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Review Article

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Protective Effect of Corn Silk on Osteoporosis: A Review on its Mechanism and Recommendations

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Abstract

Osteoporosis is the low bone mineral density and continuous deterioration of bone tissue, which makes bones prone to fractures. It's caused by the imbalance in the bone remodeling processes, with increased activity of osteoclasts. Factors like being underweight, diabetes, obesity, genetics, physical activity, and alcohol consumption with dietary history affect osteoporosis's occurrence and severity. Hyperglycemia stimulates the production of reactive oxygen species (ROS) and advanced glycation end product (AGE) which increases oxidative stress and results in abnormal bone homeostasis. Corn silk extract is proven to repair the injured β-cells, increase insulin levels, and give a hypoglycemic effect. Obesity can cause an increase in inflammatory cytokines which activate osteoclasts, deterioration of osteoblasts, a mutation in fat mass and obesity associated (FTO) gene and an increase in the formation of fat cells in the bone marrow. Corn silk contains maysin which has an anti-adipogenic agent that can reduce lipid accumulation in the cell and decrease the rate of adipocyte differentiation and lipogenesis. Postmenopausal osteoporosis is caused by decreased estrogen production and ageing. Some of the flavonoids present in corn silk are found to act as phytoestrogens and can mimic the action of estrogen in the post-menopausal period, reducing the activity of osteoclasts. The severity of inflammation in the gut and malabsorption in the intestine can result in a deficiency of vitamin D and calcium, leading to negative effects on bone health. Corn silk contains magnesium, which helps to regulate the body's anti-inflammatory response. Additionally, its crude ethanolic extract shows a TNF (Tumor necrosis factor) antagonistic activity which helps stop inflammation. This current review focuses on different mechanisms through which corn silk can be used for the management of osteoporosis.

Keywords

Corn silk, Osteoporosis, Bone tissue

Introduction

Osteoporosis is characterized as a skeletal disease. The significant symptoms are loss of bone mass and micro architectural deterioration of bone tissue, which increases the risk of fractures as the bone becomes fragile. The disease is a global burden with osteoporosis-related fractures costing approximately $17.9 and £4 billion every year in the USA and UK, respectively [1]. It's estimated that more than 200 million people are suffering from the disease globally [2]. Common sites of fragility fracture are vertebral bodies, hip, distal radius, proximal humerus, and pelvis. The ageing of the UK population is estimated to increase the fragility of fractures to 19.6% by 2030 [3]. People living with osteoporosis are estimated to be 125 million across Europe, Japan, the USA and India [4]. Decreased body height, fractures in bones, and impairment of the respiration system with

dowager's hump are some of the clinical symptoms of old age osteoporosis [5].

Bone contains two main highly differentiated cells: Osteoblasts and osteoclasts. Osteoblasts account for 4-6% of bone-residing cells and help in bone formation while osteoclasts account for 95% of bone cells and are responsible for bone resorption [6]. The balance between bone resorption and the formation of bone matrix maintains the homeostasis of the bone. Osteoporosis is understood as the disruption in the balance and resorption will be faster than the formation of bone. World Health Organization defines osteoporosis by BMD (Bone mass density) 2.5 standard deviation or more below the average (T-score ≤ 2.5) for young healthy women [7]. The bone remodeling process is regulated by glucocorticoids, calcitonin, vitamin D3, parathyroid hormone, estrogen, thyroid hormone, and growth hormones [8]. Osteoporosis can be diagnosed by measuring BMD through dual-energy X-ray absorptiometry and using ultrasound imaging to measure the speed of sound in the tibia [5].

Osteoporosis can be caused by various factors which are categorized as modifiable and non-modifiable. Modifiable factors are weight, smoking, physical inactivity, calcium deficiency in the diet, and use of glucocorticoids while non-modifiable include race, age, genetics, gender, etc. [5]. The condition occurs in both men and women. The decrease in estrogen during the transition to menopause causes less bone formation than resorption, which results in osteoporosis. Additionally, postmenopausal women with diminished progesterone levels have a decline in bone density of the spine as progesterone exhibits a bone-forming effect via adhering to receptors present on osteoblasts [9]. Men generally suffer from secondary osteoporosis. It can be caused due to several diseases and other risk factors like alcoholism, hypogonadism, low body mass index (BMI), gastrointestinal disorders, hyperthyroidism, neuromuscular disorders and post-transplant syndrome [10]. Insufficient calcium intake primarily affects bone health, particularly in relation to fractures, osteoporosis and osteopenia in older people and rickets in children. Low calcium intake or absorption leads to bone resorption as the calcium stored in bones is used up to sustain regular biological activities [11]. Inadequate calcium levels lead to elevated PTH secretion which causes bone resorption, followed by low BMD and a greater risk of osteoporosis [12].

Corn silk has been used as a traditional medicine in different parts of the world. The silk is produced by female flowers and captures pollen for pollination. It is harvested just before pollination for medicinal purposes and can be used in both fresh and dried forms [13, 14]. A significant part of the world, especially Native Americans and Chinese consumes corn silk as traditional medicine as it acts as a diuretic agent to help pass stones and gravel in the kidneys and urinary bladder. It is also used to treat cystitis, oedema, gout, rheumatoid, and arthritis and is an antimicrobial agent. Additionally, corn silk can reduce hyperglycemia, and is an anti-depressant, and anti-fatigue compound [15]. As explained in table 1, corn silk has the potential to protect bones against osteoporosis through various mechanisms. This current review focuses on different mechanisms through which corn silk can be used for the management of osteoporosis.

Nutritional and phytochemical composition of corn silk

Zea mays is known as corn worldwide, as Milho, Yu mai, and Makai in Asian countries, as Mahiz in France, Mealie in South Africa, and called Makka, Bhutta, Mako, Makkejola, etc., in India [24]. Corn grows in two major phases: vegetative and reproductive stages. While the vegetative stage involves six steps, starting from seedling emergence to tasseling, the reproductive phase refers to silking, blistering, milk, dough, and dent stages. The final stage is completed with physiological maturity [25]. A long, silky, and yellowish hair-like structure covers the edible part of the corn and is called corn silk. It is scientifically known as [26].

