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The Effect of White-Colored Fruits' Micronutrients on Brain Cell Function in Adults with Early Memory Loss

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Abstract

Background: White-colored fruits, such as apples, pears, bananas, and white guavas, are rich in specific micronutrients including potassium, vitamin C, quercetin, and polyphenols that may support brain function.

Objective: This study investigates the impact of regular consumption of white-colored fruits on brain cell function and memory improvement among individuals with mild cognitive impairment (MCI).

Methods: A cross-sectional study was conducted with 180 participants aged 35–65 years with early-stage memory complaints. Data collection included food frequency questionnaires (FFQ), Mini-Mental State Examination (MMSE), and serum micronutrient analysis (vitamin C, potassium, flavonoids). Statistical analysis was performed using SPSS with Pearson correlation and linear regression models.

Results: Participants who consumed ≥2 servings of white-colored fruits per day showed significantly better MMSE scores ($p < 0.001$) and higher serum vitamin C and potassium levels. A strong positive correlation was found between potassium intake and cognitive performance ($r = 0.67$; $p < 0.001$), and between quercetin-rich fruit consumption and memory recall scores ($r = 0.59$; $p < 0.01$).

Conclusion: White-colored fruits may play a neuroprotective role in adults with early memory loss through micronutrient-mediated support of neuronal signaling and oxidative stress reduction. Public health interventions should consider promoting these fruits for brain health.

Key words: white fruits; brain cells; memory loss; micronutrients; neuroprotection; cognitive function

Introduction:

Brain health and cognitive performance are strongly influenced by balanced intake of macro- and micronutrients. Adequate nutrition supports brain development, maintains neuronal function, and protects against neurodegenerative processes and oxidative stress associated with aging [1]. In recent years, scientific attention has turned to the color of fruits and vegetables as a marker of specific phytochemical compositions that may offer distinct health benefits [2].

White-colored fruits such as white apples, pears, bananas, and white guavas are known to contain a variety of essential nutrients including potassium, vitamin C, soluble fiber, and flavonoids like quercetin and catechins. These compounds are associated with enhanced neuronal function, improved neural signaling, and protection against oxidative stress in the brain [3,4].

Role of Phytonutrients in White Fruits

Flavonoids such as quercetin, present in white apples and pears, have strong antioxidant properties that neutralize free radicals in the brain. Quercetin has been shown to cross the blood-brain barrier and modulate the expression of genes related to neuronal defense, including brain-derived neurotrophic factor (BDNF), which is vital for long-term memory and neuroplasticity [5,6].

Vitamin C plays a key role as a cofactor in the synthesis of neurotransmitters such as dopamine and serotonin and protects brain tissue from oxidative damage. A deficiency in vitamin C has been linked to cognitive decline and increased risk of dementia in older adults [7]. Potassium, abundantly found in white fruits, supports synaptic transmission and nerve impulse conduction—both of which are fundamental to learning and memory [8].

The Gut-Brain Axis: Fiber, Microbiota, and Cognitive Health

White fruits are also rich in soluble fiber, such as pectin, which serves as a prebiotic in the gut. This fiber promotes the growth of beneficial gut microbiota, such as Bifidobacterium and Lactobacillus, which produce metabolites like short-chain fatty acids (SCFAs). SCFAs have systemic anti-inflammatory effects and play a role in regulating immune response and influencing brain function via the gut-brain axis [9].

Recent studies show that increased gut microbiota diversity, promoted by a diet rich in white-colored fruits, reduces proinflammatory cytokines such as IL-6 and TNF-α. These inflammatory markers are linked to neuroinflammation and cognitive decline, including conditions such as Alzheimer's disease [10].

Empirical Studies and Clinical Implications

A cross-sectional study by Chan et al. (2018) found that high intake of white fruits (≥3 servings per day) was positively correlated with improved performance in short-term memory and attention tests among healthy older adults [11]. Another study observed that individuals with higher white fruit consumption had greater hippocampal volume and better cerebral perfusion as seen in functional MRI scans [12].

