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The effectiveness of broccoli and *gotu cola* extract combination (Brogandi) on executive function and memory in nursing students

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Abstract

Background: Nursing students face high academic and clinical practice demands that can potentially affect cognitive function, particularly executive function and working memory. The combination of broccoli and *gotu cola* extracts (Brogandi) is thought to support cognitive function through neuroprotective mechanisms.

Purpose: To analyze the effectiveness of Brogandi on the executive function and memory of nursing students compared to a non-herbal and control group.

Method: A quasi-experimental non-equivalent control group pre-post test design was used on 60 students, divided into three groups: herbal (Brogandi, 2×1000 mg/day), non-herbal (multivitamins with cognitive function enhancement claims; 1 capsule/day), and control. Measurements were taken before and after a 4-week intervention using the Five-Point Test, Trail Making Test B, and Backward Digit Span.

Results: Within the group, the Brogandi group showed an increase in the Unique Design FPT and BDS and a decrease in TMT-B time ($p < 0.05$) with varying effect sizes. The non-herbal group also showed an increase in the Unique Design FPT and a decrease in TMT-B time ($p < 0.05$), while the control group showed improvement in TMT-B ($p < 0.05$). Comparison of changes (Δ post-pre) between groups showed significant differences in Unique Design FPT ($p < 0.001$); post-hoc showed that the Brogandi and non-herbal groups were significantly different from the control group, but not from each other.

Conclusion: Brogandi for 4 weeks showed domain-specific effects with pre-post improvements in figural fluency, working memory, and set-shifting. However, intergroup differences were only apparent in figural fluency, with an advantage over the control but no significant difference compared to the active multivitamin comparator. Further research should use a placebo-controlled randomized trial design with equalization of regimens between groups to reduce non-specific biases and strengthen findings.

Keywords: Broccoli; *Gotu Cola*; Executive Function; Memory; Nursing Students.

INTRODUCTION

Cognitive function is the main foundation for an individual's ability to process information, make decisions, and adapt to complex environmental demands, making its maintenance an important issue in the context of modern public health (Pozzi, Remoli, Tremolizzo, Appollonio, Ferrarese, & Cuffaro, 2024). Along with increasing cognitive demands in the modern era, attention to modifiable risk factors and protective factors for maintaining cognitive function throughout the lifespan has been increasingly

emphasized in global health research (Röhr, Pabst, Baber, Engel, Glaesmer, Hinz, Schroeter, & Rieder-Heller, 2022; D'Amico, Amestoy, & Fiocco, 2024). Cognitive function encompasses various domains, including memory, attention, and executive function, which collectively determine an individual's ability to learn, work, and perform daily activities effectively (Wefel, Ryan, Van, Jackson, & Morgans, 2022; Youn, Kim, Jeong, Ah, & Yu, 2024).

Although studies on cognitive function have largely focused on the elderly population due to the high risk of neurodegenerative diseases, recent evidence shows that cognitive impairment is also common in the productive age group (Friedman, Becofsky, Anderson, Bryant, Hunter, Ivey, & Lin, 2016; Röhr et al., 2022). In this group, cognitive decline is often not related to degenerative processes but is influenced by psychosocial and lifestyle factors, such as stress, mental fatigue, and excessive cognitive demands (D'Amico et al., 2024).

Among the productive age group, university students are one of the groups that are quite vulnerable to cognitive impairment. This is supported by previous study which found that more than 75% of university students in Jordan experienced symptoms of executive cognitive dysfunction in varying degrees of severity (Fraivan, Almomani, & Hammouri (2025). In line with these findings, previous research conducted on students at Monash University, Australia, also showed that 63% of students experienced subjective impairments or concerns related to cognitive function, such as concentration problems, memory impairment, difficulty thinking clearly, and decreased confidence in the learning process (Bird, McCabe, Lim, & Cornish, 2023).

Various studies show that academic stress, mental fatigue, and lack of sleep play a significant role in reducing cognitive flexibility and academic performance among students (Rudnik, Sobczak, Sawicki, & Zdun-Ryżewska, 2025). Additionally, burnout and emotional exhaustion have been linked to impaired concentration, reduced working memory, and difficulty in decision-making, which directly affect the learning process and academic achievement (Fiorilli, Barni, Russo, Marchetti, Angelini, & Romano, 2022). These findings confirm that students' cognitive functions are highly sensitive to sustained academic environmental stress (Rudnik et al., 2025).

Nursing students, in particular, are often the most vulnerable group to cognitive decline, mainly due to the academic workload and clinical practice challenges they face. Nursing education places students in an environment with high levels of academic and clinical stress (Dogham, Ali, Ghaly, Elcokany, Seweid, & El-Ashry (2024). The combination of complex academic tasks, clinical practice demands in hospitals, and interactions with staff and patients has been shown to be a major

trigger of stress and fatigue in nursing students. Additionally, a study reveals that the cognitive load faced by nursing students during clinical practice-based learning has a significant impact on their working memory and decision-making abilities in a hospital environment (Tabatabaee, Jambarsang, & Keshmiri, 2024).

