

# THE EFFECTS OF CHOCOLATE ON BRAIN

## 1. Alzheimer's disease(AD) and other neurodegenerative diseases

Degenerative nerve diseases affect many of body's activities, such as balance, movement, talking, breathing, and heart function. Many of these diseases are genetic. Sometimes the cause is a medical condition such as alcoholism, a tumor or a stroke. Other causes may include toxins, chemicals, and viruses. Sometimes the cause is unknown.

Alternative strategies based on multimodal approaches (diet, exercise, and cognitive training) seem to be more promising.

The focus on dietary patterns rather than on single food components could be more useful in preventing or counteracting the pathological processes typical of AD.

Nutrition is believed to be a modifiable environmental factor that seems to strongly impact on AD pathology by modulating its phenotypic expression (*the result of a complex interplay between an organism's genes and its environment*).

Recent literature reports have underlined the protective role of a number of individual food components, including micro- and macronutrients in the prevention and management of AD.

Omega-3 fatty acids, vitamin B and E, choline and uridine have been proven to be effective in AD prevention and clinical management.

**The Mediterranean diet (MeDi)** would appear to be promising for AD prevention, including the earlier predementia stages.

The MeDi diet is characterized by high consumption of fruits and vegetables, cereals, legumes, olive oil, nuts, and seeds as the major source of fats, moderate consumption of fish, low to moderate consumption of dairy products and alcohol (wine), and low intake of red and processed meats.

It can be considered a nutritional model for healthy dietary habits since it contains all the essential nutrients including monounsaturated fatty acids (mainly in olive oil), polyunsaturated fatty acids (in fatty fish), antioxidants (e.g., allium sulphur compounds, anthocyanins, beta-carotene-flavonoids, catechins, carotenoids, indoles, or lutein), vitamins (A, B1, 6,

9, 12, D, and E), and minerals (magnesium, potassium, calcium, iodine, zinc, and selenium).

Growing evidence indicates the neuro-protective potential of the MeDi dietary pattern can be a preventative approach towards reducing the risk of cognitive decline, mild cognitive impairment and AD.

**The DASH diet (Dietary Approaches to Stop Hypertension)** is high in fruits, vegetables, nuts, whole-cereal products, low-fat dairy products, fish, and poultry, all of which are rich in blood pressure-deflating nutrients like potassium, calcium, “lean proteins,” minerals, and fiber.

DASH also discourages the intake of foods like red and processed meats, full-fat dairy foods, and tropical oils, as well as sugar-sweetened beverages and sweets; therefore, it is designed to be low in sodium, saturated fats, total fats, and cholesterol.

This type of dietary pattern has been shown to protect against many cardiovascular risk factors that play a role in the development of dementia and AD (such as high blood pressure or LDL cholesterol), at least in part by modulating the pathological processes that characterize the physiopathology of AD (oxidative stress, inflammation and insulin resistance).

DASH and MeDi share many food components (i.e., whole-grains, vegetables, and nuts), but there are also some differences, such as the frequency of consumption of low-fat dairy products (moderate-to-high intake and low consumption, respectively). Only a few studies have evaluated the potential effects of the DASH diet on cognitive functions or on the prevention of AD and other types of dementia.

*(Berries have the high content of polyphenols such as flavonoids which are the main compounds responsible for the antioxidant and anti-inflammatory characteristics of berries. The association between a high intake of berries and flavonoids and slower rates of cognitive decline have also been reported in humans.)*

AD is known to be associated with early neurovascular dysfunction and damage to small arteries, arterioles, and brain capillaries. These changes play a part in disease pathogenesis and lead to neuronal and synaptic dysfunction, neurodegeneration, and cognitive impairment

**Flavanol** rich foods are associated with better endothelial function, tissue perfusion, and enhanced neuronal viability.

*(viability=ability to work successfully)*

The flavonoids contained in cocoa powder (mainly epicatechin) act directly on the endothelium of brain vessels enhancing the activity of endothelial nitric oxide synthase and thereby increasing the dilatation of blood vessels that decreases blood pressure and cerebrovascular perfusion.

*(Endothelium is a single layer of squamous endothelial cells that line the interior surface of blood vessels, and lymphatic vessels. The endothelium forms an interface between circulating blood or lymph in the lumen and the rest of the vessel wall.*

*Perfusion= the rate at which blood is delivered to tissue)*

Diets that are rich in saturated fats/trans fatty acids and refined sugars lead to neurodegeneration, learning and memory impairment (because this food promotes/causes inflammation).

Dietary patterns based on foods that are rich in omega-3 fatty acids, flavonoids, and other antioxidants stimulate neurogenesis, reduce oxidative activity, and downregulate proinflammatory processes.

## **2. Chocolate**

Habitual chocolate intake is related to cognitive performance and frequent chocolate consumption is significantly associated with improved memory.

