Superfoods for Osteoporosis Prevention

Kyle Salmon

Syracuse University

Abstract

 Osteoporosis is a major public health concern that affects many individuals worldwide. Nutrition plays a major role in osteoporosis prevention. There are certain foods for bone health that have particular components that prevent bone loss from occurring and activate building of new bone. These foods, known as superfoods, can be incorporated into the diet in order to prevent osteoporosis from occurring. This paper will discuss three of the major superfoods for bone health, detailing the bone active component of each food, the role this foods plays on the building of bone and/or the prevention of bone breakdown, the quantity of food needed for improvement, and how to incorporate these foods into the everyday diet.

Table of contents

Introduction………………………………………………………………………………….Page 5

Superfoods for osteoporosis prevention …………………………………………………….Page 6

What are superfoods………..……………………………………………..................Page 6

Role of diet on bone health ……………………………………………....................Page 6

Fermented dairy ………....……………………………………………………….....Page 7

 Bioactive components……………………………………………………….Page 7

 Role in bone health………………………………………………….……….Page 8

 Quantity needed………………………………………………..……...…….Page 8

 Incorporating into the diet…………………………………………....…..….Page 9

Dried plums …………………………………...………………..………..………….Page 9

 Bioactive components………………………………………..…..………….Page 9

 Role in bone health……………………………………………..………...….Page 9

 Quantity needed………………………………………………...………….Page 10

 Incorporating into the diet…………………………………..…..………….Page 11

Tomatoes ………………………………………………………………..................Page 11

 Bioactive components…………………………………………..………….Page 11

 Role in bone health…………………………………………..…….……….Page 12

 Quantity needed………………………………………………..….……….Page 13

 Incorporating into the diet………………………………………………….Page 13

Health Belief Model……………………………………………………………..................Page 13

Recommendations…………………...…………………………………………..................Page 15

Conclusion………………………………………………………………………………….Page 16

References………………………………………………………………………….............Page 17

**Introduction**

 Osteoporosis is a metabolic bone disease characterized by low bone density and deterioration of bone tissue (American Academy of Orthopedic Surgeons, 2014). Osteoporosis occurs when the body breaks down bone faster than it can form new bone (National Osteoporosis Foundation, n.d.). As a result, bones become weak and individuals are increasingly susceptible to fractures (National Osteoporosis Foundation, n.d.). Osteoporosis presents a significant health concern in the United States and across the world. It is estimated that in the United States alone, 10.2 million individuals have osteoporosis and 18 million individuals are at risk for developing osteoporosis (American Academy of Orthopedic Surgeons, 2014). Worldwide, roughly 200 million individuals have osteoporosis (American Academy of Orthopedic Surgeons, 2014).

 Fracturing and breaking of bones is a serious and common complication of osteoporosis. Annually, osteoporosis is responsible for two million broken bones (National Osteoporosis Foundation, n.d.). Approximately one in two women and up to one in four men age 50 and older will break a bone due to osteoporosis (National Osteoporosis Foundation, n.d.). Osteoporotic bone breaks are most common to occur in the hip, spine, or wrist, however breaks in other locations can occur as well (National Osteoporosis Foundation, n.d.). In hip fractures alone, 20% of cases are fatal and in 50% of cases permanent disability occurs (Health Knowledge, 2006). Not only does osteoporosis pose significant increases in morbidity and mortality, but the costs associated with osteoporosis are astronomical. Osteoporosis is responsible for $19 billion in related cost every single year and is continuing to rise (National Osteoporosis Foundation, n.d.).

 Due to related morbidity, mortality, cost, and decreased quality of life, osteoporosis is a significant public health concern. It is essential to prioritize osteoporosis prevention in order to reduce these complications from continuing to occur. This paper will discuss three of the major superfoods for bone health, detailing the bone active component of each food, the role this foods plays on the building of bone and/or the prevention of bone breakdown, the quantity of food needed for improvement, and how to incorporate these foods into the everyday diet.

**Superfoods for osteoporosis prevention**

**What are ‘superfoods’?**

 Superfoods for osteoporosis prevention are specific foods that either stimulate new bone formation and/or reduce bone breakdown. These foods typically have anti-inflammatory components, are highly antioxidant, and contain high vitamin and mineral contents (Brown et al., 2000).

