122.47 | ± | 2.32 | | |
| Diastolic Blood Pressure (mmHg) | | | | | |
| Before | 87.07 | ± | 1.43 | 5.20 | <0.001 |
| After | 81.87 | ± | 1.50 | | |
| Control Group | | | | | |
| Systolic Blood Pressure (mmHg) | | | | | |
| Before | 135.87 | ± | 2.29 | 3.46 | <0.001 |
| After | 132.40 | ± | 2.77 | | |
| Diastolic Blood Pressure (mmHg) | | | | | |
| Before | 87.27 | ± | 1.22 | 2.40 | <0.001 |
| After | 84.87 | ± | 1.55 | | |

*$p < 0.05$ was considered significant (paired t-test), with a 95% confidence interval (CI).*

The intervention group received 230 mL of combined juice (100 g red dragon fruit, 100 g green kiwi, and 170 mL young coconut water) for 7 days, alongside nutritional counseling. The control group received only counseling. The intervention group exhibited a significant reduction in SBP (-14.5 mmHg) and DBP (-5.2 mmHg) compared to the control group (-3.5 mmHg and -2.4 mmHg, respectively; $p<0.001$). Independent t-tests confirmed post-intervention differences between the groups (SBP: $p<0.001$; DBP: $p<0.001$). In general, JNC 8 recommends a blood pressure target of <140/90 mmHg for patients aged < 60 years.

The intervention group aligns with studies on individual fruits but exceeds their reported effects. For instance, red dragon fruit alone reduced SBP by 10–12 mmHg in hypertensive patients (Aprianti et al., 2021), whereas greenkiwi reduced SBP by 6–8 mmHg (Monro et al., 2022). The synergistic effect of combining the three potassium-rich ingredients likely amplified vasodilation and ACE inhibition, which is a novel finding in non-pharmacological hypertension management.

The combined juice exerts antihypertensive effects through multiple synergistic mechanisms mediated by its rich composition of potassium, flavonoids, anthocyanins, and vitamin C. Potassium, present at 1,041 mg per serving, contributes significantly to the WHO's recommended daily intake of 3,510 mg and plays a dual role in blood pressure regulation. First, it induces vasodilation by hyperpolarizing endothelial cells through enhanced potassium efflux, thereby reducing vascular resistance and improving the blood flow (Chan et al., 2024). Second, potassium inhibits sodium reabsorption in the renal tubules by antagonizing the $Na^+$-$K^+$-$2Cl^-$ cotransporter, leading to a decrease in plasma volume and a subsequent reduction in blood pressure (Sriperumbuduri et al., 2024). In addition, bioactive compounds from the juice ingredients further target vascular and endothelial pathways. Red dragon fruit, containing 38.3 mg/100g of anthocyanins, inhibits angiotensin II, -converting enzyme (ACE), thereby preventing the formation of angiotensin II a potent vasoconstrictor and alleviating vascular tension (Hanura et al., 2021).

flavonoids such as quercetin from green kiwi enhance nitric oxide (NO) bioavailability by reducing oxidative degradation, which improves endothelial-dependent vasodilation and microcirculatory function (Zuraini et al., 2021). Additionally, the high vitamin C content of kiwifruit (100 mg/100g) mitigates oxidative stress, a key contributor to endothelial dysfunction, by scavenging free radicals and preserving the integrity of vascular tissues (Guan et al., 2020). Together, these mechanisms of vasodilation, sodium excretion, ACE inhibition, NO enhancement, and antioxidant protection collectively lower blood pressure through both direct vascular effects and indirect modulation of renal and oxidative pathways, demonstrating the multifactorial cardioprotective potential of the juice.

The antihypertensive efficacy observed in this study surpassed the outcomes reported in prior trials focusing on single-fruit interventions, underscoring the synergistic benefits of combining bioactive ingredients. For instance, a 7-day trial of red dragon fruit supplementation demonstrated a systolic blood pressure (SBP) reduction of 10 mmHg in menopausal women, attributed to its vasoactive anthocyanins (Mufida, 2019). Similarly, daily consumption of green kiwifruit over 7 weeks resulted in a modest SBP decline of 6.3 mmHg, which was linked to flavonoid-mediated enhancement of endothelial nitric oxide bioavailability (Monro et al., 2022). In comparison, young coconut water administered over a 5-day period reduced SBP by 10 mmHg in individuals with stage 1 hypertension, likely due to its electrolyte balance and mild diuretic effects (Fadlilah et al., 2021).

While these single-ingredient interventions achieved clinically meaningful reductions, the combined formulation in the current study, integrating potassium, flavonoids, anthocyanins, and vitamin C, appears to amplify and accelerate antihypertensive effects through multi-target mechanisms. The superior outcomes may arise from complementary actions: potassium dual vasodilatory and natriuretic effects, anthocyanin ACE inhibition, flavonoid endothelial protection, and vitamin C antioxidant activity, which collectively address the vascular, renal, and oxidative pathways simultaneously.

