Journal for Re Attach Therapy and Developmental Diversities
eISSN: 2589-7799
2025 February; 8 (1) : 41-45

Chocolate in Moderation keeps your Bone in Celebration

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ABSTRACT:

Chocolate can affect bone health in both positive and negative ways. Chocolate contains minerals and flavonoids that may help bones, but it also contains other components that may be harmful. Bone loss resulting in increased risk for osteoporosis is a major health issue worldwide. Chocolate is a rich source of antioxidant and anti-inflammatory flavonoids and dietary minerals with the potential to benefit bone health. However, other chocolate constituents such as cocoa butter, sugar, and methylxanthines may be detrimental to bone. Human studies investigating the role of chocolate consumption on serum bone markers and bone mineral density (BMD) have been inconsistent.

A contributing factor is likely the different composition and thereby the nutrient and bioactive content among chocolate types. White and milk chocolate are high in sugar and low in flavonoids and most minerals. Dark chocolate (45-85% cocoa solids) is high in flavonoids, most minerals, and low in sugar with ≥70% cocoa solids resulting in higher fat and methylxanthine content. Studies showed postmenopausal women had no bone effects at moderate chocolate intakes, whereas adolescents consuming chocolate had greater longitudinal bone growth.

Based on flavonoid and mineral content, unsweetened cocoa powder appeared to be the best option followed by dark chocolate with higher cocoa content in terms of supporting and preserving bone health. Determining dietary recommendations for chocolate consumption relative to bone health is important because of the growing popularity of chocolate, particularly dark chocolate, and an expected increase in consumption owing to suggestions of health benefits against various degenerative diseases.

This review article aims to throw light on the relationship between chocolate consumption and its constituents, including flavonoid content, on bone health and osteoporosis risk.

Keywords: Chocolate, Osteoporosis, Bone health.

INTRODUCTION:

Osteoporosis is a degenerative skeletal disease caused by an imbalance between bone formation and resorption, resulting in bone mineral loss and microstructural deterioration that places bones at increased risk for fracture. An estimated 200 million people worldwide have osteopenia, reduced bone mineral density (BMD) or osteoporosis (BMD > 2.5 SD below the mean for young adults). This represents about one in three women and one in five men ≥50 years of age. In the United States, osteoporosis-related morbidity and mortality is expected to increase 2.4-fold in women and 3.1-fold in men by 2050.

Many authors attributed the greater projected increase of osteoporosis in men to their improved life expectancy. Treatments for osteoporosis include medications and hormone therapy. However, the high cost of drugs, inconvenient dosage regimens, and potential side effects (e.g., esophagitis, gastrointestinal symptoms) often result in poor compliance. Nutrients important to bone health such as vitamin D, calcium, phosphorus, magnesium, and trace minerals (e.g., copper, zinc, and iron) are readily available in the diet or as dietary supplements.[1] Diets that promote bone health have mainly focused on increasing calcium and vitamin D consumption, but there is growing interest in phytochemicals.

INGREDIENTS:

Dietary polyphenols consist of a large group of plant-derived secondary metabolites divided into four different classes, one of which is the flavonoids (diphenylpropanes C_6-C_3-C_6). Flavonoids contain several classes of bioactive compounds. Evidence has demonstrated that intake of specific flavonoids may promote bone health. These include soybean isoflavones (e.g., genistein and daidzein), flavonols (e.g., aglycone quercetin) found in plums, and flavonones (e.g., hesperidin) found in citrus pulp and juice. Another food source noted for its flavonoid content is chocolate. Cocoa, a major constituent in chocolate, has the highest flavanol content of all foods on a per-weight basis and contributes to greater total dietary intake of flavonoids than tea, fruits, and vegetables.[1]

CHOCOLATE POLYPHENOL CONTENT:

Cacao (Theobroma cacao) refers to the raw unprocessed bean from the cacao fruit tree. Cocoa bean is the term used after the cacao bean has undergone processing to obtain the ingredient used in chocolate manufacturing. Variety and genetics of the cacao bean influences its polyphenol content. Even within a cacao species, polyphenol content is variable owing to factors such as the growing region, climatic conditions during growth, maturity at harvest, and storage time.[2]

OTHER CHOCOLATE CONSTITUENTS:

In addition to flavonoid content, chocolate is a rich source of other bioactive compounds with the potential to exert either positive or negative osteogenic effects. Although chocolate is low in vitamins important for bone health, cocoa powder is used to flavour milk to encourage consumption of milk as a good source of vitamins A and D as noted by the 2015–2020 Dietary Guidelines for Americans.[3]

EPIDEMIOLOGY:

Western Europe and the United States are among the countries with the highest chocolate consumption with a maximum of 9 kg/y (∼209 regular size 43 g or 1.5 oz chocolate bars per person) in Switzerland and 4.3 kg/y in the United States. Consumption patterns indicate that ∼15% of women 40 to 49 years of age consume chocolate at least once every 3 days. This represents a significant proportion of the population at risk for developing osteoporosis because bone is lost at a rate of ∼0.2% to 0.5% per year after the age of 40 to 45 y, with bone loss in women accelerated by 2% to 5% immediately before menopause. The aim of this study was to review evidence of a potential role of consuming chocolate, its flavonoid content, and other chocolate constituents in bone health and osteoporosis risk.[3]

