Effects of coconut oil on Alzheimer disease

Tahani Ahmad Al-Matrafi *

Department of Anatomy, College of Medicine, King Saud University, Riyadh, Saudi Arabia

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A B S T R A C T

Dementia is a general term for loss of memory, language, problem-solving, and other thinking abilities that are severe enough to interfere with daily life. Alzheimer’s disease (AD) is the most common cause of dementia. Risk factors as age, genetics, environment, lifestyle, and metabolic disease. The etiology of AD remains not fully explained, but both genetic and environmental risk factors have been proposed to be involved. Microscopically, intraneuronal neurofibrillary tangles (NFTs) and extracellular senile plaques characterize the AD. The amyloid cascade hypothesis (ACH) suggests that the imbalance between the Amyloid-β generation and its clearance causes dysfunction and consequently cell death. Coconut oil may represent a cheap and natural treatment for AD. This is because coconut oil contains medium-chain triglycerides (MCTs), which are digested to ketones in the liver that are linked to mitochondrial function enhancement and oxidation-reduction. Recent studies have investigated the possibility of using trans-zeatin and phytoestrogen and other sex hormones like substances present in coconut water and a young coconut juice (YCJ) in reducing the chance of AD. Coconut is known as a 'functional food' that is extremely nutritious. Virgin coconut oil (VCO) differs from ordinary coconut oil as the former contains a lot more biologically active components. Phenolic compounds and hormones contained in coconut can help prevent amyloid b peptide aggregation, potentially inhibiting a key step in the pathogenesis of AD. Coconut can be useful in the treatment of obesity, dyslipidemia, elevated low-density lipoproteins, insulin resistance, and hypertension-these are the risk factors for chronic venous disease and type II diabetes, as well as for AD.

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1. Introduction

Alzheimer’s disease (AD) is a neurodegenerative disorder related to the increase of age and it is the main cause of dementia in the world. AD affects cognitive functions, such as memory, with an intensity that leads to several functional losses (Solomon et al., 2014; Kumar and Singh, 2015).

It is estimated that the worldwide prevalence of AD will triple by 2050 (Langa, 2015). The World Alzheimer Report 2015 revealed that 46.8 million people worldwide were living with dementia in 2015, and the total global societal cost of dementia was estimated to be the US $818 billion. Alzheimer’s disease AD is the most common dementia type and may account for 60–70% of dementia cases (Prince, 2015). AD is an extremely debilitating condition currently falling within the top 10 causes of death across the world. This causes a severe fiscal burden on health services since AD is an extremely financially costly neurological disease to manage (Nichols et al., 2019). Epidemiologic studies have been documented that women comprise two-thirds of people living with AD, regardless of age and ethnicity (Alzheimer's Association, 2016). The number of factors may increase or decrease an individual’s chances of developing the disease. These risk factors include age, genetics, environment, lifestyle, and metabolic diseases (Fernando et al., 2015).

The etiology of AD remains not fully explained, but both genetic and environmental risk factors have been proposed to be involved. Thus, the etiopathogenesis of AD has been linked to hypometabolism (Kashiwaya et al., 2013), mitochondrial dysfunction (Johri and Beal, 2012; Rusek et al., 2019), inflammation (Takahashi et al., 2017; Rusek et al., 2019), and oxidative stress (Pinto et al., 2018).
2. Neuropathology of AD

The gradual accumulation of the pathology of cerebral extracellular AD known as amyloid, which is mostly composed of aggregated amyloid-b (Ab) peptides, as well as the accumulation of intracellular neurofibrillary tangles, appears to start up to 17–20 years before a clinically observable disease (Villain et al., 2012).

