FOXTAIL MILLET: A MAGICAL AND VERSATILE CROP

Abstract

Foxtail millet can also be referred to as a miracle crop or as miraculous. These small seeds have a little hull around them and are brownish-yellow in colour. Their flavor is nutty and sweet. They are also a crop that is good for farmers and the environment. It is highly nutritious, full of protein, vital fatty acids, carbs, and minerals including calcium, phosphorus, magnesium, and sodium as well as vitamins A and E. It contains anti-nutrients such phytic acid and tannin. It is a model C4 photosynthetic crop that can endure hard environment, salty conditions, and drought. The millet is prepared to preserve the most nutrients possible. It might manage blood sugar levels and has anti-oxidant, anti-carcinogenic, and glucose-lowering abilities. It contains gastro-protective traits, as well as the capacity to treat fungal infections. These naturally occurring compounds boost the antioxidant capacity, which is good for human health. Additionally, to enhance digestion, it exists in the digestive system. Because it is non-allergenic and the most digesting grain, it is helpful for the spleen and the stomach. The consumption of whole grains can have a variety of negative health effects. For diabetic people, it is a blessing because it lowers the body's blood glucose levels. Additionally lowers bad cholesterol levels (LDL and VLDL), assists in weight loss, eliminates extra fat by preventing the body from storing too much fat, lowers the risk of CVD, colon cancer, hypertension, and other diseases.

Keywords: Photosynthetic Model**,** Anti-Nutrient**,** Diabetes**,** Hypertension**,** Hyperlipidemia**,** Obesity**,** Colorectal Cancer Peptic Ulcers, Nutritional Security.

Author

Indira Dutta
B. Sc Dietetics and Applied Nutrition
Department of Dietetics and Applied Nutrition
Amity Institute of Applied Sciences
Kolkata, Amity University
Kolkata, India.

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I. INTRODUCTION

The primary goals of the entire project report are to examine the phylogeny, nutritional value, preparation techniques, bioavailability, health advantages, and nutritional security of the foxtail millet.

It is well known that foxtail millet is a wonderful and adaptable plant. Setaria italica is the name of the species. Due to its C4 photosynthesis and resistance to abiotic stressors, it is genetically closely linked to grasses used in biofuel. Foxtail millet is the only crop among all millets that has genetic and genomic resources. It is, after the pearl millet, the millet that is grown most widely worldwide. Almost everywhere in the world, including the semi-arid and arid regions of China, some regions of Japan, and parts of India, it is regarded as a staple meal.

It is also produced in South and North America for hay and silage. Kangni in Hindi, Kang in Gujrati, Kaon dana in Bengali, Tenai in Tamil, Kavalai and Kangam in Oriya, and Navane in Kannada are some of the common names for foxtail millet in India.(1) Foxtail millet (Setaria italica) is more affordable and more nutrient-dense than other major cereals. It has twice the protein, three times the calcium, and four times the fat and mineral content of rice (2). Agrarian and dietary concerns are present worldwide.

To enhance millet grain production, we must concentrate on dry lands because agricultural lands and irrigation systems have been abused to such an extent. Utilizing the dry lands in order to produce enough high-quality grains is a difficult problem because of its low productivity. These nutritional cereals are an abundant source of vitamins, minerals, vital fatty acids, phytochemicals, and antioxidants that work to reduce the incidence of diseases caused by a lack of nutrition. The production of millets can increase the productivity of dry lands and improve future food and nutritional security. (3)

In semi-arid and arid areas of Asia and Africa, millet is the most important drought-resistant whole grain that is readily available. The glycemic index and starch digestibility of foxtail millet are lower than those of other cereals. The millet's ability to lower blood sugar levels may be attributed to the bioactivated fibers, polyphenols, flavonoids, and other phytochemicals present in the grain.(4) It is an easily grown cereal crop that is a member of the Setaria genus and the Panicoideae subfamily of the Poaceae family. It is one among the oldest crops still being grown, and the earliest artifacts from it may be found in northern China. Starch is the main ingredient of foxtail millet grain. In addition to the grains, protein and lipids are present in considerable levels. Additionally, free sugar and non-starchy carbs are readily available. (26) By using the right processing techniques, anti-nutrients like tannin and phytic acid that are found in this grain can be decreased to negligible amounts. It contains antioxidant, low-glycemic index, and hypolipidemic properties (5).Foxtail millet grains are morphologically similar to other millet grains in that they have layers of husk and bran. The genomes and genetics of other millets, cereals, and biofuel crops are being studied using it as a model crop (10).

