

Farm Science Today

BRIDGING SCIENCE AND FARMING

From the Editor's Desk

Dear Readers,

It gives me immense pleasure to present the October 2026 issue of Farm Science Today, a monthly e-magazine dedicated to bringing scientific agricultural knowledge closer to the farming community. The fundamental objective of this magazine is to bridge the gap between agricultural research and its practical application in the field by presenting contemporary scientific information in a simple, accessible and farmer-friendly manner.

Agriculture is undergoing rapid transformation. Farmers today are facing multiple challenges arising from climate variability, changing consumer preferences, increasing input costs, soil degradation, declining natural resources and the need for safe and nutritious food. In this changing scenario, the role of scientific knowledge, innovation and effective agricultural extension has become more important than ever. The present issue attempts to address some of these emerging dimensions of agriculture.

A particularly important theme covered in this issue is natural farming and the role of agricultural extension in its promotion. The article on Agricultural Extension Services for Strengthening Natural Farming highlights the importance of awareness creation, capacity building, behavioural change, demonstrations, farmer field schools and participatory learning in encouraging farmers to adopt sustainable practices. The discussion also draws attention to the challenges faced by extension systems, including inadequate human resources, limited infrastructure, lack of standardized protocols, weak institutional convergence and gaps in monitoring and impact assessment.

The issue further explores the institutional dimensions of natural farming. Farmer Producer Organizations, Self-Help Groups and cooperatives have considerable potential to strengthen collective action, improve access to inputs and technology, facilitate capacity building and create better market opportunities for farmers. A coordinated and farmer-centric institutional ecosystem can therefore play a crucial role in making sustainable agriculture economically viable as well as environmentally responsible.

Another noteworthy feature of this issue is its focus on nutritionally important and value-oriented crops. The article on leafy mustard highlights the nutritional and medicinal potential of traditional leafy vegetables, including their bioactive compounds, vitamins and minerals. Similarly, the article on finger millet presents its nutritional richness, particularly its dietary fibre, calcium and other important nutrients, while also discussing opportunities for value-added products. The issue also takes readers into the fascinating world of crop science and molecular biology through the article on waxy maize. The discussion explains how mutation in the waxy1 (wx1) gene affects amylose synthesis and results in the accumulation of amylopectin, giving waxy maize distinctive nutritional and industrial characteristics. As agriculture becomes increasingly knowledge-intensive, we believe that farmers, students, researchers, extension professionals and policymakers must remain connected with emerging scientific developments. Farm Science Today will continue its endeavour to provide credible, practical and relevant agricultural information while giving adequate attention to innovation, sustainability, entrepreneurship, nutrition and farmer empowerment.

I sincerely thank all the authors and contributors for sharing their knowledge and expertise with our readers. I also invite researchers, teachers, extension professionals, students and practitioners to contribute articles that can transform scientific knowledge into meaningful action in the field.

Let us continue to learn, innovate and work together for a scientifically empowered, sustainable and prosperous farming community.

Editor

Farm Science Today

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Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 07-09-2026

Published: 02-10-2026

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Molecular Basis of Waxy Maize: From *Waxy1* Mutation to High Amylopectin Maize

Introduction

Maize is a versatile crop that holds immense economic importance as a source of food, feed and raw material for various industries (Murdia et al., 2016). It is a nutritionally rich crop that serves various health benefits (Murdia et al., 2016). Waxy maize, popularly known as ‘sticky maize’ or ‘glutinous maize’ so named because of the waxy appearance of its kernel due to presence of almost 100% amylopectin in its starch, as a result of mutation in the *waxy1* (*wx1*) gene (Talukder Z. A. et al., 2022). It shows a higher viscosity and greater digestibility compared to the normal maize (Gu et al., 2020); high viscosity of amylopectin makes the starch of waxy grains suitable for adhesive, paper and textile industries (Hossain et al., 2019). It is also gaining popularity as a vegetable and breakfast food in various parts of the world and is also being consumed as a staple food by various ethnic groups (Talukder Z. A. et al., 2022) that is why it has been regarded as the “new nutritional health food,” “green vegetable,” and “longevity food” (Zhang et al., 2024). Thus, waxy maize holds immense potential as a food, feed and industrially important crop due to its special starch characteristics (Devi et al., 2017).

Composition of starch in maize kernel:

The major portion of the maize grain is occupied by starch (68-74 %) in the triploid (3n) endosperm (Singh N. et al., 2014). It is composed of two components, amylose and amylopectin (Stamp et al., 2017). Amylopectin is a branched chain polymer with α -1,4 glycosidic linkage and α -1,6 glycosidic branched linkage while amylose is a linear chain with α -1,4 glycosidic linkage (Stamp et al., 2017; Martin C. et al., 1995) (Figure 1). The wild-type *Waxy1* (*Wx1*) gene encodes for granule bound starch synthase1 (GBSS1) enzyme responsible for the synthesis of amylose but, recessive mutations in the *waxy1* (*wx1*) gene impairs the synthesis of GBSS1 enzyme, that results in almost null synthesis of amylose and nearly complete accumulation of amylopectin (Talukder Z. A. et al., 2022). The soluble starch synthase enzymes (SSSs) are responsible for the synthesis of branched-chain amylopectin (Yu G. et al., 2022).

Structure of Amylose

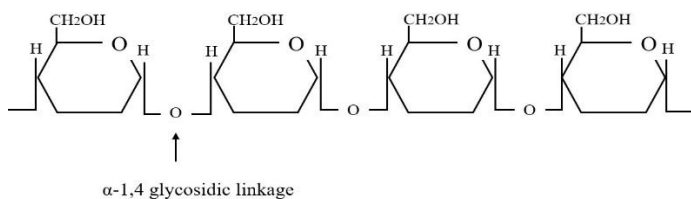
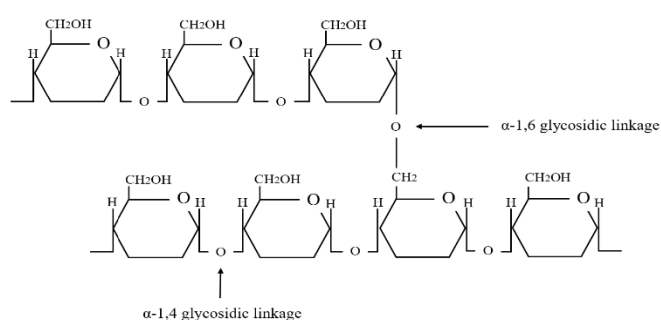


Fig. 1: Structure of Amylose and Amylopectin

The short-branched (DP, <17) chains and long-branched (DP, 30-80) chains were found to be negatively

Structure of Amylopectin



correlated with the *waxy1* (*wx1*) gene dosage while the intermediate-branched (DP, 17-30) chains and extra-long branched (DP >80) chains were positively correlated with the *waxy1* (*wx1*) gene dosage (Yangcheng et al., 2016). In addition, the molecular weight of amylopectin shows differences in the normal and waxy maize, where it is smaller in case of normal maize and higher in waxy maize (Yangcheng et al., 2016).

