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CAN DARK CHOCOLATE IMPROVE OUR COGNITIVE SKILLS? EVALUATING THE IMPACT OF COCOA FLAVANOLS ON FUNCTION OF THE BRAIN – A REVIEW ARTICLE

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ABSTRACT

This review evaluates the impact of cocoa consumption, particularly flavanol-rich dark chocolate, on cognitive function based on evidence from 25 human studies. A structured literature search was conducted in the PubMed database using predefined keywords, and relevant studies were selected according to methodological quality and relevance. Cognitive domains assessed included memory, processing speed, executive function, and visual cognition.

Findings from randomized controlled trials and meta-analyses indicate modest cognitive benefits, especially in long-term memory and processing speed, primarily among middle-aged and older adults following chronic flavanol intake. Functional neuroimaging studies support underlying mechanisms such as enhanced cerebral perfusion, increased neuronal efficiency, and modulation of hippocampal function. Short-term improvements were observed in episodic and spatial memory, reaction time, and visual sensitivity. However, results across studies are inconsistent. Large-scale trials, notably the COSMOS project, reported no significant cognitive benefits from daily cocoa flavanol supplementation in the general population, though limited improvements were noted in individuals with poor dietary quality. Some trials reported null or adverse outcomes, particularly in younger adults and when cocoa was combined with omega-3 fatty acids.

In conclusion, cocoa flavanol intake may confer cognitive benefits in specific populations and contexts. However, variation in study design, dosing, and baseline characteristics limits generalizability. Further research is warranted to establish optimal intake regimens, identify responsive subgroups, and determine long-term safety.

KEYWORDS

Cocoa Flavanols, Cognitive Function, Memory, Executive Function, Dark Chocolate, Polyphenols

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Introduction.

Cocoa beans (*Theobroma cacao*) are a rich source of micro and macronutrients. This is attracting interest from the scientific community due to its potential health benefits, including positive impact on cognitive functions, such as memory. Among these compounds, flavonoids play a key role. In addition, cocoa beans contain methylxanthines, including theobromine and caffeine, which are mild stimulants and can affect mood, alertness and cognitive performance by modulating the neurotransmitter system (Smit et al., 2004). Other key cocoa nutrients, such as magnesium, iron and zinc, play an important role in various fields such as central nervous system function, oxygen transport and neuroprotection.

Cocoa is processed into a variety of products that vary in composition and potential health effects. The most health benefits are attributed to dark chocolate, which contains 50% to 90% cocoa pulp, due to its high flavonoid content and minimal number of additives. Milk chocolate, composed of 10% to 50% cocoa solids along with considerable amounts of milk and sugar, has significantly reduced flavonoid concentration, diminishing its potential cardiometabolic and neuroprotective benefits. Cocoa powder, commonly used in beverages and baked goods, retains a significant amount of flavonoids as long as it is not highly processed. Cocoa beans, on the other hand, in the form of crushed seeds, are the least processed form of cocoa and contain the highest concentration of polyphenols. Other products are cocoa extracts, which are concentrated sources of flavanols, methylxanthines and other micro and macronutrients. Their standardized composition enables precise therapeutic applications and enhances their suitability for research studies.

Cacao has played an important role in culture for centuries. Ancient civilizations in Central America, such as the Mayans and Aztecs, treated cacao as a remedy and part of religious rituals, consuming it as a bitter drink with spices. After chocolate was brought to Europe in the 16th century, it became a symbol of luxury. The addition of sugar and milk made it popular across various social groups. Currently, chocolate is a widely available, popular and well-liked product.

Memory and cognitive functions are crucial components of human beings. These capabilities enable individuals to process information, adapt to new situations, and navigate daily life effectively. Enhancing cognitive functions has significant implications, including improved academic performance, increased productivity, and a better quality of life. Moreover, strengthening these functions may delay the onset of age-related cognitive decline and neurodegenerative diseases.

Understanding the relationship between cocoa consumption and cognitive enhancement is crucial for developing nutritional strategies aimed at preserving and improving brain health across the lifespan. This review article examines the existing evidence on the influence of cocoa and chocolate consumption on memory and cognitive functions, highlighting potential mechanisms and implications for public health recommendations.

Methodology

The authors conducted a comprehensive search of the PubMed electronic database using the keywords "(chocolate OR cocoa) AND memory," "dark chocolate AND cognitive," and "dark chocolate AND memory." The search yielded 57 results, which were screened for relevance. Duplicate studies were removed, and the remaining articles were evaluated based on title and abstract content.

