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Influence of Celery Leaf Substitution on the Sodium and Potassium Composition of a Functional Cucumber Powder Drink for Hypertension Management

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ABSTRACT

Functional beverages innovatively formulated from natural ingredients such as cucumber (*Cucumis sativus* L.) and celery (*Apium graveolens* L.) contain abundant bioactive compounds with antihypertensive properties, offering a nutritious and safe alternative to support the prevention and management of hypertension. This study aimed to determine the effect of celery extract powder substitution on the organoleptic properties and the sodium and potassium contents of functional cucumber powder drinks. This experimental research employed a non-factorial Completely Randomized Design (CRD) consisting of three treatments and three replications. The parameters tested included acceptability (color, taste, aroma, and texture) through hedonic testing by semi-trained panelists, as well as sodium and potassium analysis conducted at the Center for Standardization and Industrial Services. Data were analyzed using ANOVA, followed by Duncan's test when significant differences were observed. The highest mean scores for color and aroma were obtained in treatment P (50% celery: 50% cucumber), for taste in treatment R (60% celery: 40% cucumber), and for texture in treatment N (40% celery: 60% cucumber), with all treatments categorized as "slightly liked." Treatment N (40% celery: 60% cucumber) showed the lowest sodium content (3.85 mg/200 ml, 0.25% RDA) and the highest potassium content (24.21 mg/200 ml, 0.51% RDA). Substitution of celery leaf powder in treatments N, P, and R had no significant effect on color, taste, aroma, or texture, but significantly affected sodium and potassium levels. The formulation in treatment N (40% celery: 60% cucumber) demonstrated the greatest potential as a functional beverage for hypertension management.

Keywords: celery leaf, cucumber, functional drink, hypertension

Introduction

According to the 2018 Basic Health Research (Riskesdas), more than 63 million Indonesians suffer from hypertension. The national prevalence increased from 25.8% in 2013 to 34.1% in 2018, with a particularly sharp rise of 26.45% reported in Aceh Province. It is estimated that 63,309,620 Indonesians have been diagnosed with hypertension, and approximately 427,218 deaths are attributed to this condition annually. The highest prevalence rates were observed among individuals aged 31–44 years (31.6%), 45–54 years (45.3%), and 55–64 years (55.2%). Among all hypertensive patients, only 8.8% had been diagnosed, 13.3% were inconsistent with medication, and 32.3% did not adhere to regular treatment schedules (Kemenkes RI, 2018).

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The development of a functional powdered beverage from celery and cucumber offers a non-pharmacological approach to managing hypertension. Among various beverage formulations, instant powdered drinks are particularly advantageous due to their high water solubility, rapid rehydration, convenient serving size, and long shelf life (Yolandari, 2021).

Celery (Apium graveolens L.) is widely recognized for its antihypertensive properties, primarily due to its high content of apiin, a flavonoid with diuretic activity. Apiin promotes the excretion of sodium and water through urine, thereby reducing blood volume and pressure. Celery also contributes to vasodilation, which enhances blood flow and reduces vascular resistance. Its high potassium concentration supports intracellular fluid balance by attracting extracellular sodium, which may further help regulate blood pressure through the sodium–potassium pump mechanism (Nurhalima et al., 2020).

Cucumber (Cucumis sativus L.) similarly exhibits hypotensive effects owing to its high potassium and water content. Potassium facilitates sodium reuptake into cells and promotes vasodilation, lowering systemic vascular resistance. As the main intracellular cation, potassium maintains fluid, electrolyte, and acid–base balance and supports neuromuscular function. Furthermore, potassium contributes to blood pressure regulation by inhibiting the renin–angiotensin–aldosterone system (RAAS), decreasing aldosterone release, and reducing sodium and water reabsorption in the renal tubules, which together enhance diuresis and lower blood volume (Ivana et al., 2021; Rahayu et al., 2022).

Based on this background, this study aims to examine the effect of substituting celery leaf extract powder on the acceptability and chemical characteristics of a cucumber-based functional powdered drink for hypertension management. It is expected that this product will serve not only as a nutritious and acceptable beverage but also as a supportive intervention for controlling blood pressure among hypertensive individuals.

