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Decoding the delights: Unraveling the health benefits of dark chocolate in comparison to white chocolate

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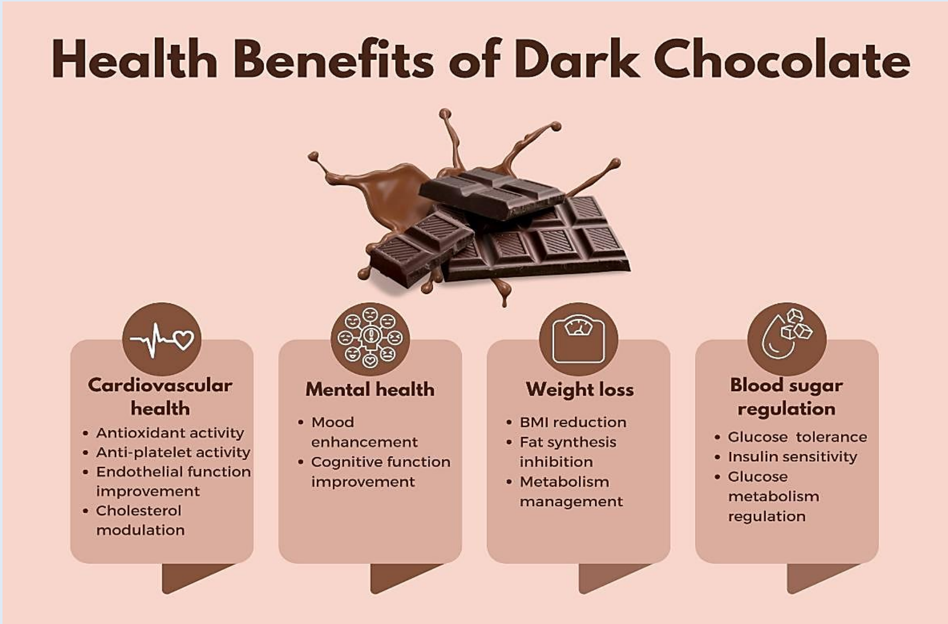
ABSTRACT

This review article will examine the nutritional and health disparities between dark and white chocolate. After examining the ingredients involved, dark chocolate appears as a nutritionally beneficial food, rich in cocoa solids, antioxidants, and minimal amounts of additives, in stark contrast to the sugar-laden content of white chocolate. Antioxidants (such as procyanidins), abundant in dark chocolate significantly contribute to cellular protection and overall health. Regarding cardiovascular health, studies indicate a notable correlation between dark chocolate consumption and improved cardiovascular function. This feature is typically attributed to the abundant presence of flavonoids, therefore white chocolate, which lacks these compounds, may not offer similar cardiovascular benefits. Dark chocolate is also preferred over white chocolate in terms of cognitive health. It has been shown that there is a potential relationship between dark chocolate consumption, increased cognitive performance, and improved mood. In terms of blood glucose regulation, dark chocolate displays a favorable profile, potentially contributing to improving glycemic control. However, white chocolate may not have such benefits due to its high sugar content. In summary, this literature review highlights the multifaceted health benefits of dark chocolate compared to white chocolate. From its superior nutritional profile, antioxidant richness, potential cardiovascular benefit, and possible role in cognitive enhancement, dark chocolate emerges as a scientifically supported choice for individuals seeking a confectionery option with potential health benefits.

Keywords: Dark Chocolate; White Chocolate; Antioxidants; Polyphenols



INTRODUCTION

In recent years, there has been an increasing interest in the role of functional food in improving health status and promoting overall well-being, ranging from antioxidant-rich fruits like pomegranate and berries to heart-healthy options such as nuts and whole grains [1-2]. Chocolate, the beloved treat cherished by people of all ages, holds a rich history that spans centuries among these foods. By passing through the ancient civilizations of the Mayans and the Aztecs, chocolate has established its place in modern-day global industry as one of the most delicious and popular foods worldwide [3-4]. The economic significance of chocolate cannot be overstated. The global chocolate industry generates substantial revenue (about USD 130 billion in 2021) and provides livelihoods for numerous individuals involved in its cultivation, production, and distribution. From the cacao farmers in tropical regions to the manufacturers and chocolatiers worldwide, the chocolate industry plays a crucial role in local and international economies [5-6].