Table 2 shows that corn silk has (9.65–10.4%) moisture, (9.42–17.6%) protein, (0.29–4.74%) fat, (1.2–3.91%) ash, (7.34%) dietary fiber, and (65.5–74.3%) carbohydrates, and contains a good number of vitamins and minerals as sodium, potassium, calcium, magnesium, iron, zinc, manganese, and copper. When processed, it holds significant crude fiber (13%), crude protein (13%), and carbohydrates (69%) [26]. Also, corn silk contains (0.1-6.3%) flavonoids, (3%) saponins, and (0.2%) volatile oil. Corn silk can increase the elimination of water from tissues, suitable for heart diseases and obesity conditions [27]. While corn silk doesn't exhibit any antibacterial activity, it's claimed to treat cystitis, edema, kidney stones, diuretics, prostate disorder, and urinary infections along with bedwetting and obesity [13]. Corn silk is also found to reduce and stimulate bile flow and have an inhibitory effect on the formation of IgE by glycoproteins, reduces hyperglycemia, promotes neuroprotective effects against oxidative stress, antitumor effect, and anti-fatigue activity by inhibiting the production of blood lactic acid. It can be used in healthcare for its chemical composition and mechanism of action of its bioactive substances like phenolics, terpenoids, polysaccharides and glycoproteins [28].

Protective effect of corn silk on osteoporosis

Corn silk has different properties which can promote bone health. The risk factors of osteoporosis include diabetes, obesity, epilepsy, hypertension, hyperthyroidism, inflammation, reproductive disorders, oxidative stress etc. Corn silk exhibits anti-diabetic properties as it contains flavonoids, crude polysaccharides and aqueous extract which has been proven to repair the injured β-cells, increase insulin levels and give a hypoglycemic effect. The maysin compound present in corn silk has an anti-adipogenic effect leading to a reduction in lipid accumulation in the cell and a decrease in the rate of adipocyte differentiation and lipogenesis. Stigmasterol, formononetin, quercetin, β-sitosterol, and catechin found in corn silk decrease the risk of osteoporosis, especially in the postmenopausal phase. Corn silk methanolic extract is found to revert the hyperthyroid condition. Magnesium helps regulate the body's anti-inflammatory response. Corn silk crude ethanolic extract shows a TNF antagonistic activity which helps stop inflammation. Corn silk extract also inhibits ACE (Angiotensin-converting enzyme) and exhibits anti-hypertensive activity. Corn silk also contains vitamins E and K which have antioxidant potential and protect the body against oxidative stress. As shown in figure 1, corn silk hinders the potential

Table 1: Causes of osteoporosis and protective effect of corn silk.

Causes	Mechanism of action	Ref.	Protective effect of corn silk
Epilepsy	Antiepileptic drugs affect the cytochrome P450 enzyme system in the liver, further affecting calcium and vitamin D metabolism leading to bone loss.	[16]	CS extract rich in phenolic compounds and flavonoids exhibits potential antioxidant roles and modulates the GABAA-Cl-channel complex in the CNS, producing an anticonvulsant effect.
Premature ovarian insufficiency	Estrogen deficiency leads to elevated bone resorption along with failure to achieve peak bone mass.	[17]	Formononetin, luteolin, stigmasterol, and β-sitosterol are flavonoids in corn silk and can reduce bone resorption.
Diabetes mellitus (type I and type II)	Anabolic hormones, low IGF-1 levels and insulin deficiency affect the peak bone mass achievement along with hyperglycemia and AGE accumulation, affecting osteoblast activity.		Corn silk contains quercetin which reduces hyperglycemia condition. Also, corn silk hexane extract can reduce blood glucose levels by association with thymol and mannitol present in corn silk.
Male hypogonadism	Hypogonadism leads to elevated bone remodeling loss due to lower levels of hormones like testosterone and estrogen.	[18]	Quercetin in corn silk reduces the risk of osteoporosis induced by testosterone deficiency by regulating glucose metabolism and inhibiting lipid metabolism. Also, corn silk extracts decrease lipid peroxidation and recover sex hormones and sperm count to normal conditions.
Hyperthyroidism	Thyroid hormone has a direct impact on osteoclast function, thus promoting bone resorption.	[19]	Methanolic extract of corn silk can revert hyperthyroid condition.
Obesity	An increase in inflammatory cytokines activate osteoclasts, deterioration of osteoblasts, a mutation in fat mass and obesity-associated (FTO) gene and an increase in the formation of fat cells in bone marrow.	[20]	Corn silk contains maysin, an anti-adipogenic agent that can reduce lipid accumulation in the cell and decrease the rate of adipocyte differentiation and lipogenesis. Maysin is also found to enhance β-oxidation, resulting in lipolysis.
Inflammation	Severe inflammation in the gut and malabsorption in the intestine can result in a deficiency of vitamin D and calcium in patients, leading to negative effects on bone health.	[21]	Corn silk contains magnesium, which helps regulate the body's anti-inflammatory response. Additionally, its crude ethanolic extract shows a TNF antagonistic activity which helps stop inflammation.
Hypertension	The condition elevates cytokines, sympathetic outflow, angiotensin II, oxidative stress and vascular disease which affects the bone remodeling process negatively and contributes to osteoporosis.	[22]	Corn silk has CSBp5, an ACE inhibitory phytopeptide that decreases Systolic blood pressure levels, therefore acting as an anti-hypertensive effect.
Oxidative stress	Osteoporosis occurs due to oxidative stress as it promotes the resorption of osteoclasts and loss of bone through increased apoptosis of osteocytes.	[23]	Corn silk n-butanol fraction exhibits the most potent anti-oxidant properties. Also, corn silk also contains vitamins E and K which exhibit antioxidant potential and protect the body against oxidative stress. The flavonoid catechin in corn silk can scavenge ROS and chelate metal ions and give an anti-oxidant effect.

causes of osteoporosis and gives a protective effect on bones.

Anti-diabetic

According to studies, osteoporosis can occur in diabetic patients as a complication. Hyperglycemia stimulates the production of ROS and AGE which increases oxidative stress and results in abnormal bone homeostasis. It's found that AGE inhibits the action of osteoblasts and promotes osteoclasts' activity. Type-1 diabetes causes low bone mineral density and increases the risk of fracture. Type-2 diabetes is also found to decrease bone quality [4]. Recent studies also found that type-2 diabetes patients have a lower BMD which leads to an increased risk of fracture, mainly in vertebral fractures and hip [29]. It's reported that ethyl acetate and n-butanol fractions of corn silk exhibit inhibitory activities against α-amylase, α-glu-

Table 2: Nutritional and phytochemical composition of corn silk.