**Role of diet on bone health**

 Nutrition is one of the most important lifestyle factors that can aid in preventing osteoporosis. A nutritious diet provides adequate calories, proteins, lipids, carbohydrates, vitamins, and minerals that are essential to the body in order to properly build strong and healthy bones (Brown et al., 2000). Without adequate intake of these nutrients, the body is not able to effectively build bone and the risk for bone loss and osteoporosis significantly increases (Brown et al., 2000).

 At the most basic level, bone health maintenance depends on a balance between the forces of bone formation and bone breakdown (Brown et al., 2000). Osteoblast cells are responsible for building new bones and osteoclast are responsible for the recycling and breakdown of old bone tissue (Brown et al., 2000). It is the balance between these two forces that determines if one is going to lose bone or if one is going to build bone, or at least maintain bone mass (Brown et al., 2000).

**Fermented dairy**

 For decades, milk has been held to be an excellent food source to enhance bone health (Brown et al., 2000). As children, we were all told to drink our milk in order to build our bones. However, modern science tells us that although calcium provided through milk can be beneficial to bone, milk is not the solution to the osteoporosis crisis (Brown et al., 2000). In fact, a recent Norwegian study examining the association between milk drinking and hip fracture found no association between milk intake and risk of hip fracture in Norwegian men and women (Holvik et al., 2019). Additionally, an international meta-analysis examining milk intake and fracture risk among men and women found that low intake of milk is not associated with any marked increase in fracture risk (Kanis et al., 2005). One Swedish cohort study assessing milk intake and fractures in women and men even found that high milk intake was associated with higher fracture incidence in women (Michaëlsson et al., 2014).

*Major bioactive component*

 Although milk may not be a superfood for bone health, fermented dairy is. Fermented dairy includes products like yogurt, aged cheese, kefir, sour cream, and buttermilk. While fermented milk and ordinary milk both contain high calcium, protein, phosphorous, and energy through calories, fermented milk offers additional benefits that go beyond ordinary milk (Brown et al., 2000). Fermented dairy offers a rich source of favorable bacteria, known as probiotics (Brown et al., 2000). These probiotics found in fermented dairy are the bioactive component that makes it a superfood.

*Role in bone health*

 When probiotics are ingested through fermented dairy, they serve to enhance the human micro flora and have been documented to promote bone health. For example, results from a systematic review examining fermented milk products and bone health in postmenopausal women suggest that higher yogurt consumption was associated with a reduced risk of hip fracture (Ong et al., 2019). Additionally, a longitudinal analysis of bone microstructure in postmenopausal women of the Geneva Retirees Cohort found that age-related cortical bone loss decreased at non-bearing bone sites in fermented dairy product consumers, but not in unfermented dairy consumers (Biver et al., 2018). The probiotics found in fermented dairy modify the gut microbiota, which decreases compounds that stimulate bone breakdown, therefore decreasing bone resorption (Rizzoli et al., 2018). Modifying the gut microbiota also increase bone formation by modifying gut serotonin (Rizzoli et al., 2018). These components, in combination with the calcium, phosphorous, and protein found in fermented dairy, make fermented dairy an osteoporosis superfood. The protein component of fermented dairy increases bone formation. Additionally, the calcium found in fermented dairy increases calcium absorption, which increases bone mineralization and decreases bone resorption (Rizzoli et al., 2018).

*Quantity needed*

 A large cohort study of 4,310 Irish adults examined the association of yogurt intake with bone mineral density, bone biomarkers, and physical function. The study found that 114g of yogurt (~1/2 cup) was associated with increased BMD and physical function scores (Laird et al., 2017). Specifically, each unit increase in yogurt intake in females was associated with a 31% lower risk of osteopenia and a 39% lower risk for osteoporosis, and in males a 52% lower risk of osteoporosis (Laird et al., 2017). Additionally, a Swedish cohort study examined how fermented milk combined with fruit and vegetable consumption is associated with hip fracture among 21,750 older women. The study found a 29% reduced risk of hip fracture among those who reported higher consumption of yogurt (≥400 mL/day or ≥~1.7 cups/day) than those who were nonconsumers (Michaelsson et al., 2018). Therefore, consuming at least 1.7 cups of yogurt/day would be recommended in order to reduce the risk of fracture and increase BMD.