Beyond its delectable taste, chocolate has captured the attention of researchers due to its potential health benefits. While lipids contribute to its smooth texture, fiber provides a sense of satiety and promotes digestive health. Additionally, chocolate contains essential minerals, such as iron, magnesium, and potassium, vital for various bodily functions [7]. However, not all types of chocolate have the same nutritional value. With its higher cacao content, dark chocolate is often touted for its potential health-promoting properties due to its increased antioxidants and lower sugar content. On the other hand, white chocolate, lacking cacao solids, does not offer the same polyphenol-rich profile and is considered a less healthy counterpart.

Dark chocolate has been the focus of numerous studies exploring its impact on various aspects of health, including its antioxidant properties [8-9], cardiovascular effects [10-12], and potential mood-enhancing effects [13-14]. It is a rich source of flavonoids, particularly flavanols, associated with various health benefits [7].

Flavanols have demonstrated antioxidative and anti-inflammatory characteristics, potentially playing a role in enhancing cardiovascular health and cognitive function [15-16]. Furthermore, the vasodilatory effects mediated through nitric oxide (NO) production have been proposed as one mechanism underlying its cardiovascular benefits [17].

This review article aims to explore the health impacts of chocolate, focusing on comparing the potential benefits and drawbacks of dark chocolate and white chocolate. The nutritional components of chocolate, such as lipids, fiber, minerals, and the potent polyphenols responsible for many of its health properties, are addressed in this article. The epidemiological studies linking chocolate consumption to various health outcomes, including its impact on cardiovascular health and mood, are explored. Ultimately, the findings of this review will enhance comprehension about the possible health effects of consuming chocolate and guide future research endeavors in this field.

Nutritional composition: Numerous varieties of chocolate are available, with dark and white chocolate emerging as the two primary types. (Table 1). Understanding the natural ingredients of these two is essential before examining their health effects. Dark chocolate usually consists of cocoa solids and butter, with minimal or no added milk or sugar. Conversely, white chocolate lacks cocoa solids. It primarily comprises cocoa butter, sugar, and milk, giving it a creamier and sweeter taste than its dark counterpart [18]. This distinction in the composition will result in completely different flavors and nutritional profiles. The following sections will explore the intricate chemical compositions of cocoa beans, the foundational ingredient for dark and white chocolate.

Table 1. Comparison between composition (% w/w) of dark and white chocolate [a]

Composition	Dark chocolate	White chocolate
Protein	7	7
Saturated fat	24	19
Unsaturated fat	19	12
Sugar	29	60
Other carbohydrates	19	0

[a] Reference: Tunick and Nasser [18]

Lipids: Cacao beans contain significant amounts of lipids (approximately 50% of dry weight), of which cocoa butter is the predominant form. Cocoa butter comprises a mixture of monounsaturated and saturated fatty acids, whose monounsaturated component is mainly composed of oleic acid akin to olive oil [19]. The saturated fatty acids in cocoa butter include palmitic acid (16:0) and stearic acid (18:0) [20].

Additionally, cocoa beans contain phospholipids, such as lecithin or phosphatidylcholine, characterized by structural diversity in terms of fatty acid chains and locations of double bonds [21]. The polar head in phospholipids, carried at the sn-3 position, contributes to their structural variability [22].

Carbohydrates: Cacao beans exhibit a diverse composition of mono-, oligo-, and polysaccharides, contributing to their nutritional profile. The major digestible polysaccharide in cocoa beans is starch, constituting a range of 3% to 7% [21]. Notably, cell wall polysaccharides (CWP) account for approximately 12% of unfermented cocoa beans, including cellulose, along with pectic polysaccharides [20]. These pectic polysaccharides are composed of rhamnogalacturonans, arabinose, galactose, and hemicellulosic polysaccharides, with arabinose representing a proportion of 52% of CWP [20-21].