Variety	Moisture (%)	Lipid (%)	Protein (%)	Dietary/Crude fiber (%)	Carbohydrate (%)	Mineral content	Phytochemicals	Ref.
Corn silk	9.65–10.4%	0.29–4.74%	9.42–17.6%	7.34%	65.5–74.3%	Na, K, Ca, Mg, Fe. Zn, Mn and Cu	Polyphenols (like tannins, alkaloids, saponins, steroids, glycosides, resins), Flavonoids (luteolin, flavones, isoflavones, apigenin, maysin, quercetin), Sterols (Phytosterols like stigmasterol, beta-sitosterol)	[25, 26]
Processed corn silk	–	–	Crude protein-13%	Crude fiber-13%	69%	–		
Immature corn silk	89.13%	1.27%	12.96%	48.50%	27.80%	Ca, Mg, Cu and Zn		
Mature corn silk	84.40%	0.66%	8.95%	41.25 g	29.40%	Na, K, Fe and Mn		
Sweet corn silk	7.89 g	0.55 g	15.29 g	–	56.16 g	Na, Mg, K, Ca, Cu, Fe and Mn		
Purple corn silk	72.20%	3.50%	13%	67.9% hemicelluloses 31.4% cellulose 0.7% lignin	41%	Mg, P and K, Vitamin A, D, E and K		

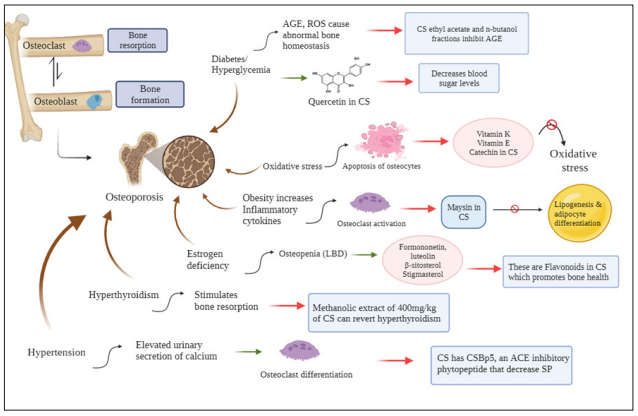

Figure 1: Osteoporosis and mechanism of action of corn silk.

cosidase, and AGEs [30]. Even though corn silk is considered agricultural waste, it's been used as diabetes therapy for decades in the Chinese population [14].

The antidiabetic activity of corn silk flavonoids, crude polysaccharides and aqueous extract is studied in various experiments. Corn silk extract can repair the injured β-cells, increase insulin levels, and give a hypoglycemic effect. In alloxan-induced diabetic mice, corn silk flavonoids decreased the rate of weight loss and reduced the blood glucose level of diabetic mice [31]. Diabetes is a chronic disease that can be controlled by the hypoglycemic response of corn silk. corn silk extracts are suggested to increase insulin levels as well as potentially recover injured beta cells. Particularly, corn silk hexane extract can reduce blood glucose levels by association with thymol and mannitol present in corn silk. The presence of phytochemical components in corn silk-like flavonoids, phenolics, terpenoids, tannins, sterols, and alkaloids exhibit hypoglycemic activity and a mechanism for lowering blood glucose levels [32]. Additionally, corn silk contains quercetin which reduces hyperglycemia condition [33]. The recent research conducted on corn silk ethanol extract also revealed that it can decrease blood glucose levels [34]. A study concluded that 4-week corn silk extract treatment reduced Fasting blood glucose and increased the glucose tolerance in the body, improved IR (Insulin resistance) indicated by decreased HOMA-IR (Homeostatic Model Assessment of insulin resistance) and elevated insulin sensitivity index [35].

Anti-obesity

Individuals with low BMI are at greater risk for fragility fractures and lower BMD, with a BMI less than 20 kg/m^2 being the most harmful. On the other hand, obesity can serve as a protective barrier to protect from bone loss but the disease can increase the risk of fracture at certain skeletal locations like the upper leg, ankle and proximal humerus [36]. Osteoporosis occurrences are found to be less in obese women compared to normal or overweight women [37]. Obesity can increase the risk of fractures in some sites while decreasing the risk in others. The condition can harm the bones by several mechanisms which include: an increase in inflammatory cytokines that activate osteoclasts, deterioration of osteoblasts, mutation in fat mass and obesity-associated (FTO) gene and increase in the formation of fat cells in bone marrow [20]. Corn silk contains maysin which has the potential antiobesity effect. It has been proven that pure maysin is an anti-adipogenic agent that can reduce lipid accumulation in the cell and decrease the rate of adipocyte differentiation and lipogenesis. Maysin is also found to enhance β-oxidation, resulting in lipolysis [38]. Purple corn-silk is rich in polyphenolic components and is investigated for its anti-obesity potential. At high concen-

trations, purple corn silk inhibits adipocyte proliferation and also induces lipolysis and apoptosis [39]. Research focusing on corn silk extract containing maysin also revealed that maysin inhibits gene expression of processes like fat synthesis, adipocyte differentiation, and fat accumulation and promotes the gene expression of lipolysis and fat oxidation [40].

Flavonoids

In women, osteoporosis is first caused by estrogen deficiency in the menopausal phase. Postmenopausal osteoporosis is caused by decreased estrogen production and ageing. In the first 15 years after menopause, 75% of bone loss occurs due to estrogen deficiency rather than ageing [41]. The menopausal period for women is 45-51 years old and is confirmed when women complete 12 menstrual cycles without any menstrual bleeding. Estrogen deficiency is high in the post-menopausal phase and can develop osteopenia (low bone density) which can result in osteoporosis eventually [42]. Corn silk contains stigmasterol which acts as a phytoestrogen and reduces bone resorption. Studies found that ethanol extract of corn silk produces a positive effect on bone density and helps prevent postmenopausal osteoporosis [43]. Dietary intake of soy and isoflavones is also associated with good bone mineral density (BMD) and a low occurrence rate of osteoporosis [44]. Formononetin, a flavonoid found in corn silk promotes the formation of osteoblasts and protects against menopausal bone loss. In research based on ovariectomized rats, it was proven that treatment with formononetin restores the disoriented trabecular microarchitecture in the limbs and induces the formation of new bone cells [45].