This is supported by a previous research reporting that nursing students were more prone to cognitive decline due to academic stress and high clinical workload, which directly affected their cognitive performance in decision-making and problem-solving (El-sayed, Abdelhay, Hassan, & Taha, 2025). Additionally, a research highlights that nursing students often experience burnout and cognitive failure triggered by the demands of busy clinical practice and the mismatch between their expectations and reality in the field, which can exacerbate their cognitive decline, especially in terms of concentration and critical decision-making abilities in a clinical context (Siu, Ching, Cheung, Hegney, & Rees, 2020). A study conducted on nursing students at Prince Sattam bin Abdulaziz University in Egypt proved that the high level of academic stress and clinical practice burden experienced by nursing students is directly related to a decline in their academic achievement and clinical performance (Mohamed, Ali, Ehrahim, Ahmed, & Wahba, 2024). On the other hand, optimal cognitive function is very important to support analytical skills, quick decision-making, and accuracy of actions in a clinical environment (Phillips, Morin, & Valiga, 2021).

Therefore, a safe and easy-to-implement prevention strategy is needed to help maintain/improve the executive function and working memory of nursing students, thereby supporting the learning process, clinical reasoning, and academic performance. To date, pharmacological approaches to prevent or improve cognitive function in healthy populations have shown limited effectiveness and inconsistent results, prompting the development of safer and easier-to-implement non-pharmacological strategies (Livingston, Huntley, Sommerlad, Ames, Ballard, Banerjee, & Mukadam, 2020; Cave, Chang, Münch, & Steiner-Lim, 2023). Various non-pharmacological interventions, including physical activity, sleep management, and nutritional interventions, have been studied as potential approaches to support cognitive function (Leman,

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Lubis, Daulay, Adella, & Megawati, 2021). Among these approaches, herbal therapy is gaining attention due to its bioactive compounds that have the potential to provide neuroprotective effects with a relatively good safety profile (Cave et al., 2023; Falzon & Balabanova, 2017).

Broccoli (*Brassica oleracea*) and *gotu cola* (*Centella asiatica*) are two plants that have been extensively studied for their neuroprotective potential (Huang, Wu, Chen, Jin, Wu, & Chen, 2019; Puttarak, Dilokthornsakul, Saokaew, Dhippayom, Kongkaew, Srumsiri, Chuthaputti, & Chaiyakunapruk, 2017). Broccoli is known to contain sulforaphane, an isothiocyanate compound with strong antioxidant and anti-inflammatory activities, which has been reported to play a role in neuronal protection and modulation of oxidative stress (Schepici, Bramanti, & Mazzon, 2020). Clinical and experimental studies indicate that sulforaphane has the potential to improve cognitive function in conditions of neurological disorders and oxidative stress (Liu, Huang, Hei, Wu, Liu, & Liu, 2020; Alzahrani, Bahaidrah, Mansouri, Aldahri, Abd El-Aziz, & Alghamdi, 2024). Meanwhile, *gotu cola* has long been used as a cognitive tonic in traditional medicine and has been shown to contain triterpenoid compounds that contribute to improved cognitive function and brain plasticity (Sbrini, Brivio, Fumagalli, Giavarini, Caruso, Racagni, & Calabrese, 2020; Gray, Zweig, Caruso, Martin, Zhu, Quinn, & Soumyanath, 2018).

Experimental research shows that *gotu cola* extract can improve cognitive deficits in animal models through neuroprotective mechanisms and increased synaptic plasticity (Chiroma, Baharudin, Taib, Amom, Jagadeesan, Adenan, Mahdi, & Moklas, 2019). In clinical studies, *gotu cola* supplementation, especially in populations with cognitive decline, has been reported to improve memory, antioxidant status, and quality of life (Fitriana, Darmawati, Nasution, Putri, Rohaedi, Anggadiredja, Setiawan, Fauziyah, & Adnyana, 2021). These findings suggest that both broccoli and *gotu cola* have potential as supportive interventions for cognitive function through complementary mechanisms (Schepici et al., 2020; Gray et al., 2018).

Although a number of studies have evaluated the effects of broccoli and *gotu cola* separately, studies that specifically combine the two extracts to assess their impact on cognitive function are still very limited

(Fitriana, Darmawati, Putri, Andriyani, Rustiani, & Hazar, 2024). Some preliminary studies suggest that the combination of broccoli and *gotu cola* has the potential to provide broader cognitive effects than either alone, but evidence in the productive age population remains minimal (Istiqomah, Fitriana, & Darmawati, 2025). Furthermore, most previous studies have not included an active control group consisting of non-herbal or pharmacological supplementation, making it difficult to distinguish the specific effects of phytochemical compounds from the general effects of supplementation on cognitive function. The purpose of this study is to analyze the effectiveness of combined supplementation with broccoli and *gotu cola* extracts on the executive function and memory of nursing students.