amylopectin in maize

Biosynthesis of starch

Biosynthesis of starch in maize involves the conversion of photosynthetic product, sucrose into fructose and UDP-glucose (UDPG), catalysed by sucrose synthase (SUS) (Li C. et al., 2017). The biosynthesis pathway of the kernel starch components is given in Figure 2. UDPG releases glucose-1-phosphate which is subsequently converted into ADP-glucose by ADP-Glucose pyrophosphorylase (ADPase) (Li C. et al., 2017). ADPG is a key precursor for the synthesis of both amylose and amylopectin (Ji D. et al., 2026). The ADPG from the cytosol is then transported to amyloplast, where it is catalysed by different proteins to synthesize amylose and amylopectin (Niu L. et al., 2023). Granule bound starch synthase1 (GBSS1), the product of *wild-type Waxy1* gene directs the synthesis of amylose while soluble starch synthases (SSSs) viz. SSI, SSII and SSIII primarily directs the elongation of amylopectin chains with varying degree of polymerization (DP) (Ji D. et al., 2026). Starch branching enzymes (SBEs) creates branches in the amylopectin chains through α -1,6 glycosidic linkages and debranching enzymes (DBEs) viz. isoamylase and pullulanase removes improperly positioned branches to refine the amylopectin structure (Ji D. et al., 2026). Zhang et al. (2024) reported that waxy maize had the highest content of amylopectin B1-chain (DP 13–24) and secondary proportion of A chain (DP 6–12) and low proportions of B2- (DP 25–36) and B3-chains (DP $\geq$ 37). They also reported a positive correlation of SBE activity with the proportion of A-chain and negative correlation with the proportion of B3-chain and average chain length, but DBE activity showed the almost opposite relation (Zhang et al., 2024).

Molecular mechanism of high amylopectin maize

Collins reported that *wx1* gene located it on the short arm of chromosome Collins, 1909). The coding region of *wx1* gene comprises 3718 bp which is

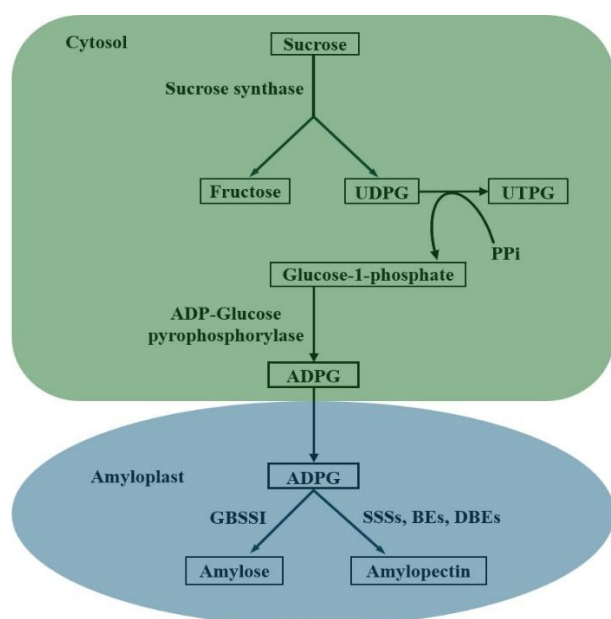


Fig. 2: Biosynthetic pathway of kernel amylose and amylopectin

composed of 14 exons, ranging in size from 64 to 392 bp, and 13 introns of 81 to 139 bp where the exon and the promoter regions are G-C rich (Huang et al., 2010). The region upstream of maize waxy locus possesses higher nucleotide polymorphism than the coding region does (Huang et al., 2010). The diversity of waxy maize due to mutations in the *wx1* gene is largely associated with structural changes such as insertions or deletions (Huang et al., 2010). These mutations can affect the *wx1* gene either by disrupting its coding sequence or by altering its regulatory regions, thereby causing synthesis of altered transcript with premature stop codon or change in amino acids in key domain or translational errors that in turn stops the activity of wild-type (*Wx1*) allele leading to reduced or null synthesis of amylose (Huang et al., 2010; Devi et al., 2017). More than 50 mutant waxy alleles have been identified among which the mutants *wx-m1*, *wx-m5*, *wx-m6*, *wx-m7*, *wx-m9*, *wx-B3*, *wx-B4* and *wx-hAT* results from Ac/Ds insertion system (Luo et al., 2020; Huang B.-Q. et al., 2010). Mutants such as *wx-stonor*, *wx-G*, *wx-B5*, *wx-I*, *wx-K*, *wx-M*, *wx-Cin4* and *wx-Rina* contains RNA transposon (retrotransposons) insertion (Luo et al., 2020; Varagona et al., 1992). Mutant *wx-m8* is an insertion mutation of the *dSpm* element, *wx-844* is a mutation caused by the *En/Spm* element and *wx-D7* and *wx-D10* are deletion mutants (Luo et al., 2020). A fine structure map of the *waxy1* locus was studied to better understand the relationship between various waxy mutants, (Wessler S.R. et al., 1985). Ji D. et al., (2026) identified “soft-waxy maize” a novel type of waxy maize that exhibited extra soft texture and several distinct characteristics. The schematic daigram showing the molecular mechanism of mutant *wx1* gene causing high amylopectin maize is given in Figure 3.

Conclusion

Further studies can be taken up to explore the diversity of new *wx1* alleles and understanding how different mutations affect GBSS1

activity, starch composition and the fine structure of amylopectin. The use of genome sequencing, transcriptomics, metabolomics and other multi-omics approaches can help in identifying new genes and regulatory pathways involved in starch biosynthesis. The recent identification of “soft-waxy maize” with different starch properties also provides an opportunity to develop waxy maize with specific eating and industrial qualities by understanding the molecular mechanisms controlling starch structure. Genome-editing technologies may further help in developing improved waxy maize cultivars by utilizing the favourable mutant allele of *wx1* gene in breeding programs. Employing suitable plant breeding methods to develop improved waxy maize cultivars with improved starch properties, nutritional quality would be beneficial for famers and industries.

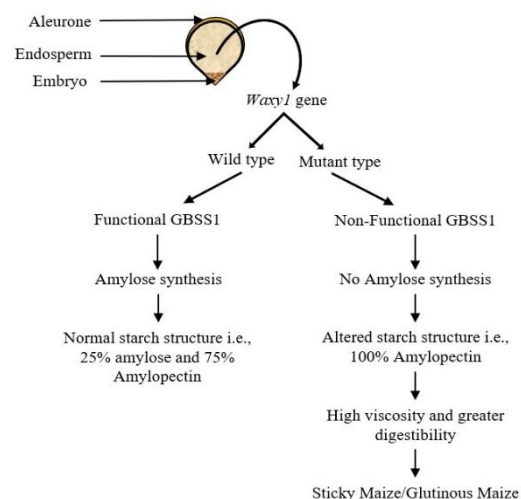


Fig. 3: Wild type and mutant type expression of *Waxy1* gene in maize

References:

- Devi, E. L., Hossain, F., Muthusamy, V., Chhabra, R., Zunjare, R. U., Baveja, A., Jaiswal, S. K., Goswami, R., & Dosad, S. (2017). Microsatellite marker-based characterization of waxy maize inbreds for their utilization in hybrid breeding. *3 Biotech*, 7: 316. <https://doi.org/10.1007/s13205-017-0946-8>
- Gu, W., Yu, D., Guan, Y., Wang, H., Qin, T., Sun, P., Hu, Y., Wei, J., & Zheng, H. (2020). The dynamic transcriptome of waxy maize (*Zea mays* L. sinensis Kulesh) during seed development. *Genes &*