BIOLOGICAL PLAUSIBILITY:

In a cross-sectional study conducted in Scotland on postmenopausal women (N = 5119, 45–54 y of age), flavonoid intake was associated with higher hip ($r = 0.054$, $P \leq 0.05$) and lumbar spine ($r = 0.036$, $P \leq 0.05$) BMD (Bone Mineral Density) . Flavonoid intake was mainly attributed to tea drinking (57%) and the flavanol; Catechin was identified as the main flavonoid consumed. Another rich source of flavonoids are cocoa beans, ∼37% of which are comprised of catechins and epicatechin accounts for ∼35% of the total.[4]

CHOCOLATE CONSUMPTION AND BONE HEALTH:

Although studies have investigated the consumption of flavoured milk such as chocolate milk as a strategy to increase milk and calcium consumption in children, these studies did not include an assessment of bone status. This is important because bone mineral accrual during childhood and adolescence is a key determinant of future risk for osteoporosis[5].

TOO MUCH OF ANYTHING IS GOOD FOR NOTHING:

It is unclear to what extent chocolate, which comes in many different forms, impairs calcium absorption. According to a 2019 evidence review in Nutrition, the bone effects of chocolate vary based on the type of chocolate consumed, and more laboratory and human studies are needed to tease out how or if chocolate impacts the minerals you consume significantly. Chocolate does contain a compound that is known to get in the way of mineral absorption called oxalate. Oxalate is abundant in chocolate and can range from 500 to 900 milligrams per 100 grams. Studies have also pointed toward other components in chocolate that may inhibit mineral absorption or affect bone health, such as:

- Added cocoa butter
- Sugar
- Methylxanthines

What gets complicated is that chocolate also contains compounds such as flavonoids and antioxidants that support bone health.

The largest study to date published in The American Journal of Clinical Nutrition in 2008 unveiled that elderly women who ate chocolate more than one time each day had thinner bones (less bone density) than women who ate chocolate less than once per week. The researchers concluded that daily chocolate eating may interfere with the absorption of calcium needed for maintaining bone density, but that more studies would be needed to confirm the findings.[5]

Since the 2008 study, there has not been enough large-scale research to warn women at risk for osteoporosis to avoid chocolate. The Bone Health & Osteoporosis Foundation warns that legumes, some beans, spinach, rhubarb, beet greens and caffeine may interfere with calcium absorption, but it does not mention chocolate.

Based on the current limited evidence, the researchers in Nutrition note that cocoa powder, followed by dark chocolate with high cocoa content, were the least likely to affect bone health negatively, but that more research is needed in the field.[6]

CURRENT GUIDELINES FOR BONE HEALTH:

According to the 2020-2025 Dietary Guidelines for Americans, most people should be able to get enough calcium from a healthy diet that includes healthy dairy products and protein from seafood, lean meats, poultry and eggs. The guidelines say that tofu made with calcium salts and fish with edible bones like canned salmon or sardines are good sources of calcium. Although the guidelines do not mention avoiding chocolate, they do suggest avoiding foods high in added sugar and saturated fat.[7]

CHOCOLATE AND ORTHODONTIC MOVEMENT:

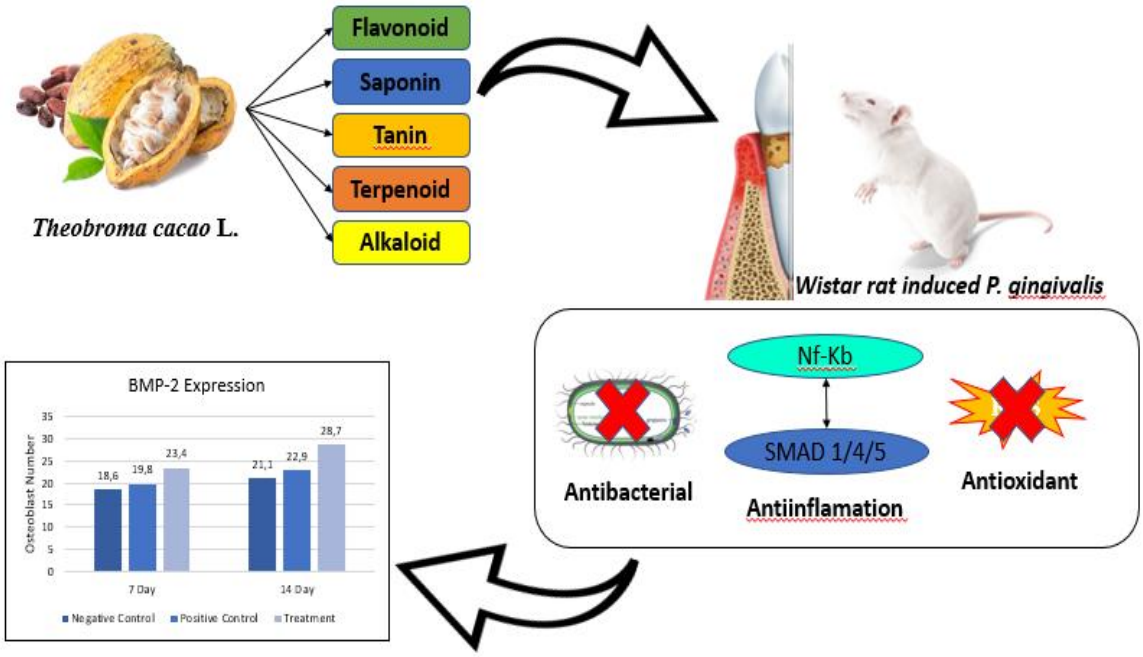
The Orthodontic movement of teeth is a complicated mechanical and biological process that involves many different molecules. When the tooth gets orthodontically strengthened, it will experience a process of pressure by the osteoclasts, and the other side will experience the tension of the osteoblast, this is called the remodelling process. If the teeth are given optimal strength, the facts shown are on the side of the pressure that experiences excessive resorption and this in turn will disrupt the balance of the bone remodelling process. Therefore, herbal ingredients are needed that can balance bone remodelling.