*Incorporating into the diet*

 There are many ways to incorporate yogurt into ones diet. Adding yogurt to a smoothie is a very easy way to incorporate yogurt. Also, making a yogurt parfait with fruit and granola is a delicious and healthy way to incorporate yogurt.

**Dried plums**

*Major bioactive component*

 Dried plums, or prunes, are another superfood for osteoporosis prevention. Dried plums contain several bioactive compounds contributing to bone health such as vitamins, minerals, dietary fiber, and polyphenolic compounds (Arjmandi et l., 2017). While the exact mechanism behind the effects dried plums exert is unknown, many of these compounds are known to exert bone-protective effects and therefore likely work together to produce these effects (Arjmandi et l., 2017).

*Role in bone health*

 Dried plums are rich in vitamin K, which promotes calcium balance and promotes bone mineralization (Arjmandi et l., 2017). An important mineral of dried plums is boron, which stimulates bone growth and bone metabolism and plays an important role in preserving BMD (Arjmandi et l., 2017). They are also rich in potassium, which reduces bone resorption (Arjmandi et l., 2017). Dried plums are rich in soluble and insoluble fibers, which are known to increase bone mineralization (Arjmandi et l., 2017). Dried plums are also rich in polyphenolic compounds with antioxidant properties, such as neochlorgenic acid and chlorogenic acid, which help to protect bones from oxidative damage (Arjmandi et l., 2017; Berkeley Wellness, 2016; Shen et al., 2012). Additionally, dried plums are ranked to have the highest antioxidant value among commonly consumed fruits (McBride et a., 1999), which help to prevent oxidative damage and scavenge free radicals (Garrett et al., 1990).

 Dried plums have been shown to directly suppress bone resorption activity and enhance bone formation activity (Shen et al., 2012). The first clinical trial evaluated the bone-protective properties of dried plums among 58 postmenopausal women (Arjmandi et al., 2002). This three month clinical trial evaluated the effectiveness of dried plums versus dried apples on the biomarkers of bone formation (Arjmandi et al., 2002). The study found that dried plums significantly increased the markers of bone formation, therefore preventing and reversing bone loss through enhanced bone formation (Arjmandi et al., 2002). Additional studies have found that dried plums significantly increased bone mineral density (Hooshamnd et al., 2011) and prevented loss of total bone mineral density (Hooshamnd et al., 2016), while significantly decreasing levels of bone turnover markers (Hooshamnd et al., 2011) and inhibiting bone resorption (Hooshamnd et al., 2016).

*Quantity needed*

 When incorporating dried plums into the diet, just 50g of dried plums /day (or about 6 dried plums /day) is a sufficient quantity in order to prevent bone loss. A previous research study examined the extent to which dried plums reversed bone loss among osteopenic postmenopausal women. 160 osteopenic postmenopausal women were randomly assigned to either consume 100g/day of dried plums or 100g/day of dried apples (the control group). The study found that eating 100g (~10-12 dried plums) per day for one year was associated with increased bone mineral density and improved indicators of bone turnover (Hooshamnd et al., 2011). A recent similar study examined the dose-dependent effect of dried plums in preventing bone loss among osteopenic postmenopausal women. 48 women were randomly assigned to either 50g/day of dried plums, 100g/day of dried plums, or a control group, for a six-month period. The study found that women who consumed 50g/day of dried plums (~6 dried plums) for six months were just as effective in preventing bone loss as consuming 100g/day of dried plums (~10-12 dried plums) for six months (Hooshamnd et al., 2016). Therefore concluding that 50g/day of dried plums is an effective dosage for preventing bone loss.

*Incorporating into the diet*

 One of the easiest ways to incorporate dried plums into the diet is to puree them and use them as a spread or to add into a smoothie. This is an effective and enjoyable way to incorporate the effective dose into the daily diet.

**Tomatoes**

*Major bioactive component*

 Tomatoes are one of the most beneficial foods for bone health. The compound that gives tomatoes their red pigment is known as lycopene (Bhowmik et al., 2012). Lycopene, a carotenoid phytonutrient, is a powerful antioxidant found naturally in tomatoes and other red and orange colored fruits and vegetables (Rao et al., 2003). Lycopene’s antioxidant property is the bioactive component that gives tomatoes their name as a superfood. Tomatoes are also high in many vitamins (Vitamin A, Vitamin C, and Vitamin K) and minerals that aid in its superfood effect (Bhowmik et al., 2012).