3. Genomics, 42: 997–1010. <https://doi.org/10.1007/s13258-020-00967-z>
4. Hossain, F., Chhabra, R., Devi, E. L., Zunjare, R. U., Jaiswal, S. K., & Muthusamy, V. (2019). Molecular analysis of mutant granule-bound starch synthase-I (*waxy1*) gene in diverse waxy maize inbreds. *Biotech*, 9: 3. <https://doi.org/10.1007/s13205-018-1530-6>
5. Hossain, F., Muthusamy, V., Bhat, J. S., Zunjare, R. U., Kumar, S., Prakash, N. R., & Mehta, B. K. (2022). Maize Breeding. In D. K. Yadava et al. (Eds.), *Fundamentals of Field Crop Breeding* (pp. 221–253). Springer Nature Singapore Pte Ltd. https://doi.org/10.1007/978-981-16-9257-4_4
6. Hossain, F., Zunjare, R. U., Muthusamy, V., & Prasanna, B. M. (2022). Biofortification of maize for nutritional security. In S. Kumar, S. N. Sanyal, & K. K. Sharma (Eds.), *Biofortification of Staple Crops* (pp. 147–174). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-3280-8_6
7. Huang, B.-Q., Tian, M.-L., Zhang, J.-J., & Huang, Y.-B. (2010). *waxy* locus and its mutant types in maize (*Zea mays* L.). *Agricultural Sciences in China*, 9: 1–10. [https://doi.org/10.1016/S1671-2927\(09\)60061-4](https://doi.org/10.1016/S1671-2927(09)60061-4)
8. Ji, D., He, Y., Ran, J., Fu, Z., Liu, X., He, Z., Xing, G., Wang, J., & Zhou, L. (2026). Comparative analysis of starch structure and multi-omics profiles reveals candidate pathways associated with a novel soft-waxy maize trait. *Frontiers in Plant Science*, 17: 1784081. <https://doi.org/10.3389/fpls.2026.1784081>
9. Li, C., Huang, Y., Huang, R., Wu, Y., & Wang, W. (2017). The genetic architecture of amylose biosynthesis in maize kernel. *Plant Biotechnology Journal*, 16: 688–695. <https://doi.org/10.1111/pbi.12821>
10. Luo, M., Shi, Y., Yang, Y., Zhao, Y., Zhang, Y., Shi, Y., Kong, M., Li, C., Feng, Z., Fan, Y., Xu, L., Xi, S., Lu, B., & Zhao, J. (2020). Sequence polymorphism of the *waxy* gene in waxy maize accessions and characterization of a new *waxy* allele. *Scientific Reports*, 10: 15851. <https://doi.org/10.1038/s41598-020-72764-3>
11. Martin, C., & Smith, A. M. (1995). Starch biosynthesis. *The Plant Cell*, 7: 971–985. <https://doi.org/10.1105/tpc.7.7.971>
12. Niu, L., Liu, L., Zhang, J., Scali, M., Wang, W., Hu, X., & Wu, X. (2023). Genetic engineering of starch biosynthesis in maize seeds for efficient enzymatic digestion of starch during bioethanol production. *International Journal of Molecular Sciences*, 24(4), 3927. <https://doi.org/10.3390/ijms24043927>
13. Singh, N., Kaur, A., & Shevkani, K. (2014). Maize: Grain structure, composition, milling, and starch characteristics. In D. P. Chaudhary, A. Kumar, & S. Babu (Eds.), *Maize: Nutrition dynamics and novel uses* (pp. 65–76). Springer India. https://doi.org/10.1007/978-81-322-1623-0_5
14. Stamp, P., Eicke, S., Jampatong, S., Le-Huy, H., Jompuk, C., Escher, F., & Streb, S. (2017). Southeast Asian waxy maize (*Zea mays* L.), a resource for amylopectin starch quality types? *Plant Genetic Resources*, 15(5), 430–437. <https://doi.org/10.1017/S1479262116000101>
15. Talukder, Z. A., Muthusamy, V., Chhabra, R., Gain, N., Reddappa, S. B., Mishra, S. J., Kasana, R., Bhatt, V., Chand, G., Katral, A., Mehta, B. K., Guleria, S. K., Zunjare, R. U., & Hossain, F. (2022). Combining higher accumulation of amylopectin, lysine and tryptophan in maize hybrids through genomics-assisted stacking of *waxy1* and *opaque2* genes. *Scientific Reports*, 12(1), Article 706. <https://doi.org/10.1038/s41598-021-04698-3>
16. Varagona, M. J., Purugganan, M., & Wessler, S. R. (1992). Alternative splicing induced by insertion of retrotransposons into the maize *waxy* gene. *The Plant Cell*, 4(7), 811–820. <https://doi.org/10.1105/tpc.4.7.811>
17. Yangcheng, H., Blanco, M., Gardner, C., Li, X., & Jane, J.-l. (2016). Dosage effects of *Waxy* gene on the structures and properties of corn starch. *Carbohydrate Polymers*, 149, 282–288. <https://doi.org/10.1016/j.carbpol.2016.04.100>
18. Yu, G., Gaoyang, Y., Liu, L., Shoaib, N., Deng, Y., Zhang, N., Li, Y., & Huang, Y. (2022). The structure, function, and regulation of starch synthesis enzymes SSIII with emphasis on maize. *Agronomy*, 12(6), Article 1359. <https://doi.org/10.3390/agronomy12061359>
19. Zhang, H., Qin, F., Xu, G., Geng, S., Yuan, Y., Wang, M., Jiao, F., & Chen, J. (2024). The relationship between starch synthesis enzyme activity, gene expression, and amylopectin fine structure in waxy maize. *Cereal Research Communications*, 52(4), 1579–1586. <https://doi.org/10.1007/s42976-024-00509-3>

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 12-09-2026

Published: 02-10-2026

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Leafy Mustard: Nutritional and Medicinal Potential in Northeast India

Introduction

Leafy mustard is among the most well-known vegetables with nutritional and medicinal values. Underlining this, the climatic condition and traditional farming practices of the Northeast India are ideal for organic farming. Researches reveal the presence of different kinds of bioactive compounds in mustard greens and the leafy mustard varieties mainly include *Brassica juncea*, *Brassica rapa*, and *Brassica nigra*. These include glucosinolates, isothiocyanates, and phenolic compounds with several health benefits such as antioxidant, anti-inflammatory, and anticancer effects. Besides, vitamins A, C, and K along with selenium and other trace elements support the immune system, eye and bone health and enhance antioxidant potential of the crops. Consequently, the varieties of leafy mustard have gained prominence in the dietary and medicinal value of Northeast Indian food systems, particularly in their adaptation to local environments that potentially contribute to the public health.

Nutritional Potential of Leafy Mustard

Leafy mustard is rich in various bioactive constituents, which play a vital role in determining its therapeutic properties. The glucosinolates commonly found in Brassica family have been shown to be extensively metabolized into isothiocyanates possessing strong antioxidant and anti-inflammatory activities (Poyil et al., 2023). The phenolic compounds found in the green also exhibit antioxidant properties which are vital in mitigating chronic diseases risk (Rashmi & Negi, 2020). Coupled with its high content in essential vitamins(A,C,K) and micro minerals (particularly selenium) , the greens help strengthen the physiological functions that support immunity (Vitamins A), support eye health (Vitamins C & K) and promotes bone density (Vitamin K). These nutritional properties found in the varieties cultivated in the northeast of India, support the widespread use of mustard greens in the dietary practices of the region as its distinct culinary preferences and status as a functional food source that elevates collective well-being and health among its people. In addition, the unique climatic features of Northeast India play a role in the enhanced bioactive properties of leafy mustard.