A list of soluble carbohydrates in fermented cocoa beans can be seen in the table 2. Fructose and sucrose are major sugars, with their concentrations varying due to different fermentation conditions that notably impact sucrose levels [23]. As a result of the hydrolysis of fructose during the fermentation process and mainly with the activity of invertase, reducing sugars will be produced, which play a role in creating the specific aroma of cocoa [24]. This stage is not enough to create the final flavor of cocoa and the complete destruction of reducing sugars is needed in the roasting stage [21]. However, there is no change in the concentration of non-reducing sugars like raffinose and stachyose [24].

Table 2. Soluble carbohydrates found in fermented cacao beans [a].

	Glucose (mg/20 g)	Sucrose (mg/20 g)	Raffinose (mg/20 g)	Fructose (mg/20 g)	Stachyose (mg/20 g)	Verbascose (mg/20 g)
Ghana	12.4	83.6	31.6	4.0	15.1	1.9
Ivory Coast	15.9	56.0	31.0	3.0	12.2	0.9
Ecuador	16.8	34.4	96.6	12.2	20.1	0.8

[a] Reference: Redgwell et al. [25]

Polyphenols: Cacao beans harbor a rich reservoir of polyphenolic compounds, serving as defensive protection for the plant against external threats [26]. Polyphenols make up approximately 1 to 2% wt.% of cocoa beans, a proportion that decreases in fermented cocoa beans [27]. Key polyphenols in cocoa include catechins (e.g., (−)-epicatechin, (+)-catechin, (+)-gallocatechin, and (−)-epigallocatechin), anthocyanins (e.g., cyanidin-3-(alpha)-L-arabinoside and cyanidin-3-(beta)-D-galactoside), and proanthocyanidins (flavan-3,4-diols) [20]. The polyphenol concentration in the final chocolate product is contingent upon the proportion of nonfat cocoa solids, where dark chocolates containing higher cocoa solid content, exhibit elevated polyphenol levels than white chocolate [28]. The provenance of cocoa beans further influences polyphenol content, varying significantly across regions [29]. However, fermentation and high-temperature roasting can modify polyphenol levels [30-31].

Minerals: Cocoa beans are a rich source of essential minerals crucial for vascular function, with notable contributions from magnesium, copper, potassium, and calcium. Dark chocolate, containing 70%–85% cacao, emerges as a significant dietary source, providing 36 mg of magnesium per 100 kcal serving [32]. Magnesium plays a crucial role as a cofactor in protein synthesis, muscle relaxation, and energy production, exhibiting antiarrhythmic and hypotensive properties [33]. Copper, another essential mineral, acts as a cofactor for various enzymes involved in iron transport, glucose metabolism, and infant growth [34]. Dark chocolate offers a substantial source of copper, providing 31% of the U.S. recommended dietary allowance (RDA) per 100-kcal serving, while milk chocolate and cocoa powder contribute 10% and 23%, respectively [7]. Dietary potassium, found in dark chocolate at 114 mg per 100 kcal, plays a role in mitigating hypertension resulting from excess sodium intake [7]. Despite variations in mineral content, cocoa and its derivatives contribute significantly to meeting dietary requirements, supporting vascular health, and potentially reducing the risk of cardiovascular diseases.

Antioxidant richness: The association between antioxidant-rich foods and a reduced risk of cardiovascular disease is well-established, with chocolate emerging as a notable contributor to this protective effect [6]. Chocolate flavanols, particularly epicatechin, catechin, and procyanidins, confer potent antioxidant properties because of their specific structure. These compounds showcase the ability to scavenge reactive oxygen species, neutralize free metal radicals (Fe^{2+} and Cu^{2+}), and modulate enzymatic activity [35].