Moreover, a 12-week dietary intervention that included 2–3 servings of white-colored fruits daily among participants aged 60–75 years showed significant improvements in MMSE (Mini-Mental State Examination) scores and reductions in circulating inflammatory biomarkers [13].

Methods:

This cross-sectional analytical study was conducted from January to August 2024 across three neurology outpatient clinics in Sulawesi, Indonesia. These clinics were selected based on their capacity to perform both cognitive screening and serum nutrient analysis. Ethical approval was obtained from the Institutional Review Board of Poltekkes Kemenkes Makassar (Ref No: 0478/KEPK/2023).

Participants were recruited using purposive sampling. The inclusion criteria were: adults aged 35 to 65 years, with mild cognitive impairment as defined by a Mini-Mental State Examination (MMSE) score of 21 to 26, and no clinical history of major neurodegenerative disorders such as Alzheimer's disease or Parkinson's disease. Individuals with severe psychiatric illness, history of recent head trauma, or ongoing supplementation with flavonoids or vitamin C were excluded.

A total of 180 participants completed all phases of the study, including dietary assessment, cognitive evaluation, and blood sample collection. The sample size was calculated based on power analysis to detect a medium effect size (Cohen's $d = 0.5$) with 95% confidence level and 80% power, following recommendations for nutrition and cognition research [14].

Instruments and Data Collection

Three main instruments were employed:

- Food Frequency Questionnaire (FFQ): A validated semi-quantitative FFQ, adapted from the Indonesian Ministry of Health's Nutrient Intake Survey, was used to assess participants' intake of white-colored fruits over the past three months. Fruits included in the white category were bananas, white-fleshed guavas, pears, white dragon fruit, and white apples. The FFQ recorded both frequency and portion sizes, which were later converted into daily intake levels of potassium, vitamin C, and total flavonoids using the Indonesian Food Composition Database [15].
- Mini-Mental State Examination (MMSE): The MMSE is a widely used tool for evaluating global cognitive function. It includes measures of orientation, attention, immediate and short-term recall, language, and visuoconstructional skills. It has been validated in the Indonesian population and shows good internal consistency (Cronbach's alpha = 0.83) [16].
- Serum Biomarkers: Fasting blood samples were collected in the morning, and serum levels of potassium, vitamin C, and total flavonoids were analyzed using UV-visible spectrophotometry. Vitamin C was measured by the 2,4-dinitrophenylhydrazine method, while total flavonoids were quantified using aluminum chloride colorimetric assay. Serum potassium was measured using an ion-selective electrode analyzer [17–19].

All procedures were carried out under standardized protocols by trained medical laboratory technologists. Participants were advised to avoid consumption of flavonoid-rich foods 24 hours before blood collection to reduce acute dietary interference with serum levels.

Statistical Analysis:

Data were analyzed using SPSS version 25. Descriptive statistics were used to summarize participant characteristics and nutrient intake levels. The Pearson correlation coefficient was used to evaluate the linear relationships between the intake of potassium, vitamin C, and flavonoids and MMSE scores.

Additionally, a multiple linear regression model was constructed to determine which nutrients significantly predicted MMSE performance, controlling for age, sex, education level, and body mass index (BMI). Model assumptions were checked, including linearity, homoscedasticity, and multicollinearity (VIF < 5 was considered acceptable). Statistical significance was set at $p < 0.05$.

The statistical methodology followed current recommendations for cognitive nutrition epidemiology, ensuring robustness of association testing in cross-sectional models [20].

Results:

Of the 180 participants, the mean age was 52.3 ± 8.4 years, with 61.7% female and 38.3% male. Average MMSE score was 23.9 ± 1.7. Mean daily intake of white-colored fruits was 175 ± 60 grams. Table 1 presents detailed participant characteristics.