The moderately cool climate and high rainfall in the region allows for the growth of mustard greens with better accumulation of bioactive compounds such as glucosinolates and phenolics (Saini et al., 2022). Moreover, organic farming is widely practiced in the region, which avoids the use of synthetic fertilizers and pesticides that could adversely affect the bioactive properties of mustard greens. Farming without synthetic agrochemicals also improves the efficacy of bioactive compounds in leafy mustard, thereby increasing the accumulation of vitamins and minerals that are beneficial for human health (Sharma et al., 2021). The environmental factors, coupled with the organically - produced practices therefore guarantee that varieties of mustard cultivated in Northeast India stand out in their nutritive value, offering unique and far-reaching health benefits.

Medicinal Benefits of Leafy Mustard

Glucosinolates and their hydrolytic products derived from bioactive components, including isothiocyanate molecules found in leafy mustard, hold considerable medicinal values that go beyond the purview of the nutrient's nutrition contribution. Isothiocyanates contained in these leaves have been reported as effective antioxidants, scavenging free radicals and decreasing oxidative stress, known to be responsible for chronic degenerative diseases including cardiovascular disease (Meena et al., 2022). Likewise, these bioactive constituents have profound anti-inflammatory effects that modulate the body inflammation response and reduce the progression of diverse inflammatory disease (Pant et al., 2020). More importantly, scientific studies have revealed the anticancer mechanism of the isothiocyanates, which has been noted to trigger apoptosis and prevent the proliferation of malignant cells, thus providing a potential intervention for cancer preventive measures. With the medicinal role these health claims highlighted

contributes to the biological importance attached to the leafy mustard as a common source of nutrient in traditional diets in Northeast India, particularly used in folk medicine as therapeutic food source. Furthermore, the anti-hyperlipidemic and health promoting efficacy of bioactive compounds comprising of phenolics and vitamins in mustard leafy vegetables are vital for combating chronic disease complications such as cardiovascular disease (CVD). Free radical production results in oxidative stress, increasing individual susceptibility towards many chronic diseases which can be countered with the inclusion of leaf mustard in its antioxidant-rich capacity due to its phenolics (Rashmi & Negi, 2020). Leaf mustard also serves as an excellent source of vitamins A, C and K that provides immunity, promoting eyesight and preserving bone density wherein vitamin A significantly promotes eyesight and the prevention of night blindness, vitamin C serves as collagen synthesizer promoting immunity (Ibrahim et al., 2023). Vitamin K also takes its credit for preserving bone health by promoting calcium metabolism reducing chances for osteoporosis through improved bone density. The above description provides key insight on health promoting potential of leafy mustard due to defined and undetermined bioactive compounds present in it.

Varieties of Leafy Mustard in Northeast India

The mustard greens are well known cultivars in Northeast India, comprising of varied species under the Brassica genus, namely *Brassica juncea*, *Brassica rapa* and *Brassica nigra*. Each of these species are known to possess unique bioactive metabolites and hence are a good source of nutraceuticals and phytochemicals. Among the species, *Brassica juncea* is highly polymorphic and is rich in phytochemical content such as glucosinolates which provide significant antioxidant and anticancer activity (Sharma et al., 2020). *Brassica rapa* and *Brassica nigra* adds to the phenolic and vitamin diversity and yield enhanced health benefits (Sharma et

al., 2024). The variation in climate enables these unique species to grow and explore vast bioactivity and health benefits while supporting diversity in traditional dishes that can be incorporated in the daily diets of the natives (Li et al., 2023).

Conclusion

The above bioactive compounds, particularly certain varieties of leafy mustard in Northeast India, converge on prized attributes of nutrition and medicinal utility. Besides their bioactive compounds, the distinctive mustard greens contain significant vitamins and minerals, adding to their antioxidant, anti-inflammatory and cancer prophylactic characteristics. The region's unique agro-climatic profile caters to the growth of leafy mustard, which thrives under organic cultivation. Combining these two factors hints to their bioactive content - the bioactive compounds in the greens and brassica hints to their traditional use Edibility in Northeast India. Hence, the convergence hints to these bioactive benefits and that leafy mustard perpetrators are invaluable gastronomically and therapeutically. In this light, their historical use in medicine and as an ordinary and collective marker of cuisines and eating habits showcases the diversity of rare mustard greens in local and regional context, marrying health preservation with biodiversity practices.

References

- Ibrahim, R. M., Eltanany, B. M., Pont, L., Benavente, F., ElBanna, S. A., & Otify, A. M. (2023). Unveiling the functional components and antivirulence activity of mustard leaves using an LC-MS/MS, molecular networking, and multivariate data analysis *Food Research International*, 168, 112742. <https://www.sciencedirect.com/science/article/pii/S0963996923002879>
- Li, Z., Di, H., Cheng, W., Zhang, Y., Ren, G., Ma, J., Yang, J., Huang, Z., Tang, Y., Zheng, Y., & Li, H. (2023). Variation in health-promoting compounds and antioxidant activities in mustard (*Brassica juncea*) sprouts. *Scientia Horticulturae*, 309, 111673. <https://www.sciencedirect.com/science/article/pii/S030442382200783X>
- Meena, R. K., Kumari, M., Koli, G., & Meena, R. (2022). Leafy mustard: A healthy alternative to green vegetables. *J. Biotica Research Today*, 4(5), 376–378. <https://bioticapublications.com/journal-backend/articlePdf/91230fc0ce.pdf>
- Pant, U., Bhajan, R., Singh, A., Kulshethra, K., Singh, A. K., & Punetha, H. (2020). Green leafy mustard: A healthy alternative. *Electronic Journal of Plant Breeding*, 11(01), 267–270. <https://ejplantbreeding.org/index.php/EJPB/article/view/3306>
- Poyil, T., Rasane, P., Singh, J., Kaur, S., Kaur, J., Gunjal, M., Avinashe, H., Dubey, N., & Mahato, D. S. (2023). Bioactive compounds of mustard, its role in consumer health and in the development of potential functional foods. *Current Nutrition & Food Science*, 19(9), 950–960. <https://www.benthamdirect.com/content/journals/cnf/10.2174/1573401319666230309151954>
- Rashmi, H. B., & Negi, P. S. (2020). Health benefits of bioactive compounds from vegetables. In *Plant-derived bioactives: Production, properties and therapeutic applications* (pp. 115–166). Springer. https://link.springer.com/chapter/10.1007/978-981-15-1761-7_5
- Saini, R. K., Yu, J. W., Song, M. H., Ahn, H. Y., Lee, J. H., Keum, Y. S., & Lee, J. H. (2022). Profiling of Redox-Active Lipophilic Constituents in Leaf Mustard (*Brassica juncea* (L.) Czern.) Cultivars Using LC-MS and GC-MS. *Antioxidants*, 11(12), 2464. <https://www.mdpi.com/2076-3921/11/12/2464>
- Sharma, A., Garg, M., Sharma, H. K., & Rai, P. K. (2024). Mustard and Its Products. In *Handbook of Spices in India: 75 Years of Research and Development* (pp. 2385–2451). Springer Nature Singapore. https://link.springer.com/content/pdf/10.1007/978-981-19-3728-6_33.pdf