Microscopically, intraneuronal neurofibrillary tangles (NFTs) and extracellular senile plaques (or amyloid plaques) characterize the AD. While senile plaques are constituted by extracellular deposits of β-amyloid (Aβ) peptide, the hyperphosphorylation and abnormal deposition of tau protein compose the NFTs (Selkoe and Hardy, 2016). Aβ derives from abnormal proteolysis of a larger protein called amyloid precursor protein (APP), an integral membrane protein that possesses the general properties of a cell surface receptor (Dawkins and Small, 2014), which passes through the neuronal membrane and gets accumulated outside the neurons, by the consecutive action of β- and γ-secretases (amyloidogenic pathway). However, this amyloidogenic pathway can be stopped by the competition of α-secretase with γ-secretase (non-amyloidogenic pathway) (Zhang et al., 2015). The amyloid cascade hypothesis (ACH) suggests that the imbalance between the Aβ generation and its clearance causes dysfunction and consequently cell death. Aβ polymerizes in a variety of structurally different forms including oligomeric, protofibrillar, and fibrils, forming the senile plaques (Mohamed et al., 2016). Several findings suggest that oligomers play an important role in the ACH (Sengupta et al., 2016). Nowadays, it is proved that Aβ oligomers, including protofibrils and prefibrils, are more toxic than fibrils (Verma et al., 2015). Tauopathy—characterized by hyperphosphorylated, filamentous tau aggregates prior to microtubule collapse—a major requisite for the formation of neurofibrillary tangles NFTs (Guo et al., 2016; Nilson et al., 2017). NFTs accumulate inside the neurons, resulting in their death. The ACH suggests that toxic concentrations of Aβ cause changes in tau protein and subsequent formation of NFTs, leading to synaptic and neuronal loss (Barage and Sonawane, 2015). Though a direct relationship between the degree of AD and the amount of Aβ aggregates and tau levels have been established, numerous other mechanisms of neurodegeneration have been suggested, such as neuroinflammation (Heneka et al., 2015), oxidative stress (Huang et al., 2016), genetic (Karch et al., 2014) and environmental factors (Chin-Chan et al., 2015).

Molecular imaging studies such as those using amyloid positron emission tomography (PET) have shown that Aβ deposition reaches a plateau before brain atrophy can be identified from structural magnetic resonance imaging (MRI) and cognitive symptom. However, recent case series showing AD-diagnosed patients lacking Aβ deposits challenge the generalizability of the criteria, as well as the role of protein aggregates in the development and progression of AD (Crary, 2016). Nonetheless, the combined presence of Aβ aggregates, neurofibrillary tangles, which are associated with progressive dementia and neurodegeneration, is the most widely accepted view (Hardy and Selkoe, 2002; Crary, 2016). Another essential finding is brain atrophy, particularly in the hippocampus. In addition, a recent study by Laurent et al. (2017) showed that T-cells from the hippocampus mediate the inflammation process and promote cognitive decline (Laurent et al., 2017).

Antioxidants are substances of natural and synthetic origin that have a high potential to scavenge free radicals (Tepe et al., 2005). The development of AD has been linked to oxidative stress, and studies have suggested that antioxidant-rich natural diets may protect against AD. Although studies on the benefits for AD have not been conclusive (Park and Kim, 2002; Necula et al., 2007), many suggest that combinations of (rather than individual) antioxidants are beneficial (Shah, 2013).

Based on these mechanisms, different therapeutic molecules can act through different pathways (Loureiro et al., 2014; Karch and Goate, 2015). Nowadays, the study of these natural compounds revealed that they present neuroprotective effects, arousing an increasing interest in the scientific community and in the pharmaceutical industry (Dey et al., 2017; David et al., 2015). There have been many works on Virgin coconut oil (VCO) and its potential to salvage neurons from amyloid-induced degeneration, reduce inflammation, and provide ketone bodies for therapeutic effects and increased cognitive function (Nafar and Mearrow, 2014). Since 2000, it has become increasingly evident that biophenols, plant phenolic compounds containing foods received extreme attention due to their vast occurrence and versatile actions including several cellular functions modulation, processes that go well beyond their first-described natural antioxidant capacities, and neuroprotection (Silva and Pogačnik, 2017). Vegetables, fruit, nuts, chocolate, and other types of foods and beverages, such as wine, coffee, and tea, are all rich sources of biophenols.

3. Origin of virgin coconut oil

The Scientific name for Coconut is Cocos nucifera and the plant is a member of Arecaceae (Janick and Paul, 2008) that is cultivated to provide a large number of products, although it is mainly grown for its nutritional and medicinal values.

4. Antioxidant effect of virgin coconut oil

Virgin Coconut oil (VCO) has captured a lot of interest because of its possible role in enhancing body defense against oxidative stress. VCO is different from ordinary coconut oil (CO) as the former contains a lot more biologically active components such as polyphenols, tocopherols, 2 Evidence-Based Complementary and Alternative
Medicine sterols, and squalene. It has been established that the antioxidant activity in VCO is higher than refined CO. VCO has been shown to enhance antioxidant enzyme activity and inhibit lipid peroxidation in rats (Abujazia et al., 2012).

