Cocoa/Dark Chocolate and Obesity
Subjects: Nutrition
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Definition

Obesity remains a major public health problem due to its increasing prevalence and the role it plays in contributing to the occurrence of chronic disease. Natural products have become common as adjunct therapeutic agents for treating obesity and preventing metabolic diseases. Cocoa and its products are a rich source of polyphenols are commonly consumed worldwide and recently received attention in the management of obesity. This entry also depicts the relation between cocoa polyphenols and dark chocolate and obesity.

1. Introduction

Obesity has become a public health problem globally due to its alarmingly high rate and increasing prevalence, as well as the role it plays in the occurrence of many chronic diseases[1]. Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health[2]. The rate of obesity has increased globally, tripling since 1975. More than 1.9 billion adults aged 18 years and older were reported to be overweight in 2016; of these, 600 million adults were obese. In addition, the prevalence of overweight and obesity was also found to be high in low- and middle-income countries, especially in urban areas[3].

A lack of physical activity and poor nutrition have been documented to contribute significantly to the increased prevalence of obesity and its associated complications[4]. Obesity contributes to many impacts, including physical, social, psychological, and, most importantly, medical[5]. Substantial evidence shows that overweight and obese people are more likely to develop a variety of chronic diseases, including hypertension, type 2 diabetes, and cardiovascular disease (CVD)[6]. Obesity is often characterized as low-grade chronic inflammation with irregular inflammatory response, weak antioxidant capability, and low insulin sensitivity, resulting in inflammation, oxidative stress, and insulin resistance[7]. Adipose tissue inflammation plays a crucial role in causing obesity-related metabolic complications, including the development of insulin resistance[8]. In response to the increased obesity prevalence, numerous efforts have been made and strategies implemented to tackle this problem. Lifestyle interventions such as a calorie-deficit diet and exercise are often difficult or unsuccessful[9]. Thus, the use of natural products as therapeutic agents for the treatment of metabolic disorders has become a common alternative or complementary method for the treatment of obesity.

Polyphenols are present in several widely consumed foods, such as fruits and vegetables, and in beverages, such as coffee, tea, and wine, as well as dry legumes, chocolate and cocoa products. Over the past two decades, polyphenols have gained considerable attention mainly due to their antioxidant and their potential role in the prevention of many diseases, such as CVD, cancer, diabetes, and other oxidative stress-related diseases[10][11]. Polyphenols, classified according to their chemical structure, include phenolic acids, flavonoids, stilbenes, lignans, and tannins[12]. Flavonoids are the most abundant type of polyphenol in food. Flavonoids can be classified into groups: flavonols, anthocyanidins, flavones, flavanones, flavanonols, and isoflavonoids. Cocoa and its products, a commonly consumed food around the world, are a source of polyphenols[13] that show higher phenolic content and total antioxidant capacity than tea and red wine[14]. Cocoa polyphenols consist primarily of flavanols (epicatechin, catechin, and procyanidins) and a flavonol (quercetin). Other polyphenols have also been reported to be present in small quantities, such as anthocyanins, phenolic acids, and stilbenes[15]. The benefits of cocoa and cocoa products depend on polyphenol content. Cocoa flavanols can be found in dark chocolate, with a content estimated to be five times higher than that in milk chocolate[16]; the content of catechin and epicatechin is approximately 20 times higher than in tea.
Several in vitro and in vivo studies have shown that polyphenols, with antioxidant, anti-inflammatory, and anti-obesity properties, can boost energy expenditure and thermogenesis, and lessen oxidative stress and inflammation, while supporting weight loss management[17]. The popularity and regular consumption of chocolate and cocoa products and their postulated role in improving obesity have made them the subject of several research studies.

2. The Related Research on Cocoa Polyphenols and Dark Chocolate on Obese Adults

There are several existing human studies on the effects of cocoa polyphenol or chocolate consumption on obesity-related outcomes (anthropometric measurements, glucose profiles, lipid profiles, and inflammatory and oxidative biomarkers) in obese subjects. Many clinical trials investigating the effects of cocoa polyphenols have shown favorable effects, but there are also conflicting results, so it is crucial to do further investigation to address the difference.

The studies included in this review incorporated different forms of cocoa (chocolate, beverage, and powder) that were administered either in a normal caloric diet or as part of a reduced-calorie diet or in combination with exercise. The outcomes for the majority of these studies in anthropometric measurements do not favor the weight-reducing role of polyphenols in obese individuals. In fact, two studies reported an increase in body weight after an intervention with cocoa plus 500 mL of skim milk[18][19]. In contrast, three studies found reductions in anthropometric measurements (either body weight, BMI, or waist circumference)[20][21][22]. The dosage of cocoa used in these studies was 100 to 645 mg of polyphenols and the trial duration was 4 to 18 weeks. Two of the studies incorporated cocoa consumption with an energy-restricted diet (ERD) as their active arm intervention. A systematic review and meta-analysis of the effects of cocoa/dark chocolate supplementation on body weight and BMI concluded that body weight was only reduced in trials of >8 weeks’ duration and with cocoa or chocolate supplementation of >30 g per day. People with BMI up to 25 kg/m² showed more prominent changes in body mass index, waist circumference, and cholesterol level after consumption of flavanol-containing products, and this supports the claim that supplementation with these products may have a greater impact on these risk factors for overweight and obese people[23].