Methods

This study employed an experimental design using a non-factorial Completely Randomized Design (CRD) with three treatments and three replications, resulting in a total of nine experimental units ($3 \times 3 = 9$). Three formulations were prepared: treatment N (40% celery leaf powder and 60% cucumber), treatment P (50% celery leaf powder and 50% cucumber), and treatment R (60% celery leaf powder and 40% cucumber). Each formulation weighed 30 g and was dissolved in 200 ml of water prior to analysis. The parameters tested included organoleptic properties (color, taste, aroma, and texture) which were evaluated through a hedonic test to determine the level of consumer preference. The sensory evaluation was conducted in the Food Laboratory, Department of Nutrition, Poltekkes Kemenkes Aceh. The panel consisted of 30 moderately trained panelists, all of whom were students from the Department of Nutrition who had completed the Food Technology (FT) course. Chemical analyses, including the determination of sodium and potassium content, were performed at the Standardization and Industrial Service Center, Banda Aceh. Data were analyzed statistically using Analysis of Variance (ANOVA), and when significant differences were observed, the Duncan's Multiple Range Test (DMRT) was applied to identify differences among treatment means.

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Results

Organoleptic Characteristics

The organoleptic test of the functional cucumber powdered drink with celery leaf substitution was conducted using the hedonic test method to assess the panelists' preference levels regarding color, taste, aroma, and texture.

Table 1. Result of Color Organoleptic Test in Functional Beverage

Formulation	Average	*p-value*
Celery 40 % : Cucumber 60% (N)	3,24[a]	0,396
Celery 50 % : Cucumber 50% (P)	3,42[a]	
Celery 60 % : Cucumber 40% (R)	3,29[a]	

Based on table 1, it shows that the average panelists gave a slightly favorable response (3.24) to the color of the functional beverage in treatment N (40% celery : 60% cucumber), a slightly favorable response (3.42) to the color of the functional beverage in treatment P (50% celery : 50% cucumber), and a slightly favorable response (3.29) to the color of the functional beverage in treatment R (60% celery : 40% cucumber). The analysis of variance (ANOVA) results indicate that the functional beverages in treatments N (40% celery : 60% cucumber), P (50% celery : 50% cucumber), and R (60% celery : 40% cucumber) had no significant effect on the color of the functional beverage, with a p-value of 0.396 > 0.05.

Tabel 2. Result of Taste Organoleptic Test in Functional Beverage

Formulation	Average	*p-value*
Celery 40% : Cucumber 60% (N)	3,19[a]	0,348
Celery 50% : Cucumber 50% (P)	3,17[a]	
Celery 60% : Cucumber 40% (R)	3,34[a]	

Based on table 2, it shows that the average panelists gave a slightly favorable response (3.19) to the taste of the functional beverage in treatment N (40% celery:60% cucumber), a slightly favorable response (3.17) to the taste of the functional beverage in treatment P (50% celery:50% cucumber), and a slightly favorable response (3.34) to the taste of the functional beverage in treatment R (60% celery:40% cucumber). The analysis of variance (ANOVA) results indicate that the functional beverages in treatments N (40% celery:60% cucumber), P (50% celery:50% cucumber), and R (60% celery:40% cucumber) had no significant effect on the taste of the functional beverage, with a p-value of 0.348 > 0.05.

Tabel 3. Result of Aroma Organoleptic Test in Functional Beverage

Formulation	Average	*p-value*
Celery 40% : Cucumber 60% (N)	2,97[a]	0,511
Celery 50% : Cucumber 50% (P)	3,13[a]	
Celery 60% : Cucumber 40% (R)	3,06[a]	

Based on table 3, it shows that the average panelists gave an unfavorable response (2.97) to the aroma of the functional beverage in treatment N (40% celery:60% cucumber), a slightly favorable response (3.13) to the aroma of the functional beverage in treatment P (50% celery:50% cucumber), and

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a slightly favorable response (3.06) to the aroma of the functional beverage in treatment R (60% celery:40% cucumber). The analysis of variance (ANOVA) results indicate that the functional beverages in treatments N (40% celery:60% cucumber), P (50% celery:50% cucumber), and R (60% celery:40% cucumber) had no significant effect on the aroma of the functional beverage, with a p-value of 0.511 > 0.05.

Tabel 4. Result of Texture Organoleptic Test in Functional Beverage

Formulation	Average	*p-value*
Celery 40% : Cucumber 60% (N)	3,79[a]	
Celery 50% : Cucumber 50% (P)	3,71[a]	0,694
Celery 60% : Cucumber 40% (R)	3,70[a]	

Based on Table 4, it shows that the average panelists gave a slightly favorable response (3.79) to the texture of the functional beverage in treatment N (40% celery:60% cucumber), a slightly favorable response (3.71) to the texture of the functional beverage in treatment P (50% celery:50% cucumber), and a slightly favorable response (3.70) to the texture of the functional beverage in treatment R (60% celery:40% cucumber). The analysis of variance (ANOVA) results indicate that the functional beverages in treatments N (40% celery:60% cucumber), P (50% celery:50% cucumber), and R (60% celery:40% cucumber) had no significant effect on the texture of the functional beverage, with a p-value of 0.694 > 0.05.

