

Prevention of Osteoporotic Disorders with Foxtail Millet (*Setaria Italica*)

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Abstract

Objectives: 1. To review the effect of foxtail millet in Bone health. 2. To review *Asthivikara* according to Ayurvedic science. 3. To review about ayurvedic and modern concept of Foxtail Millet and Osteoporosis.

Materials and methods: All the research work regarding foxtail millet, Osteoporosis, Bone health, *Sandhankarma* has been searched from science direct, PUBMED, scholar articles. Various classical text of ayurveda and modern science has been reviewed.

Discussion: foxtail millet possesses Madhura (sweet), Astringent (Kashaya) rasa, Guru guna (heavy), ruchya property (increases taste), Sheeta veerya (cold potency), brumhana karma (nourishing), sandhankar (healing) property. It is rich in Vitamin B12, protein, good fat, carbs and dietary fibre content. Besides copious amounts of lysine, thiamine, iron and niacin, it also offers abundant amounts of calcium. Osteoporosis was first considered to be an age-related disorder characterized by low bone mass and increased bone fragility, thereby putting the patient at risk of fractures. Studies have reported an increased risk of developing osteoporosis in patients with various inflammatory conditions. Bound polyphenols of inner shell (BPIS) from foxtail millet bran can display anti-inflammatory effects

Conclusion: Foxtail millet diet consumption will help in prevention of osteoclastic activity i.e. bone resorption process and may promote the activity of osteoblastic cells i.e. bone forming cells. It can promote anti-inflammatory effect. But according to Ayurveda, its consumption should be limited to once a day to prevent vitiation of *Vata Dosha*. So mass awareness and large scale research study is required for significant result.

Keywords: Foxtail Millet, *Kangu*, Osteoporosis, bone health, *Asthivikara*, *Asthidhatu*, *Asthisaushirya*

INTRODUCTION

Osteoporosis

Osteoporosis is a non-communicable disease and the most common bone disease. Currently, it has been estimated that more than 200 million people are suffering from osteoporosis. It affects one in three women and one in five men over the age of 50 worldwide.¹ Osteoporosis is a bone disease that develops when bone mineral density and bone mass decreases, or when the quality or structure of bone changes. This can lead to a decrease in bone strength that can increase the risk of broken bones.²

Osteoporosis weakens bones to the point that they can break easily. It affects a bone in the hip, spine, or wrist. Bones are made of living tissue. In a healthy human body, older bones break down and replaced by newer bone to keep them strong. The inside of a bone looks something like a honeycomb. When someone

has osteoporosis, the bone, which forms the “walls” of the honeycomb, get smaller, and the spaces between the bone grow larger. The outer shell of the bone also gets thinner. All of this makes a bone weaker. In serious cases of osteoporosis, a simple motion such as a cough or minor bump can result in a broken bone, also called a fracture. People with osteoporosis also have a harder time recovering from broken bones, which can sometimes cause pain that persist for long time. Broken hip and spine bones are especially serious, as these injuries can cause older adults to lose their mobility and independence.

In ayurveda there is no clinical entity mentioned in Samhitas like Osteoporosis but it can be used under Asthikshyaya & Asthisaushirya. Asthisaushirya means “porous bones”, Hemadri commented on word Saushirya as Samrandhratwa which means with pores³.

Management of osteoporosis mainly focuses on slowing or stopping the bone loss to prevent breaks. For this Diet and Lifestyle changes are recommended to lower chances of breaking a bone.

Healthy food revolution has given way to discover the value of traditional millets over the past few years. They have high nutritional value and are rich in proteins, vitamins, minerals, and fibres. In this article Foxtail millet or *Kangu* has been mentioned as a potential millet. It is mentioned as *Kangu*, *Kanguni*, *priyangu* etc in ayurvedic texts. *Kangu* (Foxtail Millet) is also called as *Priyangu* which is *Trunadhanya* or *Kudhanya*.

Foxtail millets is sweet and astringent to taste, Guru, cold in potency, Brumhana in action and show Bhagna sandhankar effect as per Ayurvedic Samhita.

Osteoporosis is the most common bone disease in humans which represent a major public health problem. As bone loss occurs without symptoms, osteoporosis is often considered a ‘silent disease’. Hence to prevent the occurrences of osteoporosis Diet can play a major role. Hence present study is designed to review the Osteoporosis & its management through Foxtail millet Diet.

