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THE INFLUENCE OF COCOA ON THE CARDIOVASCULAR SYSTEM

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review

Summary

Cocoa contains a range of chemicals that can interact with cells and tissue components, providing protection against the development and improvement of pathological conditions. The most important effects of cocoa and chocolate are related to cardiovascular disease. Due to the high content of flavonoids, it has numerous positive effects on cardiovascular diseases, including: antioxidant, anti-inflammatory, antithrombotic effects, and possibly increased HDL, lowering blood pressure and improving endothelial function. The beneficial effects of cocoa are most likely a consequence of reducing oxidative stress and increasing the bioavailability of nitric oxide. Although many positive effects of chocolate on the cardiovascular system have been proven, precautions in its use are mandatory.

Keywords: cocoa, flavanols, polyphenols, cardiovascular diseases, blood pressure

Introduction

Cocoa is the dried and fully fermented seed from the fruits of cocoa tree, lat. *Theobroma cacao* (McShea et al., 2009). The first data on the use of cocoa dates back to 1600 BC. In Honduras, archeologists have discovered specially designed bowls, thousands of years old, believed to be used by Aztecs to drink liquid cocoa (Henderson et al, 2007). It is known that consuming large amounts of fruits and vegetables, i.e. foods rich in natural polyphenols, are associated with a lower risk of coronary heart disease and stroke. Epidemiologicaly, a similar relationship was observed with cocoa.

Polyphenols

Cocoa contains about 380 known chemicals, of which 10 are psychoactive. Unprocessed cocoa beans are inseparable due to the high content of polyphenols that give them a bitter taste. In finished products such as chocolate, the content of cocoa can be reduced from 100% to 10% due to different production processes (Rusconi and Conti, 2010). Cocoa contains a large number of polyphenolic compounds, but is particularly rich in flavanoids, specifically flavanols. The flavanols are responsible for the bitterness of cocoa because they build complexes with saliva proteins (Manach et al., 2004). Cocoa contains the highest concentration of antioxidants in comparison with any other food. It has been shown to have the highest content of polyphenols (611 mg per serving) and flavonoids (564 mg per serving), higher than tea and wine together (Lee et al., 2003). Dark chocolate has a higher content of phenol compared to milk chocolate. Dark chocolate, in addition to the greater content of flavonoids, has better biological effects because milk in milk chocolate can inhibit intestinal absorption of flavanoids (Serafini et al., 2003). The main flavanols that cocoa contanis are catechin, epicatechin and procyanidins, which are mostly responsible for antioxidant activity in cocoa products (Ramiro-Puig and Castell, 2009). Thanks to their properties, flavonoids positively affect the cardiovascular system, including antioxidant and antithrombotic activity, immune regulatory properties and the endothelium (Corti et al., 2009).

Theobromine

In addition to polyphenols, cocoa also contains methylxanthine compounds, predominantly theobromine, and, in lower amounts, caffeine (Katz et al., 2011). The content of methylxantine depends on the genotype of cocoa tree. Theobromine stimulates the heart muscle, relaxes the bronchial smooth musculature in the lungs and plays a significant role in the transmission of intracellular signals (Shively and Tarka, 1984). In addition, theobromine has an antioxidant effect, and some antioxidant substances are believed to be effective in the treatment of depressive disorders (Scapagnini et al., 2014). Although new studies have shown that theobromine does not affect mood, there is a literature that states that theobromine and cocoa flavanols alone or in combination may have significant neurocognitive effects (Scholey and Owen, 2013).

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Minerals

Cocoa bean is a source of many essential minerals, including magnesium, copper, potassium and iron. These minerals can affect the health and function of blood vessels, influencing the nutritional value of cocoa. In its composition, there is mostly magnesium, which catalyzes a large number of biological reactions, including protein synthesis and energy production (Steinberg et al., 2003). The lack of magnesium in the body is associated with some diseases, among others with metabolic syndrome, insulin resistance and diabetes (Gums, 2004). Dark chocolate is an important source of copper that is essential in the body for processes such as iron transport, glucose metabolism, infant growth and brain development (Olivares et al., 1996).

Chocolate and cardiovascular diseases

According to the World Health Organization, by 2030, 23.6 million people will die of cardiovascular disease. The lifestyle, with a great emphasis on healthy nutrition, is one of the most important factors for the emergence, prevention and control of cardiovascular disorders. In general, chocolate is one of the most famous foods in the world, and there is more and more attention to its potential benefits in cardio metabolic health. It has been proven that cocoa products contain flavanol and as such have great potential in preventing cardiometabolic disorders (Corti et al., 2009).

Some studies indicate that chocolate consumption has a positive impact on human health, with various effects such as antioxidant, antihypertensive, anti-inflammatory, anti-atherogenic and antithrombotic effects, also affecting the function of vascular endothelium and activation of nitric oxide. These positive effects have been confirmed in meta-analysis supporting the positive role of cocoa and cocoa products on cardiovascular risk factors such as blood pressure, cholesterol levels, atherosclerosis, and insulin resistance. However, generally the effect of chocolate consumption on vascular functions is much more pronounced in healthy subjects compared to the impact on cardiovascular disease, where the evidence is much weaker. There are some limited studies that focus on the association of cholesterol with severe cardio metabolic outcomes (heart attack, diabetes, cardiovascular disease) (Buitrago-Lopez et al., 2011). Cardiovascular risk factors and diseases are associated with endothelial dysfunction or damage. According to meta-analysis published in 2008, consumption of food rich in polyphenols is mainly associated with an improvement in the endothelial function in the short-term and long-term form. This was established for tea consumption (Ras et al., 2011), red wine, grape juice and orange juice consumption (Morand et al., 2011). As cocoa is particularly rich in polyphenols, it doesn´t surprise that it induces NO (nitric oxide) dependent vasodilatation in rabbits (Karim et al., 2000) and improves endothelium in healthy people as well as in patients with cardiovascular risk factors (Sudano et al., 2012).