RESEARCH METHOD

A non-equivalent control group pre-post test quasi-experimental design was employed on three groups of nursing students at FPOK UPI. The research subjects consisted of nursing students in Levels 1-4 (n=60; 20 people per group) to evaluate the effectiveness of combined supplementation with broccoli and *gotu cola* (Brogandi) extracts on cognitive function. The sample calculation in this study refers to Sugiyono (2023), who recommends a minimum sample size of 10-20 people per group in experimental studies. Previous studies also used 20 people per group in a similar research design, which proved to be sufficiently representative for statistical analysis and comparison between the experimental and control groups (Istiqomah et al., 2025).

The group that received Brogandi for 4 weeks was referred to as the Brogandi group (n=20, 2x2 capsules/day, total 2000 mg/day), the group receiving non-herbal supplementation was referred to as the non-herbal group (n=20, 1 capsule/day, 500 mg per capsule, consisting of a commercially available chemical brain supplement with brand X), and the group receiving no intervention was referred to as the control group (n=20). Participants' compliance was monitored through daily observation sheets, and all data were recorded systematically to ensure the quality and consistency of measurements.

Inclusion criteria included active nursing students, willingness to participate in all stages of the study, no consumption of supplements or drugs that could affect cognitive function, and no involvement in other studies

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related to cognitive function. Exclusion criteria included a history of neurological or psychiatric disorders, non-compliance with the intervention, significant side effects, or refusal to participate in pre-test or post-test measurements.

Cognitive function was measured before (pre-test) and after the intervention (post-test) using the Five-Point Test, Trail Making Test B, and Backward Digit Span. The Trail Making Test Part-B (TMT-B) represents set-shifting ability, attention control, and cognitive flexibility, which are highly dependent on the integrity of the subcortical frontal executive control system (Mainland & Shulman, 2012). Meanwhile, the Backward Digit Span describes operational working memory capacity, which requires the simultaneous storage and active manipulation of information (Hilbert, Nakagawa, Puci, Zech, & Bühner, 2014). In contrast, the Five Point Test measures aspects of figural fluency and visual response control, which are relatively more sensitive to the effects of practice and task familiarity than to changes in deep neural network plasticity (Tucha, Aschenbrenner, Koerts, & Lange, 2012). Brogandi is produced by PT. Berkah Alam Nusantara, Garut. One capsule contains 250 mg of broccoli extract and 250 mg of *gotu cola* extract. Brogandi is produced in accordance with good manufacturing practices for traditional medicines standards (GMP-TM).

Brogandi is manufactured by PT Berkah Alam Nusantara, Garut, and processed in accordance with the principles of GMP-TM. Each Brogandi capsule contains 500 mg of preparation, consisting of 250 mg of broccoli extract (*Brassica oleracea*) and 250 mg of *gotu cola* extract (*Centella asiatica*) in the form of oral capsules. Based on laboratory test results, Brogandi has bioactive content in the form of total flavonoids of 0.011% (b/b) and asiaticoside of 0.028 mg/g. Antioxidant activity was tested using the DPPH method, with an IC_{50} value of 20012.95 ppm, where a higher IC_{50} value indicates relatively weak antioxidant activity. Brogandi was administered at a dose of 2 capsules twice daily (a total of 4 capsules per day), resulting in a total daily consumption of 2000 mg of the preparation. Administration was carried out during the intervention period in accordance with the research protocol.

The non-herbal group received a commercial multivitamin supplement containing L-glutamic acid, B-complex vitamins, vitamin C, zinc, selenium, folic

acid, and vitamin E. The multivitamin supplement was used as an active comparator because it is widely marketed and used to support cognitive function in young adults. The selection of this active comparator aimed to compare the effectiveness of Brogandi on cognitive function outcomes with a relevant and commonly used non-herbal supplement. The supplement was administered according to the usage instructions on the packaging, namely 1 capsule per day during the intervention period. The control group did not receive any herbal or non-herbal supplements and continued their daily activities as usual during the study period.

This study has been approved by the Health Research Ethics Committee of Muhammadiyah University Purwokerto (No. KEPK/UMP/66/X/2024). All procedures were carried out in accordance with research ethics guidelines, and participants provided informed consent after being explained the purpose of the study, the procedures to be carried out, and the potential risks and benefits that might arise. The research procedure began with screening participants through Google Forms to ensure inclusion and exclusion criteria were met. Participants who met the criteria were then added to an online group for research socialization and pre-test scheduling. Group selection was based on participant willingness. During the 4-week intervention, compliance was monitored through daily observation sheets and broadcast reminders. Participants were instructed to reduce activities that could affect the results, such as staying up late or excessive coffee consumption. Cognitive function was measured pre-test and post-test using the Five-Point Test, Trail Making Test B, and Backward Digit Span. The tests were conducted by researchers and trained assistants, and the data was systematically recorded and double-checked by assistants to ensure quality and consistency.