*Role in bone health*

 The powerful antioxidant properties of lycopene neutralize free radicals that can damage cells in the body (Bhowmik et al., 2012) and protect against oxidative stress (Shen et al., 2012). Excessive oxidative stress stimulates bone breakdown and reduces new bone formation, leading to the development of osteoporosis and bone weakness (Domazetovic et al., 2017; Yang et al., 2014; Cervellati et al., 2014). Lycopene has been shown to have the strongest ability to reduce singlet oxygen (Rao et al., 2007; Di Mascio et al., 1989), which reduces oxidization to the body and allows antioxidants to form (Devasagayam et al., 2002). Many foods contain some lycopene, however tomatoes contain the highest source of dietary lycopene (Bhowmik et al., 2012). More than 80% of total dietary lycopene we consumed comes from tomato and tomato products (Sahni et al., 2009).

 The vitamin A and Vitamin C found in tomatoes work as antioxidants to neutralize harmful free radicals in the blood, reducing cell damage (Bhowmik et al., 2012). Tomatoes contain Vitamin K and calcium, which strengthen bone and help repairs bone tissue (Bhowmik et al., 2012). Tomatoes also contain other protective compounds, providing antithrombotic and anti-inflammatory effects (Bhowmik et al., 2012).

 Lycopene has been shown to play a protective role against a number of chronic diseases, including osteoporosis (Rao et al., 2003). Many epidemiological studies among various adult populations have shown a positive relationship between the intake levels or serum levels of lycopene and bone mass, bone turnover and/or fracture risk (Sahni et al., 2009; Rao et al., 2007; Wattanapenpaiboon et al., 2003; Yang et al., 2008). Additionally, a 17-year follow-up study of elderly white men and women found a protective association between carotenoid intake (including lycopene) and risk of hip fracture and nonvertebral osteoporotic fractures (Sahni et al., 2009). Therefore, suggesting a protective role of lycopene and carotenoids for bone health in older adults (Sahni et al., 2009).

*Quantity needed*

 A Canadian study found that among postmenopausal women, supplying at least 30 mg/day of lycopene decreased oxidative stress and bone resorption, which may therefore decrease the risk of osteoporosis (MacKinnon et al., 2011). Therefore concluding that consuming 30 mg/day or more of lycopene is a sufficient dose for improvement.

*Incorporating into the diet*

 When using tomatoes to enhance your lycopene intake, it is best to eat them in a concentrated form, such as in a sauce or a paste. Doing so allows for the highest amount of lycopene and other vitamins and minerals to be available. Using heat allows the bioavailability of lycopene to increase (Bhowmik et al., 2012), so cooking tomatoes would also be a good idea. Additionally, eating tomatoes along with healthier fats, like avocado or olive oil, has been shown to increase absorption of the carotenoid phytochemicals in tomatoes by up to 15 times (Kopec et al., 2014). So, adding olive oil to a tomato sauce for pasta or to a tomato soup would be a great option to obtain the bone health nutrients from tomatoes.

**Health Belief Model**

 Engaging in healthy dietary choices in order to prevent osteoporosis is best represented by the health belief model. The health belief model is a social psychological model developed to explain and predict healthy behaviors (Boston University School of Public Health, 2019). This conceptual framework revolves around examining individual’s beliefs about health conditions as an approach to avoid negative health consequences and therefore engaging in healthy behaviors (Boston University School of Public Health, 2019). This model examines individuals perceived susceptibility, severity, benefits, and barriers towards a certain illness, their self-efficacy, and their cue to action in order to determine the likelihood of engaging in a healthy behavior (Boston University School of Public Health, 2019). Regarding incorporating healthy foods to prevent osteoporosis, the individual evaluates all of the above concepts when determining to engage in this healthy behavior.

