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MILLET CULTIVATION, PROCESSING AND VALUE ADDITION FOR INCREASING FARMERS INCOME - A REVIEW

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SUMMARY

Millets are resilient, climate-smart crops with short growing seasons and low input requirements, making them ideal for smallholder and marginal farmers. Cultivating and processing millets, along with value addition technologies, can significantly improve farmers' incomes, nutritional security, and rural employment. Millet processing and value addition technologies have emerged as pivotal solutions in promoting sustainable agriculture and enhancing the economic viability of millet growers. The establishment of primary millet processing units involves the integration of advanced machinery such as graders-cum-aspirators, destoners, dehullers, and milling machines. These technologies facilitate cleaning, grading, and dehulling processes, improving the quality, shelf life, and marketability of millet products while reducing labor intensity and post-harvest losses. Value-added products—including baked goods, extruded snacks, fermented dishes, pasta, noodles, flakes, and puffed millets—have gained prominence by aligning with modern dietary trends. Innovations in baking, extrusion, and fermentation techniques, complemented by suitable packaging solutions, enhance both product appeal and nutritional value. Despite challenges such as impurities, pest infestations, and high moisture content, village-level processing setups have provided scalable models for economic empowerment, reduced dependency on intermediaries, and improved nutritional security. By integrating the agronomical and physiological traditional with modern processing techniques, millet value chains and business opportunities can achieve a transformative impact on farmer incomes, consumer health, and rural livelihoods.

Key words: Business opportunities, major and minor millets, processing, value addition, technology

Major millet crops include jowar or sorghum (*Sorghum bicolor*), bajra or pearl millet (*Pennisetum typhoides*), mandua/ragi or finger millet (*Eleusine coracana*), and small millets comprising kangni or foxtail millet (*Setaria italica*), kutki or sama or little millet (*Panicum miliare*), kodo millet (*Paspalum scrobiculatum*), jhangora or sawan or barnyard millet (*Echinochloa frumentacea*), cheena or proso millet (*Panicum miliaceum*), and korale or brown top millet (*Brachiaria ramosum*). India's agricultural system is highly dependent on rainfed areas, with approximately 52% of the country's net sown area being rainfed. This land is responsible for producing about 40% of India's food output while sustaining 40% of the population and 60% of its cattle. However, yields in these areas are highly unpredictable, and farmers face several challenges, including the impacts of climate change, soil degradation, and inadequate access to resources (Reddy *et al.*, 2022). Millets, often referred to as "nutri-cereals," are resilient crops known for their adaptability to climate variability and rich nutritional profile. With high fibre content, essential amino acids, and a wealth of micronutrients such as iron, calcium, and magnesium, millets offer unique health benefits, making them essential components of a balanced diet. Due to their drought tolerance and ability to thrive in low-fertility soils, millets are widely cultivated in semi-arid and arid regions, making them particularly valuable for smallholder farmers facing climate-related challenges. Beyond their nutritional and ecological advantages, millets hold significant potential for ensuring food security and improving the livelihoods of millions of rural families. Despite their promising characteristics, the economic potential of millets remains largely underutilized due to limited awareness, inadequate infrastructure, and a lack of

advanced processing technologies. Many millet-producing regions lack proper facilities for cleaning, dehulling, grading, and storage, resulting in post-harvest losses and restricting farmers to low-margin, raw-grain sales. Moreover, the absence of organized processing units and efficient market linkages often prevents millet farmers from tapping into premium, health-conscious urban markets, where demand for millet-based products is growing. However, emerging advancements in millet processing and value addition technologies offer the potential to bridge these gaps and economically empower millet farmers. By adopting primary and secondary processing technologies, farmers can enhance the quality and shelf-life of their millet crops, transforming them into a variety of consumer-friendly products such as flour, ready-to-eat snacks, and nutritious beverages. This value addition significantly increases the marketability and profitability of millet products, enabling farmers to command higher prices and diversify their income sources.

Identification of climate resilient crops:

For millets processing and value addition technologies and business opportunities empowering farmer's income need to identified the climate resilient crops. The climate resilient crops such as forage cereals including millets: pearl millet and sorghum (Singh *et al.,* 2010, Malathi *et al.,* 2022, Amrutha, *et al,* 2023, Dheeravathu and Vadithe, 2024, Sravanthi *et al.,* 2024, Dheeravathu *et al.,* 2024), grasses: guineagrass, bajra -napier hybrids and tri-specific hybrids, dinanath grass, (Dheeravathu *et al.,* 2018, Singh *et al.,* 2020, Dheeravathu *et al.,* 2021a, Dheeravathu *et al.,* 2021b, Dheeravathu *et al.,* 2021c., Dheeravathu *et al.,* 2022a, Antony *et al.,* 2021, Dheeravathu *et al.,* 2022b), pulses: cow pea,berseem, clitoria, centrosema, siratro (Dheeravathuet *et al.,* 2017a, Dheeravathu *et al.,* 2017 b, Dheeravathu *et al.,* 2022c), have been proven to be climate smart.