Cacao-containing foods such as chocolate and cocoa may have beneficial effects on human health. Cacao is rich in fat and carbohydrates—representing 50% and 25% of the total weight, but the most noteworthy ingredients in this regard are flavonoids and methylxanthines.

Both **flavonoids** and **methylxanthines** appear to improve cognitive and cardiovascular function.

The flavonoids that are most often found in cocoa are epicatechin and catechin. These flavonoids function as antioxidants through upregulation of nitric oxide production.

The methylxanthines that are most often found in cocoa are theobromine and caffeine. These act as mild central nervous system stimulants.

Theobromine is the primary methylxanthine found in products made from cacao (Theobromacacao). It helps in mediating neuronal functions, like learning and memory.

*(It increases intracellular cyclic adenosine monophosphate (cAMP) levels and permeates through the blood–brain barrier. The cAMP signaling essentially influences the brain mechanism that mediates neural wiring and cognitive processes. An increase in intracellular cAMP level activates the cAMP-response element-binding protein (CREB), which in turn, leads to the expression of the brain-derived neurotrophic factor (BDNF), one of the neurotrophins that mediates neuronal functions such as learning and memory.)*

-Dark chocolate intake increases NGF and theobromine levels in plasma and enhances cognitive function and performance.

-White chocolate consumption doesn't affect NGF and theobromine levels in plasma or cognitive function.

These results suggested that consuming dark chocolate for long periods of time has beneficial effects on health by enhancing cognitive function.

The effect of eating dark chocolate for long periods of time on cognitive function lasts several weeks after the consumption of dark chocolate has ceased.

The flavonoids and methylxanthines from chocolate have the ability to act directly on the brain, which could potentially lead to cognitive enhancement.

Theobromine was found to increase the level of BDNF so dark chocolate may upregulate NGF and/or BDNF in the human brain and improve cognitive function.

Dark chocolate may not only exert direct effects on the brain but could potentially act indirectly through blood supply.

*(NGF=nerve growth factor provides instructions for making a protein called nerve growth factor beta. This protein is important in the development and survival of nerve cells (neurons), especially those that transmit pain, temperature, and touch sensations (sensory neurons).*

*BDNF=Brain-derived neurotrophic factor is a protein that is encoded by the BDNF gene. The BDNF gene provides instructions for making a protein found in the brain and spinal cord called brain-derived neurotrophic factor. This protein promotes the*

*survival of nerve cells (neurons) by playing a role in the growth, maturation (differentiation), and maintenance of these cells.)*

It is possible for cocoa to improve cognitive performance indirectly through improvements to cerebral blood flow.

The ability of flavonoid rich foods to improve cognitive function has been demonstrated in both epidemiological studies and clinical trials.

High levels of flavanols are also found in tea, red wine, and fruits such as grapes and apples. In addition to cocoa flavanols, other psychoactive components of chocolate include the methylxanthines, caffeine and theobromine, both of which have been associated with improving alertness and cognitive function.

100 grams of dark chocolate contains approximately 100 mg of flavanols, 100 g of unsweetened cocoa powder without methylxanthines can contain up to 250 mg of flavanols.

Study, has provided evidence that daily consumption of cocoa flavanols can improve cognitive function in healthy, elderly individuals. Consistent with the immediate effect improvements in processing speed and attentional tasks were seen following 8-weeks of consuming an intermediate to high daily dose of cocoa flavanols.

There have not been made any studies that have examined associations between longer-term habitual chocolate consumption over a number of years, with cognitive functioning measures.

Results of the study:

- Women ate chocolate more frequently than men.
- Those who ate chocolate on a weekly basis, had higher total and LDL-cholesterol, but lower glucose levels, than those who never or rarely ate chocolate.
- Hypertension and type 2 diabetes was lower in regular chocolate consumers than in non-consumers.

- From a dietary perspective, those who ate chocolate also consumed more energy (food=energy) overall, and more daily serves of meat, vegetables and dairy foods, but significantly less alcohol.

- All cognitive scores were significantly higher in those who consumed chocolate at least once per week, than in those who never/rarely consumed chocolate.

Chocolate intake was significantly and positively associated with the Global Composite, Visual-Spatial Memory and Organization, Working Memory, Scanning and Tracking, the Similarities test (abstract reasoning).

Chocolate intake was positively associated with cognitive performance, across a range of cognitive domains in this dementia-free, community-dwelling population.

The associations between more frequent weekly chocolate consumption and cognitive performance remained significant after adjustment for a number of cardiovascular risk factors, including total and LDL-cholesterol, glucose levels, and hypertension.

Associations were not attenuated with the addition of dietary variables (alcohol, meats, vegetables, and dairy foods), indicating that chocolate may be associated with cognition irrespective of other dietary habits.