VCO has a high percentage of phenolic acids, and these are phytochemicals, sometimes also referred to as polyphenols (Marina et al., 2009b). Phenolic acids are recognized for their antioxidant properties. p-Coumaric acid, ferulic acid, caffeic acid, and catechin acid are the major phenolic acids found in CO (Marina et al., 2009a). VCO is also rich in active polyphenol compounds, which are strong inhibitors of lipid peroxidation (Dosumu et al., 2010). Polyphenols are known for their neuroprotective actions, especially in preventing the neurotoxic effects of β-amyloid (Menard et al., 2013). The beneficial effects of VCO have been widely investigated. In fact, VCO has been reported for its excellent antioxidative, anti-inflammatory, and antistress properties (Yeap et al., 2015). VCO increased the production of antioxidants in the brain, namely SOD, CAT, GSH, and GPx. The up-regulated antioxidants served as protection against lipid peroxidation (MDA) by oxidative stress (NO). The collective effects of these two components would eventually prevent or delay neurodegeneration. The promising outcomes of this study strongly imply the possible use of VCO, not only as neuroprotective agents for those suffering from neurodegenerative diseases but also as brain food (supplements for the health populations) (Rahim et al., 2017). VCO is well-known as an antioxidant and anti-inflammatory natural compound, VCO has a potential prophylactic effect for memory enhancement, anti-excitotoxicity, and antioxidants in the AD model (Alghamdi, 2018).

Coconut oil (CO), derived from the coconut fruit, has been recognized historically as containing high levels of saturated fat; however, closer scrutiny suggests that coconut should be regarded more favorably. Unlike most other dietary fats that are high in long-chain fatty acids, CO comprises medium-chain fatty acids (MCFA). MCFA are unique in that they are easily absorbed and metabolized by the liver, and can be converted to ketones (Fernando et al., 2015). The difference between MCFA and LCFA is the length of the fatty acid carbon chain. LCFA contains fourteen or more carbons (Traul et al., 2000), whereas MCFA has a chain length of six to twelve carbons (Traul et al., 2000; Marina et al., 2009b). The length of the carbon chain determines the physical and chemical properties of the fats as well as their metabolism in the human body (Traul et al., 2000). MCT or MCFA can act as a non-carbohydrate fuel source by enhancing the formation of ketones or ketone bodies in the body which are AcAc, 3-b-hydroxybutyrate (3HB), and acetone (Traul et al., 2000). The first two molecules are used for energy production, whereas acetone is a breakdown product of AcAc. Fatty acids cannot pass the blood-brain barrier (BBB); thus, the human brain primarily depends on glucose. However, it can utilize alternative fuels such as monocarboxylic acids, lactate, and ketones to maintain energy homeostasis (Page et al., 2009), and ketone bodies are used extensively as an energy source during glucose deficiency (ketosis) (Sumithran et al., 2013) and may be beneficial to people developing or already with memory impairment, as in AD and epilepsy (Fernando et al., 2015). VCO improved hippocampus histological changes reduced Aβ plaques and phosphorylated tau. A high-fat diet has exacerbated the effects of Aβ, while VCO showed a potential neuroprotective effect (Mirzaei et al., 2018).

Coconut oil comprises medium-chain fatty acids (MCFAs) with a high amount of medium-chain triglycerides. Coconut oil downregulates the expression of ADP-riboosylation factor 1, thereby inhibiting the secretion and aggregation of Aβ and restraining the expression of APP (Pinto et al., 2018). MCFA could be converted into ketone bodies, which are related to the improvement of mitochondrial function and reduction of oxidation (Yuan et al., 2017). Coconut oil can resist oxidation and neuroprotection.

5. Effect of hormone in reducing the chance of AD

A phase 3 clinical trial to investigate the effect of coconut oil in mild to moderate AD was initiated in June 2013. However, it was terminated in February 2017. The reasons for the termination were funding limitations and a low enrollment rate (Huang et al., 2020).

The Aβ-plaques are increased in andropausal human brains (Vickers et al., 2000) and in the brains of aging male mice (Rosario et al., 2010). With advancing age, a significant decrease in sex steroid hormones occurs in men and women leading to the development of AD (Ad) (Söhrø and Arroo, 2018). In males, the depletion of testosterone level affects different organs that are dependent on androgen, especially the brain. It was reported that the level of testosterone in the brain is inversely correlated with the brain levels of β-amyloid1-42 (Aβ), which is well known as one of the AD hallmark pathologies (Rosario and Pike, 2008). Although estrogen supplements could reduce AD pathologies in human brains, they could also cause gynecomastia and induce benign prostatic hyperplasia and prostatic cancer (Chen et al., 2015). Therefore, plant-derived phytoestrogens may be a better choice than estrogens. Similar to 17β estradiol (E2), phytoestrogens can also bind to α and β estrogen receptors (ERα and ERβ) (Osooki and Kennelly, 2003).