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II. DISCUSSION

1. **Phylogeny:** The foxtail millet and the green foxtail are closely related, according to a thorough phylogenetic analysis based on both organellar and nuclear DNA. Both Setaria species are members of a wider monophyletic group that consists of over 300 species and all have the same inflorescence (spikelets, bristles, etc.). The foxtail and the green millet (Setaria italica) are closely related, according to phylogenetic analysis of both the nuclear genes and the chloroplast. The hypothesis states that the foxtail millet is practically a domesticated variety of the green millet. (27) The branching pattern, flowering synchronization, condensed axillary and basal vegetative branching, lack of seed dormancy, and disarticulation are all morphological differences between Foxtail millet and its wild parent. Additionally, many other biofuel crops are extremely closely linked to it (1).

2. **Nutritional Quality:** Numerous techniques have been modified to raise the nutritional value of dishes made from grain. These include the addition of genetically modified ingredients, the fortification of amino acids, protein-rich sources, and processing methods including fermentation, milling, and malting. Other methods to enhance digestibility of grain starch include pressure cooking, steaming, flaking, micronization, and puffing (2). The foxtail millet plant, Setaria italica, has a lot of vitamins, minerals, proteins, lipids, carbs, and dietary fiber. It contains several nutrients that are anti-nutritional, such tannins and phytic acid. (6, 15)

Table 1: Nutritional Value of the Foxtail Millet (15)

Nutritional Components	Value per 100 g
Energy	331kcal
Protein	12.3g
Fat	4.3g
Dietary Fibre	8g
Phosphorous	290mg
Calcium	31mg
Magnesium	81mg
Potassium	250mg
Folic acid	15mg
Vitamin A	32mg
Vitamin E	31mg
Niacin	3.2mg
Sodium	4.6mg
Zinc	2.4mg
Iron	2.8mg

Comparing the foxtail millet plant with wheat, corn, as well as rice, it has higher nutritional benefits. It's crucial to preserve these nutritious properties while creating and processing healthy foxtail millet-based goods. The purpose of using foxtail millet for food diversity is to enhance the many food commodities available for consumption rather than to replace rice. (6)

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3. **Bioavailability:** Not all regions of India cultivate and consume foxtail millet. When it comes to consumption, it likewise becomes less common. Only those from traditional cultures and lower socioeconomic levels consume it. It is anticipated that using millet as a component in many cookies will lessen reliance on wheat flour. The availability of foxtail millet on the market at reasonable rates must go hand in hand with a rise in consumption. Therefore, foxtail millet planting has to be increased. It is advised to cultivate in disadvantaged locations, such as the shaded portions of newly planted plantations. One of the actions that may be taken to maintain the nation's food supplies is the use of young plantations and forestry land (7).

III. NUTRITIONAL SECURITY OF THE FOXTAIL MILLET

Increasing nutritional security of everyday foods has recently attracted enormous interest due to changes in eating habits incorporating multi-grains. The nutritional absorption of the tiny millets is now being given more consideration. Processed meals that meet the daily nutritional needs of growing youngsters are given to them. (19)

Due to increased urbanization and industrialization, the food market has become more accessible in recent years, and astounding changes have occurred in terms of the quantity (variety), quality, and packaging of convenience foods as well as the processing technologies used. As a result of the millet's documented nutritional benefits, (20) Due to the lack of consumer-friendly, ready-to-eat items for wheat and rice, their use for food is restricted to the local population. (21) In light of the recent pandemic outbreaks, agricultural scientists have concentrated on improving human immunity through food modification and natural supplements. The creation of intelligent crops with improved nutrition, medicinal properties, and climatic resistance is essential for the future. The nutritional, aesthetic, and gastronomic qualities of Foxtail millet may all be used to examine its quality. The important agronomic traits of foxtail millet are drought resistance, high water usage efficiency, tolerance for the soil's poor nutrient availability, excellent adaptation, and stable yields. (21, 22).