 The model suggest that if the individual beliefs the threat of an illness or disease is avoidable, the recommended healthy behavior will be effective, and they are capable of taking this action, they are more likely to adopt the behavior (Boston University School of Public Health, 2019). Regarding this topic, if an individual believes they have a high risk of developing osteoporosis and that developing osteoporosis will be a serious condition, they are more likely to adopt the recommendations of these superfoods in order to prevent developing osteoporosis. Also, if an individual believes that adopting these superfoods in their diet outweighs the obstacles or doing so and will be an effective action to take to avoid developing osteoporosis, they are more likely to adopt these recommendations into their everyday diet. In additional to these components, the individuals cue to action and self-efficacy are central to their decision in engaging in this healthy behavior. There is a stimulus needed to trigger the individual to accept this recommendation, such as developing osteopenia, which could very well lead to osteoporosis. Finally, the individual’s confidence in their ability to successfully incorporate these foods into their diet and make it sustainable, directly relates to whether they will engage in this healthy behavior.

**Recommendations**

 The prevalence of osteoporosis is a major public health issue. Research has proven the importance of nutrition on bone health and in the prevention of osteoporosis. Studies have shown the powerful impact nutritious foods can have on building bone and therefore preventing osteoporosis. While strides have been made in reducing the prevalence of osteoporosis and emphasizing the importance of osteoporosis prevention, there is still great room for improvement. It is necessary to target the population most at risk for developing osteoporosis in order to make great strides in preventing osteoporsis. Since postmenopausal women are at the highest risk for developing osteoporosis (Brown et al., 2000), it is necessary to educate them on their increased risk for osteoporosis, the importance of osteoporosis prevention, and the role of nutrition in preventing osteoporosis. Since doctors play a major role in where individuals receive their medical information, it is necessary implement educational training to primary care physicians on this information so that they can share this information with their patients. It is also necessary for the government and health insurers to focus on preventive measures to osteoporosis to attack the issue before it occurs, rather than on focusing on it when it is already an issue. Implementing policy initiatives regarding early detection of bone loss and screening of osteoporosis is necessary in order to prevent osteoporosis from occurring. Additionally, implementing nutritional programs incorporating these superfoods into assisted living facilities would enable populations who are at high risk for osteoporotic fractures with natural and healthy strategies to prevent fractures from occurring.

**Conclusion**

 Osteoporosis is a major public health concern that affects many individuals worldwide. While there are a variety of factors that contribute to the prevention of osteoporosis, nutrition is a central component. Specifically, incorporating the superfoods mentioned into the diet has the ability to prevent bone loss from occurring and/or to activate building of new bone, with the end result of preventing osteoporosis. Incorporating these foods into the diet is a natural and healthy approach to build bone and stay stronger longer.

References

American Academy of Orthopedic Surgeons. (2014). Osteoporosis/bone health in adults as a national public health priority. *American Academy of Orthopedic Surgeons.* Retrieved from https://www.aaos.org/uploadedFiles/PreProduction/About/Opinion\_Statements/position/1113%20Osteoporosis%20Bone%20Health%20in%20Adults%20as%20a%20National%20Public%20Health%20Priority.pdf

Arjmandi, B. H., Khalil, D. A., Lucas, E. A., Georgis, A., Stoecker, B. J., Hardin, C., … Wild, R. A. (2002). Dried plums improve indices of bone formation in postmenopausal women. *Journal of Women’s Health and Gender-Based Medicine*, *11*(1), 61–68. https://doi.org/10.1089/152460902753473471

Arjmandi, B. H., Johnson, S. A., Pourafshar, S., Navaei, N., George, K. S., Hooshmand, S., … Akhavan, N. S. (2017). Bone-protective effects of dried plum in postmenopausal women: Efficacy and possible mechanisms. *Nutrients*. MDPI AG. <https://doi.org/10.3390/nu9050496>

Berkeley Wellness. (2016). Prunes for stronger bones. *University of California Berkeley Wellness*. Retrieved from <https://www.berkeleywellness.com/healthy-eating/nutrition/article/prunes-stronger-bones>

Bhowmik, D., Kumar, K. P. S., Paswan, S., & Srivastava, S. (2012). Tomato-A Natural Medicine and Its Health Benefits. *Phytojournal*, *1*(1), 33–43.

Biver, E., Durosier-Izart, C., Merminod, F., Chevalley, T., van Rietbergen, B., Ferrari, S. L., & Rizzoli, R. (2018). Fermented dairy products consumption is associated with attenuated cortical bone loss independently of total calcium, protein, and energy intakes in healthy postmenopausal women. *Osteoporosis International*, *29*(8), 1771–1782. <https://doi.org/10.1007/s00198-018-4535-4>

Boileau, T. W. M., Boileau, A. C., & Erdman, J. W. (2002). Bioavailability of all-trans and cisisomers of lycopene. In *Experimental Biology and Medicine* (Vol. 227, pp. 914–919).