Recent studies have investigated the possibility of using trans-zeatin and phytoestrogen and other sex hormones like substances present in coconut water and a young coconut juice (YCJ) in reducing the risk of AD (Karch et al., 2014; Huang et al., 2016). In contrast, experimental studies have suggested that coconut/coconut cream consumption can cause hyperlipidemia and atherosclerosis, which are risk factors for AD. In contrast, several studies have reported that hyperlipidemia and heart diseases are
uncommon among high coconut-consuming populations (Chin-Chan et al., 2015).

Radenahmad et al. (2009) reported that giving YCJ to ovariectomized rats could increase NF200- and PV-reactive cells in the brain and reduce the accumulation of Aβ. The active ingredient(s) of YCJ was found to be β-sitosterol (Rattanaburee et al., 2014). YCJ was found to prevent osteoporosis (Yusuh et al., 2010; Suwanpal et al., 2011), preserve cals involved in motility of the gastrointestinal tract (Radenahmad et al., 2014), accelerate wound healing, and improve skin complexion (Radenahmad et al., 2012). It was also found that YCJ at a dose of 40 ml/kgb.w./day was the best to reduce AD pathologies in ovariectomized rats within 10-weeks (Balit et al., 2019). However, a high dose of YCJ supplement had caused unfavorable side effects, such as glycojen deposition in the liver.

Recent literature has suggested that the use of CO (extra virgin/virgin), coconut water, and coconut cream may have significant positive effects on the lowering of plasma cholesterol, blood pressure (BP) control, and blood glucose levels, all of which are risk factors associated with AD.

6. Effect of coconut in treatment of diabetes and hypertension

Coconut is classified as a highly nutritious ‘functional food’. It is rich in dietary fiber, vitamins, and minerals; however, notably, the evidence is mounting to support the concept that coconut may be beneficial in the treatment of obesity, dyslipidemia, elevated LDL, insulin resistance, and hypertension—these are the risk factors for CVD and type II diabetes, and also for AD. In addition, phenolic compounds and hormones (cytokinins) found in coconut may assist in preventing the aggregation of the amyloid-b peptide, potentially inhibiting a key step in the pathogenesis of A (Fernando et al., 2015).

The high levels of saturated fat have generally deterred those who are more health-conscious from using CO, cream, or milk. Furthermore, low-fat diets have been considered to be the best approach to reduce the risk of AD, in particular the Mediterranean diet (Gu et al., 2010). CO is rich in medium-chain fatty acids (MCFA), which are metabolized differently from the long-chain fatty acids (LCFA) commonly found in human diets. In addition, CO offers anti-aging and antioxidant properties (Marina et al., 2009a).

The major components in CO are fatty acids (such as lauric acid (45–50%) and capric acid) and phenolic compounds (such as ferulic acid and p-coumaric acid) (Nomura et al., 2003). Levels of the beneficial components are believed to be higher in VCO, which, as mentioned earlier, is prepared via a cold or low-heat-based extraction method. This oil contains higher levels of phenolic acids than copra or refined CO.

There is literature that indicates that the circulating D-b-3hydroxybutyrate ketone body, which is formed out of MCFA, crosses the BBB and enters the mitochondria where it is metabolized to AcAc and converted to acetyl-CoA, which enters into the Krebs cycle. One in vivo study with mice has identified the capacity of caprylic acid, a constituent of CO, to cross the BBB. This study indicates that as a result of crossing the BBB, caprylic acid demonstrated anti-convulsant and a neuroprotective effect (Wlaż et al., 2012). Medium-chain fatty acyl-CoA molecules easily transfer into the mitochondria and can then be converted into acetoacetate (AcAc) and b-hydroxybutyrate, mainly by medium-chain fatty acyl-CoA-dehydrogenase (Rosario and Pike, 2008). These two products can be metabolized further in the liver to produce CO2, H2O, and energy (Tepe et al., 2005).

CO is principally composed of SFA (about 92%), with 62–70% being MCFA (Chandrashekar et al., 2010), making CO unique among dietary fats (Marina et al., 2009b). The concern that CO may increase plasma lipid levels and adversely affect health is a point of contention. MCFA are partially hydrolyzed from dietary TAG by lingual lipase in the stomach and completely digested by pancreatic lipase within the intestinal lumen (Ruppin and Middleton, 1980). Therefore, MCFA is absorbed directly from the intestines into the portal vein and sent straight to the liver (Ruppin and Middleton, 1980). Unlike MCFAs, other fats such as cholesterol, as well as saturated fat, monounsaturated fat, and polyunsaturated fat-containing LCFA, combine with proteins and form lipoproteins (Hardy and Selkoe, 2002; Tepe et al., 2005; Necula et al., 2007; Guo et al., 2016). These lipoproteins enter the bloodstream via the lymphatic system, thus mostly bypassing the liver (Ruppin and Middleton, 1980).