Moreover, chocolate's impact on antioxidant capacity extends beyond its consumption. It leads to a simultaneous reduction of low-density lipoprotein (LDL) oxidation and improvement in the bioavailability of NO. *In vitro* studies demonstrated that purified epicatechin, a prominent component of chocolate, effectively prevented LDL and liposome oxidation, showcasing its potential as a safeguard against atherosclerosis development [36]. Given the pivotal role of LDL oxidation in cardiovascular diseases, the observed inhibition becomes a significant way to reduce this risk factor. Numerous *in vitro* and *in vivo* investigations have supported the idea that chocolate products exhibit a protective effect by reducing LDL oxidation, which holds promise for cardiovascular disease prevention [37-38].

The interaction between chocolate's antioxidant effects and NO bioavailability is another aspect of the cardiovascular protective effects of chocolate. Antioxidants of chocolate scavenge reactive oxygen species and enhance NO availability, promoting optimal endothelial function [39].

Despite the apparent role of chocolate in antioxidant defense, the exact mechanism of action of the compounds responsible for this antioxidant property is still unknown. Recent research challenges the traditional view that flavanols are the only contributors. Instead, they suggest that compounds such as anthocyanins may also play an important role [40]. Such a situation emphasizes the need for further research to uncover the complexities of chocolate's antioxidant mechanisms.

In the assessment of dark chocolate compositions, the content of theobromine was determined in various commercially available chocolates, including dark chocolate, sweet chocolate, milk chocolate, and chocolate spreads. The study revealed the presence of the highest amount of theobromine in dark chocolate (9.6 mg/g) and the reduction of this substance in other samples to at least 1.9 mg/g. Importantly, the authors observed a positive correlation between theobromine levels and labeled cocoa solid percentage in both sweet and dark chocolate categories ($r = 0.523$, $p = 0.081$ and $r = 0.771$, $p = 0.009$, respectively). This study underscores the potential of labeled cocoa mass content as a preliminary indicator for consumers regarding the theobromine levels of their intended product [41].

In an effort to investigate the effect of including milk in chocolate formulation on the potential antioxidant benefits linked to dietary flavonoids, specifically (±)epicatechin, Serafini et al. (2023) conducted a comparison between the consumption of dark chocolate, milk chocolate, and chocolate consumed with milk. The research reveals that consuming plain, dark chocolate significantly increases total antioxidant capacity and (±)epicatechin content in blood plasma. These positive effects are, however, substantially diminished when chocolate is consumed with milk or as milk chocolate. The antioxidant content analysis indicates that dark chocolate has a significantly higher *in vitro* total antioxidant capacity compared to milk chocolate, with respective ferric reducing antioxidant power values of 147.4 ± 5.0 and 78.3 ± 3.4 micromol reduced iron per 100 g. The study suggests that the inhibitory effect may be attributed to the formation of secondary bonds between chocolate flavonoids and milk proteins, reducing the bioavailability of flavonoids and their potential antioxidant properties [42].

White chocolate, composed of ingredients like cocoa butter, sugar, and milk solids, generally demonstrates limited intrinsic antioxidant activity. In contrast, dark chocolate, with its high cocoa solid content, is renowned for its rich supply of antioxidants such as flavonoids and polyphenols. For this reason, nutrition researchers add natural additives to the chocolate formulation to increase the nutritional value of white chocolate. In this regard, Dimas Rahadian et al. (2019) addressed the perception of white chocolate as having low phenolic content and antioxidant activity, attributed to the absence of cocoa liquor. The research focuses on exploring the potential enhancement of the antioxidant activity of white chocolate after adding cinnamon essential oil to the ingredients. The investigation reveals that cinnamon essential oil, rich in cinnamaldehyde, exhibits notable antioxidant properties. When incorporated into white chocolate at a level of 0.1% (w/w), the essential oil increases the chocolate's antioxidant activity by more than twofold without significantly affecting its hardness, melting properties, or color [43]. It is crucial to recognize that the overall antioxidant potential in white chocolate is subject to compositional variations influenced by the inclusion of such additives, ultimately influencing its health-related attributes.