Luteolin, catechin and quercetin are present in corn silk [26]. In a study done on rats, luteolin was found to have the potential to decrease bone loss and the suggested mechanism behind it was its ability to promote osteogenic differentiation of bone marrow mesenchymal stem cells [46]. A deficiency of testosterone in men can lead to a decline in BMD. Quercetin reduces the risk of osteoporosis induced by testosterone deficiency by regulating glucose metabolism and inhibiting lipid metabolism [33]. Glucocorticoids can result in suppressed bone formation by altering the activity of osteoblasts, promoting osteoclast production and inducing apoptosis of both osteocytes and osteoblasts. 30-40% of patients taking long-term glucocorticoid therapy experience non-vertebral and vertebral fractures. This effect seems to be dose-dependent [47]. Glucocorticoid-induced osteoporosis can be inhibited with luteolin as the flavonoid increases the level of glutathione and superoxide dismutase activity and lowers the ROS level. It has also been found to promote osteoblastic differentiation [48]. Corn silk contains β-sitosterol which protects osteoblasts and suppresses osteoclastogenesis which is suggested to protect against glucocorticoid-induced osteoporosis [49]. Another study on *Clinacanthus nutans* Lindau also confirmed the enhancement in osteoblastogenic activity of β-sitosterol [50].

Promotes hypothyroidism

The thyroid secretes Triiodothyronine (T3) and Thyroxine (T4). Hyperthyroidism refers to a group of heterogeneous disorders caused by increased levels of thyroid hormones [51]. Thyroid hormones are significantly important for cell differentiation and regulation of metabolism. Hyperthyroidism is found to decrease BMD by almost 10% which leads to reduced bone mass and increased risk of fractures [8]. Thyroid hormone has a direct impact on osteoclast function, thereby stimulating bone resorption. Subclinical hyperthyroidism is associated with a risk of hip fracture [19]. A study focused on sweet corn's effect on hyperthyroid Swiss albino rats has found that methanolic extract of 400 mg/kg of corn silk is highly effective and can revert the hyperthyroid condition in the rats [51].

Anti-inflammatory

Inflammatory bowel disease is considered a risk factor for osteoporosis. It is hypothesized that the severity of inflammation in the gut and malabsorption in the intestine can result in a deficiency of vitamin D and calcium in patients, leading to negative effects on bone health [21]. Proteinases (metalloproteinases) and proinflammatory cytokines (IL-1, TNF-α) initiate cartilage and bone destruction in rheumatoid arthritis condition which accelerates bone loss in both the joints and throughout the skeleton. Therefore, disease activity is suggested to be an independent risk factor for osteoporosis in rheumatoid arthritis [52]. Corn silk contains magnesium, which helps regulate the body's anti-inflammatory response. Additionally, its crude ethanolic extract shows a TNF antagonistic activity which helps stop inflammation [13, 27]. Acidic-hydrolysed cornsilk polysaccharides are found to have a protective effect against H_2O_2-injured epithelial cells of the intestine [53]. Also, corn silk has vitamin K [26] which has anti-inflammatory properties [54].

Anti-hypertensive

In a healthy person, the blood pressure is 120/80 mmHg (systolic pressure (heart pumps)/diastolic pressure (heart relaxes)). The condition is called hypertension if it is 140/90 mmHg. This increase in the pressure of blood flow may damage blood vessels [55]. A study highlighted the results of hypertension, including elevated cytokines, sympathetic outflow, angiotensin II, oxidative stress, and vascular disease which affects the bone remodeling process negatively and contributes to osteoporosis [22]. Hypertension is linked to elevated urinary secretion of calcium and low concentration of plasma vitamin D which increases PTH secretion. It promotes the activity of osteoclast differentiation and helps in bone resorption. Additionally, in a study when the renin-angiotensin system was activated in hypertensive mice, it promoted bone resorption and accelerated the risk of fragile fractures [56]. The secretion of excess urinary calcium induces secondary parathyroidism. It leads to the release of calcium from bone to increase serum calcium levels and can elevate osteoporosis [57].

Corn silk has CSBp5, an ACE inhibitory phytopeptide that decreases systolic blood pressure levels, therefore acting as an anti-hypertensive effect. The boiling water extract of corn silk gave anti-hypertension effects in spontaneously hypertensive rats by inhibiting ACE, which is a general target of anti-hypertensive drugs. Also, corn silk tea along with anti-hypertensive medication can help treat hypertension effectively

[58, 59]. ACE regulates the transformation of angiotensin I to the strong vasoconstrictor angiotensin II which decreases active bradykinin. Bradykinin is found to play a significant role in regulating blood pressure. Therefore, corn silk inhibiting ACE produces an anti-hypertensive effect [60]. It has also been reported that a combination of cornsilk water with hypertensive drugs lowers blood pressure compared to when hypertensive drugs are taken individually [61]. Quercetin, a flavonoid in corn silk, is also found to be helpful in reducing blood pressure [33].

Anti-convulsant activity

Antiepileptic drugs affect the cytochrome P450 enzyme system in the liver, further affecting calcium and vitamin D metabolism and leading to bone loss [16]. There is an increased risk of vertebral and non-vertebral fractures in individuals with epilepsy with the addition of vitamin D deficiency which is a risk factor for osteoporosis [62]. There are various mechanisms associated with convulsion including oxidative stress, activity of pentylene tetrazol, etc. Pentylene tetrazol inhibits the activity of gamma amino butyric acid (GABA) which leads to the irregulating GABA neurotransmission and enhances convulsion. Corn silk extract confirms its anti-convulsive effect on CNS by delaying the pentylene tetrazol-induced convulsion. Additionally, corn silk extract is rich in phenolic compounds and flavonoids which exhibit potential antioxidant roles, and modulate the GABAA-Cl-channel complex in the CNS, hence confirming the anticonvulsant activity of corn silk [63].

Protective effect on reproductive disorders

Hypogonadism leads to elevated bone remodeling loss due to lower levels of hormones like testosterone and estrogen [18]. A study in male mice focused on the protective effect of aqueous and methanolic corn silk extract on the reproductive disorders induced by nicotine found that nicotine consumption results in elevated Luteinising hormone, oxidative stress, and decreased testosterone and sperm count. It led to primary hypogonadism in animals. Corn silk extracts decreased lipid peroxidation and recovered sex hormones and sperm count to normal conditions [64].

Anti-oxidant

Osteoporosis occurs due to oxidative stress as it promotes the resorption of osteoclasts and loss of bone through increased apoptosis of osteocytes [23]. Osteoblasts induce cell mitochondrial apoptosis pathway due to the accumulation of ROS in the body and promote osteoclast differentiation through different mechanisms. It's more prominent in postmenopausal osteoporosis because of the lack of estrogen which leads to weakened osteogenesis and elevated osteoclastogenesis [65]. Long-term smoking is found to create an unbalanced rate of bone turnover which furthers the loss of bone length and bone mass and the raised risk of fractures [66]. The intricate mechanism involved in this affects elements like rising oxidative stress and hormonal alterations, which contribute to further bone mass loss and impact osteogenesis [67]. Corn silk n-butanol fraction exhibits the most potent anti-oxidant property.