Studies examining the effects of cocoa or chocolate consumption on cognitive function in human participants and reporting measurable cognitive outcomes were included. A total of 25 studies met the inclusion criteria and were subjected to critical analysis, evaluating methodological design, sample characteristics, intervention type and duration, and cognitive assessment methods. The synthesis aimed to provide an objective evaluation of the potential cognitive benefits of cocoa intake. The foundational research for this article was conducted in March 2025.

Results

A high-quality meta-analysis (Cheng et al., 2022) of 80 randomized controlled trials encompassing over 5,500 participants provided strong evidence for cognitive benefits from dietary flavonoid intake. Benefits were most notable in long-term memory and processing speed, particularly in middle-aged and older adults receiving chronic, moderate flavanol doses. Postmenopausal women represent other population that may benefit from long-term cocoa supplementation through modest improvements in information processing speed (Garcia-Yu et al., 2022). Another study (Brickman et al., 2014) investigated the long-term impact of high-dose flavanol supplementation (900 mg/day) on hippocampal function in older adults (aged 50–69). Functional MRI revealed increased cerebral blood volume in the dentate gyrus of the hippocampus, a region critically involved in memory encoding. Sumiyoshi et al. (Sumiyoshi et al., 2019) showed that subchronic (30 days) consumption of dark chocolate (70% cocoa) may improve cognitive functions and increase NGF levels, which may support neuronal plasticity. Moreover, the effect persisted for several weeks after the end of supplementation. Supporting these findings, Shateri et al. (Shateri et al., 2023) in their systematic review, concluded that regular cocoa consumption improves executive functioning and verbal skills. Although no significant benefits were found in domains of attention, memory, or processing speed.

Some studies, in turn, indicate a beneficial effect even after short-term cocoa consumption. The consumption of just 35 g of dark chocolate may lead to a short-term improvement in episodic memory (Lamport et al., 2020). Additionally, Field et al. (Field et al., 2011) observed that the consumption of dark chocolate (containing 720 mg of cocoa flavanols) may improve spatial memory and shorten reaction time to visual stimuli. Similar findings were reported by Rabin et al. (Rabin et al., 2018), who noted a significant improvement in sensitivity to low-contrast, small-font visual stimuli. A minimal, borderline-significant enhancement in visual acuity was also recorded.

Functional magnetic resonance imaging studies further clarify the tissue-level cerebral mechanisms underlying the beneficial effects of cocoa on cognitive functions. In the study conducted by Sasaki et al. (Sasaki et al., 2023), individuals who consumed high-polyphenol chocolate (635 mg) exhibited reduced activation in the dorsolateral prefrontal cortex and the inferior parietal lobule. This pattern hasn't been followed by the intake of low-polyphenol chocolate (211.7 mg), which suggests that consumption of dark chocolate rich in polyphenols may enhance brain efficiency during demanding cognitive tasks. Cocoa flavanols may acutely enhance cerebral perfusion, which could represent a mechanism supporting the improvement of cognitive function (Lamport et al., 2015).

Cocoa flavonoids may support the central nervous system function under demanding conditions. In a study involving professional cyclists conducted by Banaei et al. (Banaei et al., 2023), the combination of dark chocolate consumption and transcranial direct current stimulation improved reaction time and increased endurance compared to placebo conditions. Additionally, cocoa may exert modulatory effects on physiological responses during acute stress. A randomized trial conducted by Regecová et al. (Regecova et al., 2020) demonstrated that a single intake of dark chocolate may increase resting blood pressure, while concurrently attenuating cardiovascular reactivity to stress.

Finally, experimental and preclinical data (Albadrani et al., 2024) support the neuroprotective potential of cocoa in the context of neurodegenerative diseases. Dietary polyphenols, including cocoa flavonoids, may modulate key pathophysiological mechanisms in Alzheimer's disease, such as oxidative stress, neuroinflammation, tau phosphorylation, and amyloid-beta aggregation. However, clinical evidence confirming their disease-modifying effects remains limited.

While numerous trials support a beneficial effect of cocoa flavanols on cognitive function, a substantial number of studies have failed to demonstrate significant improvements in cognitive performance following cocoa or flavanol supplementation. Notably, three large-scale clinical trials from the COSMOS project reported consistent findings. In the three-year COSMOS-Mind study (Baker et al., 2023) (n = 2,262), daily supplementation with 500 mg of cocoa flavanols had no effect on global cognitive function, episodic memory, or executive function. Similar results were obtained in the COSMOS-Clinic (Vyas et al., 2024) and COSMOS-Web (Brickman et al., 2023) studies, which also showed no significant impact on overall cognitive performance. However, both trials reported a modest improvement in executive function among participants with low dietary quality. Moderate-term (8-week) supplementation with cocoa flavonols may be insufficient to induce cognitive improvements in older adults without baseline cognitive impairment as Suominen et al. (Suominen et al., 2020) showed. Additionally, another trial (Vauzour et al., 2023) involving older adults with mild cognitive impairment, supplementation with cocoa flavanols (500 mg/day) combined with DHA/EPA did not result in any improvement in cognitive functions. Moreover, the intervention group demonstrated a decline