Heart health and cardiovascular benefits: Cardiovascular disease (CVD) persists as a substantial global health challenge, playing a significant role in both morbidity and mortality [44]. Amidst ongoing efforts to identify modifiable factors influencing CVD risk, the role of dietary habits has come under increased scrutiny [45]. Recent epidemiological cohort studies offer profound insights into the intricate relationship between chocolate, cocoa, and heart health [46-47]. The Kuna Indians of the San Blas Islands present a compelling case study. Consuming substantial amounts of cocoa, approximately 4 cups or 30–40 oz of a cocoa-based beverage daily, these indigenous people exhibit remarkable cardiovascular health. The absence of roasted cacao beans in their diet results in an exceptional flavanol content of 2000 mg/100 g of cocoa, significantly higher than the 150 mg found in processed cocoa. Strikingly, the incidence of arterial hypertension, age-dependent blood pressure increase, stroke, myocardial infarction (MI), and cancer for Kuna Indians was lower than mainland Panamanians. Their cardiovascular mortality rate of 9.21±3.1 age-adjusted deaths per 100,000 stands in stark contrast to the mainland's 83.4±0.7. This discrepancy is hypothesized to be linked to the Kuna Indians' high cocoa intake, sparking further investigation into cocoa's potential cardioprotective effects [33].

A recent Mendelian randomization study by Yang et al. (2024), further strengthened the link between chocolate consumption and cardiovascular health. The study employed a fixed-effect model to evaluate the association between dark chocolate intake and various CVDs. Their results revealed a significant association between dark chocolate intake and a decreased risk of essential hypertension, suggesting a potential protective effect of dark chocolate against hypertension. Additionally, the authors observed a potential correlation between dark chocolate intake and a reduced risk of venous thromboembolism. Their findings underscore the potential benefits of dark chocolate consumption in lowering the risk of essential hypertension [48].

Numerous studies corroborate the cardiovascular benefits of chocolate consumption (Table 3). In an intriguing study, the link between regular chocolate consumption and incidents of coronary artery disease (CAD) in participants from the Million Veteran Program was explored by Ho et al. (2021). Analyzing data from over 188,000 participants, the study revealed a significant negative correlation between regular chocolate intake and CAD risk. The incidence rates for CAD events decreased with higher chocolate consumption. After adjusting for relevant factors, hazard ratios demonstrated a consistent reduction in CAD risk, showing a significant linear trend [49].

Table 3. Studies assessing the effects of chocolate on cardiovascular health.

Study type	number of samples	Duration	Dose/Form	Results	Reference
Randomized Controlled Trial	30 overweight adults	4 weeks	37 g/d of sugar-free cocoa beverage	-↓ risk of CVD -↓ significant s and d Blood pressure (BP), heart rate -↓ significant insulin concentration -Improve endothelial function -No changes in FMD -No adverse effect on body weight, fasting lipid levels, BMI	[50]
Randomized Controlled Trial	84 normal and overweight Age 20 to 35	6 months	2 g/d DC (70% cocoa) 2 g/d of milk chocolate	-↓ significant total cholesterol (TC), triglyceride (TG), and LDL cholesterol -↓ significant BP	[51]
Single-blind, parallel, randomized, clinical trial	210 diabetic patients	8 weeks	30 g/d DC	-↓ significant TG, LDL -↓ significant Fasting blood sugar (FBS), hemoglobin A1C, TNF-α, IL-6 and CRP -Not significant change in BP	[52]
Randomized controlled four-period cross-over trial	31 overweight/obese age 30–70	4 weeks	43 g/day DC 42.5 g/d of almond	-↓ significant all groups TC and LDL -↓ significant sBp after average American diet (AAD) and almond diet (ALD) -↓ significant dBp after the ALD Not significant sBp after the chocolate diet (CHOC) and CHOC+ALD -no changes in insulin	[53]
Population- based prospective cohort	31,917 men	14 years	6 g/week of DC	-↓ significant heart failure (HF) rate	[54]
Randomized Controlled Trial	92 participants hypertensive participants	8 weeks	50 g of dark chocolate	-↓ significant TC and LDL -↓ significant s and d BP - No significant changes in BMI -↓CVD mortality -significant improvement in endothelium-dependent vasodilation	[55]