MATERIALS AND METHODS:

Literature search was performed focusing on the nutritional aspects of bone health and fracture healing, using the following keywords: bone health, Asthidhatu, asthivikara, osteoporosis, nutrition, *bhagna sandhankar*, *kangu*, foxtail millet. All the research work regarding foxtail millet has been searched from science direct, PUBMED, scholar articles. various classical text of ayurveda and modern science has been reviewed.

Aim and objectives:

1. to review the effect of foxtail millet in Bone health
2. to review about ayurvedic and modern concept of Foxtail Millet and Osteoporosis

Bone biology

Bone is living tissue that makes up the body’s skeleton. Bones continue to change over the course of a lifespan. This process of skeletal change is known as bone remodeling which both protects the structural integrity of the skeletal system and metabolically contributes to the body’s balance of calcium and phosphorous. Bone remodeling provides a source of systemic calcium and phosphate and is means of replacing aged and damaged bone, thus maintaining bone health. Bone development continuous throughout the adulthood. Even after adult strature is attained bone development continues for repair of fractures and for remodeling to meet changing lifestyle.⁴ Osteoblast, osteoclast and osteocyte are the three cell types involved in the development, growth and remodeling of bones. Osteoblasts are bone forming

cells, osteocytes are mature bone cells and osteoclasts break down and reabsorb bone. Impaired remodeling favouring bone resorption over bone formation is a fundamental pathophysiological mechanism leading to bone pathologies such as osteoporosis.⁵

Osteoporosis

The term Osteoporosis was coined by Pommerin in 1985 which means “porous bones”. Greek word osteon means the bone tissue & porosis is derived from latin word “porous” which means “full of pores”. Thus, combined meaning of the word Osteoporosis is porous bones.⁶

Definition

Osteoporosis is the most frequent form of metabolic bone disease, is defined as a skeletal disorder characterised by compromised bone strength predisposing a person to an increased risk of fracture. Bone strength is defined as integration of bone density and bone quality.⁷

Osteoporosis often occurs as people age. At this time bone resorption overweighs bone formation. Osteoporosis is a classic example of a multifactorial disease with a complex interplay of genetic, intrinsic, exogenous, and life style factors contributing to an individual's risk of the disease.⁸

Risk factors:⁹

- A family history of broken bones or osteoporosis
- Age. Bone density peaks around age 30 after which bones begin to lose mass.
- History of a broken bone after age 50
- Previous surgery to remove the ovaries before menstruation periods stopped naturally
- Poor dietary habits, including insufficient amounts of calcium or Vitamin D or protein
- Physical inactivity or prolonged periods of bedrest
- Smoking cigarettes
- Heavy use of alcohol
- Long-term use of certain medications such as corticosteroids, proton pump inhibitors, and antiepileptic medications
- Altered levels of hormones, such as too much thyroid hormone, too little estrogen in women, or too little testosterone in men.
- Low body mass index or underweight

The most important risk factor for osteoporotic fractures is reduced bone mass. During growth, bone mass increases between the ages of 25 & 35 and falls thereafter in both sexes. It is most common in women than men due to oestrogen deficiency at the age of menopause. Genetic factors are important in the pathogenesis of Osteoporosis. Family studies suggest that genetic influences are accounted for 70-85% of individual variance in bone mass.

Osteoimmunology

The concept of osteoimmunology refers to the mutual interactions between the immune system and bone. In the English literature the term “osteoimmunology” was coined in 2000 by Arron and Choi. At the cellular level, the **osteoclast**, the cell responsible for bone resorption, can be regarded as the prototype of an osteoimmune cell: osteoclasts share common precursor cells with monocytes, macrophages, and (myeloid) dendritic cells.