Corn silk ethanol extract is also found to have good reducing power and donate electrons, resulting in the termination of the free radical chain reaction [13]. Mature and the upper part of corn silk shows more antioxidant properties compared to immature and lower corn silk respectively [25]. Corn silk also contains vitamins E and K [26]. These vitamins exhibit antioxidant potential and protect the body against oxidative stress [54, 68]. The flavonoid catechin in corn silk can scavenge ROS and chelate metal ions and give an anti-oxidant effect [69]. In another study, the highest DPPH activity was found in PCFD (Purple waxy corn silk using freeze drying), while the lowest was shown by SCTD (sweet corn using tray-dried). Freeze-drying preserved higher DPPH radical scavenging activity than tray-drying. It's also reported that corn silk extracted with methanol shows increased DPPH scavenging activity (81.7% at 1000 μg/ml) compared to the water extract (63.5%) at the same concentration. In ABTS, similar results were found with PCFD having high ABTS activity and SCFD [70].

Promotes kidney health

Chronic kidney disease is linked with osteoporosis, mineral bone disorder and fragility fractures. Early decreased renal function results in high fracture risk. In CKD patients, hypocalcemia leads to an increase in parathyroid levels, resulting in an abnormal bone remodeling process. Phosphate retention also induces hypocalcemia condition, leading to decreased calcitriol synthesis and high parathyroid gene expression [71]. Vitamin D deficiency is also common in kidney patients due to renal failure. It increases the production of parathyroid to reconstruct calcitriol but also results in a high risk of proteinuria, bone loss, bone turnover and mortality. Chronic kidney disease patients show a high prevalence of osteoporosis, increased risk of hip fracture and elevated rate of morbidity and mortality [72]. Low parathyroid levels, repressed WNT/β-catenin and chronic inflammation lead to an increased risk of osteoporosis along with low levels of bone turnover [73]. Corn silk contains calcium and potassium [74]. In various studies, it is confirmed that intake of potassium is associated with low calcium loss, resulting in good bone mineral density. It inhibits the osteoporosis mechanism [56, 75]. Another conducted research found that nephrotoxicity caused by cisplatin, a cytotoxic agent in cancer therapy, was studied in rat models. Corn silk extracts were found to have the potential to lower nephrotoxicity and lipid peroxidation induced by cisplatin in rats [76]. Oxidative stress can lead to chronic renal failure, hypertension and other complications. Corn silk acts as a diuretic and increases urine flow from the body, decreasing the risk of kidney stone development [77].

Discussion on Future Scope

Corn silk is suggested to hinder the occurrence of osteoporosis through various mechanisms and promote bone health. Different studies have investigated and claimed that corn silk extracts' have beneficial health properties such as hypoglycemic, anti-hypertensive, lipid-lowering, anti-fungal, anti-diabetic, etc. Due to a lack of awareness, the consumption of corn silk in India is comparatively lesser than in other Asian countries like China and Korea, and to this date, corn silk is known as agricultural waste. Osteoporosis is a global disease with a significant economic burden and is understood as the low bone mineral density and continuous deterioration of

bone tissue, which makes bones prone to fractures. It's caused by the imbalance in the bone remodeling processes, with increased activity of osteoclasts.

Factors like being underweight, diabetes, obesity, genetics, physical activity, and alcohol consumption with dietary history affect osteoporosis's occurrence and severity. These risk factors of osteoporosis can be attenuated through corn silk properties like anti-obesity, anti-oxidant, anti-inflammatory, anti-diabetic, anti-hypertensive, and anti-convulsant in addition to the beneficial flavonoids, and trace elements present in the plant extract. It also contains phytoestrogen (isoflavones) which can act as estrogens in the post-menopausal phase and help in the bone remodeling process. Different value-added products like noodles, pasta, and vinegar have been made with corn silk. Therefore, it can be used in the food industry to prepare value-added products like dairy beverages. Milk is a rich source of calcium and the incorporation of corn silk in dairy beverages can elevate its protective function against osteoporosis. The future scope for this research is vast and different clinical trials could be done to further confirm the protective effects of corn silk on bone health

Conclusion

In conclusion, this review paper summarizes the potential of corn silk in the management of osteoporosis. Different properties of corn silk with its phytochemical composition have the potential to decrease the risk of osteoporosis. The review of the literature shows that there is not much research done on the effect of corn silk on the management of osteoporosis. Corn silk can be incorporated to make value-added products so its nutritional properties could be utilized well. Corn silk in dairy beverages can help promote bone health, and further research and trials can be conducted to enhance its value as a product and ensure the safety of consumption. This area is under-researched and has a scope of study.

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None.

Conflict of Interest

None.