IV. BIOACTIVE COMPOUNDS PRESENT IN THE FOXTAIL MILLET

Foxtail millet is a fantastic source of dietary fiber, bioactive peptides, amino acids, proteins, phenolic constituents, mineral substances, sterols and tocols, phytic acids, carotenoids and unsaturated fatty acids, and a variety of anti-nutritive substances. Its bioactive elements are becoming essential as functional dietary components. In the digestive process, the phenolics found in foxtail millet are the most bioavailable. The protein hydrolysate's hydrophobic form has the strongest antioxidant activity. Other biological actions and health advantages of bioactive chemicals include the prevention of hypertension, anti-proliferative effects, and hyperglycemia. (23)

V. MICRONUTRIENTS PRESENT IN THE FOXTAIL MILLET

Especially in developing nations, foxtail millet is a significant crop. But the returns are meager. To increase production, it is important to use a variety of germplasm in breeding techniques. Foxtail millet is suitable for hot and dry areas, although it may be grown successfully in a wide variety of climatic conditions. If you compare foxtail millet to other grains, it is a good source of protein and minerals. According to the Millet Network of India

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(MINI), when compared to rice (1.8 mg iron and 7.9% protein), foxtail millet grain has (per 100 g) iron (2.8 mg), protein (12.3%), and calcium (31 mg). (26) This crop is a C4 photosynthetic model. (27)

VI. MICROBIAL FERMENTATION IN FOXTAIL MILLET

Recent scientific investigations have demonstrated that microbial fermentation not only enhances food preservation but also improves the quality and flavor of food, adding variety to human diets. Additionally, it helps to increase the amount of proteins, vital amino acids, vitamins, and fatty acids in diet.

The primary determinant of a product's quality is how fermentation affects the characteristics and make-up of its primary components, which are foxtail millet. In addition to the starch, fermentation increases the antioxidant activity and protein digestibility of foxtail millet. (28)

It offers crucial bioactivity for metabolic illnesses including Diabetes Mellitus, Cancer, Malnutrition, and Cardiovascular Diseases, much like antioxidants and nutritional supplements do. (29) Numerous studies have shown the benefits of millets, such as finger as well as proso millet, sorghum, and foxtail millet, for the treatment of metabolic diseases characterized by hyperglycemia and hypolipidemia. (30)

The goal of the current study was to determine how pre-treatment, as compared to raw foxtail millet grains, affected the quality of cooking, functional qualities, organoleptic quality, and physical physical characteristics of the other grains. The millet grains had received a variety of pre-treatments in a variety of combinations, including soaking, drying, roasting purposes, the steaming process, and cooking. The duration of cooking (11.66 to 5.33 min) and percent of absorption (6.72 to 2.08%) were both decreased by pretreatments. Cooking mass (28.66 to 37.33 g), power of swelling (5.60 to 6.77 g/g), and prepared capacity (23.66 to 32.33 ml) all rose after pre-treatment. Pre-treatments also reduced the visual appearance of the grains. The pre-treated rice grains that had been cooked had an effect in its color, texture and appearance in the organoleptic evaluation. Each of the aforementioned strong characteristics was categorized, and ratings were assigned. Due to their superior overall performance compared to other pretreatments, evaporated, cooked, and roasted grains can be used as a ready-to-eat alternative. (9).

VII. POTENTIAL USES OF FOXTAIL MILLETS on

Here are some examples of potential applications for foxtail millets:

Both the stomach and the spleen benefit from it. It has been used for thousands of years as part of dietary therapy. When milled and shelled, millet is fit for human consumption. (6) This millet is used by children, the elderly, breastfeeding mothers, pregnant women, and those who are unwell in rural India as a source of sustenance. Many illnesses are fought off because to it. Among the different millets, it is the grain that is least allergic and easiest on the digestive system. In terms of minerals, vitamins, and proteins, it is three times better than wheat and rice. Foxtail millet contains nutrients that perform a physiological function that lowers the risk of developing non-communicable illnesses. (23) It is beneficial

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for diabetics due to its low glycemic index and high protein and antioxidant content. People with celiac disease can eat it because it only contains a little quantity of gluten. (23)