Osteoporosis was first considered to be an age-related disorder characterized by low bone mass and increased bone fragility, thereby putting the patient at risk of fractures. However, over time, it has come to be viewed as a heterogeneous condition that can occur at any age and its aetiology is attributed to various endocrine, metabolic, and mechanical factors. Studies have reported an increased risk of developing osteoporosis in patients with various inflammatory conditions. Inflammation is characterized by the activation of several cell populations of the innate and adaptive immune system that produce inflammatory cytokines. Inflammation perturbs normal bone homeostasis and is known to induce bone loss because it promotes both local cartilage degradation and local and systemic bone destruction by osteoclasts and inhibits bone formation by osteoblasts.¹⁰

Pathogenesis: The underlying mechanism in all cases of Osteoporosis is an imbalance between bone resorption & bone formation. In normal bone there is constant matrix remodeling of bone, up to 10% of all bone mass may be undergoing remodeling at any point in time.¹¹ Hormonal factors strongly determine the rate of bone resorption, lack of oestrogen, increases bone resorption as well as decreasing the deposition of new bone that normally takes place in weight-bearing bones. Calcium intake is also important in determining the rate of post-menopausal bone loss. Osteoporosis may also occur as a complication of endocrine, inflammatory and

Asthivikara in Ayurveda

Asthi is derived from the root “As+kthin” which means to stay or in the sense of stability. Asthidhatu is the fifth dhatu among seven dhatus. It’s properties are Guru, Kathina, Sthula & Sthira, Murtimanta.¹² According to Charakacharya, Asthi dhatu formed from Medodhatu & from Asthidhatu the nutritious part becomes majjadhatu in dhatu utapatti nyaya¹³ Main functions of Asthi dhatu are Deha dharana, Majjapusthi & Ashraya of vatadosha. The increase & decrease of Asthi & vata are inversely proportional to each other i.e. when vata increases Asthidhatu decreases & vice versa¹⁴.

In Ayurveda there is no separate terminology for osteoporosis. But osteoporosis can be correlated to Asthikshaya, Asthisaushirya

Asthikshaya- In Asthikshaya there is pains in joints & in Majjakshaya there is Asthisaushirya¹⁵

Asthisaushirya- Asthisaushirya means porous bones. Hemadri commented on word “Saushirya” as Sarandhratwam which means with pores. This condition explained in context of Majjakshaya¹⁶. From these above references we can discuss the Osteoporosis under Asthisaushirya & Asthikshaya

Vitiation of vata & dhatukshaya is natural phenomenon occur in old age. Vatadosha contributes one of the important factors in Asthi related diseases as unique relationship of Vata & Asthi. So in old age to prevent osteoporotic fractures Ayurvedic measures are useful.

Kangu millet/ Foxtail Millet

Foxtail Millet is an annual grass grown for human food. It is the second-most widely grown species in the world after Pearl millet. India is the second-largest producer of foxtail millet, next to China. Foxtail millet cultivation was found around 8,000 years before along the ancient course of Yellow river in Cishan, China. Foxtail millet was widely cultivated in the ancient era but it has lost its importance with time.^[17]

Foxtail millet is a dry crop and is planted in the last week of May and it takes up to 70 days to harvest the crop. This is annual plant that grows erect with robust culms can reach up to 150 cm, with leaves extending to 40 cm in lanceolate shape.^[18]

Foxtail millet like other millets is a powerhouse of nutrition. It is rich in Vitamin B12, protein, good fat, carbs and dietary fibre content. Besides copious amounts of lysine, thiamine, iron and niacin, it also offers abundant amounts of calcium.

Foxtail millet ^[19]

Vernacular names	
Sanskrit name :	<i>Kangu</i>
English name :	<i>Foxtail millet</i>
Hindi name:	<i>Kanguni, kagani, Tanguni</i>
Bengali name:	<i>Kanguni</i>
Marathi name :	<i>Kang, Rala</i>
Telugu name :	<i>Koralu Korra</i>
Tamil Name:	<i>Thinai, KavalaiKambankorai, Nuvanam</i>
Gujarati name:	<i>Kanga</i>
Kannada Name:	<i>navane, navanakki</i>
Panjabi Name:	<i>Kangni</i>
Malayalam Name:	<i>Thina</i>
Nepali Name:	<i>Kaguno</i>

Botanical classification of Foxtail millet ^[20]

Super division:	Spermatophyta
Division:	Magnoliophyta
Class:	Liliopsida
Subclass:	Commelinidae
Order:	Cyperales
Family:	Poaceae
Genus:	Setaria
Species:	<i>italica</i>
Botanical name:	<i>Setaria italica</i>

Fig. 1 Foxtail millet plant



Fig. 2 Seeds of Foxtail millet



Ayurvedic Properties of Foxtail Millet ^[21]