- Sharma, D., Nanjundan, J., Singh, L., Singh, S. P., Parmar, N., Sujith Kumar, M. S., Singh, K. H., Mishra, A. K., Singh, R., Verma, K. S., & Thakur, A. K. (2020). Genetic diversity in leafy mustard (*Brassica juncea* var. *rugosa*) as revealed by agro-morphological traits and SSR markers. *Physiology and Molecular Biology of Plants*, 26, 2005–2018. <https://link.springer.com/article/10.1007/s12298-020-00883-2>
- Sharma, P., Roy, M., Roy, B., & Sushant, G. (2021). Nutritional attributes of indigenous vegetables and its consumption in the regions of North Eastern India. *Pharma Innovation Journal*, 10(4), 373–380. https://www.researchgate.net/profile/Priyanka-Sharma-59/publication/350750362_Nutritional_attributes_of_indigenous_vegetables_and_its_consumption_in_the_regions_of_North_Eastern_India/links/606fcda6299bf1c911ba237f/Nutritional-attributes-of-indigenous-vegetables-and-its-consumption-in-the-regions-of-North-Eastern-India.pdf

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 20-09-2026

Published: 02-10-2026

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Agricultural Extension Services for Strengthening Natural Farming

Introduction

Agricultural extension plays a pivotal role in transforming India's farming landscape, particularly in the promotion and adoption of natural farming practices. Agricultural extension refers to the systematic transfer of knowledge, skills, and technology from research institutions to farmers. In the context of natural farming, extension services are instrumental in creating awareness, building capacity, facilitating behaviour change, and promoting community-based learning (Khadse, *et al.*, 2019). Unlike conventional extension models that emphasize high-input technologies, natural farming requires a more participatory, experiential, and localized approach, which extension systems in India are increasingly adopting. In India, the extension system comprising Krishi Vigyan Kendras (KVKs), State Agricultural Universities (SAUs), State Departments of Agriculture, NGOs, and Farmer Producer Organizations (FPOs) serves as the bridge between research institutions and farming communities. Natural farming, characterized by low-cost, chemical-free, and ecological approaches, is gaining significant attention as a sustainable alternative to conventional agriculture (Koner, *et al.*, 2021). It aligns with the principles of agroecology, resource conservation, and soil health regeneration.

However, transitioning millions of farmers especially smallholders from input-intensive methods to nature-based solutions requires structured support, awareness, and capacity building, where agricultural extension becomes critical (Om, *et al.*, 2019). Through on-farm demonstrations, training programs, farmer field schools, and participatory learning models, extension professionals enable farmers to understand and adopt natural farming techniques that enhance productivity while reducing dependence on synthetic inputs. Agricultural extension, therefore, plays a strategic role not only in technology dissemination but also in behaviour change communication, farmer empowerment, and policy implementation. A robust and adaptive extension system is essential for mainstreaming natural farming and achieving long-term sustainability in Indian agriculture.

Challenges in Extension Services for Natural Farming

1. Inadequate Knowledge and Skills: Many extension personnel are trained primarily in conventional, chemical-based agriculture. They often lack adequate knowledge and field experience in natural farming principles such as *Jeevamrut*, *Beejamrut*, mulching, and soil biology. This leads to ineffective advisory services and low farmer confidence (Mondal, *et al.*, 2023).

2. Limited Human Resources and Infrastructure: The ratio of extension workers to farmers remains low, particularly in remote and tribal areas. Lack of mobility, ICT tools, demonstration kits, and decentralized training facilities further limits outreach and follow-up support.

3. Absence of Standardized Protocols: Natural farming practices vary by agro-climatic region and farmer innovation, which results in the absence of uniform technical packages. This creates confusion among both extension staff and farmers, affecting credibility and scalability.

4. Weak Convergence and Institutional Support: Poor coordination among line departments, research institutions, NGOs, and Farmer Producer Organizations (FPOs) limits integrated support systems. Schemes like Bhartiya Prakritik Krishi Paddhati (BPKP) are not fully aligned with existing extension frameworks.

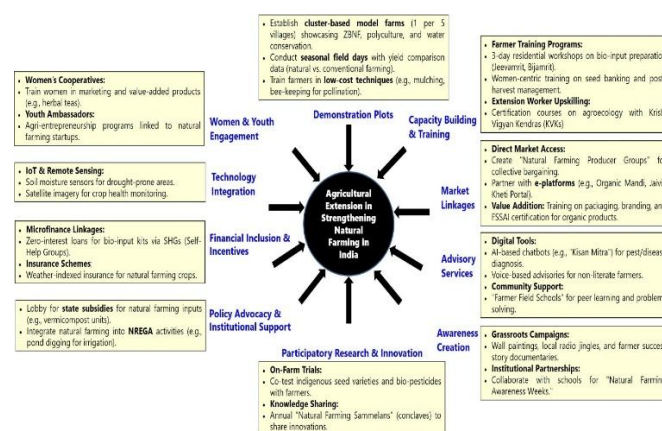
5. Behavioral and Economic Resistance: Farmers often demand visible, short-term returns, while natural farming offers long-term ecological benefits. Extension efforts must overcome scepticism, risk aversion, and social pressures favouring conventional methods (Duddigan, *et al.*, 2023).

6. Monitoring and Impact Assessment Gaps: Lack of scientific data on yield, cost-benefit analysis, and soil

health improvements under natural farming restricts evidence-based promotion by extension services.

Fragmented extension efforts and poor use of demonstration plots further weaken farmer confidence. Strengthening natural farming requires retraining staff, improving digital outreach, linking farmers to markets, and treating natural farming as a holistic socio-ecological shift.

Figure 1. Strategies for strengthening Natural Farming Initiatives



Strategies for strengthening Natural Farming Initiatives

Agricultural extension plays a vital role in promoting natural farming across India by integrating various support mechanisms that empower farmers, build capacity, and enhance sustainability (Kumar, *et al.*, 2023). Technology integration, such as soil moisture sensors and satellite imagery, supports better decision-making in drought-prone areas and improves crop health monitoring. Financial inclusion through microfinance and insurance enables smallholders to access zero-interest loans for bio-input kits and obtain protection through weather-indexed insurance.

Institutional support and favourable policies are crucial for natural farming adoption. Advocating for subsidies on inputs like vermicomposting and integrating natural

farming components into employment schemes such as MGNREGA ensures state-level backing. Farmers' involvement in participatory research, including on-farm trials of indigenous seeds and bio pesticides, helps localize innovation and enhance effectiveness. Knowledge-sharing platforms like annual "Natural Farming Conventions" foster collaboration and farmer-to-farmer learning.

Demonstration plots act as live learning centers, showcasing techniques like Zero Budget Natural Farming (ZBNF), water conservation, and polyculture. Seasonal field days comparing natural and conventional practices, along with low-cost technologies such as mulching and bee-keeping, build practical confidence among farmers. Capacity-building initiatives like 3-day workshops on input preparation, seed banking, and post-harvest techniques strengthen farmers' skills, particularly for women. Certification programs for extension workers further improve service delivery.

Market linkages are vital for economic sustainability. Creating farmer producer groups and connecting them to e-platforms like Organic Mandi and Jaivik Kheti Portal improves bargaining power and market access. Training in packaging, branding, and obtaining organic certification ensures better price realization. Advisory services are enhanced through digital tools like AI-based chatbots and voice advisories for non-literate users, while farmer field schools support peer learning and collective problem-solving.