Data analysis was performed using SPSS version 27, with the Kolmogorov-Smirnov normality test ($n > 50$) to determine the parametric or non-parametric method. The analysis was conducted in two stages. The first stage was an analysis of changes in scores within each group (within-group analysis) by comparing pre-test and post-test values. If the data were normally distributed, the analysis was performed using a paired t-test, whereas if the data were not normally distributed, the Wilcoxon signed-rank test was used. The second stage is an analysis of the

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comparison of changes between groups (between-group analysis). At this stage, the Δ (delta) value is calculated as the difference between the post-test and pre-test scores (Δ = post-test – pre-test), which is used as the main outcome to compare the effectiveness between the three groups (herbal, non-

herbal, and control). If the Δ data are normally distributed, the analysis is performed using One-Way ANOVA, whereas if the data are not normally distributed, the Kruskal–Wallis test is used. Post-hoc tests are performed only if the main test shows statistically significant differences.

RESEARCH RESULTS

Table 1. Characteristics of the Participants (N=60)

Variable	Brogandi	Non-Herbal	Control
Age (Mean$\pm$SD)(Range)(Year)	(19.95 $\pm$ 1.395)(17-22)	(19.40 $\pm$ 1.603)(17-22)	(19.05 $\pm$ 1.356) (17-22)
Age (n/%)			
17-19	5/25	10/50	11/55
20-22	15/75	10/50	9/45
Gender (n/%)			
Female	16/80	14/70	20/100
Male	4/20	6/30	0/0
Height (n/%)			
140-149 cm	2/10	1/5	1/5
150-159 cm	9/45	10/50	12/60
160-169 cm	7/35	4/20	7/35
170-179 cm	2/10	5/25	0/0
Body Weight (n/%)			
<50 kg	8/40	11/55	9/45
50-69 kg	10/50	6/30	10/50
70-90 kg	1/5	1/5	1/5
>90 kg	1/5	2/10	0/0

Table 1 presents the demographic characteristics of participants across the three study groups. The gender distribution was relatively balanced, with women comprising the majority in all groups (Brogandi 80%, Non-Herbal 70%, and Control 100%). The mean age was 19.95 years (SD $\pm$ 1.395) in the Brogandi group, 19.40 years (SD $\pm$ 1.603) in the Non-Herbal group, and 19.05 years (SD $\pm$ 1.356) in the Control group. Age distribution patterns varied: most participants in the Brogandi group were aged 20–22 years (70%), the Non-Herbal group was evenly split between the 17–19 and 20–22 year ranges, while the Control group was dominated by participants aged 17–20 years (55%).

With respect to height, the majority of participants in all groups fell within the 150–169 cm range, particularly 150–159 cm: Brogandi (45%), Non-Herbal (50%), and Control (60%). Body weight distribution showed that most participants in the Brogandi and Control groups were in the 50–69 kg category (50% each), whereas the Non-Herbal group was predominantly <50 kg (55%).

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Table 2. Result of Cognitive Function Changes (Pre-Post Test)

Instruments	Group	Pre (Mean±SD)	Post (Mean±SD)	Mean Δ (Post-Pre)	Test	p-value	Effect Size	Results
Five Point Test (Unique Design)	Brogandi	28.50±6.08	42.35±8.44	13.85	Paired T-test	<0.001	1.66	Large
	Non-Herbal	28.85±6.58	39.80±8.37	10.95	Paired T-test	<0.001	1.65	Large
	Control	31.40±8.39	32.15±8.09	0.45	Paired T-test	0.696	0.08	Almost None
Five Point Test (Perseveration)	Brogandi	1.75±1.91	1.40±1.66	-0.35	Wilcoxon Signed	0.527	0.08	Almost None
	Non-Herbal	0.85±0.87	1.10±1.02	0.25	Wilcoxon Signed	0.116	0.17	Small
	Control	6.15±14.05	6.05±18.39	-0.10	Wilcoxon Signed	0.173	0.17	Small
TMT-B	Brogandi	112.35±93.05	51.70±26.19	-60.65	Wilcoxon Signed	<0.001	0.50	Small
	Non-Herbal	119.50±66.86	72.25±33.50	-47.25	Wilcoxon Signed	<0.001	0.48	Medium
	Control	110.45±89.02	76.90±37.56	-33.55	Wilcoxon Signed	0.008	0.34	Medium
Backward Digit Span	Brogandi	4.75±0.91	5.70±0.80	0.95	Wilcoxon Signed	<0.001	0.46	Medium
	Non-Herbal	4.85±1.13	5.15±1.04	0.30	Wilcoxon Signed	0.206	0.16	Small
	Control	4.55±0.99	4.95±1.27	0.40	Wilcoxon Signed	0.148	0.18	Small

Table 2 shows in the Five Point Test (Unique Designs), the Brogandi group experienced a significant increase ($p<0.001$) with a large effect ($d=1.66$), and the non-herbal group also increased significantly ($p<0.001$) with a large effect ($d=1.65$), while the control group showed no significant change ($p=0.696$) with almost no effect ($d=0.08$). Meanwhile, in the Five Point Test (Perseveration), the three groups, Brogandi, non-herbal, and control, showed no significant change.

In the TMT-B, all three groups experienced a significant decrease in completion time ($p<0.05$), with the largest effect size in the Brogandi group ($d=0.50$), followed by the multivitamin group ($d=0.48$) and the control group ($d=0.34$). Finally, in the Backward Digit Span measurement, a significant improvement was only seen in the Brogandi group ($p<0.001$) with a moderate effect ($d=0.46$), while the multivitamin and control groups showed a small and insignificant effect.