1.	Taste	<i>Kashaya, Madhura</i> , (sweet, Astringent)
2.	Guna :	<i>Ruksha</i> (dry in nature) <i>Ruchya</i> (improve taste) <i>Guru</i> (heavy to digest)
3.	Virya (Potency):	<i>sheeta</i> (cold)
4	Effect on body:	<i>Bhagna sandhankar</i> (heals fracture) <i>Bruhani</i> (nourishes) <i>Dahagna</i> (relieves burning sensation) <i>Vajinaam</i> (good for horses)
5	Effect on tridosha	Decrease <i>Kapha dosha</i> Increase <i>vaata dosha</i>

Nutritional components Value per 100 g ^[22]

Energy	331 kCal
Protein	12.3 g
Dietary fibre	8 g
Fat	4.3 g
Phosphorus	290 mg
Potassium	250 mg
Magnesium	81 mg
Vitamin A	32 mg
Calcium	31 mg
Vitamin E	31 mg
Folic acid	15 mg
Sodium	4.6 mg
Niacin	3.2 mg
Iron	2.8 mg
Zinc	2.4 mg

DISCUSSION

Lifestyle Changes, Hormone Replacement Therapy, Bisphosphonates and Calcium Supplementary are the choice of treatments for osteoporosis. In ayurveda prime importance is given to prevention of disease.²³ Diet is very important aspect in prevention of osteoporosis. Here foxtail millet diet may be helpful in prevention of osteoporosis in older age.

Discussion on ayurvedic properties of Foxtail millet

Foxtail millet is prominently have Madhura Kashaya rasa. According to Acharya Charaka, Madhura rasa causes Sarvadhata vivardhana and is Balya, Brimhana, Ksheena-kshata, sandhana kara. Kashaya rasa has Sangrahi, Sandhankara and Ropana properties. According to Acharya Sushruta Madhura rasa is *Bala-sandhankrita*, Kshata *Ksheen* hita and Kashaya rasa possesses *Sangrahi* and *ropana* properties.²⁴ In osteoporosis there is deterioration of bone tissues which leads to compromised bone strength and increase risk of fractures. Foxtail millet diet will provide strength to the bone. It is *Sandhanakara* (healing) in effect i.e. it will lead to bone formation and regulate bone destruction in osteoporosis. Foxtail millet has Ropana property.

Foxtail millet is having *Guru guna* i.e., heavy quality. It contributes to weight and gravity of substance. *Guru guna* with *Madhura* and *Kashaya rasa* helps in *Bhrumhana* karma^[25] i.e., it maintains nutrition of the body by improving immunity.

Foxtail millet is having *Ruchya* property i.e., it improves taste. *Ruchya* property of foxtail millet will be helpful in palatability and balanced consumption of its recipes.

Foxtail millet is *Ruksha* i.e., dry in nature. Hence it can increase Vata dosha. For this it can be prepared using any oil so that *vata shamana* can be done. Consumption of foxtail millet recipe can be limited to once a day for minimising the *vata prakopa*.

Foxtail millet is *Sheeta* (cold) in potency. Power or internal strength with which a substance performs its actions are called as *veerya* or potency. *Sheeta veerya* of foxtail millet will help in providing stability, strength to the bones^[26]

Foxtail millet is said to be *Bhagna Sandhanhkar* i.e., it helps in healing fractures. From the properties of foxtail millet like *Madhura* and *Kashaya* rasa, *Sheeta veerya*, *Guru Guna*, and *Ruchya Guna*, we can understand the fracture healing action of foxtail millet.

Foxtail millet is having *Bhrumhana karma*. *Brumhana* therapy is aimed to improve the nutrition level of body. It is associated with heaviness and bulkiness which are Kapha qualities and opposite to Vata and Pitta qualities. *Brumhana* therapy is indicated to Ksheena (having muscle wasting), Kshata (injured), Krusha (emaciated patient), Vriddha (elderly patients), Durbala (weak) etc. Thus, with the help of *Madhura* rasa, *Guru guna*. And *Brumhana Karma* it improves nutrition of the body.²⁷

Foxtail millet is having *Dahagna* i.e. it relives burning sensation. It will not cause acidity.