Similarly, the 2018 systematic review and meta-analysis by Gianfredi et al. examined the association between chocolate consumption and cardio-cerebrovascular risk in the general population. The meta-analysis of 16 eligible studies revealed an overall risk reduction for cardiovascular diseases with a risk ratio (effect size [ES]) of 0.77, indicating a moderate protective impact with moderate heterogeneity. Subgroup analyses further highlighted a significant decrease in the risk of MI with an ES of 0.78 and minimal heterogeneity. The results of this research showed the potential protective effects of moderate chocolate consumption against cardiovascular risk, particularly concerning MI, and underscored a potential benefit, especially for women [56].

The cardiovascular effects of chocolate, particularly dark chocolate with high cocoa content, are attributed to various bioactive compounds, including polyphenols, flavanols, and minerals. The mechanisms of action underlying these effects involve complex interactions with physiological processes. Here are some key mechanisms:

Endothelial function improvement: Endothelial function, a critical indicator of cardiac risk, is closely associated with arterial vasomotor responses primarily regulated by releasing of NO (vasodilator) and endothelin (vasoconstrictor) from the vascular endothelium. Dysregulation between vasodilation and vasoconstriction plays a pivotal role in developing many cardiovascular conditions, including atherosclerosis and hypertension [57-58]. Endothelial dysfunction, characterized by impaired NO production, abnormal signaling, and increased oxidative stress, has been identified as a predictor of recurring and incident cardiovascular events [59].

Meta-analyses of randomized, controlled trials have emphasized the effect of consuming flavonoid-containing foods, particularly dark chocolate, on endothelial function. In a 2020 meta-analysis by Ebaditabar et al., the impact of dark chocolate on flow-mediated dilatation (FMD), a noninvasive measure of endothelial function, was explored. This analysis included 17 studies with 615 participants and showed that chronic consumption of dark chocolate significantly increased FMD (0.69, 95% CI 0.22–1.16, $p < 0.001$). In addition, acute consumption of dark chocolate also demonstrated beneficial effects on FMD ($p < 0.001$). Notably, the study identified a non-linear dose-response relationship, suggesting that doses lower than 20 g/day of dark chocolate resulted in a more significant reduction in FMD. The findings emphasized the positive effect of acute and chronic consumption of dark chocolate on FMD by considering the non-linear association of dietary intake effects on vascular function [60].

Antiplatelet activity: Chocolate, particularly dark chocolate rich in flavanols, has been associated with notable antiplatelet activity, offering potential cardiovascular benefits [61]. Flavanols, specifically procyanidins, have been shown to inhibit platelet aggregation, which plays a role in blood clot formation. As a result, dark chocolate may help reduce the risk of clot-related cardiovascular events, such as heart attacks or strokes, through this mechanism [62].

The exact mechanisms by which flavanols influence platelet activity still need to be fully elucidated, but several theories have been proposed. Flavanols have the potential to induce modifications in membrane fluidity, alter ligand-receptor affinity, and impact intracellular signaling pathways within platelets [62-63]. Additionally, it has been suggested that flavanols might impact platelet-derived nitric oxide, a molecule with antiplatelet properties [64]. The richness of dark chocolate in flavanols makes it a concentrated source compared to its white compartment.