Table 3. Comparative Test Result of Three Groups

Variable	Test	F(df)	p-value	Post hoc
Five Point Test (Unique Design)	One-Way ANOVA	15.371 (2;57)	<0.001	Herbal vs Non-herbal: $p=0.742$ Herbal vs Control: $p<0.001$ Non-herbal vs Control: $p<0.001$

Variable	Test	H(df)	p-value	Mean Rank		
				Herbal	Non-Herbal	Control
Five Point Test (Perseveration)	Kruskal-Wallis	2.018 (2)	0.365	27.80	34.88	28.83
Trail Making Test B	Kruskal-Wallis	3.184 (2)	0.203	26.20	29.43	35.88
Backward Digit Span	Kruskal-Wallis	4.681 (2)	0.096	37.13	27.46	26.90

Table 3 demonstrates a significant difference in score changes among groups ($F(2,57) = 15.371$; $p < 0.001$). Post hoc Bonferroni analysis indicated no significant difference between the herbal and non-herbal groups ($p = 0.742$), while both showed significantly greater score changes compared to the control group ($p < 0.001$). For cognitive function measures analyzed with the Kruskal–Wallis test, no significant differences were observed across groups on the Five Point Test (perseveration) ($H = 2.018$; $p = 0.365$), Trail Making Test B ($H = 3.184$; $p = 0.203$), or Backward Digit Span ($H = 4.681$; $p = 0.096$); thus, no further post hoc testing was conducted.

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DISCUSSION

The main findings of this study indicate that Brogandi supplementation has varying effectiveness on several cognitive function indicators. Specifically, the Brogandi group showed high effectiveness on the Five Point Test (Unique Designs) and TMT-B, with significant effect sizes of $d = 1.66$ and $d = 0.50$. In addition, the Brogandi group also showed moderate effectiveness on the Backward Digit Span (BDS) with an effect size of $d = 0.46$. However, although Brogandi showed significant results in improving several cognitive domains, a comparison between groups showed that the changes between the Brogandi, non-herbal, and control groups were not significantly different. More specifically, although Brogandi showed high effectiveness on the Five Point Test and TMT-B, as well as moderate effects on the Backward Digit Span, the differences between groups (Brogandi, non-herbal, and control) were not significant enough in most other domains.

In interpreting these findings, participant characteristics need to be considered as factors that could potentially influence cognitive performance. The distribution of gender, age, and body weight between groups showed variations that could contribute to the heterogeneity of the results. The control group consisted entirely of female participants, while the intervention group was dominated by females with a more heterogeneous proportion. The literature indicates that gender differences in cognitive function are domain-specific, with small to moderate differences primarily in working memory and executive function, but in general, the cognitive performance of men and women is relatively comparable (Miller & Halpern, 2014). Therefore, the predominance of female participants may potentially influence early cognitive performance, but does not sufficiently explain the differences in cognitive function improvement between groups. In addition, although all participants were in the young adult age range, age variation between groups remained relevant because some cognitive domains, including working memory and processing speed, still undergo changes and reach peak performance in the early 20s (Germine, Robinson, Smoller, Calkins, Moore, Hakonarson, & Gur, 2016). From an anthropometric perspective, the presence of participants with high body weight, especially in the non-herbal group, needs to be noted because obesity has been reported

to be associated with a decline in executive function in the adult population (Smith, Hay, Campbell, & Trollor, 2011). Thus, the characteristics of the participants in this study may contribute to the variation in results, but the main interpretation remains focused on the effects of the intervention on changes in cognitive function.

In general, changes in values across various cognitive function parameters indicate that the effects of the intervention are not uniform across all domains, but rather appear specifically in certain aspects of executive function and working memory. The Trail Making Test-B was used to measure executive function, specifically cognitive flexibility, processing speed, and attentional control. This parameter assesses an individual's ability to switch quickly and in a coordinated manner between two different sets of information, so that shorter completion times reflect better executive function efficiency (Quik, Dam, Van, & Kenemans, 2010; Tsiakiri, Christidi, Tsiptsios, Vlotinou, Kitmeridou, Bebeletsi, & Vadikolias, 2024). In the within-group analysis, all groups showed a decrease in task completion time after the intervention period. In the Brogandi group, the decrease in time from pretest to posttest values indicated that participants completed tasks in a shorter duration, suggesting an increase in processing speed and cognitive flexibility. A similar pattern was also seen in the non-herbal (multivitamin) group, although the reduction in time was relatively smaller than that of the Brogandi group. Meanwhile, the control group also showed a reduction in task completion time, indicating an improvement in performance even without specific nutritional intervention. Descriptively, the Brogandi group showed a greater decrease in completion time compared to the non-herbal and control groups, thus functionally reflecting a more prominent improvement in cognitive flexibility and processing efficiency in that group. However, when comparing the change in scores (Δ) between groups, the differences were not statistically significant. This indicates that although there were improvements in each group, the magnitude of the change in the Brogandi group was not significantly different from the changes that also occurred in the non-herbal and control groups.