Awareness creation through grassroots campaigns, local media, and partnerships with schools increases outreach and acceptance of natural farming practices. These efforts ensure that natural farming is not only ecologically sound and climate-resilient but also socially inclusive and economically viable. By adopting this integrated extension approach, India can strengthen its natural farming movement and move toward a more

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sustainable agricultural future.

References

- Mondal, K., Paul, A., & Mondal, P. (2023). *Zero Budget Natural Farming: An Agricultural Revolution, Prospects and Problems. International Journal of Plant & Soil Science*, 35(20), 228-235.
- Om, H., Vijay, V., & Singh, B. (2019). *Zero budget natural farming: A promising model in Indian agriculture. Indian Farming*, 69(1).
- Khadse, A., & Rosset, P. M. (2019). *Zero Budget Natural Farming in India -from inception to institutionalization. Agroecology and Sustainable Food Systems*, 43(7-8), 848-871.
- Koner, N., & Laha, A. (2021). *Economics of alternative models of organic farming: Empirical evidence from zero budget natural farming and scientific organic farming in West Bengal, India. International Journal of Agricultural Sustainability*, 19(3-4), 255-268.
- Duddigan, S., Shaw, L. J., Sizmur, T., Gogu, D., Hussain, Z., Jirra, K., & Collins, C. D. (2023). *Natural farming improves crop yield in SE India when compared to conventional or organic systems by enhancing soil quality. Agronomy for Sustainable Development*, 43(2), 31.
- Kumar, S., Nain, M. S., Sangeetha, V. & Satyapriya (2023). *Determinants and Constraints for Adoption of Zero Budget Natural Farming (ZBNF) Practices. Indian Journal of Extension Education*, 59(4), 135-140.

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 20-09-2026

Published: 02-10-2026

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Institutional Models

Supporting Natural Farming: Pathways for Sustainable Agricultural Transformation

Introduction

Agriculture in developing nations, particularly in India, stands at a critical juncture. It is grappling with the triple challenge of severe soil degradation, plateauing productivity, and an unsustainable dependence on chemical inputs, which has led to rising production costs and farmer indebtedness (Dubey et al, 2025). In this context, natural farming has surged from a niche practice to a mainstream strategy for sustainable agriculture (Kumar et al, 2026). Promoted by initiatives like Andhra Pradesh's Community Managed Natural Farming (APCNF) now one of the world's largest agroecology programs and backed by national policy frameworks such as the National Mission on Natural Farming (NMNF), this approach offers a viable pathway toward regenerative and climate-resilient farming (Thallam & Patel, 2025). Natural farming is increasingly recognized not merely as a set of chemical-free techniques, but as a holistic production model that works in harmony with natural ecosystems. It emphasizes the enhancement of soil organic matter, the restoration of on-farm biodiversity, and a significant reduction in external input costs, thereby boosting farmer autonomy and profitability (Vaja et al, 2024). However, the transition from conventional, input-intensive agriculture to knowledge-intensive natural farming is complex. It demands a robust institutional ecosystem to facilitate the dissemination of knowledge, provide access to finance, and create equitable market linkages. The success of this transition hinges on the strength of farmer-centric institutions.

The Institutional Imperative for a Farming Revolution

Formal and informal institutions provide the essential scaffolding for scaling natural farming. They transform isolated efforts into a powerful collective movement, enabling small and marginal farmers who constitute over 86% of India's agricultural holdings—to overcome chronic limitations. These include:

- **Knowledge Asymmetry:** Bridging the gap between traditional wisdom and modern agroecological science.

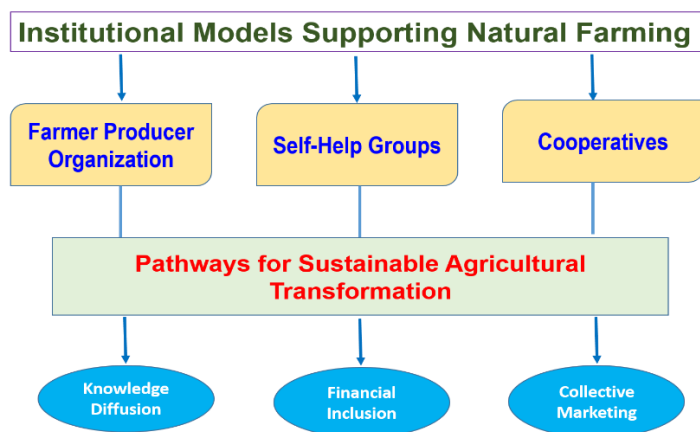
- **Financial Exclusion:** Facilitating access to credit and initial risk capital for the transition period.
- **Market Fragmentation:** Aggregating produce to achieve economies of scale and negotiate better prices.
- **Policy Invisibility:** Providing a collective voice to influence agricultural policy and extension services.

Conceptual Understanding of Natural Farming

Natural farming, also known as Agroecological or Zero-Budget Natural Farming (ZBNF), operates on the principle that nature itself provides all the essential nutrients and pest control mechanisms for crops. It discourages the use of synthetic fertilizers, pesticides, and genetically modified seeds. Instead, it promotes:

- **Jeevamrit** (microbial culture from cow dung and urine),
- **Beejamrit** (Seed treatment with inoculants)
- **Mulching** (soil cover with biomass) and
- **Whapsa** (Soil moisture condition)

Institutional Models Supporting Natural Farming



Farmer Producer Organizations (FPOs) and their Role in Natural Farming

Farmer Producer Organizations are registered entities where farmers collectively engage in input procurement, production, processing, and marketing. They operate under the **Companies Act, 2013** or the **Producer Companies Act, 2002** (Singh, 2016). Farmer Producer

Organizations (FPOs) are vital in advancing natural farming across rural India. They unite small and marginal farmers who often struggle individually to access markets, technology, and financial support. Through collective strength, FPOs help these farmers reduce costs, share knowledge, and gain better bargaining power. In the context of natural farming, which relies on ecological balance and locally available resources instead of synthetic fertilizers and pesticides, FPOs act as a bridge between traditional practices and modern sustainability goals. By organizing workshops, training programs, and demonstrations, FPOs educate farmers about natural farming techniques such as the use of Jeevamrutha, mulching, intercropping, and composting. They also help members access organic inputs at lower costs through bulk procurement. Moreover, FPOs facilitate certification processes and establish direct marketing channels, ensuring that farmers earn fair prices for their chemical-free produce. This collective model not only enhances soil health and biodiversity but also improves farmers' livelihoods by reducing dependency on expensive chemical inputs. In the long run, FPOs contribute to building resilient rural economies by promoting environmentally sound practices, increasing productivity sustainably, and connecting farmers to conscious consumers and green markets. Together, FPOs and natural farming represent a strong movement toward sustainable agriculture that benefits people, the planet, and rural prosperity.