References

1. Clynes MA, Harvey NC, Curtis EM, Fuggle NR, Dennison EM, et al. 2020. The epidemiology of osteoporosis. *Br Med Bull* 133(1): 105-117. https://doi.org/10.1093/bmb/ldaa005
2. Fahimfar N, Noorali S, Yousefi S, Gharibzadeh S, Shafiee G, et al. 2021. Prevalence of osteoporosis among the elderly population of Iran. *Arch Osteoporos* 16(1): 16. https://doi.org/10.1007/s11657-020-00872-8
3. Gregson CL, Armstrong DJ, Bowden J, Cooper C, Edwards J, et al. 2022. UK clinical guideline for the prevention and treatment of osteoporosis. *Arch Osteoporos* 17(1): 58. https://doi.org/10.1007/s11657-022-01061-5
4. Aung M, Amin S, Gulraiz A, Gandhi FR, Pena Escobar JA, et al. 2020. The future of metformin in the prevention of diabetes-related osteoporosis. *Cureus* 12(9): e10412. https://doi.org/10.7759/cureus.10412
5. Salari N, Ghasemi H, Mohammadi L, Behzadi MH, Rabieenia E, et al. 2021. The global prevalence of osteoporosis in the world: a comprehensive systematic review and meta-analysis. *J Orthop Surg Res* 16(1): 609. https://doi.org/10.1186/s13018-021-02772-0
6. Emmanuelle NE, Marie-Cécile V, Florence T, Jean-François A, Françoise L, et al. 2021. Critical role of estrogens on bone homeostasis in both male and female: from physiology to medical implications. *Int J Mol Sci* 22(4): 1568. https://doi.org/10.3390/ijms22041568
7. Song S, Guo Y, Yang Y, Fu D. 2022. Advances in pathogenesis and therapeutic strategies for osteoporosis. *Pharmacol Ther* 237: 108168. https://doi.org/10.1016/j.pharmthera.2022.108168
8. Apostu D, Lucaciu O, Oltean-Dan D, Mureșan AD, Moisescu-Pop C, et al. 2020. The influence of thyroid pathology on osteoporosis and fracture risk: a review. *Diagnostics* 10(3): 149. https://doi.org/10.3390/diagnostics10030149
9. Gupta PD, Sood PP. 2022. Osteoporosis: a gender based analysis. *J Cell Tissue Res* 22(1): 7183-7186.
10. Rinonapoli G, Ruggiero C, Meccariello L, Bisaccia M, Ceccarini P, et al. 2021. Osteoporosis in men: a review of an underestimated bone condition. *Int J Mol Sci* 22(4): 2105. https://doi.org/10.3390/ijms22042105
11. Shlisky J, Mandlik R, Askari S, Abrams S, Belizan JM, et al. 2022. Calcium deficiency worldwide: prevalence of inadequate intakes and associated health outcomes. *Ann N Y Acad Sci* 1512(1): 10-28. https://doi.org/10.1111/nyas.14758
12. Hejazi J, Davoodi A, Khosravi M, Sedaghat M, Abedi V, et al. 2020. Nutrition and osteoporosis prevention and treatment. *Biomed Res Ther* 7(4): 3709-3720. https://doi.org/10.15419/bmrat.v7i4.598
13. Hasanudin K, Hashim P, Mustafa S. 2012. Corn silk (*Stigma maydis*) in healthcare: a phytochemical and pharmacological review. *Molecules* 17(8): 9697-9715. https://doi.org/10.3390/molecules17089697
14. Azevedo ASD, Seibert JB, Amparo TR, Antunes ADS, Sousa LRD, et al. 2022. Chemical constituents, antioxidant potential, antibacterial study and photoprotective activity of Brazilian corn silk extract. *Food Sci Technol* 42: e98421. https://doi.org/10.1590/fst.98421
15. Aukkanit N, Kemngoen T, Ponharn N. 2015. Utilization of corn silk in low fat meatballs and its characteristics. *Procedia Soc Behav Sci* 197:1403-1410. https://doi.org/10.1016/j.sbspro.2015.07.086
16. Diemar SS, Sejling AS, Eiken P, Andersen NB, Jørgensen NR. 2019. An explorative literature review of the multifactorial causes of osteoporosis in epilepsy. *Epilepsy Behav* 100(Pt A): 106511. https://doi.org/10.1016/j.yebeh.2019.106511
17. Ebeling PR, Nguyen HH, Aleksova J, Vincent AJ, Wong P, et al. 2022. Secondary osteoporosis. *Endocr Rev* 43(2): 240-313. https://doi.org/10.1210/endrev/bnab028
18. Rozenberg S, Bruyère O, Bergmann P, Cavalier E, Gielen E, et al. 2020. How to manage osteoporosis before the age of 50. *Maturitas* 138: 14-25. https://doi.org/10.1016/j.maturitas.2020.05.004
19. Xu N, Wang Y, Xu Y, Li L, Chen J, et al. 2020. Effect of subclinical hyperthyroidism on osteoporosis: a meta-analysis of cohort studies. *Endocrine* 69(1): 39-48. https://doi.org/10.1007/s12020-020-02259-8
20. Proietto J. 2020. Obesity and bone. *F1000Res* 9: F1000 Faculty Rev-1111. https://doi.org/10.12688/f1000research.20875.1
21. Kärnsund S, Lo B, Bendtsen F, Holm J, Burisch J. 2020. Systematic review of the prevalence and development of osteoporosis or low bone mineral density and its risk factors in patients with inflammatory bowel disease. *World J Gastroenterol* 26(35): 5362-5374. https://doi.org/10.3748/wjg.v26.i35.5362
22. Do Carmo L, Harrison DG. 2020. Hypertension and osteoporosis: common pathophysiological mechanisms. *Med Nov Technol Devices* 8: 100047. https://doi.org/10.1016/j.medntd.2020.100047
23. Domazetovic V, Marcucci G, Iantomasi T, Brandi ML, Vincenzini MT. 2017. Oxidative stress in bone remodeling: role of antioxidants. *Clin Cases Miner Bone Metab* 14(2): 209-216. https://doi.org/10.11138/ccmbm/2017.14.1.209
24. Hedayetullah M, Zaman P. 2021. Forage Crops of the World, 2-Volume

Set: Volume I: Major Forage Crops; Volume II: Minor Forage Crops. CRC Press, Boca Raton, United States.