Chemical Analysis

Tabel 5. Results of Sodium Content Analysis in 200 ml of Functional Beverage

Formulation	Sodium Content (mg) Test			Average	*p-value**
	1	2	3		
Celery 40% : Cucumber 60% (N)	3,89	3,77	3,89	3,85[a]	
Celery 50% : Cucumber 50% (P)	4,14	4,09	4,24	4,16[b]	0,000
Celery 60% : Cucumber 40% (R)	4,27	4,26	4,35	4,29[b]	

Based on table 5, the average results of the sodium content analysis in the functional cucumber powder beverage with celery leaf powder substitution show that the sodium content in treatment N (40% celery:60% cucumber) is 3.85 mg/200 ml, in treatment P (50% celery:50% cucumber) is 4.16 mg/200 ml, and in treatment R (60% celery:40% cucumber) is 4.29 mg/200 ml. The analysis of variance (ANOVA) results indicate that the beverages in treatments N (40% celery:60% cucumber), P (50% celery:50% cucumber), and R (60% celery:40% cucumber) had a significant effect on the sodium content of the functional beverage, with a significance level (p-value) of 0.000 < 0.05.

Tabel 6. Results of Duncan's Test for Sodium Content in 200 ml of Functional Beverage

Formulation	N	Sodium Content (mg)	
		1 (a)	2 (b)
Celery 40% : Cucumber 60% (N)	3	3,8503	
Celery 50% : Cucumber 50% (P)	3		4,1610
Celery 60% : Cucumber 40% (R)	3		4,2923

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Based on Table 6, it shows that the functional beverage in treatment N (40% celery:60% cucumber) is significantly different from the functional beverage in treatment P (50% celery:50% cucumber) and treatment R (60% celery:40% cucumber). The functional beverage in treatment P (50% celery:50% cucumber) is not significantly different from the functional beverage in treatment R (60% celery:40% cucumber).

Tabel 7. Results of Potassium Content Analysis in 200 ml of Functional Beverage

Formulation	Potassium Content (mg)				*p-value**
	Test			Average	
	1	2	3		
Celery 40% : Cucumber 60% (N)	24,32	24,02	24,31	24,21[a]	
Celery 50% : Cucumber 50% (P)	23,87	23,99	24,21	24,02 [b]	0,002
Celery 60% : Cucumber 40% (R)	23,13	23,21	23,53	23,28 [b]	

Based on Table 7, the average results of the potassium content analysis in the functional cucumber powder beverage with celery leaf powder substitution show that the potassium content in treatment N (40% celery:60% cucumber) is 24.21 mg/200 ml, in treatment P (50% celery:50% cucumber) is 24.02 mg/200 ml, and in treatment R (60% celery:40% cucumber) is 23.28 mg/200 ml. The analysis of variance (ANOVA) results indicate that the beverages in treatments N (40% celery:60% cucumber), P (50% celery:50% cucumber), and R (60% celery:40% cucumber) had a significant effect on the potassium content of the functional beverage, with a significance level (p-value) of $0.002 < 0.05$.

Tabel 8. Results of Duncan's Test for Potassium Content in 200 ml of Functional Beverage

Formulation	N	Potassium Content (mg)	
		1 (a)	2 (b)
Celery 40% : Cucumber 60% (N)	3		24,2153
Celery 50% : Cucumber 50% (P)	3		24,0247
Celery 60% : Cucumber 40% (R)	3	23,2880	

Based on Table 8, it shows that the functional beverage in treatment N (40% celery:60% cucumber) is not significantly different from the functional beverage in treatment P (50% celery:50% cucumber). The functional beverage in treatment R (60% celery:40% cucumber) is significantly different from the functional beverage in treatment N (40% celery:60% cucumber) and treatment P (50% celery:50% cucumber).

Discussion

Organoleptic Characteristics

Color

The functional beverage with the highest color score is the one in treatment P (50% celery:50% cucumber), although it still falls under the slightly liked category. This occurs because it tends to produce a moderate natural green color, which comes from the dominance of celery's

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chlorophyll pigment, blended with the pale green character of cucumber. The resulting beverage color appears fresh, light green with a slightly cloudy and natural look (Aurillia, 2022).