Self-Help Groups (SHGs) and their Role in Natural Farming

SHGs are small, voluntary groups usually of 10-20 members focused on savings, credit, and mutual support. Supported by the National Rural Livelihoods Mission (NRLM), SHGs have evolved as powerful platforms for women's empowerment and local capacity building. Self-Help Groups (SHGs) play an important role in spreading and supporting natural farming, especially

among rural women. These small, community-based groups empower members to save money, access credit, and work collectively toward common goals. In the context of agriculture, SHGs have become strong agents of change by encouraging eco-friendly farming practices that reduce costs and protect the environment. Through SHGs, women farmers share knowledge about natural farming methods such as composting, seed saving, mulching, intercropping, and using bio-fertilizers like Jeevamrutha and Panchagavya. The group setting allows them to learn from each other's experiences, experiment with local resources, and adopt sustainable practices that fit their conditions. SHGs often collaborate with government departments, NGOs, and Farmer Producer Organizations (FPOs) to access training, technical support, and small loans to buy natural inputs or set up compost units. Beyond just improving soil health and crop quality, SHGs help strengthen community resilience and women's economic independence. By promoting chemical-free farming, they reduce input costs and open up new income opportunities through the sale of organic produce, bio-inputs, and value-added products. In this way, SHGs serve as both social and economic platforms that drive the grassroots transformation toward natural farming creating a model that is sustainable, inclusive, and community-led.

Agricultural Cooperatives

Cooperatives are member-owned organizations established to serve the economic and social needs of farmers through mutual aid and democratic control. India's cooperative movement, rooted in the early 20th century, provides the foundation for collective agricultural action. Agricultural cooperatives play a crucial role in promoting and sustaining natural farming practices. These cooperatives are farmer-owned institutions that pool resources, share knowledge, and collectively manage production, processing, and marketing activities. In the shift toward natural farming

an approach that avoids chemical fertilizers and pesticides in favor of biological and ecological methods cooperatives act as catalysts by organizing farmers, ensuring access to natural inputs, and building strong local markets for organic produce. Through training programs and field demonstrations, agricultural cooperatives educate their members about techniques like composting, crop rotation, green manuring, mulching, and the use of bio-fertilizers such as Jeevamrutha and vermicompost. By facilitating bulk procurement of natural inputs and equipment, they help reduce costs for small and marginal farmers. Cooperatives also support the certification of organic produce and develop collective marketing channels, enabling farmers to sell directly to consumers or institutional buyers at fair prices.

Moreover, agricultural cooperatives promote knowledge sharing and community-based problem-solving, which strengthens farmers' confidence to adopt sustainable practices. They encourage collective decision-making, which is essential for maintaining soil health and ensuring long-term productivity. In the bigger picture, cooperatives not only enhance the economic stability of farming communities but also advance environmental conservation by reducing dependence on synthetic chemicals. Thus, agricultural cooperatives serve as powerful engines for scaling up natural farming, empowering farmers, and creating a more resilient and sustainable agricultural system.

Synergistic Institutional Framework

An integrated ecosystem combining the strengths of all three models is vital for scaling natural farming:

- SHGs can serve as the entry-level mobilization units, fostering awareness and local resource management.
- FPOs can handle aggregation, certification, and market linkage.
- Cooperatives can provide infrastructure and financial services for collective processing and branding.

This synergy fosters a multi-level governance structure that aligns with India's agroecological policy goals, such as those outlined in the National Mission on Natural Farming (2023-24) and Paramparagat Krishi Vikas Yojana (PKVY).

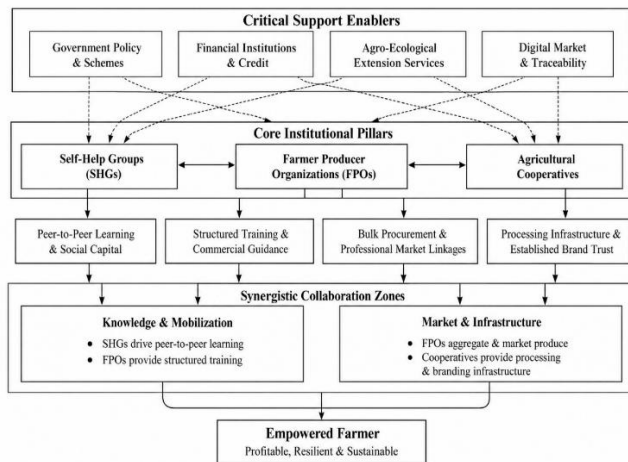


Fig. 2: Ecosystem of Collaboration for Institutional Models Supporting Natural Farming

Policy Implications and Recommendations

- Policy Integration:** Align government programs (PKVY, NRLM, FPO Scheme) to create cross-institutional linkages.
- Capacity Building:** Establish specialized training institutes for natural farming extension workers.
- Digital Infrastructure:** Promote traceability, market access, and certification through digital platforms.
- Financial Inclusion:** Expand access to low-interest credit and insurance tailored for natural farming.
- Gender Empowerment:** Strengthen women-led SHG networks to sustain social capital in farming communities.

Conclusion

Institutional models such as FPOs, SHGs, and cooperatives provide the organizational scaffolding necessary for mainstreaming natural farming. Each model contributes uniquely FPOs through scale and market access, SHGs through inclusivity and mobilization, and cooperatives through infrastructure and long-term stability. A hybrid, synergistic approach

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combining these models represents the most effective pathway for transforming India's agriculture into a sustainable, resilient, and equitable system.

References

- Dubey, A., Singh, P. K., Singh, S., Manzoor, U., Sahoo, C., & Saini, A. (2025). Impact of climate change and land degradation on agriculture. In *Eco-resilience: Climate change, land degradation and sustainable solutions* (pp. 49-95). Cham: Springer Nature Switzerland.
- Kumar, S., Ghasal, P. C., Narwal, E., Kumar, A., Kumar, K., & Choudhary, J. (2026). Natural Farming for Soil Health, Biodiversity and Sustainable Crop Production. *Indian Journal of Fertilisers*, 22(5), 490-503.
- Thallam, V. K., & Patel, R. (2025). Andhra Pradesh community managed natural farming—a conversation. *The Journal of Peasant Studies*, 52(6), 1349-1364.
- Vaja, M., Kulshrestha, K., & Lakhani, H. (2024). Natural farming in India: A sustainable alternative to conventional agricultural practices. *Farm. Manage*, 9, 63-65.
- Singh, S. (2016). Smallholder organization through farmer (producer) companies for modern markets: experiences of Sri Lanka and India. In *Cooperatives, economic democratization and rural development* (pp. 75-100). Edward Elgar Publishing.

Farm Science Today

Presenting scientific knowledge in a simple, accessible style.

ISSN (E): XXXX-XXXX

www.ijari.in

Received: 22-09-2026

Published: 02-10-2026

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Finger Millet: Health Benefits and Value-Added Products

Introduction

Finger Millet (*Eleusine coracana*), also known as Ragi is an important millet grown extensively in Karnataka, and to a limited extent in Andhra Pradesh, Tamil Nadu, Odisha, Maharashtra, Uttarakhand and Goa. Finger millet/ Ragi is one of the minor cereals and important staple food in India for people of low income groups is known for several health benefits and some of the health benefits are attributed to its polyphenol and dietary fiber contents. According to Devi *et.al* (2014), finger millets nutritionally, its importance is well recognised because of its high content of calcium (0.38%), dietary fiber (18%) and phenolic compounds (0.3-3%).