25. Kaur P, Singh J, Kaur M, Rasane P, Kaur S, et al. 2023. Corn silk as an agricultural waste: a comprehensive review on its nutritional composition and bioactive potential. *Waste Biomass Valor* 14: 1413-1432. https://doi.org/10.1007/s12649-022-02016-0
26. Nawaz H, Muzaffar S, Aslam M, Ahmad S. 2018. Phytochemical Composition: Antioxidant Potential and Biological Activities if Corn. In Amanullah, Fahad S (eds) Corn - Production and Human Health in Changing Climate. IntechOpen, London.
27. Yadav PK, Yadav SK. 2021. Impact of maize (*Zea mays*) silk in medicinal values. *Indian Farmer* 8(06): 419-426.
28. Žilić S, Janković M, Basić Z, Vančetović J, Maksimović V. 2016. Antioxidant activity, phenolic profile, chlorophyll and mineral matter content of corn silk (*Zea mays* L): comparison with medicinal herbs. *J Cereal Sci* 69: 363-370. https://doi.org/10.1016/j.jcs.2016.05.003
29. Si Y, Wang C, Guo Y, Yin H, Yong MA. 2020. Prevalence of osteoporosis in patients with type 2 diabetes mellitus in the Chinese mainland: a protocol of systematic review and meta-analysis. *Medicine* 99(16): e19762. https://doi.org/10.1097/md.0000000000019762
30. Wang KJ, Zhao JL. 2019. Corn silk (*Zea mays* L.), a source of natural antioxidants with α-amylase, α-glucosidase, advanced glycation and diabetic nephropathy inhibitory activities. *Biomed Pharmacother* 110: 510-517. https://doi.org/10.1016/j.biopha.2018.11.126
31. Tian S, Sun Y, Chen Z. 2021. Extraction of flavonoids from corn silk and biological activities *in vitro*. *J Food Qual* 2021: 7390425. https://doi.org/10.1155/2021/7390425
32. Singh J, Rasane P, Nanda V, Kaur S. 2023. Bioactive compounds of corn silk and their role in management of glycaemic response. *J Food Sci Technol* 60(6): 1695-1710. https://doi.org/10.1007/s13197-022-05442-z
33. Sun J, Pan Y, Li X, Wang L, Liu M, et al. 2022. Quercetin attenuates osteoporosis in orchiectomy mice by regulating glucose and lipid metabolism via the GPRC6A/AMPK/mTOR signaling pathway. *Front Endocrinol* 13: 849544. https://doi.org/10.3389/fendo.2022.849544
34. Lukitaningtyas D, Sudiana IK, Bakar A. 2020. The effect of corn silk ethanol extract (*Zea mays*. l) on decreasing the blood glucose levels. *Int J Nurs Health Services* 3(1): 96-100.
35. Sheng L, Chen Q, Di L, Li N. 2021. Evaluation of anti-diabetic potential of corn silk in high-fat diet/ streptozotocin-induced type 2 diabetes mice model. *Endocr Metab Immune Disord Drug Targets* 21(1): 131-138. https://doi.org/10.2174/1871530320666200606224708
36. Clynes MA, Gregson CL, Bruyère O, Cooper C, Dennison EM. 2021. Osteosarcopenia: where osteoporosis and sarcopenia collide. *Rheumatology* 60(2): 529-537. https://doi.org/10.1093/rheumatology/keaa755
37. Mazocco L, Chagas P. 2017. Association between body mass index and osteoporosis in women from northwestern Rio Grande do Sul. *Rev Bras Reumatol Engl Ed* 57(4): 299-305. https://doi.org/10.1016/j.rbre.2016.10.002
38. Lee CW, Seo JY, Kim SL, Lee J, Choi JW, et al. 2017. Corn silk maysin ameliorates obesity *in vitro* and *in vivo* via suppression of lipogenesis, differentiation, and function of adipocytes. *Biomed Pharmacother* 93: 267-275. https://doi.org/10.1016/j.biopha.2017.06.039
39. Chaiittianan R, Sutthanut K, Rattanathongkom A. 2017. Purple corn silk: a potential anti-obesity agent with inhibition on adipogenesis and induction on lipolysis and apoptosis in adipocytes. *J Ethnopharmacol* 201: 9-16. https://doi.org/10.1016/j.jep.2017.02.044
40. Lee EY, Kim SL, Kang HJ, Kim MH, Ha AW. 2016. High maysin corn silk extract reduces body weight and fat deposition in C57BL/6J mice fed high-fat diets. *Nutr Res Pract* 10(6): 575-582. https://doi.org/10.4162/nrp.2016.10.6.575
41. Delitala AP, Scuteri A, Doria C. 2020. Thyroid hormone diseases and osteoporosis. *J Clin Med* 9(4): 1034. https://doi.org/10.3390/jcm9041034
42. Al-Anazi AF, Qureshi VF, Javaid K, Qureshi S. 2011. Preventive effects of phytoestrogens against postmenopausal osteoporosis as compared to the available therapeutic choices: an overview. *J Nat Sci Biol Med* 2(2): 154-63. https://doi.org/10.4103/0976-9668.92322
43. Triutomo DH, Miranda A, Tamba LJ, Lukitaningsih E. 2016. Estrogenic effect ethanol extract corn silk (*Stigma maydis*) on bone density and histology femur profiles in ovariectomized rats female sprague dawley strain. *Indones J Cancer Chemoprevention* 7(3): 104-109.
44. Liu ZM, Chen B, Li S, Li G, Zhang D, et al. 2020. Effect of whole soy and isoflavones daidzein on bone turnover and inflammatory markers: a 6-month double-blind, randomized controlled trial in Chinese postmenopausal women who are equol producers. *Ther Adv Endocrinol Metab* 11: 2042018820920555. https://doi.org/10.1177/2042018820920555
45. Sarfraz I, Rasul A, Riaz A, Ucak I, Zahoor MK, et al. 2021. Biochanin A and Biochanin B. In Mushtaq M, Anwar F (eds) A Centum of Valuable Plant Bioactives. Academic Press, Cambridge, pp 563-588.
46. Liang G, Zhao J, Dou Y, Yang Y, Zhao D, et al. 2022. Mechanism and experimental verification of luteolin for the treatment of osteoporosis based on network pharmacology. *Front Endocrinol* 13: 866641. https://doi.org/10.3389/fendo.2022.866641
47. Barnsley J, Buckland G, Chan PE, Ong A, Ramos AS, et al. 2021. Pathophysiology and treatment of osteoporosis: challenges for clinical practice in older people. *Aging Clin Exp Res* 33(4): 759-773. https://doi.org/10.1007/s40520-021-01817-y
48. Jing Z, Wang C, Yang Q, Wei X, Jin Y, et al. 2019. Luteolin attenuates glucocorticoid-induced osteoporosis by regulating ERK/Lrp-5/GSK-3β signaling pathway *in vivo* and *in vitro*. *J Cell Physiol* 234(4): 4472-4490. https://doi.org/10.1002/jcp.27252
49. Wang T, Li S, Yi C, Wang X, Han X. 2022. Protective role of β-sitosterol in glucocorticoid-induced osteoporosis in rats via the RANKL/OPG pathway. *Altern Ther Health Med* 28(7): 18-25.
50. Nguyen HTT, Ngo QV, Le DTT, Nguyen MTH, Nguyen PTM. 2022. β-sitosterol from *Clinacanthus nutans* Lindau enhances osteoblastogenic activity via upregulation of differentiation related genes and proteins. *Biosci Biotechnol Biochem* 86(12): 1615-1622. https://doi.org/10.1093/bbb/zbac145
51. Bhaigyabati T, Ramya J, Usha K. 2012 Effect of methanolic extract of sweet corn silk on experimentally induced hyperthyroidism in Swiss albino rats. *Int Res J Pharm* 3(3): 241-245.
52. Ginaldi L, Mengoli LP, Sirufo MM, De Martinis M. 2019. Osteoporosis, Inflammation, and Aging. In Fulop T, Franceschi C, Hirokawa K, Pawelec G (eds) Handbook of Immunosenescence. Springer, Cham, pp 2437-2467.
53. Jia Y, Wang Y, Li R, Li S, Zhang M, et al. 2021. The structural characteristic of acidic-hydrolyzed corn silk polysaccharides and its protection on the H_2O_2-injured intestinal epithelial cells. *Food Chem* 356: 129691. https://doi.org/10.1016/j.foodchem.2021.129691
54. Dai L, Schurgers LJ, Shiels PG, Stenvinkel P. 2020. Early vascular ageing in chronic kidney disease: impact of inflammation, vitamin K, senescence and genomic damage. *Nephrol Dial Transplant* 35(Suppl 2): ii31-ii37. https://doi.org/10.1093/ndt/gfaa006
55. Vadakedath S, Kandi V. 2017. Dialysis: a review of the mechanisms underlying complications in the management of chronic renal failure. *Cureus* 9(8): e1603. https://doi.org/10.7759/cureus.1603
56. Hu Z, Yang K, Hu Z, Li M, Wei H, et al. 2021. Determining the association between hypertension and bone metabolism markers in osteoporotic patients. *Medicine* 100(24): e26276. https://doi.org/10.1097/md.0000000000026276
57. Nakagami H, Morishita R. 2013. Hypertension and osteoporosis. *Clin Calcium* 23(4): 497-503.
58. Shi S, Li S, Li W, Xu H. 2019. Corn silk tea for hypertension: a systematic review and meta-analysis of randomized controlled trials. *Evid Based Complement Alternat Med* 2019: 2915498. https://doi.org/10.1155/2019/2915498