Discussion on modern properties of foxtail millet

Foxtail millet is highly nutritious as compared to conventional cereals. Foxtail millet diets provides an overall calorie of 349 Kcal per 100 grams. This millet possesses 30.10 mg/100 g of calcium and 3.73 mg/100 g of iron.^[28] Foxtail millet is rich in protein content as well as it contains a good amount of fat and fiber. It contain 11.20g of protein and it also has a higher dietary fiber of 4.42 g. Foxtail millet is free of gluten.

The overall protein content in foxtail millet is 11.20 g. dietary protein may positively impact bone health by increasing muscle mass, increasing calcium absorption and suppressing parathyroid hormone. Thus, it may help in prevention of osteoporosis.

Foxtail millet possesses 30.10 mg/100 g of calcium. Calcium helps in building strong bones which can help in bone fracture healing. Adequate calcium intake throughout lifetime is important for bone health and the prevention of osteoporosis and related fractures. Adequate calcium provide improvements in bone mass and reduction in fracture risk.²⁹

Foxtail millet possesses 3.73 mg/100 g of iron. The risk of osteoporosis in females decreases with a moderate increase in dietary iron consumption.³⁰ Foxtail millet diet provide dietary iron which will help in preventing the risk of osteoporosis by increasing or maintaining bone mass.

Foxtail millet also has a higher dietary fiber of 4.42 g. Foxtail millet diet can provide high fiber to combat constipation.

Foxtail millet possesses 250 mg/100 g of potassium. This mineral prevents the body from losing calcium through urine.

The study performed on Foxtail millet indicates that bound polyphenols of inner shell (BPIS) from foxtail millet bran can display anti-inflammatory effects in LPS-induced HT-29 cells and in nude mice. Mechanistically, BPIS restrained the level of various pro-inflammatory cytokines (IL-1 β , IL-6, IL-8), and enhanced the expression level of anti-inflammatory cytokine (IL-10) by blocking the nuclear factor-kappaB (NF κ B)-p65 nuclear translocation.^[31] Osteoporosis was first considered to be an age-related disorder. However, over time, it has come to be viewed as a heterogeneous condition that can occur at any age and its etiology is attributed to various endocrine, metabolic, and mechanical factors. Studies have reported an increased risk of developing osteoporosis in patients with various inflammatory conditions.³² Inflammation is characterized by the activation of several cell populations of the innate and adaptive immune system that produce inflammatory cytokines. Inflammation perturbs normal bone homeostasis and is known to induce bone loss because it promotes both local cartilage degradation and local and systemic bone destruction by osteoclasts and inhibits bone formation by osteoblasts.³³ So consumption of foxtail millet diet may lead to anti-inflammatory action which will prevent bone loss.

Cautions: Millets essential to be cooked well for deriving full benefits, however, this particular millet should never be mixed with milk, as it may cause severe indigestion.

Recipes of Foxtail millets: foxtail millet kheer, Upama, biriyani, Vegetable Pulav, foxtail millet flour chapati, bhakari, idli, Dosa, appam

CONCLUSION

Osteoporosis is the most common bone disease in humans which represent a major public health problem. As bone loss occurs without symptoms, osteoporosis is often considered a 'silent disease'. Counselling is the integral part of prevention as well as treatment of osteoporosis. Preventive approach includes life style changes, exercise, intake of calcium and vitamin D, avoiding alcohol, smoking and excessive intake of salt. Foxtail millet contain enough amount of energy, protein, calcium, iron, dietary fibre and important minerals. According to ayurveda foxtail millet possesses Madhura (sweet), Astringent (Kashaya) rasa, *Guru guna* (heavy), *ruchya* property (increases taste), Sheeta veerya (cold potency), brumhana karma (nourishing), *sandhankar* (healing) property. Hence it will provide strength, stability, to the bone. Its bran

possesses anti-inflammatory property which will help in prevention of osteoporosis due to inflammation. Foxtail millet diet consumption may help in prevention of osteoclastic activity i.e. bone resorption process and may promote the activity of osteoblastic cells i.e. bone forming cells. This will help in improving bone mineral density and bone mass and thus maintain quality or structure of bone. But its consumption should be limited to once a day to prevent vitiation of Vata Dosh. In spite of having so beneficial properties, this millet is not popular in local population. So mass awareness and large scale research study is required for significant result.

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