Nutritive value of Ragi

Finger millet is considered one of the most nutritious cereals. Finger millet contains about 5-8% protein, 1-2% ether extractives, 65-75% carbohydrates, 15-20% dietary fiber and 2.5-3.5% minerals, calcium (344mg%) and potassium (408mg%) highest among cereals. 100 grams of ragi has an average of 336 KCal of energy. Being non-glutinous, finger millet is safe for people suffering from gluten allergy and celiac disease. Finger millet is rich in amino acids (Tryptophan, Threonine, Valine, Isoleucine and Methionine). It contains tryptophan which controls our appetite, hence keeps weight under control (Kakade and Hathan, 2015).

Tables 1: Nutrient profile of Finger Millets

Crop	Protein (g)	Fat (g)	Fiber (g)	CHO (g)	Energy (kcal)	Ca (mg)	Fe (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Finger Millet	7.70	1.5	3.6	72.6	336	35	3.9	0.42	0.19	1.1

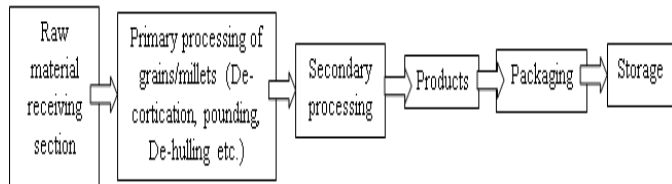
Source: Hulse and others (1980); United States national research council/national academy of sciences (1982); USDA/HNIS (1984).

Health benefits of finger millet (Ragi)

- Finger millet is an excellent source of natural calcium which helps in strengthening bones for growing children and aging people.

- It has phytates, polyphenols and tannins that can contribute to antioxidant activity which is an important factor in health, aging and metabolic diseases.
- Finger millet's phytochemicals help in slowing digestion process.
- This helps in controlling blood sugar level in condition of diabetes.
- Finger millet-based diet helps diabetics as it contains higher fibre than rice and wheat.
- It is a very good source of natural Iron and its consumption helps in recovery of Anemia.
- Finger millet consumption helps in conditions of anxiety, depression and insomnia.
- Green ragi (finger millet) is recommended for conditions of blood pressure, liver disorders, asthma and heart weakness.

Millet Processing Lines



Ragi Laddu

Ingredients: 2 cups Nachani flour, 1 cup Ghee, 1 cup jaggery, 1/2 tsp cardamom powder, 2 to 3 tsp. dried coconut, roasted, 3 tbsp milk, 2 tbsp raisins, cashew nuts, almond slices

Method: In a pan, fry the ghee flour for about 10 to 15 minutes until the flour smells good. Let it cool down. Cook the jaggery and add the roasted flour and once the flour is well roasted, add milk. When milk is added, the flour becomes fluffy. Then mix well. Add roasted dry coconut, cardamom powder, powdered sugar and dried fruits and mix well. Then make laddu.

Ragi Dosa

Ingredients: 1 cup nachani flour, 1/2 cup rice flour, 1/2 cup black gram dal, 7 to 8 fenugreek seeds, salt to taste, a little oil while making dosa

Method: Soak nachani flour and rice flour in water for at least 5 hours. In another bowl, combine black gram dal and fenugreek seeds and soak for 5 hours. After 5 hours, remove the water from the black gram dal and make a fine paste in a mixer. Add water as required and keep the usual dosa flour as thin as the flour. Add salt to taste. Heat a nonstick frying pan, spread the dosa thinly. Release the oil from the side. When one side is roasted, turn the dosa over and give the other side a stew. Serve with hot dosa chutney.

Ragi Biscuits

Ingredients: 4 cups of ragi flour, 2 cups of powdered sugar, 2 cups of ghee, 1 tea spoon of baking powder, salt to taste

Method: Mix the ragi flour and baking powder and sift well. Add ghee and beat well. Then add powdered sugar and a little milk and beat again till it becomes homogeneous. After that make a thick ball. Then roll it to the size you want and cut it with the help of a bowl. Bake it on 180° C for 20 minutes.

Ragi Papad

Ingredients: Ragi flour 2 kg, Papadkhar 60 gms, 6 tsp asafoetida, half a cup of salt

Method: Wash and dry the ragi and grind it finely. After that asafoetida, papadkhar and salt mix well in the ragi flour. Boil as much water as you can. When the water boils, add flour and mix well with a large spoon. After steaming for 10-15 minutes on low flame, immediately take the flour in a pan and mix it well with hot water. Then make papad on rolling board and pin. Then dry in the sun on a clean cloth. You can fry it whenever you want.

Ragi Cak

Ingredients: 200 gms of flour, 200 gms of butter, 100

gms of sugar, 4 eggs, cashew nuts, 1 tbsp of almonds, cardamom to taste and water as required

Method: First mix ragi flour and water well in a bowl. Then make a fine paste of sugar and butter in a mixer. Add a teaspoon of cardamom powder and mix well again. Take another pot, put butter inside it and pour the above mixture in it and keep the pot in the microwave oven for 30 minutes.

Ragi Nankatai

Ingredients: 2 cups of ragi flour, half a cup of gram flour, 1 cup of powdered sugar, 1 cup of ghee, 1 teaspoon of baking powder, cashew or almond pieces, 2 teaspoons of essence and cardamom

Method: First add powdered sugar in ghee and beat till it becomes light. Then add baking powder and essence and mix well again. Add nachani flour and gram flour and mix well. Then make small balls by pressing them on the palm of your hand. Place cashew nuts or almond pieces on top of the prepared Nankatai and fry in a frying pan on low heat.

Ragi Idli

Ingredients: 2 cups of ragi, half cup of black gram dal, baking powder, half teaspoon of curd, half cup, salt to taste

Method: Wash the ragi and then soak the ragi and black gram dal separately at night. In the morning, make fine pest in the mixer mix it well. Then add baking powder and curd and soak for 4 to 5 hours. Add salt to taste. idli will be ready within a 10-15 min.

Ragi Sattu

While making ragi Sattu, clean ragi, soak it in water overnight, then drain it and keep it in a clean cloth. Then dry it in the shade till it becomes hard and grind it finely. They became ready to eat.

Ragi Paratha

Ingredients: 2 cups ragi flour, 2 cups rice flour, 1 cup gram flour, 30 grams beet leaves, 30 grams cabbage, 20 grams onion, 20 grams oil

Method: First chop the cabbage and onion finely. Then add rice flour, ragi flour, gram flour and all the chopped ingredients and knead well. Roll the paratha as you like and roast it with a little oil.

Conclusion

Utilization of millet grains as food is still limited to populations in rural areas. Their nutritional and functional property is best among all cereals grains. Vitamins, minerals, fatty acids and antioxidant properties of this make its strong contribution to human nutrition. Processing and value addition technologies have made it possible to process and prepare value added products acceptable to both rural and urban consumers. Due to lack of processing industry and enough support this industry hasn't grown as per requirement. Innovative technologies must be introduced to fasten the adoption of millet farming with proper capacity building in line with knowledge management.

References

Devi, P. B., Vijayabharathi, R., Sathyabama, S., Malleshi, N. G., & Priyadarisini, V. B. (2014). Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review. *Journal of food science and technology*, 51, 1021-1040.

Subhash, B., & Kakade, H. B. (2015). Finger Millet Processing: Review. *International Journal of Agriculture Innovations and Research*, 2319-1473.

Hulse, J. H., Laing, E. M., & Pearson, O. E. (1980). *Sorghum and the millets: their composition and nutritive value*. Academic press.

United States National Research Council/National Academy of Sciences. *United States-Canadian tables of feed composition*. Washington, DC: National Academy Press, 1982.