Numerous intervention studies support the antiplatelet effects of cocoa. The 2022 ECLAIR pilot study by Seecheran et al. explored the effects of a 1-week trial involving the consumption of 30 g/day of 65% cocoa (dark chocolate) on platelet reactivity in patients with stable coronary artery disease (CAD) under dual antiplatelet therapy. The study involved 20 patients receiving maintenance dual antiplatelet therapy with aspirin (ASA) and clopidogrel. Platelet function was assessed before and after the cocoa intervention. Results demonstrated that cocoa significantly augmented the inhibitory effect of clopidogrel. However, the inhibitory effect of ASA remained unaffected by cocoa. Notably, no serious adverse events were reported, suggesting that cocoa's impact on platelet reactivity, particularly in combination with clopidogrel, could offer potential insights for patients with stable CAD, emphasizing the need for further long-term investigations to validate these preliminary findings [65].

Cholesterol modulation: The impact of chocolate on serum lipids, particularly LDL cholesterol, has been the subject of extensive research with varying results based on the cacao solid contents [66-67].

The impacts of cocoa products on lipid profiles, focusing on diabetic patients was investigated by Darand et al. Through a systematic search of databases, eight randomized controlled trials encompassing 433 participants were analyzed. Their results revealed a significant reduction in low-density lipoprotein cholesterol (LDL-c) levels following cocoa/dark chocolate consumption. These findings suggest a potential role for cocoa/dark chocolate in improving lipid profile in diabetic patients. However, the authors emphasize the necessity for further high-quality trials to confirm the clinical efficacy of cocoa/dark chocolate consumption on lipid profile [68].

In their 2023 systematic review and meta-analysis, Amoah et al. explored the impact of cocoa beverage and dark chocolate consumption on lipid profiles in individuals with normal and elevated LDL cholesterol. Conducting a comprehensive literature search, the study found that circulating concentrations of total cholesterol, LDL cholesterol, and triglycerides were not altered by cocoa beverage and chocolate consumption significantly. However, circulating concentration of high-density lipoprotein (HDL) cholesterol increased significantly by 0.05 mmol/L. Interestingly, this improvement in HDL cholesterol was consistent across populations with normal and elevated LDL cholesterol. Additionally, cocoa beverage consumption led to a significant increase in HDL cholesterol by 0.11 mmol/L, whereas the effect was not statistically significant for chocolate alone or a combination of cocoa beverage and chocolate. The study suggests that cocoa consumption, particularly in the form of cocoa beverages, could be recommended as part of a healthy dietary approach for individuals with both normal and elevated LDL cholesterol [69].

As previously noted, white chocolate contains minimal or no cocoa solids, resulting in the deprivation of the majority of bioactive compounds associated with the positive effects of cocoa and dark chocolate on cardiovascular health. Notably, the substantial presence of cocoa butter in white chocolate, as indicated by the references discussed in the preceding section, is associated with fewer beneficial effects on lipid profile control, proper vascular endothelial function, and antiplatelet activity.

Cognitive function and mood enhancement: Chocolate can affect mood through pleasurable sensory experiences, psychoactive compounds (flavanols and methylxanthine), and possible effects on psychological well-being [18,70].

In their 2021 meta-analysis, Fusar-Poli et al. systematically reviewed nine studies to explore the impact of cocoa-derived products on mood. The analysis revealed a significant positive effect of cocoa-rich products on depressive symptoms (Hedge's g = -0.42) and anxiety symptoms (Hedge's g = -0.49). The authors suggest that short-term consumption of cocoa-rich products may enhance mood. However, the researchers stated that caution is needed in interpreting these findings due to the limited period and relatively small number of participants in the analyzed studies [71].

In contrast, other studies have investigated the potential psychoactive effects of specific compounds in cocoa, such as flavanols and methylxanthines. In a 2023 study by Murakami et al., 60 healthy middle-aged Japanese women experiencing fatigue were enrolled in a randomized, double-blind, placebo-controlled pilot study. Participants aged 40 to 60 were given flavanol-rich cocoa extract (240 mg/200 ml per day) or a placebo for eight weeks. The results of the study indicated a significant reduction in negative mood indicators such as depression, fatigue, and anger, along with a general decrease in mood disorders in the cocoa group compared to the placebo group. Moreover, the cacao group exhibited a notable increase in positive mood, specifically in the vigor index. Although no significant differences were observed in fatigue scale scores or autonomic nervous system activity levels between the groups, the results suggest that flavanol-rich cacao extract may serve as a beneficial dietary supplement, improving mood conditions in middle-aged women and contributing to their overall well-being [72].