A possible explanation for the nonsignificant improvement in anthropometric measurements includes the different doses and forms of cocoa used in the interventions leading to different amounts of calories, sugar, and fat of the investigated products, as extra calories may have hampered the weight-reduction effects. In addition, the difference in polyphenol and fat content between cocoa and dark chocolate could have made their comparison inaccurate. Generally, cocoa powder contains higher amounts of total polyphenols, catechin, and epicatechin than dark chocolate but less fat[24]. On the other hand, dark chocolate that contains relatively high amounts of cocoa (50 to 85%) also contains high amounts of polyphenols (460–610 mg/kg)[25][42]; however, dark chocolate may also have high amounts of saturated fat and sugar[26]. Although many human studies have reported the health benefits of dark chocolate, the effects are limited by the calorie, sugar, and fat content; therefore, it must be introduced in the context of a well-balanced diet and controlled calories. In contrast, Almoosawi et al.[27] indicated that consumption of 20 g dark chocolate, providing 500 mg of polyphenols and a total of 102 kcal per day, by overweight and obese individuals is considered acceptable and can counteract the dietary impact on fat and energy content. The lipid content in cocoa is contributed by cocoa butter, a mixture of saturated and monounsaturated fatty acids. Although chocolate lipid content is relatively high, one-third of it is stearic acid, which is known to have non-atherogenic and natural effects on CVD. Stearic acid is unique in that it does not increase serum lipid levels to the same degree as other saturated fatty acids[28][29]. In addition, chocolate contains other nutrients that may be more beneficial to health than saturated fat content. Given the potential adverse effects on human health and the documented positive health benefits of chocolate consumption, it is important to enjoy chocolate in moderate quantities to avoid potential adverse effects.

Among all studies that reported body weight as their outcome measure, only one included body fat
composition. The study showed significant reductions in both body weight and body fat. Further studies that include body fat measurements are needed to better understand the role of polyphenol intake in modulating body fat reduction, particularly by altering lipid metabolism, such as fatty acid oxidation\textsuperscript{[30] [46]} and synthesis\textsuperscript{[31] [47]}. On another note, the smell of chocolate has been reported to suppress appetite, which is inversely related to levels of ghrelin\textsuperscript{[42] [33]}. This finding suggests that cocoa polyphenol intake may be beneficial in reducing both appetite and weight gain; however, none of the intervention studies included in this scoping review reported any satiety- or peptide-related hormones (ghrelin, leptin, and adiponectin) as part of their outcome measures in obese adults. This information may be helpful in further understanding the effects of cocoa consumption on body weight and body fat.

Cocoa polyphenols have been previously suggested to lower CVD risk by modulating the lipid profile and blood pressure. In this review, improvements in lipid profiles were mainly achieved in subjects with some risk of CVD, such as metabolic syndrome\textsuperscript{[15] [30] [35] [21] [36]}. In contrast, Munguia et al.\textsuperscript{[21]}, in a study using cocoa powder extract for 4 weeks, reported a 23.4% increase in TG level. It was also noted that HDL-c level was significantly reduced by 17% when compared to placebo. We suspect that this was due to the time effect, as Leyva Soto et al.\textsuperscript{[33]} reported reductions in TC, TG, and LDL-c as well as blood pressure after 6 months of daily intake of 2 g of dark chocolate. Interestingly, studies have also reported only increased HDL-c, but no improvement in TC, TG, and LDL-c\textsuperscript{[18] [19] [37]}. Acute consumption of cocoa beverage providing 960 mg of polyphenols showed that postprandial HDL remained higher compared to placebo after 6 h in subjects with type 2 diabetes after consuming a high-fat breakfast\textsuperscript{[37]}.

The evidence on the relationship between the amount of cocoa or dark chocolate and serum lipids is still inconclusive. As for the experiments carried out on subjects without cardiovascular risk, the findings were controversial. Studies included in this review found no significant changes in serum lipids following consumption of 500 mg of polyphenols in dark chocolate for 2 weeks\textsuperscript{[38]} or 4 weeks\textsuperscript{[27]} in healthy obese individuals. A systematic review on the effect of cocoa on serum lipid reported consistent findings, whereas cocoa consumption was only effective in reducing LDL-c and TC among participants with some type of cardiovascular disease or metabolic risk factors, but not among healthy subjects\textsuperscript{[39]}. In terms of flavanol dose, a systematic review and meta-analysis indicated that studies in which less than 500 mg of flavanol was administered daily showed greater LDL-c reduction compared to higher doses\textsuperscript{[40]}, concurring with Jia et al.\textsuperscript{[39]}, who showed an effective dose of less than 260 mg. This could be because a high amount of polyphenols can counteract their benefits to the lipid profile\textsuperscript{[39]}. Similarly, Tokedo et al.\textsuperscript{[39]} reported a saturation effect with a 500 mg daily dose; therefore a confirmatory study is needed to elucidate the optimal daily dose of flavanol for consumption.