Millet Processing Unit

To set up a primary millet processing unit, machines for cleaning, grading, dehulling, and producing value-added products are required. Primary processing involves basic cleaning, dehulling, and grading of millet grains, making them suitable for direct consumption or further processing. Processing millets without husk (naked grains), such as sorghum, pearl millet, and finger millet, is relatively easy. In contrast, processing millets with husk, such as little millet, proso millet, kodo millet, barnyard millet, and foxtail millet, is more challenging due to their inedible husks, which must be removed through processing. Technologies such as mechanical dehullers and graders are essential for effective millet processing. By investing in these machines, farmers and Farmer Producer Organizations (FPOs) can enhance the quality, shelf life, and economic value of millets, while also reducing labor and post-harvest losses.

1. Destoner

The destoner operates by utilizing the difference in density between various fractions—such as impurities, grains, and hulled fractions like rice and broken kernels—to separate them under continuous vibration and airflow. Destoners used for small millets are similar to those designed for paddy destoning, but with a smaller mesh size in the destoner bed. This machine replicates manual operations, such as those performed using a winnowing pan. The destoner plays a critical role in both pre- and post-hulling processes, significantly improving the quality of the final product. By using this machine, labor intensity is reduced, and the volume of material processed within a given time is greatly increased.

Additionally, the destoner helps extend the life of de-hullers by removing stones and other particles that could potentially damage key components, such as rotors and receiving plates.

Material from the grader is transferred to the destoner to remove small stones and mud balls that are similar in size to the grains. The destoner operates on the principle of gravity.

A destoner consists of two sieves beneath the hopper that grade the incoming material. The graded material then falls onto the destoner bed, where lighter fractions move toward the front and heavier fractions move toward the rear.

The air adjustment slot must be carefully regulated depending on the type of material being processed.

2. Grader-cum-Aspirator

Primary cleaning of millet grains is carried out using a grader-cum-aspirator, which utilizes different sieve sizes for various types of millet. The grader effectively separates the grains from

contaminants such as sand, stones, sticks, mud balls, and straws. Selecting the correct sieve size is crucial to ensure high-quality millet output. Before feeding the grains into the machine, it is important to check their moisture content, which should be around 11–12%. If the moisture level is outside this range, the grains should be dried in sunlight for 2–3 days until the desired moisture content is achieved.

To prevent clogging, the machine operator should regularly inspect and remove any grains stuck in the sieve using a brush. For processing smaller millet varieties, a triple-deck grader with three sieves is typically used. The top sieve separates larger debris such as stones, sticks, and straws that are bigger than the millet grains. The middle sieve collects the good-quality millet, while the bottom sieve filters out fine and coarse sand particles. Additionally, the aspirator attached to the grader removes fine dust particles and directs them to the rear end of the machine.

3. Dehuller-cum-Aspirator

The raw materials after proper cleaning are sent for husk removal into the huller. Dehullers can be classified into two types under the millet processing machinery.

4. Centrifugal Dehullers:

A Centrifugal Dehuller has an impeller that is responsible for the husk removal. The material is sent to the hopper which then enters the impeller, where it gets thrown with a great centrifugal force onto the impeller casing. Due to the heavy impact, the husk gets separated from the millet rice and is sent to the aspirator where the lighter husk is collected at the back and the rice is collected at the front. The quality of the dehuller is measured depending on the retention of the bran layer on the millet rice after dehulling.

5. Abrasive Dehuller:

Abrasive dehuller is classified into two types, one is the Emery type and the other one is the Rubber roller type. In Emery type dehuller two grinding stones are used for husk removal, where one stone is stationary and the other rotates at a constant speed. The raw material passes through these two grinding stones and the husk gets sheared or abrased off.

In the Rubber roller type, rubber rollers are used instead of stones

Milling Machines

Milling machines convert dehulled millet grains into flour. Millet flour is popular for making various traditional and modern recipes, from flatbreads to baked goods, and serves as an essential ingredient in value-added millet products.

Roller Mills: Roller milling produces fine, consistent flour, ideal for use in recipes that require uniform texture. It's particularly useful for producing flour from finger millet and pearl millet, which are commonly used in bakery and confectionery items.

Hammer Mills: Hammer mills are often used to produce coarser flour or grits, suitable for traditional dishes. This machine is suitable for community-based processing setups as it is relatively low-cost and can be used for multiple millet types (Chapke *et al.,* 2018 and 2025)

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Benefits of Millet Primary Processing Machines

1. Enhanced Grain Quality: Primary processing machines improve the cleanliness, uniformity, and shelf life of millets, resulting in products that meet market standards and attract higher prices.