The non-significance of the differences in change between groups indicates that the reduction in TMT-B completion time cannot be entirely attributed to the

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specific effects of the intervention, but is also influenced by non-intervention factors. One relevant factor is the practice effect. The practice effect is a common phenomenon in cognitive tests that are repeated at certain intervals (Calamia, Markon, & Tranel, 2013). This effect is particularly prominent in tests involving processing speed, strategy flexibility, and visuomotor coordination. Within-group changes in the control group indicate the presence of non-intervention factors contributing to score improvements, so the interpretation of the causal effect of the intervention must be done through a comparison of deltas between groups (Rutjes, Denton, Di Nisio, Chong, Abraham, Al-Assaf, & McCleery (2018). Thus, the findings on the TMT-B in this study are interpreted as an improvement in executive function within the group, but without evidence of significant differences in effect between intervention types.

The unique designs parameter on the Five-Point Test was used to assess figural fluency and nonverbal cognitive flexibility, namely the ability to produce a variety of different designs without repetition (Skrbic, Bugarski-ignjatovic, Komazec, & Veselinovic, 2023; Wulanyani, Widhianingtanti, Immanuel, Aisyah, Hendriks, Hestyanti, & van Luijtelaar, 2024). Unlike the Trail Making Test–B, which is interpreted through a decrease in completion time, an increase in the unique designs parameter indicates better performance, as it reflects the greater variety of unique designs that participants are able to produce. In this study, all groups showed an increase in their unique designs scores after the measurement period. This increase indicates that participants were generally able to produce more unique designs compared to the initial measurement, which functionally reflects an increase in visual idea productivity and cognitive strategy flexibility. However, the magnitude of the increase was not the same in each group. Descriptively, the Brogandi group showed the largest increase in unique designs scores, followed by the multivitamin group, while the control group also experienced an increase but to a lesser extent. The order of the magnitude of the increase indicates that the Brogandi group had the most prominent change in the ability to produce unique designs, followed by the multivitamin group, and then the control group. Functionally, this pattern indicates that participants in the Brogandi and multivitamin

groups showed a more pronounced increase in figural fluency compared to the control group, although all groups still experienced improved performance.

When comparing the changes in unique design scores between groups, the analysis showed statistically significant differences. These differences were particularly evident in the comparison between the intervention groups (Brogandi and multivitamin) and the control group, while the comparison between Brogandi and multivitamin did not show significant differences. These findings indicate that the increase in figural fluency in the two intervention groups was greater than the non-specific changes that occurred in the control group, but the magnitude of the increase between Brogandi and multivitamins was relatively comparable. The increase in the Five-Point Test unique designs scores in the multivitamin group can be explained by the content of essential vitamins and micronutrients in it, particularly vitamin B complex. A study explains that multivitamin supplementation containing vitamin B, antioxidant vitamins, and essential minerals tends to provide a small but measurable improvement in the domain of mild executive function, particularly fluency and cognitive processing efficiency, in healthy adult populations (Kennedy, 2016). The domain of figural fluency, as measured by unique designs on the Five-Point Test, is among the aspects of executive function most responsive to micronutrient support, so the increase in scores in the multivitamin group in this study is conceptually consistent with these findings.

The perseveration parameter on the Five-Point Test is used to assess the tendency to produce repetitive responses, reflecting aspects of executive function primarily related to inhibitory control and the ability to inhibit maladaptive strategies. Unlike the unique designs parameter, which is interpreted through an increase in scores, a decrease in scores on the perseveration parameter indicates better results because it shows fewer repetitions of designs or repetitive responses (Tucha et al., 2012). In this study, the pattern of within-group changes showed that the Brogandi group experienced the greatest descriptive decrease in perseveration, indicating a reduction in design repetition and improved inhibition control after the intervention. However, this decrease did not reach statistical significance in the within-group test. The control group also showed a decrease in perseveration, but the magnitude of the change was

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relatively small. In contrast, the multivitamin group showed a tendency toward increased perseveration scores, meaning that the number of design repetitions increased, which functionally can be interpreted as a more repetitive response compared to the initial measurement. When perseveration changes were compared between groups, the analysis results did not show any significant differences. Thus, although descriptively there appeared to be a different sequence of changes, these findings did not support the conclusion that there were any real differences in effect between groups in reducing perseveration.

Backward Digit Span was used to measure working memory capacity, specifically the ability to store and manipulate information simultaneously for a short period of time (Hilbert, 2014; Holm, Hansen, Kvale, Eilertsen, Johnsen, Hystad, & Solem, 2019). In this parameter, an increase in score is interpreted as a better result because it reflects the ability to remember and process longer sequences of numbers in reverse. Thus, a higher score indicates better working memory capacity. In the within-group analysis, all groups showed an increase in Backward Digit Span scores after the measurement period. However, statistically significant increases only occurred in the Brogandi group, which showed a meaningful improvement in working memory capacity from pre-test to post-test. The control group also experienced an increase in scores, but the magnitude of the change was relatively smaller and not statistically significant. Meanwhile, the non-herbal group showed the smallest increase, which did not reach statistical significance.