59. Li CC, Lee YC, Lo HY, Huang YW, Hsiang CY, et al. 2019. Antihypertensive effects of corn silk extract and its novel bioactive constituent in spontaneously hypertensive rats: the involvement of angiotensin-converting enzyme inhibition. *Molecules* 24(10): 1886. https://doi.org/10.3390/molecules24101886
60. Rabi OO, Omoba OS, Aderonke Ibidunni O. 2022. *In vitro* antioxidants and antihypertensive properties of corn silk–lemon infusion. *Bull Natl Res Cent* 46: 46. https://doi.org/10.1186/s42269-022-00728-w
61. Ryuk JA, Ko BS, Moon NR, Park S. 2022. Protection against neurological symptoms by consuming corn silk water extract in artery-occluded gerbils with reducing oxidative stress, inflammation, and post-stroke hyperglycemia through the gut-brain axis. *Antioxidants* 11(1): 168. https://doi.org/10.3390/antiox11010168
62. Dussault PM, Lazzari AA. 2017. Epilepsy and osteoporosis risk. *Curr Opin Endocrinol Diabetes Obes* 24(6): 395-401. https://doi.org/10.1097/med.0000000000000366
63. Okokon JE, Davies K, Nyong EE, Udoh AE. 2018. Anticonvulsant activity of corn silk (*Stigma maydis*). *J Basic Pharmacol Toxicol* 2(2): 6-10.
64. Sa'adatzadeh M, Oroojan AA, Behmanesh MA, Mard-Soltani M. 2023. Protective effect of aqueous and methanolic extracts of corn silk on nicotine-induced reproductive system disorders in male mice. *JBRA Assist Reprod.* https://doi.org/10.5935/1518-0557.20230034
65. Yang K, Cao F, Xue Y, Tao L, Zhu Y. 2022. Three classes of antioxidant defense systems and the development of postmenopausal osteoporosis. *Front Physiol* 13: 840293. https://doi.org/10.3389/fphys.2022.840293
66. Weng W, Li H, Zhu S. 2022. An overlooked bone metabolic disorder: cigarette smoking-induced osteoporosis. *Genes* 13(5): 806. https://doi.org/10.3390/genes13050806
67. Ratajczak AE, Szymczak-Tomczak A, Rychter AM, Zawada A, Dobrowolska A, et al. 2021. Impact of cigarette smoking on the risk of osteoporosis in inflammatory bowel diseases. *J Clin Med* 10(7): 1515. https://doi.org/10.3390/jcm10071515
68. Galli F, Bonomini M, Bartolini D, Zatini L, Reboldi G, et al. 2022. Vitamin E (alpha-tocopherol) metabolism and nutrition in chronic kidney disease. *Antioxidants* 11(5): 989. https://doi.org/10.3390/antiox11050989
69. Bernatoniene J, Kopustinskiene DM. 2018. The role of catechins in cellular responses to oxidative stress. *Molecules* 23(4): 965. https://doi.org/10.3390/molecules23040965
70. Senphan T. 2019. Comparative studies on chemical composition and antioxidant activity of corn silk from two varieties of sweet corn and purple waxy corn as influenced by drying methods. *Food Appl Biosci J* 7(3): 64-80.
71. Hsu CY, Chen LR, Chen KH. 2020. Osteoporosis in patients with chronic kidney diseases: a systemic review. *Int J Mol Sci* 21(18): 6846. https://doi.org/10.3390/ijms21186846
72. Tasnim N, Dutta P, Nayeem J, Masud P, Ferdousi A, et al. 2021. Osteoporosis, an inevitable circumstance of chronic kidney disease: a systematic review. *Cureus* 13(10): e18488. https://doi.org/10.7759/cureus.18488
73. Haarhaus M, Evenepoel P. 2021. Differentiating the causes of adynamic bone in advanced chronic kidney disease informs osteoporosis treatment. *Kidney Int* 100(3): 546-558. https://doi.org/10.1016/j.kint.2021.04.043
74. Rahman NA, Rosli WI. 2014. Nutritional compositions and antioxidative capacity of the silk obtained from immature and mature corn. *J King Saud Univ Sci* 26(2): 119-127. https://doi.org/10.1016/j.jksus.2013.11.002
75. Kong SH, Kim JH, Hong AR, Lee JH, Kim SW, et al. 2017. Dietary potassium intake is beneficial to bone health in a low calcium intake population: the Korean national health and nutrition examination survey (KNHANES) (2008-2011). *Osteoporos Int* 28(5): 1577-1585. https://doi.org/10.1007/s00198-017-3908-4
76. Tanideh N, Zarifi F, Rafiee S, Khastkhodaei M, Koohi Hosseinabadi O, et al. 2018. Effect of methanolic extract of corn silk on cisplatin-induced nephrotoxicity in rats. *Galen Med J* 7: e1258. https://doi.org/10.22086/gmj.v0i0.1258
77. Vranješ M, Popović BM, Štajner D, Ivetić V, Mandić A, et al. 2016. Effects of bearberry, parsley and corn silk extracts on diuresis, electrolytes composition, antioxidant capacity and histopathological features in mice kidneys *J Funct Foods* 21: 272-282. https://doi.org/10.1016/j.jff.2015.12.016