One of these ingredients is cacao beans (*Theobroma cacao L*) . One of the ingredients of cacao bean extract and the most abundant is polyphenols, which can differentiate osteoblast cells. Teeth that are given orthodontic strength and the said materials containing polyphenols, these polyphenols will stimulate the differentiation and proliferation of active osteoblast-progenitors, and bone apposition by activating macrophages which release the cytokine TGF 1. In addition, Receptor Activator of Nuclear Kappa Ligand (RANKL) will bind to the Receptor Activator of Nuclear Factor Kappa (RANK) to stimulate differentiation and activation of osteoclasts. Osteoprotegerin (OPG) is a membrane that surrounds and secretes a protein attached to RANKL to inhibit its role on the RANKL receptor. Bone resorption occurs due to the activity of osteoclasts, which are hematopoietic stem cells (HSCs) derived bone cells, also known as monocytes.[8]

EFFECTS OF COCOA POD HUSK EXTRACT (THEOBROMA CACAO L.) ON ALVEOLAR BONE:

Periodontitis is a destructive inflammatory disease of the periodontal tissues with a high prevalence in the world. *Phorphyromonas gingivalis* as one of the main bacteria causing periodontitis produces virulence factors that trigger immune cells to produce proinflammatory cytokines that can reduce the number of osteoblasts, thereby triggering alveolar bone resorption. Osteoblast cell differentiation is mediated by a number of growth factors such as cytokines and bone morphogenic proteins (BMPs). SRP mechanical therapy is sometimes not optimal and Metronidazole as an effective antibiotic against periodontitis has been reported to have several adverse effects. Utilization of cocoa pod waste (*Theobroma cacao* L) with its polyphenol content has antibacterial, antioxidant and anti-inflammatory effects.

A study was conducted to determine the effect of ethanol extract gel from cocoa pod husk extract (*Theobroma cacao* L.) on the number of osteoblasts and osteoclasts, as well as the expression of BMP-2 in the alveolar bone of periodontitis-model rats. This laboratory experimental study used 24 rats which were divided into negative control group (CMC-Na gel), positive control group (metronidazole gel), and treatment group (100 mg/mL cocoa pod husk extract gel).[9] 24 Wistar rats were divided into 3 groups which were observed on day 7 with haematoxylin eosin staining and BMP-2 expression by immunohistochemistry staining. One-way ANOVA test showed that there was a significant difference ($p < 0.05$) between groups. The LSD test average of BMP-2 expression in the treatment group on the day 7 and day 14 was higher than the negative control group ($p < 0.05$). The conclusion of the study was that giving 100 mg/mL of cacao pod husk extract gel (*Theobroma cacao* L.) increased the number of osteoblasts and increased the expression of BMP-2 in the alveolar bone of periodontitis rats.[8]



HIGHLIGHTS:

- Cocoa pod husk extract gel (*Theobroma cacao*) 100 mg/mL increased the ratio of osteoblasts to osteoclasts and increased BMP-2 expression in the alveolar bone of periodontitis rats.
- The histological staining with IHC was analysed using Quantitative Pathology 0.3.2 software
- The cocoa pod husk (Theobroma Cacao L.) extract gel effectively triggers and increased BMP-2 which stimulates bone formation in periodontitis rat models.

CONCLUSION:

Osteogenic effects of chocolate vary depending on the type of chocolate. Adolescents consuming chocolate had greater longitudinal bone growth. Postmenopausal women had no bone effects at moderate chocolate intakes. Daily chocolate intake in postmenopausal women reduced bone density. Cocoa powder and dark chocolate flavanols and minerals may help preserve bone health.

FINANCIAL SUPPORT AND SPONSORSHIP
Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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