Similarly examined the acute effects of cocoa flavanols on cognitive function (reaction time, visual spatial working memory), visual contrast sensitivity, and motion sensitivity, in a cross-over study in 30 healthy young adults. Participants consumed dark chocolate containing 720 mg cocoa flavanols and a matched quantity of white chocolate.

The dark chocolate improved visual spatial working memory, reaction time on some aspects of the test, contrast sensitivity, and reduced the time to detect motion direction.

The authors attributed these findings to increased cerebral bloodflow caused by the cocoa flavanols.

Flavonoids can counteract neuronal injury underlying neurodegenerative diseases such as Parkinson and Alzheimer diseases through their interaction with signaling proteins important in the prosurvival pathways.

Flavonoids and their metabolites cross the blood–brain barrier and have been localized in the brain, particularly in areas crucial for learning and memory such as hippocampus, cerebral cortex, cerebellum, and striatum.

These structures are particularly vulnerable to the effects of aging and neurodegeneration, suggesting that flavonoids could exert direct neuroprotective effects

In memory-related areas such as the hippocampus, flavonoids promote the expression of brain-derived neurotrophic factor (BDNF), that is crucial to adult neurogenesis, synaptic growth, and neuronal survival

-The daily consumption of flavanol-rich cocoa drink has been showed to positively affect cognition, leading to improvements in cognitive performance both in older adults with early memory decline and in cognitively intact elderly subjects

Similar findings were seen in healthy aged participants. Subjects in the intermediate and high cocoa flavanols groups, after a daily consumption over an 8-week period, showed better performance in several cognitive domains compared to those in the low-flavanol group.

### **3. MINDFUL EATING**

Mindfulness, a practice based on Zen Buddhism, has become popular as a way of self-calming and as a method of changing eating behaviors.

it urges conscious awareness of whatever the focus might be. It has become a method of encouraging someone to take good care of him- or herself. Likewise, “mindful eating” encourages us to gain awareness of our eating experiences.

Mindful eating (i.e., paying attention to our food, on purpose, moment by moment, without judgment) is an approach to food that focuses on individuals’ sensual awareness of the food and their experience of the food.

It is about individual experience. No one has the same experience with the same food every time. The idea is for people to have their own experiences and to be in the present while having them.

Eating mindfully is about bringing full awareness to each plate or bite of food. It begins with the first thought about food and lasts until the final bite is swallowed and the consequence of the episode is experienced.

Research shows how mindfulness benefits patients with cardiovascular disease, depression, chronic pain, and cancer, and studies report decreased stress levels and increased quality of life.

#### **4. THE MIND-GUT CONNECTION**

Digestion involves a complex series of hormonal signals between the gut and the nervous system, and it seems to take about 20 minutes for the brain to register fullness. If someone eats too quickly, satiety may occur after overeating instead of putting a stop to it.

Eating while we're distracted by activities like driving or typing may slow down or stop digestion. And if we're not digesting well, we may be missing out on the full nutritive value of some of the food we're consuming.

Eating at a physiologically moderate pace leads to a more pronounced anorexigenic gut peptide response (lower appetite) than eating very fast.

*(=Higher concentrations of anorexigenic peptides and lower orexigenic peptides.*

*Anorexigenic peptide is an appetite-depressing peptide=lowers the appetite*

*Orexigenic peptide is an appetite stimulant=increases the appetite*

*Orexigenic and anorexigenic peptide signals from the gastrointestinal tract represent the feeding state for the Central Nervous System, while leptin and insulin convey information on the nutritional state.)*

#### **5. CHOCOLATE AND BRAIN**

In men, chocolate satiation was associated with increased taste activation in the ventral striatum, insula, and orbitofrontal and medial orbitofrontal cortex and with decreased taste activation in somatosensory areas.

Women showed increased taste activation in the precentral gyrus, superior temporal gyrus, and putamen and decreased taste activation in the hypothalamus and amygdala.

Sex differences in the effect of chocolate satiation were found in the hypothalamus, ventral striatum, and medial prefrontal cortex.

## 4. CONCLUSION

Cocoa powder and chocolate contain a large percentage of flavonoids that display several beneficial actions on the brain. In addition to their beneficial effects on the vascular system and on cerebral blood flow, flavonoids interact with signalization cascades involving protein and lipid kinases that lead to the inhibition of neuronal death by apoptosis induced by neurotoxicants such as oxygen radicals, and promote neuronal survival and synaptic plasticity. They enter the brain and stimulate brain perfusion provoking angiogenesis and changes in neuron morphology that have been mainly studied in hippocampus.

Epicatechin, the main flavonoid present in cocoa and chocolate improves various aspects of cognition in animals and humans. Chocolate also induces positive effects on mood and is often consumed under emotional stress. In addition, flavonoids preserve cognitive abilities during aging, lower the risk for developing Alzheimer's disease and decrease the risk of stroke in humans.

## 6. SOURCES

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