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MINOR MILLETS: INTRODUCTION, UTILIZATION, AND FUTURE PROSPECTS

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INTRODUCTION

Minor millets are a diverse group of small-seeded, nutrient-rich cereal crops belonging to the family Poaceae, excluding sorghum and pearl millet. This group includes Foxtail millet (Setaria italica), Proso millet (Panicum miliaceum), Kodo millet (Paspalum scrobiculatum), Barnyard millet (Echinochloa crus-galli), Little millet (Panicum sumatrense), Browntop millet (Brachiaria ramosa), Job's Tear (Coix lacryma-jobi), Fonio (Digitaria exilis), and Teff (Eragrostis tef). Historically, these crops were widely cultivated and consumed across India, as documented in ancient texts like Kautilya's Arthashastra and the Ain-i-Akbari. However, during the Green Revolution, millet cultivation declined significantly due to the introduction of high-yielding rice and wheat varieties. In recent years, growing health awareness and the need for climate-resilient crops have renewed interest in minor millets, as their high nutritional value, low glycemic index, gluten-free nature, and adaptability to marginal lands make them a promising solution for enhancing food and nutritional security.

Utilization and Importance of Minor Millets

Minor millets serve multiple purposes across agriculture, nutrition, and industry. Foxtail and Proso millet have become model crops for studying salinity stress and plant adaptation. The "Xiaomi" mutant of Foxtail millet, with its fully sequenced genome, compact size, short life cycle, and high transformation efficiency, is now considered an ideal C4 model plant for molecular and physiological studies. Their rich nutrient profile has also increased their use in baby foods. Proso millet is valued for its lecithin and phosphorus content, supporting brain development, while Barnyard millet, rich in iron, helps prevent anemia. Little millet contributes healthy cholesterol and phosphorus for growth, and Foxtail millet provides more protein than wheat and 30 times more fiber than rice. It is important to note that excessive polishing of millet grains can reduce these nutritional benefits.

Beyond human nutrition, minor millets are also valuable for biofuel production. Foxtail millet biomass, rich in lignocellulose, is particularly efficient for ethanol conversion. Among millet husks, Barnyard millet shows the highest ethanol yield, while Proso millet exhibits fermentation efficiencies of up to 97%, making it a feasible alternative to maize. In the Indian diet, millets hold cultural and culinary significance. They are consumed in the form of rotis, khichdi, dosas, upma, porridges, cakes, and even sweets such as kheer and halwa. Certain millets are used during fasting, and in specific regions, they have unique traditional uses: Barnyard millet in Uttarakhand is made into paleu or chencha, Foxtail millet is consumed as "millet rice" or sargati in tribal areas, and Kodo millet often substitutes rice due to its similar texture.

Minor millets also serve as excellent animal feed and fodder. Foxtail millet is popular as bird feed and cattle fodder, Barnyard millet yields 6.3 tons per hectare of straw containing 7.6% protein and 23% fiber, and Proso millet is widely used in poultry feed, lamb fattening, and pet food. Additionally, these grains have non-conventional applications such as biodegradable packaging, where Barnyard millet starch is combined with borage seed oil to make eco-friendly films. Millet extracts are employed in green nanotechnology for synthesizing silver nanoparticles for medical and agricultural purposes, and millet hulls are used as pillow fillings due to their high fiber content.

Role of Minor Millets in Sustainability

Minor millets are climate-smart crops, capable of thriving in poor soils, drought-prone areas, and high-temperature zones while requiring minimal inputs, making them ideal for rainfed farming systems. They also contribute to

environmental sustainability by producing significantly lower greenhouse gas emissions—approximately 3,218 kg CO_2 per hectare—compared to rice, wheat, and maize. Species such as Little millet adapt to water scarcity through deeper root systems, increased antioxidant activity, and the production of compounds like glycine betaine, which enhance drought resistance. Millet-based farming systems improve soil health by increasing nitrogen, phosphorus, and potassium levels, enriching soil organic carbon, boosting microbial activity through intercropping with legumes, strengthening soil structure, and reducing erosion via deep-rooted systems.

Challenges in Minor Millet Improvement

Despite their benefits, minor millets face several challenges. A narrow genetic base restricts breeding progress, with Foxtail millet possessing the largest gene bank collection while many other species lack complete genome sequencing, limiting research. Biotechnological tools are underutilized because minor millets lack efficient tissue culture and genetic transformation systems, leaving conventional breeding as the dominant method. Pest infestations and storage issues further threaten productivity, with over 150 insect species attacking these crops, including shoot flies causing "dead hearts," stem borers damaging stems and panicles, armyworms leading to defoliation, and termites and grain weevils affecting both standing crops and stored grains.

Future Prospects and Solutions

The future of minor millets lies in advanced breeding, genomics, and integrated management practices. Breeding strategies focus on developing waxy grain varieties preferred by consumers, producing disease-resistant and shade-tolerant cultivars, and improving seed size and culm strength to enhance yield and milling efficiency. Comparative genomics with well-studied crops can identify beneficial genes, while interspecific hybridization and CRISPR/Cas9 gene editing, along with Agrobacterium-mediated transformation, show promise for improving stress tolerance and productivity, particularly in Foxtail millet. Integrated pest management (IPM), including early sowing, crop rotation, biological controls such as Trichogramma parasitoids, and selective insecticides like Spinosad, Chlorpyrifos, and Imidacloprid, provides an effective approach for managing pests.

Government Initiatives

To support the revival of millet cultivation, the Department of Agriculture and Farmers' Welfare (DA&FW), under the National Food Security Mission (NFSM), has launched a Sub-Mission on Nutri-Cereals. This initiative aims to promote millet farming, improve farmer incomes, and enhance nutritional security.

CONCLUSION

Minor millets are more than just ancient grains; they are nutrient-dense, climate-resilient, and eco-friendly crops with diverse applications in food, biofuels, fodder, and industry. While challenges such as limited research, pest infestations, and low productivity remain, advancements in biotechnology, genomics, and government policies are opening new opportunities for their revival. Promoting millet-based agriculture can ensure food security, improve health outcomes, and foster sustainable farming in the face of climate change.

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