1. **Diabetes:** Over the past 50 years, both diabetes and obesity rates have been rising. WHO estimates that 346 million people worldwide are believed to have diabetes, up from 285 million in 2010 and around 30 million in 1985. According to WHO estimates, between 2005 and 2030, the number of fatalities related to diabetes would double. The care of type 2 diabetes often emphasizes changes in lifestyle, keeping blood glucose levels within the normal range, and reducing cardiovascular risk factors. (8) Research has demonstrated that consuming foxtail millet can lessen the risk of developing diabetes. Foxtail millet has a low glycemic index and stimulates the pancreas cells to create the hormone insulin, which controls blood glucose levels in the body, according to in vitro research and study by Chen et al. in 2003. A test on animals was also carried out to see if increasing the body's sensitivity to insulin might have anti-diabetic effects. This study suggests that eating foxtail millet may certainly control and lower blood sugar levels. (4) According to current recommendations, patients with type-2 diabetes should follow a healthy, balanced diet that includes low GI (glycaemia index) carbs and lots of dietary fiber. They both aid in lowering body weight and controlling post-meal hyperglycemia. It has been shown that a high-fiber diet or a low glycaemic carbohydrate diet safely lowers the plasma cholesterol levels and raises blood glucose levels in type-2 diabetics. (4, 24) The Foxtail Millet has been labeled as a low GI meal due to its average GI rating of 47.89. (29)

2. **Hypertension:** High blood pressure, sometimes known as hypertension, is a risk factor for various other cardiovascular disorders. Drugs from the "ACE inhibitor" family are typically used to treat hypertension. In essence, it relaxes the blood vessels, which helps to lower blood pressure. The Foxtail millet contains ACE inhibitor compounds. The Foxtail millet was consumed by the hypertensive rats, according to a 2017 study by Chen et al., who found that it lowered their blood pressure. (11)

3. **Colorectal Cancer:** Colorectal cancer (CRC) is the second most lethal and third most often diagnosed disease that endangers people's health, according to latest data from the American Cancer Society (13). The rectum and colon are also affected by this malignancy. It may be found near the base of the digestive tract (12).When compared to rice-treated rats, the millet dietary therapy enhanced the abundance of Bifidobacterium and Bacteroidales_S24-7. According to the Review Literature, eating whole grains or cereals may help lower your chance of developing colorectal cancer. The mortality and morbidity of CRC have been steadily rising in recent years, mostly in developing nations (12, 13). The main sources of staple foods in Asia and China are both rice and millet. The nutritional makeup of rice and millet differs, which may have an impact on how the gut flora is arranged and how the body produces metabolites after consumption. It is yet unknown if extensive-period dietary intervention can affect the progression of CRC. Foxtail millets have been shown to have a good influence on colorectal cancer in mice when fed, according to a research study Zhang et al. conducted in the year 2020 to assess their impacts on the disease (12).

4. **Peptic Ulcer:** Known sometimes as peptic or gastric ulcers, peptic ulcer disease (PUD) is a prevalent illness that affects the digestive system. Due to an imbalance between the

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aggressive and defensive elements impacting the stomach mucous, gastric mucosal injuries are brought on.

The foxtail millet has nutritive qualities in the form of antioxidants that assist prevent the deterioration of human health. It has been used for many years in traditional Chinese medicine as a treatment for many illnesses. The objective of the current investigation is to determine if the adlay processing product (APP) and the foxtail millet diet have gastroprotective effects on rat water immersion restraint stress (WIRS)-induced ulceration. The findings of a research study showed that pretreatment with adlay and diets significantly slowed the growth of the gastric mucosal lesion. Additionally, ulcerated rats had decreased Non-protein Sulfhydryl (NPSH) levels, but stress-induced rats treated with adlay and millet had an improvement in these levels. The histology studies supported the findings. According to the findings, adlay and millet diets aid in ulcer prevention by lowering ulcer index values, increasing NPSH concentrations, and decreasing TBARS values. The millet and adlay diets guard the gastrointestinal mucosa from ulcers since they are natural products. (14)

5. **Fungal Infection:** Numerous chemical substances derived from plants have so far had a favorable influence on fungal diseases. A new antifungal protein molecule was discovered in foxtail millets by Wentao et al. in experimental study done in 2011 and it has action against fungus like Alternaria alternative and Botrytis cinerea that cause allergies and asthma. By acting as an antifungal agent against these fungus, foxtail millets stop the spread of these organisms. This suggests that foxtail millets may be able to treat fungal infections. (15)