Despite growing evidence from animal studies to support the anti-diabetic effects of some dietary polyphenols from cocoa extract\textsuperscript{[41] [42] [43]}, the present review of human studies indicated otherwise\textsuperscript{[44]}. Dark chocolate and cocoa beverages containing 960 mg total polyphenols and 480 mg flavanols did not affect glucose and increased insulin levels in obese type 2 diabetes subjects given a high-fat breakfast\textsuperscript{[21]}. A similar finding was reported in a study of subjects with hypertension and diabetes, in which consumption of 25 g of dark chocolate for 8 weeks did not improve insulin, fasting glucose, or HbA1c levels\textsuperscript{[42]}. Current data are inadequate to suggest chocolate and cocoa for glycemic control due to contradictory findings in human intervention. Although few studies have suggested the protective effects of cocoa polyphenols on insulin resistance (IR) and blood glucose, the mechanisms involved remain unclear. This is partly due to a lack of understanding of the flavanols’ mechanisms of action\textsuperscript{[43]}.

Oxidative stress, indicated by excessive production of reactive oxygen species (ROS) in cells and tissues, plays an important role in the pathogenesis of insulin resistance\textsuperscript{[45]}, inflammation, and many chronic diseases\textsuperscript{[46]}. Obesity is a dynamic multifactorial disorder characterized by excess adipose tissue mass arising through hypertrophy and hyperplasia of adipocytes\textsuperscript{[47]}, including the accumulation of ROS and the activation of cell inflammatory markers such as interleukin-6 (IL-6), tumor necrosis factor alpha (TNF-α), adiponectin, and leptin. Visceral adiposity is associated with greater production of these inflammatory adipocytokines, resulting in insulin resistance, systemic inflammation, and many obesity-related
Epidemiological studies indicate that daily intake of flavonoid-rich foods and beverages, such as cocoa, is correlated with decreased cardiovascular disease risk due to their natural antioxidant properties. The National Health and Nutrition Examination Surveys of US adults found that higher intake of flavonoid-containing food is associated with lower levels of CRP, an inflammatory marker. Moreover, it was suggested that the intake of foods rich in polyphenols decreases low-level inflammation. In this review, only eight intervention studies measured oxidative and/or inflammatory markers. No improvement in oxidative and inflammatory biomarkers was reported in studies involving obese subjects with a risk of CVD, elevated waist circumference and type 2 diabetes, or LDL-c, or in healthy obese subjects. In contrast, Stote et al., in a study comparing different doses of cocoa flavanols (30–900 mg) among 20 obese adults, showed significant reductions in biomarkers of inflammation and oxidative stress (CRP, total 8-isoprostane, and IL-6 concentration). The study also noted that the effects of cocoa consumption on IL-6 concentration was achieved with a flavanol dose of 400 mg.

The anti-inflammatory activity of cocoa depends largely on the dosage of flavanol. Findings in this review indicate variations in the dose of cocoa or chocolate flavanols because their content varies among products. In addition, the polyphenol content of cocoa also depends on its origin and the manufacturing process of the final product; therefore, the use of different cocoa products with different phenolic compositions might cause conflicting findings. Apart from flavonoids, other compounds such as dietary fiber and methylxanthines, particularly theobromine, must also be taken into account. Research that includes many aspects involving weight control such as peptide hormones, fatty acid metabolism, and related pathways is needed in order to understand and elucidate the effects of cocoa polyphenols in obese adults. Furthermore, there is increasing interest in studying the mechanisms of cocoa, such as its prebiotic effect in relation to its interaction with gut microbiota and health outcomes, but studies are scarce. None of the studies included in this review investigated the effects of cocoa on obese individuals by considering its effects on gut microbiota to further enhance the understanding of its putative anti-obesity activity.

In addition, a detailed and unbiased assessment of dietary exposure to cocoa products is required to further evaluate the relationship between cocoa consumption and health outcomes. The polyphenol content of the foods being examined and the structure of the polyphenol subclasses should also be included. Estimation of polyphenol intake, which is currently limited to data derived from food frequency questionnaires, is also problematic as it is subjected to recall bias and over- or underestimation. Knowing which metabolites are being produced upon cocoa ingestion is also important, as this knowledge will help us understand its absorption, distribution, and metabolism.

References

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**Keywords**

obesity; cocoa polyphenols; dark chocolate

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