2. Increased Market Access: Processed and packaged millets are more appealing to consumers and retailers, allowing farmers to reach new markets and tap into the health-conscious consumer base.

3. Reduced Post-Harvest Losses: By removing impurities and excess moisture, primary processing reduces spoilage and extends the usability of millets.

4. Economic Empowerment: Access to processing equipment can transform the economic outlook for smallholder millet farmers, allowing them to generate higher returns and reduce dependency on middlemen.

5. Promoting Nutritional Security: With processing facilities in place, millets can be made readily available to local communities, promoting nutritious diets and improving public health.

Challenges in Small Millet Processing

- The presence of sand particles, small stones, mud balls, and other inert impurities in the millet grains lot increases the duration of the processing, reduces the life of the machines, inferior quality millet product, and also gains lesser price in the market.

- Pest Infestation in the grains decreases the shelf life of millet rice.
- The presence of high moisture in the grains makes them difficult to process and the rice recovery goes down.
- Variations in the millet grain sizes require skilled machine operators.

Millet Processing Machine Requirements

Village/Community Level:

Space Requirement: A modest 200 square feet floor area sets the stage for millet processing at the village/community level.

Essential Machinery: A cost-effective solution comprises a Destoner-cum-Grader with Aspirator and a Table top Dehuller, boasting a capacity of 50kg/hr. This project, costing approximately 2 lakhs, is a testament to efficiency, designed for seamless operation by two individuals and adaptable to a single-phase power supply (Chapke *et al.,* 2018 and 2025)

Small Scale Level:

- Space Requirement: As ambitions grow, a minimum of 1200 square feet floor area becomes the canvas for small-scale millet processing endeavors.
- Essential Machinery: The arsenal expands to include a Destoner, Grader, and 2 Dehullers, each contributing to a capacity of 100 kg/ hour. With an estimated cost ranging between 4-5 lakhs, this setup lays the foundation for increased production and efficiency.

Medium Scale Level:

- Capacity and Infrastructure: Stepping into the medium-scale domain, the operation envisions a capacity of 500-1000 kg/hour and demands a more substantial space of 5000 to 10,000 square feet.
- Machinery Ensemble: The machinery ensemble includes 4 to 8 Destoners and Graders, coupled with 2 to 4 Dehullers. For value addition, the introduction of a Pulveriser, Semolina Machine, and Flakes Making Machine is advocated.
- Cost Implications: This venture entails a more significant investment ranging from 20-30 lakhs, reflecting the scale and potential for value addition in this enterprise (Chapke *et al.,* 2018 and 2025)

1. Incubation

ICAR-IIMR promotes Innovations and Entrepreneurship in the areas of Millets and Nutricereals sector which is a unique and first of its kind to cater start-ups needs in the country. It aims to help entrepreneurs to ideate, incubate and accelerate their innovative early-stage startups into successful ventures by providing value-added product technologies in millets, infrastructural support, mentoring, networking and business advisory. This service will be provided to startup through a structured programme known as Incubation (Chapke *et al,* 2018 and 2025). All the incubates undergoing the ICAR-IIMR Incubation Program will go through a structured program for a period of one year. Startups will have access to the below offerings during the course of Incubation program (Chapke *et al.,* 2018 and 2025)

Services offered to incubates:

Working space: Plug and play dedicated office space at Nutrihub incubator with ready to use office infrastructure.

Structured program: Incubates undergo a structured program that involves goal setting, monthly tracking, training and workshop on technical and business areas as well as engagement with mentors, experts, industry and investors.

Investor network: Nutrihub partners with various investor networks, banks and financial institutions to help start-ups with fundraising.

Mentor Network: Nutrihub brings the best technical and business mentors with breadth of experience and expertise to help the start-ups grow their start-ups faster.

Access to Infrastructure, R & D facilities: Incubate start-ups can access IIMR production facilities and research labs to validate or accelerate their product and business goals.

Discounted services: Free/discounted access to Nutrihub partner deals, start-up events and trainings at local/ national level by Nutrihub and its partners.

1. NEST Program

Empowering Agricultural Innovation: a nurturing ground for emerging agripreneurs with bright ideas to revolutionize agriculture. Tailored specifically for students and full-time entrepreneurs

at the idea or prototype stage, this program offers an enriching orientation and training experience.

Program Features

Comprehensive Engagement: Dive deep into personalized training sessions, gaining invaluable insights into business planning and market penetration strategies.