The additive effect of this combination likely stems from complementary mechanisms: ACE inhibition by dragon fruit, NO enhancement by kiwi, and electrolyte balance by coconut water. This aligns with (Filippini et al., 2020) who found that potassium-rich diets reduce SBP by 4–5 mmHg, but our intervention tripled this effect, suggesting synergy.

High extracellular potassium directly regulates sodium chloride cotransporter NCC (sodium-chloride cotransporter) function independently of hormonal mechanisms by affecting distal tubule membrane potential and intracellular chloride levels (Chan et al., 2024). Elevated potassium levels increase intracellular chloride levels, preventing the activation of the WNK signaling pathway and keeping NCC inactive. This leads to natriuresis and kaliuretic, ultimately lowering blood pressure. In contrast, excessive sodium intake raises extracellular fluid volume and blood pressure, whereas potassium has the opposite effect, helping to regulate intracellular osmotic pressure, fluid balance, heart rate, and reducing the risk of stroke and cardiovascular disease (Rohmah et al., 2023; Dewi, 2022).

The potassium in kiwi and young coconut water contributes to blood pressure reduction through several mechanisms. In young coconut water, potassium promotes natriuresis via kidney function, enhances endothelial-dependent vasodilation, and reduces blood pressure through central mechanisms by lowering the activity of the renin-angiotensin-RAA system and sympathetic nerve signals (Saputra et al., 2024). Potassium also induces vasodilation by reducing the membrane potential, inhibiting smooth muscle contraction, and decreasing total peripheral resistance (TPR), further contributing to blood pressure reduction.

First study to evaluate a triple-ingredient juice targeting multiple pathways (ACE inhibition, vasodilation, and diuresis). Demonstrated the feasibility of short-term (7-day) interventions for prehypertension, a critical window for preventing progression to hypertension. Current non-pharmacological strategies emphasize the DASH diet or single-nutrient supplementation (e.g., potassium tablets). However, dietary compliance remains low (<30%) because of palatability and cost. This study offers a palatable, culturally acceptable alternative using locally available fruits, addressing the gap in scalable interventions for low- and middle-income countries.

**Table 2.** Analysis of confounding variables

| Variable | Mean | Systolic Blood Pressure | | Diastolic Blood Pressure | |
|---|---|---|---|---|---|
| | | Coefficients (sign.) | r square | Coefficients (sign.) | r square |
| Body Mass Index (BMI) | 23.21 | 0.56 | | 0.42 | |
| Physical Activity | 780.6 | 0.74 | 0.036 | 0.29 | 0.061 |
| Sodium Intake | 1865.62 | 0.47 | | 0.83 | |

Multivariate analysis (ANCOVA) showed that confounding variables (BMI, activity, sodium) accounted for only 3.6% (SBP) and 6.1% (DBP) of the variance, confirming minimal influence on outcomes ($p>0.05$). The ability of confounding variables to influence systolic and diastolic blood pressure was <25%, so that the confounding variables were successfully controlled and did not influence the dependent variable.

Weight gain, leading to being overweight or obese is a key trigger for hypertension, as increased oxygen and nutrient demands raise blood volume, cardiac output, and vascular resistance, elevating blood pressure (Aminati, 2022). Physical activity plays a key role in improving heart strength and efficiency, reducing the burden on arteries, and lowering blood pressure. Regular and adequate physical activity helps control body weight and lowers the risk of cardiovascular diseases (Yeni et al., 2022). Excessive sodium intake can cause arterial vasoconstriction, thereby increasing peripheral resistance. This forces the heart to work harder to pump blood, leading to higher blood pressure and eventually hypertension (Fitri et al., 2023)

This multifaceted approach not only enhances the magnitude of blood pressure reduction but also potentially reduces the time required to achieve therapeutic benefits, as evidenced by the rapid and pronounced effects observed in this trial compared to longer-duration single-fruit studies. These findings highlight the advantages of leveraging nutrient synergy in functional food design for cardiovascular health.

## Conclusion

This 7-day dietary intervention combining red dragon fruit, kiwi, and young coconut water significantly reduced systolic (14.5 mmHg) and diastolic (5.2 mmHg) blood pressure in prehypertensive women. The synergistic action of anthocyanins, vitamin C, and potassium supports vasodilation, ACE inhibition, and sodium excretion, providing broader benefits than single-nutrient approaches. Confounders such as BMI, sodium intake, and physical activity were controlled for, thereby reducing potential bias. Despite the limitations related to the quasi-experimental design and short duration, these findings emphasize the potential of multi-target dietary strategies for managing chronic conditions.

Future research should prioritize randomized controlled trials with longer follow-up periods and biomarker monitoring to validate long-term efficacy. At the practical level, integrating this functional juice into Primary Health Center (PHC) nutrition programs may offer a simple, affordable, and culturally appropriate option for hypertension prevention in the community. Strengthening collaboration between health workers and local food resources could enhance the feasibility and sustainability of primary care implementation.

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