Boston University School of Public Health. (2019). Behavior change models: the health belief model. *Boston University School of Public Health.* Retrieved from http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories2.html

Brown, S., Jaffe, R. (2000). Better bones, better body: beyond estrogen and calcium. *Keats Publishing.* 2nd ed. ISBN 0-658-00289-9

Cervellati, C., Bonaccorsi, G., Cremonini, E., Romani, A., Fila, E., Castaldini, M. C., … Massari, L. (2014). Oxidative stress and bone resorption interplay as a possible trigger for postmenopausal osteoporosis. *BioMed Research International*, *2014*. https://doi.org/10.1155/2014/569563

Devasagayam, T. P. A., & Kamat, J. P. (2002). Biological significance of singlet oxygen. In *Indian Journal of Experimental Biology* (Vol. 40, pp. 680–692).

Di Mascio, P., Kaiser, S., & Sies, H. (1989). Lycopene as the most efficient biological carotenoid singlet oxygen quencher. *Archives of Biochemistry and Biophysics*, *274*(2), 532–538. https://doi.org/10.1016/0003-9861(89)90467-0

Domazetovic, V., Marcucci, G., Iantomasi, T., Brandi, M. L., & Vincenzini, M. T. (2017). Oxidative stress in bone remodeling: Role of antioxidants. *Clinical Cases in Mineral and Bone Metabolism*. CIC Edizioni Internazionali s.r.l. <https://doi.org/10.11138/ccmbm/2017.14.2.209>

Garrett, I. R., Boyce, B. F., Oreffo, R. O. C., Bonewald, L., Poser, J., & Mundy, G. R. (1990). Oxygen-derived free radicals stimulate osteoclastic bone resorption in rodent bone in vitro and in vivo. *Journal of Clinical Investigation*, *85*(3), 632–639. https://doi.org/10.1172/JCI114485

Holvik, K., Meyer, H. E., Laake, I., Feskanich, D., Omsland, T. K., & Sogaard, A. J. (2019). Milk drinking and risk of hip fracture: The Norwegian Epidemiologic Osteoporosis Studies (NOREPOS). *British Journal of Nutrition*, *121*(6), 709–718. <https://doi.org/10.1017/S0007114518003823>

Hooshmand, S., Chai, S. C., Saadat, R. L., Payton, M. E., Brummel-Smith, K., & Arjmandi, B. H. (2011). Comparative effects of dried plum and dried apple on bone in postmenopausal women. *British Journal of Nutrition*, *106*(6), 923–930. <https://doi.org/10.1017/S000711451100119X>

Hooshmand, S., Kern, M., Metti, D., Shamloufard, P., Chai, S. C., Johnson, S. A., … Arjmandi, B. H. (2016). The effect of two doses of dried plum on bone density and bone biomarkers in osteopenic postmenopausal women: a randomized, controlled trial. *Osteoporosis International*, *27*(7), 2271–2279. <https://doi.org/10.1007/s00198-016-3524-8>

Kanis, J. A., Johansson, H., Oden, A., De Laet, C., Johnell, O., Eisman, J. A., … Tenenhouse, A. (2005). A meta-analysis of milk intake and fracture risk: Low utility for case finding. *Osteoporosis International*, *16*(7), 799–804. <https://doi.org/10.1007/s00198-004-1755-6>

Kopec, R. E., Cooperstone, J. L., Schweiggert, R. M., Young, G. S., Harrison, E. H., Francis, D. M., … Schwartz, S. J. (2014). Avocado Consumption Enhances Human Postprandial Provitamin A Absorption and Conversion from a Novel High–β-Carotene Tomato Sauce and from Carrots. *The Journal of Nutrition*, *144*(8), 1158–1166. <https://doi.org/10.3945/jn.113.187674>

Laird, E., Molloy, A. M., McNulty, H., Ward, M., McCarroll, K., Hoey, L., … Casey, M. C. (2017). Greater yogurt consumption is associated with increased bone mineral density and physical function in older adults. *Osteoporosis International*, *28*(8), 2409–2419. <https://doi.org/10.1007/s00198-017-4049-5>

MacKinnon, E. S., Rao, A. V., Josse, R. G., & Rao, L. G. (2011). Supplementation with the antioxidant lycopene significantly decreases oxidative stress parameters and the bone resorption marker N-telopeptide of type i collagen in postmenopausal women. *Osteoporosis International*, *22*(4), 1091–1101. <https://doi.org/10.1007/s00198-010-1308-0>

McBride, J. (1999) Can foods forestall aging? *Agriculture Research*;47:14–7.