The influence of cocoa on blood pressure

The relationship between cocoa and blood pressure was observed in the island population in Central America, the Kuna Indians, who had a very low rate of hypertension and a constant healthy low pressure without age influence (Hollenberg, 2006; Kean, 1944). These effects are lost upon migration to urban Panama city and are likely linked to lower intake of natural cocoa drinks rich in flavanols. The tradition of this island population is consumption of three to four cups of cocoa-drinks a day, and it is assumed that they consume 1880 mg procyanidins per day (McCullough, 2006).

In a study in Iowa (USA) on the health of postmenopausal women (34,489 women) free of cardiovascular disease with a 16-year follow up, it was found that a regular intake of foods rich in flavonoids and reduced risk of death caused by cardiovascular disease was associated (Mink et al., 2007). A Zutphen study of the elderly, which included 470 elderly males without chronic disease, also suggests that the usual cocoa intake can reduce cardiovascular risk and is reversly linked to cardiovascular disease and comprehensive mortality (Bujisse et al., 2006).

In accordance with the relationship between consumption of cocoa and low incidence of hypertension, results of several short-term clinical studies show that the intake of certain chocolates can reduce blood pressure in humans. Grassi et al. (2005) studied 20 healthy young adults with a typical Italian diet with daily consumption of 100 g of dark chocolate or 90 g of white chocolate (assuming 500 mg and 0 mg of polyphenols) daily for 15 days, in random sequence with a 7-day washout period between treatments. They noticed that the addition of dark chocolate was associated with decreased systolic blood pressure, while white chocolate did not have these effects. The results have been extended to essential hypertensive patients and then to hypertensive patients with glucose intolerance (Grassi et al., 2005). Taubert et al. (2007) studied the effects of low-dose dark chocolate rich polyphenols in humans for 18 weeks. The intake of dark chocolate reduced systolic (-4.5 ± 1.35 mmHg) and

diastolic blood pressure (-2.5 ± 1.36 mmHg), as well as oxidative stress. A blood pressure decrease was followed by a constant increase in S-nitrosoglutation, indicating an improved NO formation. The above studies provide support for the inclusion of oxidative stress with the regulation of vascular tonus without the availability of NO formation (Taubert et al., 2007).

Commercially available dark chocolate (74% cocoa), but not white chocolate, improves the flow of vasodilatation by 80% in young healthy smokers. This effect was observed 2 hours after taking chocolate and lasted up to 8 hours. Since the plasma antioxidant status is significantly improved 2 hours after intake, it is likely that not only the induction of nitric oxide synthesis and increased NO levels but also reduction of oxidative stress and reduced degradation of nitric oxide to reactive species of oxidant, thus contributing to an improved function endothelium, especially in conditions of high loading with oxidative stress, as in smokers (Zhu et al., 2002). Indeed, antioxidants can prevent the transformation of NO into peroxynitrite and in turn protect against vasoconstriction and vascular damage (Wever, 1998). Oxygenate stress and reduced antioxidant defenses play a key role in the pathogenesis of atherosclerosis (Flammer, 2007).

Due to the importance of the cocoa effect in maintaining blood pressure, improving nitric oxide and endothelial function, its role in the antihypertensive effect can be explained. There is evidence that flavanols and foods rich in flavanol (Table 1), including cocoa, can inhibit the activity of angiotensin converting enzyme (ACE) *in vitro* (Actis-Goretta et al., 2006). ACE regulates the renin-angiotensin system, degrades angiotensin 1 to angiotensin 2, which stimulates the release of vasopressin or aldosterone and antidiuretic hormone, increasing sodium and water retention. It also inactivates vasodilators bradykinin and calidin. Whether ACE inhibits or mediates antihypertensive activity of cocoa flavanol in humans has not yet been fully clarified (Lavoie, 2003).

Table 1. Flavanol content in different foods

SOURCE	FLAVANOL CONTENT per mg/kg or mg/l
CHOCOLATE	460-610
BEANS	350-550
CHERRY	50-220
PEACH	50-14
BLUEBERRY	130
APPLE	20-120
GREEN TEA	100-800
BLACK TEA	60-500
RED WINE	80-300
CIDER	40

Precautions

Although many positive effects of chocolate on the cardiovascular system have been proven, precautions in its use are mandatory. Unfortunately, in the process of chocolate production, cocoa is heated and loses its nutritional and healing properties. So, because of the high caloric value (about 500 kcal/100g) and high sugar content, it is necessary to limit the intake of chocolate. It is believed that the intake of large amounts of sugar is associated with an increase in body weight, caries, diabetes, and is one of the risk factors for hypertension and dyslipidemia (Corti et al, 2009).

Conclusion

For centuries, people have been consuming and enjoying cocoa products and chocolate for good taste and for its beneficial effects on health. Although excessive consumption can have harmful effects, existing studies generally agree on a potentially useful association of chocolate consumption with a lower risk of cardio metabolic disorders. Over the past 10 years, many studies have confirmed that cocoa really improves vascular function, probably mediated by its high content of polyphenols. Reduction of oxidative stress and increased bioavailability of nitric oxide are most likely a consequence of beneficial effects of cocoa.

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