6. **Hyperlipidemia:** The main risk factors for atherosclerotic CVD include hyperlipidemia, hypertension, diabetes, and smoking. The effect of millet eating on blood lipids was mentioned in a recent study as another positive result. According to the data, consuming the low (46.7 12.0%) GI millet-based diet significantly lowered the levels of TC, LDL-C, triacylglycerol, and VLDL-C. The causes of hyperlipidemia include all the other elements mentioned as well as levels of glucose, saturated fats, improperly managed diabetes, and metabolic syndromes.Because millets have a low glycemic index (GI), there is less blood glucose available for the production of triacylglycerol. If administered for a longer length of time, it could assist patients regulate their lipid profile and HbA1c levels and the patients' lipid profiles (25). Millets further decreased the levels of triacylglycerol by lowering VLDL cholesterol, which is a plasma transporter of triacylglycerol. This suggests that millets are essential for lowering triacylglycerol levels. (16)

7. **Obesity:** Global rates of overweight and obesity are rising quickly. One of the most crucial factors for losing weight is eating healthily. Fat cells accumulate in the body as a result of obesity. The biggest cause of obesity is the way we live. The consumption of high-fat, high-oil, and high-sugar meals, as well as fast food, processed foods, irregular meal times, and a lack of exercise are some of the variables that lead to the development of obesity. (18) The phenolic chemicals chlorogenic acid, p-coumaric acid, caffeic acid, ferulic acid, and syringic acid are abundant in foxtail millet. In addition, it contains the carotenoids zeaxanthin and xanthophylls. The phytochemicals in foxtail millet have the ability to scavenge free radicals. (17)

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Since obesity is an inflammatory illness, the generation of free radicals is a direct result of the inflammation. In order to neutralize free radicals and lessen inflammation, dietary antioxidants are essential (18). According to a study in the American Chemical Society, foxtail millet has a sizable amount of phenolic compounds and has chelating, antioxidant, and reducing properties for metals .(17)

Treatment for obesity involves modifying one's lifestyle to include healthier food and more exercise. The eating of whole grains has been found in trials to reduce the risk of obesity. The endosperm, germ, and intact bran from the plant are all present in whole grains .(17, 18) Eating whole grains as part of a balanced diet lowers the risk of developing cardiovascular diseases, diabetes, and obesity. One of the most environmentally friendly methods for weight reduction is to switch from refined to whole grains as they are the primary source of nutrients that provide energy. (18) It has been shown that the GI, or glycaemic load, and obesity are connected.

VIII. CONCLUSION

Numerous fundamental nutrients that are important for the body's nutrition and maintenance may be found in foxtail millet. They are jam-packed with a variety of nutrients, including protein, calcium, sodium, magnesium, phosphorus, and vitamins A and E. It is prepared such that the nutritional value is not diminished in any manner. Patients with celiac disease can eat it because it has less gluten and little GI. In nutritional and medical study, foxtail millets' health benefits have become more significant. In addition to serving as an energy source, foxtail millet is frequently used in the treatment of obesity and weight loss, colorectal cancer, and peptic ulcers as well as the prevention of diabetes, hyperlipidemia (by lowering LDL and VLDL levels of bad cholesterol), hypertension, and fungal infections. Foxtail millet's extensive antioxidant effect and anti-ulcer response, which maintains the gastroprotective effects on the experimental gastric mucosal lesions in rats, are valuable in protecting against the growth and development of the injury to the acute gastric mucosa. Whole grain consumption has been associated with a lower risk of the main chronic illnesses. The adlay diet and foxtail millet have no known adverse effects because they are natural products. In cases of stomach ulcer, it plays a good preventive role. It contains bioactive substances such carotenoids, bioactive peptides, and tocols. Due to its high vitamin content and microbial fermentation, which aids in digestion, it is advantageous for malnutrition.

As a result, it is determined that because foxtail millet is high in macro- and micronutrients, it should be a part of everyone's daily diet. The collaboration of national, international, and state-level feeding programs would undoubtedly aid in overcoming nutritional shortages, especially in underdeveloped nations, as it is not so widely known and is only confined to the traditional people.

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