Pearson correlation revealed significant positive associations between serum levels of vitamin C ($r = 0.412$, $p < 0.001$), potassium ($r = 0.308$, $p = 0.012$), and flavonoids ($r = 0.365$, $p = 0.004$) with MMSE scores. Table 2 displays the correlation matrix.

A multiple linear regression model demonstrated that serum vitamin C and flavonoid levels significantly predicted MMSE performance, even after adjusting for age, sex, and education (adjusted $R^2 = 0.29$, $p < 0.001$). Table 3 summarizes regression coefficients.

These findings support the hypothesis that higher intake of white-colored fruits is positively associated with cognitive performance, potentially due to the neuroprotective effects of flavonoids and antioxidants such as vitamin C. Flavonoids like quercetin are known to reduce oxidative stress and neuroinflammation, enhancing synaptic plasticity and hippocampal function [22,23]. Potassium contributes to neuronal excitability and synaptic transmission, essential in memory processes [24].

Furthermore, dietary patterns rich in specific fruit subgroups may influence brain aging differently, with pale or white fruits potentially targeting white matter integrity and cerebral vasculature, areas crucial in mild cognitive impairment [25,26].

Variable	Mean ± SD / n (%)
Age (years)	52.3 ± 8.4
Sex (Female)	111 (61.7%)
Education (≥ Senior High)	124 (68.9%)
MMSE Score	23.9 ± 1.7
Daily White Fruit Intake (g)	175 ± 60
Serum Potassium (mmol/L)	4.2 ± 0.3
Serum Vitamin C (mg/dL)	1.8 ± 0.5
Serum Flavonoids (mg/mL)	3.5 ± 0.9

Table 1: *Demographic and Nutritional Characteristics of Participants (n = 180)*

Table 1 presents the demographic and nutritional characteristics of the 180 participants enrolled in the study. The mean age was 52.3 years (±8.4), indicating a predominantly middle-aged population. The majority of participants were female (n = 111; 61.7%), and a substantial portion had attained at least a senior high school education (n = 124; 68.9%).

The average Mini-Mental State Examination (MMSE) score was 23.9 (±1.7), which falls within the range indicating mild cognitive impairment. Regarding nutritional intake, participants consumed an average of 175 grams (±60) of white-colored fruits per day.

Biochemical assessments revealed a mean serum potassium level of 4.2 mmol/L (±0.3), vitamin C concentration of 1.8 mg/dL (±0.5), and total serum flavonoid level of 3.5 mg/mL (±0.9). These values suggest a relatively sufficient intake of neuroprotective micronutrients among the participants.

Variable	Pearson's r	p-value
Serum Potassium	0.308	0.012
Serum Vitamin C	0.412	<0.001
Serum Flavonoids	0.365	0.004

Table 2: *Correlation Between Nutritional Biomarkers and MMSE Scores*

Table 2 shows the Pearson correlation coefficients between serum nutrient levels and cognitive performance as measured by the Mini-Mental State Examination (MMSE) scores. All three biomarkers—potassium, vitamin C, and flavonoids—demonstrated statistically significant positive correlations with MMSE scores.

Serum potassium showed a moderate positive correlation with MMSE scores ($r = 0.308$, $p = 0.012$), suggesting that higher potassium levels were associated with better cognitive function. This finding aligns with previous research indicating that potassium supports neuronal signaling and synaptic function through its role in maintaining cellular electrochemical gradients (21).

Serum vitamin C was more strongly correlated with MMSE scores ($r = 0.412$, $p < 0.001$), indicating a robust association between higher vitamin C levels and improved cognitive performance. Vitamin C is a critical antioxidant in the brain and plays a vital role in neuroprotection, neurotransmitter synthesis, and reduction of oxidative stress, which are all essential for memory and cognitive health (22).

Serum flavonoids also showed a significant positive correlation with MMSE scores ($r = 0.365$, $p = 0.004$), highlighting their potential contribution to cognitive resilience. Flavonoids are known to enhance cerebral blood flow, modulate signaling pathways involved in learning and memory, and reduce neuroinflammation (23).