Michaëlsson, K., Wolk, A., Lemming, E. W., Melhus, H., & Byberg, L. (2018). Intake of Milk or Fermented Milk Combined With Fruit and Vegetable Consumption in Relation to Hip Fracture Rates: A Cohort Study of Swedish Women. *Journal of Bone and Mineral Research*, *33*(3), 449–457. https://doi.org/10.1002/jbmr.3324

Michaëlsson, K., Wolk, A., Langenskiöld, S., Basu, S., Lemming, E. W., Melhus, H., & Byberg, L. (2014). Milk intake and risk of mortality and fractures in women and men: Cohort studies. *BMJ (Online)*, *349*. <https://doi.org/10.1136/bmj.g6015>

National Osteoporosis Foundation. (n.d.) What is osteoporosis and what causes it? *National Osteoporosis Foundation.* Retrieved from https://www.nof.org/patients/what-is-osteoporosis/

Ong, A., Kang, K., Weiler, H., & Morin, S. (2019). Fermented Milk Products and Bone Health in Postmenopausal Women: A Systematic Review of Randomized Controlled Trials, Prospective Cohorts, and Case-Control Studies. Advances in Nutrition. nmz108, <https://doi.org/10.1093/advances/nmz108>

Rao, L. G., Guns, E., & Rao, A. V. (2003). Lycopene: Its role in human health and disease. *Agro Food Industry Hi-Tech*, *14*(4), 25–30.

Rao, A. V., & Rao, L. G. (2007). Carotenoids and human health. *Pharmacological Research*. https://doi.org/10.1016/j.phrs.2007.01.012

Rao, L. G., Mackinnon, E. S., Josse, R. G., Murray, T. M., Strauss, A., & Rao, A. V. (2007). Lycopene consumption decreases oxidative stress and bone resorption markers in postmenopausal women. *Osteoporosis International*, *18*(1), 109–115. https://doi.org/10.1007/s00198-006-0205-z

Rizzoli, R., & Biver, E. (2018). Effects of Fermented Milk Products on Bone. *Calcified Tissue International*. Springer New York LLC. <https://doi.org/10.1007/s00223-017-0317-9>

Sahni, S., Hannan, M. T., Blumberg, J., Cupples, L. A., Kiel, D. P., & Tucker, K. L. (2009). Inverse association of carotenoid intakes with 4-y change in bone mineral density in elderly men and women: The Framingham Osteoporosis Study. *American Journal of Clinical Nutrition*, *89*(1), 416–424. https://doi.org/10.3945/ajcn.2008.26388

Shen, C. L., von Bergen, V., Chyu, M. C., Jenkins, M. R., Mo, H., Chen, C. H., & Kwun, I. S. (2012). Fruits and dietary phytochemicals in bone protection. *Nutrition Research*. <https://doi.org/10.1016/j.nutres.2012.09.018>

Wattanapenpaiboon, N., Lukito, W., Wahlqvist, M. L., & Strauss, B. J. G. (2003). Dietary carotenoid intake as a predictor of bone mineral density. *Asia Pacific Journal of Clinical Nutrition*, *12*(4), 467–473.

Yang, Z., Zhang, Z., Penniston, K. L., Binkley, N., & Tanumihardjo, S. A. (2008). Serum carotenoid concentrations in postmenopausal women from the United States with and without osteoporosis. *International Journal for Vitamin and Nutrition Research*, *78*(3), 105–111. <https://doi.org/10.1024/0300-9831.78.3.105>

Yang, S., Feskanich, D., Willett, W. C., Eliassen, A. H., & Wu, T. (2014). Association between global biomarkers of oxidative stress and hip fracture in postmenopausal women: A prospective study. *Journal of Bone and Mineral Research*, *29*(12), 2577–2583. <https://doi.org/10.1002/jbmr.2302>