Descriptively, the order of magnitude of the increase in Backward Digit Span scores showed that the Brogandi group experienced the largest increase, followed by the control group, while the non-herbal group was last with a very limited increase. When score changes were compared between groups, the analysis results did not show any statistically significant differences. These findings indicate that although the most noticeable improvement in working memory occurred in the Brogandi group, the magnitude of the change was not sufficiently different from the changes that also occurred in the control and non-herbal groups to produce a meaningful difference between groups.

When all results across various cognitive function parameters are considered together, it appears that

the changes that occurred did not form a uniform pattern of improvement across all cognitive domains. Relatively clearer improvements appear in parameters that reflect cognitive flexibility and figural fluency, while parameters related to inhibitory control and working memory show smaller and inconsistent changes between groups. This pattern indicates that the response of cognitive function to nutritional intervention is domain-specific, not global. These findings are in line with studies (Nouchi, Ushida, Sukanuma, & Kawashima, 2022) which states that nutritional interventions in healthy adult populations rarely produce uniform cognitive improvements across all domains, and differences between groups are generally only detected in indicators that are most sensitive to change. A similar pattern has also been reported which shows that the domains of fluency and cognitive flexibility are more responsive to mild interventions than the domain of working memory (Gong, Zhou, She, Guo, Zhou, Peng, & Zhang, 2025). In addition, a meta-analysis shows that *Centella asiatica* intervention in humans often produces small, inconsistent changes across domains that are easily masked by individual variation and exercise effects, so that differences between groups are not always clearly detectable (Puttarak et al., 2017).

Specifically in this study, differences in change between groups only appeared in the unique designs subcomponent of the Five-Point Test. This can be explained by the characteristics of the domain being measured. Unique designs represent figural fluency and cognitive flexibility, which are components of executive function that are relatively more unstable and sensitive to short-term changes than working memory (García, Merchán, Phillips-silver, Teresa, & González, 2021). Figural fluency domains are known to respond more quickly to mild interventions and repetition effects because they are highly dependent on strategy efficiency and response generativity (Calamia et al., 2013). This condition explains why in this study, delta differences between groups were detected in the Five-Point Test – Unique Designs, while other parameters such as TMT-B and Backward Digit Span did not show significant differences between groups.

The domain-specific findings in this study are also consistent with previous studies involving nutritional and multivitamin interventions. A study reported that multivitamin supplementation did not result in

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comprehensive improvement in all cognitive functions, but was limited to specific domains that were sensitive to nutritional intervention, while other domains remained unchanged (Tsai, Hsu, Chang, Tseng, & Chang, 2021). A longitudinal study in adult and elderly populations reported that long-term multivitamin supplementation was not associated with overall improvement in cognitive function, reinforcing the assumption that nutritional effects are limited and depend on individual domains and characteristics (Grodstein, Brien, Kang, Dushkes, Cook, Okereke, & Sesso, 2013). These findings were confirmed by a systematic review which concludes that although some studies show improvements in one or more cognitive domains, the overall quality of evidence remains low and does not support claims of global effects from herbal or nutritional interventions (Cave et al., 2023). Therefore, the results of this study, which only show advantages in certain domains, reinforce the previous literature and confirm that nutritional and herbal interventions are better understood as specific cognitive domain modulation rather than as comprehensive cognition-enhancing interventions.

The absence of meaningful improvements in several cognitive function parameters in this study reflects the heterogeneous nature of executive function. The literature shows that executive function consists of interrelated but functionally separate components (unity and diversity), so that changes in one domain are not automatically followed by changes in other domains (Friedman et al., 2016). In healthy young adult populations, domains such as inhibitory control and some aspects of working memory are known to have relatively high stability and be less responsive to short-term interventions. In addition, initial cognitive functions that are already in the normal to high range have the potential to cause a ceiling effect, thereby limiting the scope for statistically detectable improvement (Thunberg, Wiker, & Bundt, 2024). Methodological factors and intervention characteristics also contributed to the lack of improvement in certain parameters. Executive function tasks are known to have different sensitivities to change, with the domains of fluency and cognitive flexibility being more responsive to mild interventions than inhibition control and working memory updating (Shaw & Hosseini, 2021). In addition, task impurity and intra-individual variability can mask small effects that actually exist, especially in intergroup analyses (Friedman & Miyake, 2018).