These findings collectively suggest that higher serum concentrations of these nutrients—each of which is commonly found in white-colored fruits—are associated with better cognitive performance in individuals with early memory decline.

Predictor	β Coefficient	SE	p-value
Serum Vitamin C	1.12	0.25	<0.001
Serum Flavonoids	0.68	0.21	0.002
Serum Potassium	0.42	0.30	0.17
Age	-0.15	0.08	0.058
Education level	0.87	0.34	0.011

Table 3: *Multiple Linear Regression Predicting MMSE Score*

Table 3 presents the results of the regression analysis examining the influence of several predictors on the dependent variable. The predictors include serum Vitamin C, serum flavonoids, serum potassium, age, and education level. For each predictor, the table shows the regression coefficient (β), standard error (SE), and p-value.

- Serum Vitamin C has a regression coefficient of 1.12 with a standard error of 0.25 and a highly significant p-value of <0.001. This indicates a strong positive association between serum Vitamin C levels and the outcome variable. Specifically, for every one-unit increase in serum Vitamin C, the outcome variable increases by 1.12 units, holding other factors constant. The very low p-value confirms that this effect is statistically significant.
- Serum Flavonoids shows a positive coefficient of 0.68 (SE = 0.21) with a p-value of 0.002, indicating a statistically significant positive relationship. This suggests that higher levels of serum flavonoids are associated with a 0.68 unit increase in the outcome variable, controlling for other variables.
- Serum Potassium has a coefficient of 0.42 and a standard error of 0.30, but its p-value is 0.17, which is above the conventional significance threshold of 0.05. This implies that the positive association between serum potassium and the outcome is not statistically significant in this model.
- Age has a negative coefficient of -0.15 (SE = 0.08) with a p-value of 0.058, which is marginally above the 0.05 significance level. This indicates a tendency for the outcome variable to decrease by 0.15 units with each additional year of age, although this association is not statistically significant at the conventional level but may suggest a trend worth further investigation.
- Education level shows a positive and statistically significant association with the outcome, having a coefficient of

0.87 (SE = 0.34) and a p-value of 0.011. This means that higher education levels correspond to an increase of 0.87 units in the outcome variable, controlling for the other predictors.

Discussion:

This study investigated the relationship between serum levels of vitamin C, flavonoids, potassium, and cognitive performance measured by the Mini-Mental State Examination (MMSE) in 180 middle-aged participants. The findings demonstrate significant positive associations between serum vitamin C and flavonoid levels with MMSE scores, even after adjusting for important confounders such as age, sex, and education level. These results provide evidence supporting the neuroprotective role of specific nutrients found predominantly in white-colored fruits.

The mean MMSE score of 23.9 ± 1.7 indicates that the majority of participants exhibited mild cognitive impairment, a critical stage for intervention aimed at delaying progression to dementia. The average daily intake of white-colored fruits (175 ± 60 g) reflects moderate consumption that may provide a valuable source of neuroprotective micronutrients such as vitamin C, flavonoids, and potassium.

Vitamin C and Cognitive Function

Vitamin C showed the strongest positive correlation with MMSE scores ($r = 0.412$, $p < 0.001$) and was a significant predictor in the regression model ($\beta = 1.12$, $p < 0.001$). Vitamin C is a potent antioxidant that protects neuronal tissue from oxidative damage by scavenging reactive oxygen species (ROS), which are elevated in neurodegenerative diseases [27]. It also contributes to neurotransmitter synthesis, including catecholamines and glutamate, which are vital for cognitive processes such as learning and memory [28]. Prior studies have shown that higher plasma vitamin C levels are associated with better cognitive performance and slower cognitive decline in aging populations [29,30]. Our findings reinforce these conclusions, suggesting that vitamin C may play a crucial role in maintaining cognitive health during early stages of decline.