Sasaki et al. (2024) conducted a study to explore how consuming dark chocolate, rich in polyphenols, affects cognitive performance during demanding tasks. Participants consumed chocolate with high or low polyphenol concentrations and performed cognitive tasks. While reaction times remained consistent, those consuming high-polyphenol chocolate, maintained accuracy, unlike those with low-polyphenol chocolate whose accuracy declined. High-polyphenol chocolate also led to increased sympathetic nerve activity, while both types of chocolate increased mental fatigue. Additionally, low-polyphenol chocolate caused a significant decrease in concentration. These findings suggest that dark chocolate consumption, particularly with high polyphenol content, may sustain cognitive performance and concentration during challenging tasks [73].

While extensive research has delved into the potential mood-altering effects of cacao and dark chocolate, exploring white chocolate in this context remains relatively limited. White chocolate, distinct from its darker counterparts due to the absence of cocoa solids, prompts inquiry into whether its sensory attributes and composition contribute to comparable or distinct influences on mood. Existing studies have predominantly focused on the bioactive compounds present in dark chocolate, such as flavanols and methylxanthines, and their impact on mood modulation. However, the unique composition of white chocolate, characterized by its reliance on cocoa butter, sugar, and milk solids without cocoa solids, necessitates a dedicated investigation into its potential psychoactive properties and influence on psychological well-being.

In conclusion, the scientific exploration of chocolate's effects on mood encompasses various factors, including sensory experiences, psychoactive compounds, and psychological responses. While some studies suggest short-term mood improvements attributed to chocolate’s palatability, others delve into the potential psychoactive effects of specific cocoa compounds. The interplay between chocolate, mood, cravings, and cognitive function is complex and influenced by individual differences. Certainly, further research is required to unravel the intricacies of chocolate’s psychological effects and their underlying mechanisms.

Moving forward, this literature review lays a solid foundation for future research endeavors aimed at elucidating the intricate relationship between chocolate consumption and health outcomes. The comprehensive analysis presented herein not only underscores the potential therapeutic implications of cocoa-derived products but also highlights the need for further investigation into their mechanisms of action and optimal efficacy and safety profiles. Moreover, advancements in analytical techniques could facilitate the precise quantification of bioactive compounds in chocolate products, enabling more accurate assessments of their health-promoting properties. Additionally, longitudinal studies assessing the long-term effects of chocolate consumption on diverse populations, coupled with mechanistic investigations at the molecular level, are warranted to provide deeper insights into the preventive and therapeutic potentials of chocolate in mitigating various health risks.

CONCLUSION

In conclusion, there is good evidence that dark chocolate can provide more health benefits compared to white chocolate. The presence of significant amounts of antioxidant, anti-inflammatory, minerals, and psychoactive compounds has made dark chocolate an ideal candidate for healthy diets. In contrast, the sugar-laden nature of white chocolate and its absence of key compounds diminishes its potential positive impact on cardiovascular health and cognitive performance. As consumers become increasingly conscious of the link between diet and health, the evidence presented in this review unequivocally supports the preference for dark chocolate as a delectable choice that satisfies the sweet tooth and contributes to overall well-being. Embracing the delights of dark chocolate can be seen as a conscientious step towards a more health-conscious and enjoyable lifestyle.

List of abbreviations: ASA: Aspirin, BMI: Body mass index, CAD: Coronary artery disease, CVD: Cardiovascular disease, CWP: Cell wall polysaccharides, EF: Effect size, dosages for specific health conditions. Future studies could explore novel interventions utilizing chocolate-based formulations in controlled clinical settings, employing rigorous methodologies to assess their

FMD: Flow-mediated dilatation, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, MI: Myocardial infarction, NO: Nitric oxide, RDA: Recommended dietary allowance

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