Financial Support: Enjoy a stipend and the opportunity to secure seed funding as a grant, propelling your innovative projects towards realization

2. N- Grain Program

About the program

Scaling Agri-Startups to New Heights: The N-GRAIN program is designed to fast-track the commercialization of viable agricultural products. Perfect for startups ready to scale their Minimum Viable Product (MVP) to market readiness, offering robust support in scaling operations and enhancing product offerings.

Program Highlights

Tailored Funding: Receive up to 85% of your project costs as a grant, with a maximum support of Rs. 25 lakhs.

Incubation and Mentorship: Benefit from customized mentorship, technical assistance, and access to a broad network of industry connections.

Training programmes

1. Startup Ignition Program

Nutrihub, ICAR- Indian Institute of Millets Research organizes a one-day workshop on "Start-up Ignition - Entrepreneurial Opportunities in Millets Production, Processing & Value-Addition" for aspiring entrepreneurs those who are willing to start a business in Millets domain. This workshop comprises sessions on Introduction to Millets, Nutritional merits, and its USP for a better market. The program also showcases the primary and secondary processing facilities, procedures to obtain the technology license. A special session is also added to create awareness amongst participants regarding various Incubation facilities provided by Nutrihub. The main objective of the program is to kick-start the entrepreneurial journey of the participants.

2. Cooking with Millets

Millets are rich in nutrition and can address many lifestyle diseases. Still lot of people do not use millets in daily cooking as cooking with millets can be a bit tricky.Since millets do not have gluten (gelatinous character), the cooking with millets is not the same as wheat-based products. It requires some skill and training to make recipes with millets. Therefore, to address this problem and provide an effective solution IIMR, Hyderabad organizes an special training program where all the participants are trained to cook millet based recipes. ICAR-IIMR has developed the expertise in making make popular recipes with millets like Dosa, Idli, Upma, Bisibele Bhat, Biscuits, Cakes and many more related items. This event, focuses on training the individuals to cook millet-based dishes so as to popularize millets. The program attracts cooking professionals, representatives of food industries, cooking enthusiasts as well as housewives (Chapke *et al.,* 2018 and 2025).

Millet Value added Technologies: ICAR-IIMR has developed 79 Millet Value added Technologies which will be given for start-ups as technology licence with the following rates.

No of technologies	Tariff rate
1	Rs. 50000
2-3	Rs. 33000
4-5	Rs. 30000
6 or more	Rs. 25000

Success stories of Start-ups:

- **Panchanahalli FPO** – Production of seeds through natural farming
- **Gobhaarati** – Manufacturing and wholesaling of millet seeds
- **Mitra Organics** – Supplies own seed to farmers for buy-back
- **Sri Velavan Agro** – Exporting millet seeds
- **Visakha Millets FPO, Green Millet FPC, etc.** – Linking farmers with market
- **Sai Sustainable Agro** and **Magasool Agro** are directly interacting and aggregating the raw material required.
- **InnerBeing, M for Millet, Health Basket,**

Rowan Agro, Indian Sisters Kitchen, Vedas Natural – Direct procurement from farmers.

- **Pardha Millets** is involved in farming and primary processing of millets, and also provides services to other millet farmers for enabling high value for the produce.
- **Sri Sai Balaji foods** grows millets and implements value addition of Ragi protein malt and Ayurvedic pain relief oil
- **HealthSutra, Soulful, InnerBeing** – marketing their mixes through amazon, flipkart, bigbasket, etc.
- **Healthbasket, Hapup** – Retailing the millet products on own e-commerce site – healthbasketonline.com, hapup.in
- **Ahobilam foods, Millet Chef and SM Millet foods** are delivering the full meals, snacks, sweets, pickles, etc. through their own restaurant and online delivery through zomato, swiggy, etc.
- **Millet Marvels** is also into millet restaurant business.
- **Rashmi Millet foods, Swedha foods and GVL foods'** business model is based on the food trucks.

CONCLUSION

Millets are an essential crop for food security, especially in the context of climate change and its impact on agriculture. To sustainably increase the productivity of millets, future agronomic research must prioritize innovative soil and moisture conservation practices, as well as the development of millets with physiological traits that confer tolerance to abiotic stresses and enhance climate resilience. Business opportunities, along with millet processing and value addition technologies, play a transformative role in empowering farmers by bridging the gap between traditional farming practices and modern market demands. These technologies increase the economic value of millets, providing farmers with new income streams and reducing their dependence on volatile raw grain markets. By improving shelf life, nutritional appeal, and market accessibility, value addition technologies ensure better returns for farmers while meeting consumer demands for healthy and sustainable food options. Additionally, they promote the establishment of rural enterprises and Farmer Producer Organizations (FPOs), fostering entrepreneurship and rural employment. Ultimately, these advancements enable farmers to harness the full potential of millets, contributing to sustainable agriculture, rural development, and global food security in the face of future climate change.

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