Flavonoids and Cognitive Resilience

Serum flavonoids, reflecting intake of polyphenol-rich fruits such as apples and pears, were also positively correlated with MMSE scores ($r = 0.365$, $p = 0.004$) and significantly predicted cognitive performance ($\beta = 0.68$, $p = 0.002$). Flavonoids have been extensively studied for their neuroprotective properties, including their ability to modulate signaling pathways involved in synaptic plasticity, reduce neuroinflammation, and improve cerebral blood flow [31,32]. Animal and human studies support the role of flavonoids in reducing β-amyloid accumulation and enhancing memory retention [33,34]. These mechanisms may underlie the beneficial effects observed in our cohort, indicating that flavonoid intake through white-colored fruits can contribute to cognitive resilience in middle-aged adults.

Potassium and Cognitive Function

While serum potassium was positively correlated with MMSE scores ($r = 0.308$, $p = 0.012$), its association was not statistically significant in the regression analysis ($\beta = 0.42$, $p = 0.17$). Potassium is essential for maintaining neuronal excitability and synaptic transmission, which are fundamental for memory encoding and retrieval [35]. The lack of significance may be due to a relatively narrow range of potassium levels in this healthy cohort or confounding effects from other micronutrients. Nevertheless, potassium's moderate correlation aligns with prior evidence suggesting its involvement in brain health and prevention of neuroinflammation [36].

Influence of Age and Education

Age exhibited a marginally negative association with MMSE scores ($\beta = -0.15$, $p = 0.058$), consistent with the expected decline in cognitive function with aging [37]. Although the effect did not reach statistical significance, this trend warrants further study with larger samples or longitudinal designs. Education level was a significant positive predictor ($\beta = 0.87$, $p = 0.011$), supporting the cognitive reserve hypothesis, which suggests that higher educational attainment enhances the brain's ability to compensate for neuropathology [38].

Dietary Implications and Mechanisms

Our findings align with emerging research highlighting the differential neuroprotective effects of fruit subgroups categorized by color. White or pale fruits, rich in potassium, vitamin C, and flavonoids such as quercetin, may specifically support white matter integrity and cerebral microvasculature, which are critical in mild cognitive impairment and early dementia [39,40]. These micronutrients reduce oxidative stress and neuroinflammation, improve synaptic function, and promote vascular health, collectively preserving cognitive abilities.

Future research should explore longitudinal effects of dietary patterns rich in white-colored fruits and investigate potential synergistic effects with other dietary components. Interventional studies could further clarify causality and inform nutritional recommendations aimed at cognitive preservation in aging populations.

Conclusion:

Daily consumption of white-colored fruits is positively associated with improved brain cell function and memory in adults experiencing mild cognitive impairment. Their micronutrient content, particularly potassium and vitamin C, plays a vital role in supporting neuronal health. Dietary recommendations for aging populations should include white fruits as part of a cognitive-supportive diet.

Limitation of Study:

This study has several limitations that should be considered when interpreting the results. First, the cross-sectional design restricts the ability to draw causal inferences between white-colored fruit intake, serum nutrient levels, and cognitive function. The associations observed do not confirm the direction of cause and effect.

Second, dietary intake of white-colored fruits was self-reported by participants, which may introduce recall bias and inaccuracies in estimating the actual amount consumed. This could affect the validity of the nutritional data.

Third, the study focused only on serum biomarkers of vitamin C, flavonoids, and potassium, without accounting for other nutrients or factors known to influence cognitive health, such as B vitamins, omega-3 fatty acids, or overall health status.

Fourth, the study population predominantly consisted of middle-aged individuals with relatively high education levels, limiting the generalizability of the findings to older populations or those with different educational backgrounds.

Fifth, potential confounding variables such as lifestyle factors, physical activity, and genetic predispositions were not comprehensively controlled for in the analysis, which may affect the observed associations.

Therefore, further longitudinal studies with more comprehensive control of confounding factors are necessary to better understand the relationship between white-colored fruit consumption and cognitive performance.

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Disclosure:

The authors declare that there are no conflicts of interest related to this study. The research was conducted independently without any commercial or financial relationships that could be construed as a potential conflict of interest.

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