Apart from the benefits already mentioned above, both lauric acid, the main fatty acid in coconut, and phenolic compounds have anti-microbial or anti-bacterial properties. Thus, these compounds are considered to be protective against low-grade infections often associated with IR (Yan et al., 2013).

Nafar et al’s (2017) study showed treatment with octanoic or lauric acid also provided protection against Aβ but was not as effective as the complete oil. Treatment with CO, as well as octanoic, decanoic and lauric acids resulted in a modest increase in ketone bodies compared to controls. The biochemical data suggest that Akt and ERK activation may contribute to the survival-promoting influence of CO. This was supported by observations that a PI3-Kinase inhibitor blocked the rescue effect of CO on Aβ amyloid toxicity, pretreatment with CO prior to Aβ exposure showed the best outcomes.

Interestingly, specific fractions of CO, extracted under hot conditions, have been shown to reduce blood glucose, cholesterol, and lipid peroxidation, and some polyphenolic compounds appear to reduce liver lipid peroxidation (Seneviratne et al., 2009). Coconut water has also been shown to have beneficial effects on serum and tissue lipid parameters when given to rats concurrently fed a high-cholesterol containing diet (Sandhya and
Another study has investigated the positive effect of regular consumption of two tropical food drinks, coconut (C. Nucifera) water and mauby (Colubrina arborescens), on the control of hypertension (Alleyne et al., 2005). The combined products were found to be almost twice as effective as the products in isolation. CO and exercise during lactation can ameliorate the effects of stress on anxiety-like behavior and episodic-like memory in young rats through evaluation cognitive test Mini-Mental State Examination for changes (da Silva et al., 2018).

Several studies consistently showed consumption of CO increases low-density lipoprotein cholesterol (LDL-C) (Sankararaman and Sfera, 2018) and hyperglycemia, hyperinsulinemia, hyperleptinemia, and hypertriglyceridemia. These metabolic consequences may contribute to hippocampal-dependent memory impairment, accompanied by a lower central leptin level, and a higher SCD1 gene expression in the brain (Lin et al., 2017), and thereby could increase adverse cardiovascular health. Even though CO has a relatively high MCT concentration, the clinical benefits of commercial MCT oils cannot be generalized to CO. Until the long-term effects of CO on cardiovascular health are clearly established, CO should be considered as a saturated fat and its consumption should not exceed the USDA’s daily recommendation (less than 10% of total calorie intake) (Sankararaman and Sfera, 2018).

7. Conclusion

The effect of coconut oil on Alzheimer’s disease is unclear and more research is required before drawing any firm conclusions. But the interest in coconut oil reinforces the value we place on research. It’s our best hope of finding effective treatments for Alzheimer’s disease and other dementias and improving the quality of life and care for those affected. The consumption and use of coconut in its various forms has a long and established history in medicinal, scientific, and nutritional arenas. Coconut is, however, widely available, inexpensive, non-toxic, and highly palatable that may be shown in the future to prophylactically reduce the risk of AD. The molecular and clinical events, including amyloid accumulation, tau accumulation, oxidative stress, neuroinflammation, cognitive decline, and occurrence of behavioral psychological symptoms, develop along with AD progression. The lipid content of coconut, being mostly MCT, offers an energy source that bypasses the usual glucose pathway, in the form of ketone bodies, and without the associated fat deposition often caused by LCFA. Coconut oil appears to improve the cognitive abilities of Alzheimer’s patients, with different intensities depending on the cognitive area, but as CO should be considered as saturated fat and its consumption should not exceed the USDA’s daily recommendation (less than 10% of total calorie intake). Observational studies must also be interpreted in context with their susceptibility to bias. In this example, people who consume coconut oil may differ from those who do not in various ways. These differences could explain why dementia is (or is not) more common in one group. For this reason, to obtain stronger evidence of “cause and effect” researchers conduct randomized controlled trials (RCTs). With RCTs, study participants are randomly assigned to receive an intervention such as a drug, diet, or lifestyle program, or not. This random assignment is meant to make the groups as similar as possible, except for having received the intervention being studied. The study participants are followed over time and their health outcomes are compared. Furthermore, research needs to be conducted to quantify the yield of and support the ability of various coconut as milk or powder to prevent or delay AD.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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