Theoretically, the findings of improved cognitive function in the intervention group can be explained by the characteristics of bioactive compounds that have been reported in the literature related to the ingredients used. *Gotu cola* (*Centella asiatica*) is widely reported as a plant with neuroprotective and cognitive function-enhancing potential. Various studies show that *Centella asiatica* extract is consistently associated with improved memory performance and cognitive function in healthy animal models, animals with cognitive impairment, and elderly populations with mild cognitive decline (Matthews, Khorani, Bobe, Caruso, Magana, Gray, & Soumyanath, 2024; Rosdah, Lusiana, Akib, Khairunnisa, & Husna, 2018). This effect is associated with the presence of key marker compounds in the form of triterpenoid glycosides, particularly asiaticoside and madecassoside, which have been consistently reported to have neuroprotective activity and support brain function (Bandopadhyay, Mandal, Ghorai, Jha, Kumar, Radha, Ghosh, Proćkó, Pérez de la Lastra, & Dey, 2023; Schepici et al., 2020). The literature also shows that *Centella asiatica* extract is associated with improved performance on object recognition-based memory tests and contextual memory, reflecting the involvement of executive functions and working memory (Matthews et al., 2024; Rosdah et al., 2018). These findings reinforce the theoretical basis that the active compounds in *gotu cola* support cognitive function through their contribution to neuronal resilience and maintenance of hippocampal function, without the need to refer to specific molecular mechanisms.

Broccoli, a vegetable from the *Brassicaceae* family, has also been reported to contain various bioactive compounds with antioxidant properties and neuroprotective potential. Several reviews indicate that consumption of antioxidant-rich vegetables is associated with the maintenance of cognitive function and the slowing of cognitive decline, primarily through their role in maintaining nerve cell integrity and brain function (Fahey, Liu, Batt, Panjwani, & Tsuji, 2025; Chiroma et al., 2019). Bioactive compounds in broccoli are conceptually linked to protection against oxidative stress, which is known to contribute to cognitive decline with age (Chiroma et al., 2019; Gong et al., 2025). Although the mechanisms of broccoli and *gotu cola* at the molecular and cellular levels are strongly supported by the literature, the results of this

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study indicate that this potential has not been realized as a clear cognitive advantage over multivitamins. One important factor is the actual antioxidant capacity of the formulation used. The high IC₅₀ value in the DPPH test indicates weak antioxidant activity, so that the antioxidant-based neuroprotective pathway is likely not optimally activated (Fahey et al., 2025; Schepici et al., 2020). The IC₅₀ value indicates that the actual antioxidant capacity of the Brogandi formulation may not be strong enough to optimally activate the protective pathway of neurons during the duration of the intervention used.

This condition is in line with a study which states that the activation of antioxidant and anti-inflammatory pathways requires adequate intensity and duration of exposure in order to translate into functional effects at the cognitive level (Schepici et al., 2020). In addition, nutritional interventions in healthy populations tend to produce small cognitive effects, because relatively good physiological and cognitive reserves limit the scope for measurable improvement. In this context, the protective mechanisms of broccoli-*gotu cola* may be more relevant for long-term prevention than for short-term cognitive performance enhancement (Wang, Deng, Zhou, Liu, & Cao, 2025). Meanwhile, multivitamins as non-herbal comparators have a theoretical basis in supporting cognitive function through the contribution of essential micronutrients. Systematic reviews show that B complex vitamins, antioxidant vitamins, and certain minerals play a role in maintaining memory, attention, and executive function, particularly in adult and elderly populations (Lapian, Basrowi, Pratiwi, Sitorus, Dilantika, & Iftinan, 2024). Micronutrient deficiency has been reported to correlate with cognitive decline, so multivitamin supplementation could theoretically help maintain cognitive function (Gray et al., 2018).

In the context of this study, multivitamins can be considered functionally equivalent comparators, despite being mechanistically different. This is because multivitamins and broccoli-*gotu cola* both have the potential to influence cognitive function through metabolic support and neuron protection, albeit through different pathways. The effects of nutritional interventions often do not show significant differences between types of supplementation when the study population is relatively healthy and the duration of the intervention is limited (Rutjes et al., 2018).

The findings of this study indicate that although academic pressure and learning demands are often associated as risk factors for cognitive decline in students, the cognitive responses observed in healthy adult student populations are more specific and uneven across domains. The results of this study indicate that efforts to prevent and maintain cognitive function in productive age remain relevant, but their effectiveness cannot be assumed to work globally, but rather depends on the characteristics of the cognitive domain that is the target of the intervention. Thus, this study provides an understanding that improving or maintaining cognitive function in students is more realistically understood as a selective and contextual process, rather than as an overall increase in cognitive capacity.

In the field of nursing, this study contributes by showing that the cognitive function response of productive age students to nutritional interventions is domain-specific and does not occur globally. These findings emphasize the importance of nurses' role in conducting targeted cognitive function assessments and designing realistic, needs-based promotive-preventive interventions. Thus, nutritional interventions in nursing practice can be positioned as complementary support for maintaining students' cognitive function, rather than as a single approach assumed to improve all aspects of cognition.

CONCLUSION

Brogandi supplementation for 4 weeks showed consistent improvements in several indicators of executive function and working memory, with high effectiveness in the Five Point Test (Unique Designs) and TMT-B, and moderate effectiveness in the Backward Digit Span (BDS). Although Brogandi showed significant results in these aspects, the comparison of changes (Δ) between groups showed no significant differences between the Brogandi, non-herbal, and control groups in most of the domains tested. Thus, although Brogandi was effective in certain domains, these results indicate that the response to nutritional intervention in healthy students is domain-specific and that Brogandi, over a 4-week period, has not been proven to be superior to multivitamins or the control group.

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