Taste

The functional beverage with the highest taste score was found in treatment R (60% celery:40% cucumber), although it still fell within the slightly liked category. This result may be attributed to the fact that some panelists preferred the distinctive fresh taste of celery, characterized by a natural herbal aroma that provides a unique cooling and refreshing sensation to the body. This phenomenon could be due to the presence of tannin compounds in celery leaves, which possess astringent properties and contribute to the characteristic flavor profile of the beverage. These tannins can influence the overall taste, offering a distinctive nuance and enhancing the flavor experience for the panelists (Fitriana, 2019).

Aroma

The functional beverage with the highest aroma score, although still within the slightly liked category, was found in treatment P (50% celery:50% cucumber). This was attributed to the optimal balance between the celery and cucumber powder mixture, which created a complementary combination of taste and aroma. This blend resulted in a fresh and natural sensation, with the celery aroma providing a distinctive herbal impression. This finding indicates that the greater the amount of celery leaves used, the stronger the characteristic aroma produced. This is due to the essential oil content and acetogenin compounds present in celery leaves, which contribute to the unique characteristics of the produc (Aurillia, 2022).

Texture

The functional beverage with the highest texture and consistency score was observed in treatment N (40% celery:60% cucumber), although it was still categorized as slightly liked. This result is attributed to the higher proportion of cucumber powder, which, due to its soft texture and high solubility, dominated the beverage’s consistency, providing a lighter sensation when consumed. Meanwhile, the 40% celery powder contributed a slight fiber texture without being overly prominent, thus maintaining drinking comfort. This combination resulted in a balanced texture, making the product more acceptable to the panelists (Fitriana, 2019).

Chemical Analysis

Sodium Content

According to the 2019 Recommended Dietary Allowances (RDA), the adequate intake of sodium is 1500 mg per day. Based on the RDA, the sodium contribution from the celery-cucumber functional beverage per 200 ml serving was 0,25% in treatment N (40% celery:60% cucumber), 0,27% in treatment P (50% celery:50% cucumber), and 0,28% in treatment R (60% celery:40% cucumber). Sodium plays an important role in regulating fluid balance and blood pressure in the body. However, excessive sodium intake can increase blood pressure by causing fluid retention, which adds stress to the blood vessels and the heart. This is consistent with the study conducted by (Donna et al., 2018), which found that the higher the amount of celery used, the higher the sodium content; however, it remains safe for consumption. Celery also contains phthalides and magnesium, which help stabilize blood pressure. Meanwhile, the sodium content in cucumber continues to play a role in maintaining the body's electrolyte functions.

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Potassium Content

According to the 2019 Recommended Dietary Allowance (RDA), the suggested potassium intake is 4700 mg per day. Based on the RDA, the cucumber powder functional drink substituted with celery leaf powder per 200 ml serving contributes 0,51% in treatment N (40% celery powder : 60% cucumber powder), 0,51% in treatment P (50% celery powder : 50% cucumber powder), and 0,49% in treatment R (60% celery powder : 40% cucumber powder). Potassium intake in individuals can influence blood pressure. Increasing potassium intake can help lower both systolic and diastolic blood pressure by reducing vascular resistance. This finding is consistent with the study conducted by (Rifaldi & Hidayati, 2023), which reported that the higher the celery substitution, the greater the potassium content. The natural potassium content in both celery and cucumber serves as a beneficial source for blood pressure regulation. An ideal sodium-to-potassium ratio for lowering blood pressure is 1:1 or lower, with greater benefits observed at a 1:2 ratio, where potassium intake is twice that of sodium. Higher potassium levels help excrete sodium through urine and support the dilation of blood vessels, thereby effectively lowering blood pressure and reducing the risk of hypertension related complications (Gautami & Kumala, 2021).

Kesimpulan

Based on the results obtained, it can be concluded that the substitution of celery leaf powder in treatments N (celery cucumber 40%:60%), P (celery cucumber 50%:50%), and R (celery cucumber 60%:40%) has no significant effect on the color, taste, aroma, and texture of the functional drink, but has a significant effect on the sodium and potassium content. The product in treatment N (celery cucumber 40%:60%) has the potential to be implemented for hypertension management, but further improvements in acceptability are needed through the addition of other ingredients and testing of active components related to hypertension.

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