in processing speed and cortical volume, along with adverse metabolic changes, raising concerns about potential negative interactions in specific populations. The study conducted by Crews et al. (Crews et al., 2008) demonstrated that short-term supplementation with dark chocolate and cocoa did not produce beneficial effects on cognitive functions. Interestingly, an increase in heart rate was observed in the group with cocoa intake. Electrophysiological data from the study by Camfield et al. (Camfield et al., 2012) revealed changes in brain activity within the parietal and frontal regions, suggesting enhanced neuronal efficiency; however, these changes were not accompanied by measurable cognitive benefits.

Although some studies have reported a beneficial effect of cocoa supplementation on reducing physical and mental fatigue (Nemoto et al., 2022) or improving subjective well-being (Pase et al., 2013), these changes were not associated with enhancements in cognitive function. Several studies have also demonstrated a lack of effect of cocoa flavanol consumption on memory improvement in young adult populations (Akyurek et al., 2024; Altinok et al., 2022).

Discussion

Several studies demonstrate that cocoa flavanol consumption is associated with improvements in specific cognitive domains. Most consistently, chronic moderate intake has been linked to enhanced long-term memory and processing speed, particularly in middle-aged and older adults. Postmenopausal women may also experience gains in information processing speed. Short-term intake of dark chocolate has shown transient improvements in episodic and spatial memory, visual reaction time, and perceptual sensitivity. Functional outcomes such as executive function and verbal skills have also shown benefits in some trials, highlighting cocoa's potential in supporting cognitive performance under both acute and sustained conditions.

Proposed mechanisms underlying the cognitive effects of cocoa include enhanced cerebral perfusion, particularly in hippocampal regions, increased NGF levels, and improved neuronal efficiency as indicated by fMRI and electrophysiological studies. The differential brain activation patterns seen with high-polyphenol chocolate suggest greater efficiency during demanding tasks. While preliminary evidence supports neuroprotective roles in neurodegenerative pathways, clinical confirmation remains limited. These findings underscore the need for targeted research to define optimal dosing strategies, population-specific responses, and long-term safety of cocoa-based interventions in cognitive health.

While many studies highlight cognitive benefits of cocoa flavanol intake, the evidence remains inconsistent. Notably, large-scale randomized trials from the COSMOS project—COSMOS-Mind, COSMOS-Clinic, and COSMOS-Web—demonstrated no significant effects of daily cocoa flavanol supplementation on global cognition, episodic memory, or executive function over long-term follow-up. Modest improvements were observed only in individuals with low baseline dietary quality, suggesting limited generalizability. Similarly, moderate-duration interventions in older adults without cognitive impairment, as well as in those with mild cognitive impairment, failed to produce cognitive gains. Some studies even reported adverse outcomes, such as reduced processing speed, cortical volume loss, and metabolic disturbances when cocoa was combined with omega-3 supplementation. In young adults, multiple trials found no significant impact on memory performance, suggesting age- and context-dependent effects. Additionally, some studies observed physiological or neurophysiological changes without corresponding cognitive improvements, raising questions about clinical relevance. These mixed results emphasize the need for standardized methodologies and more rigorous trial designs to clarify cocoa's true cognitive potential.

Conclusions

Cocoa flavanol consumption has been associated with improvements in various cognitive domains, particularly long-term memory, processing speed, and executive function. Benefits appear more pronounced in middle-aged and older adults and can result from both chronic and acute intake. Functional and neuroimaging studies support enhancements in cognitive performance, reaction time, and visual sensitivity following dark chocolate consumption. Despite promising findings, the overall evidence remains inconsistent. Several well-designed, large-scale trials have failed to demonstrate significant cognitive benefits in the general population. Additionally, some interventions have yielded adverse outcomes or no measurable improvement, particularly in young adults or when cocoa was combined with other supplements. Variation in dosage, duration, and baseline cognitive status contributes to heterogeneity in outcomes. Further studies are needed to clarify the populations most likely to benefit from cocoa flavanols, establish optimal dosing regimens, and determine the duration necessary for sustained cognitive effects. Research should also explore the mechanistic pathways through which cocoa may influence brain function and examine potential interactions with other dietary or pharmacologic interventions.

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Author's contribution:

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All authors have read and agreed with the published version of the manuscript.

Conflict of Interest Statement

The authors report that they have no conflicts of interest.

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