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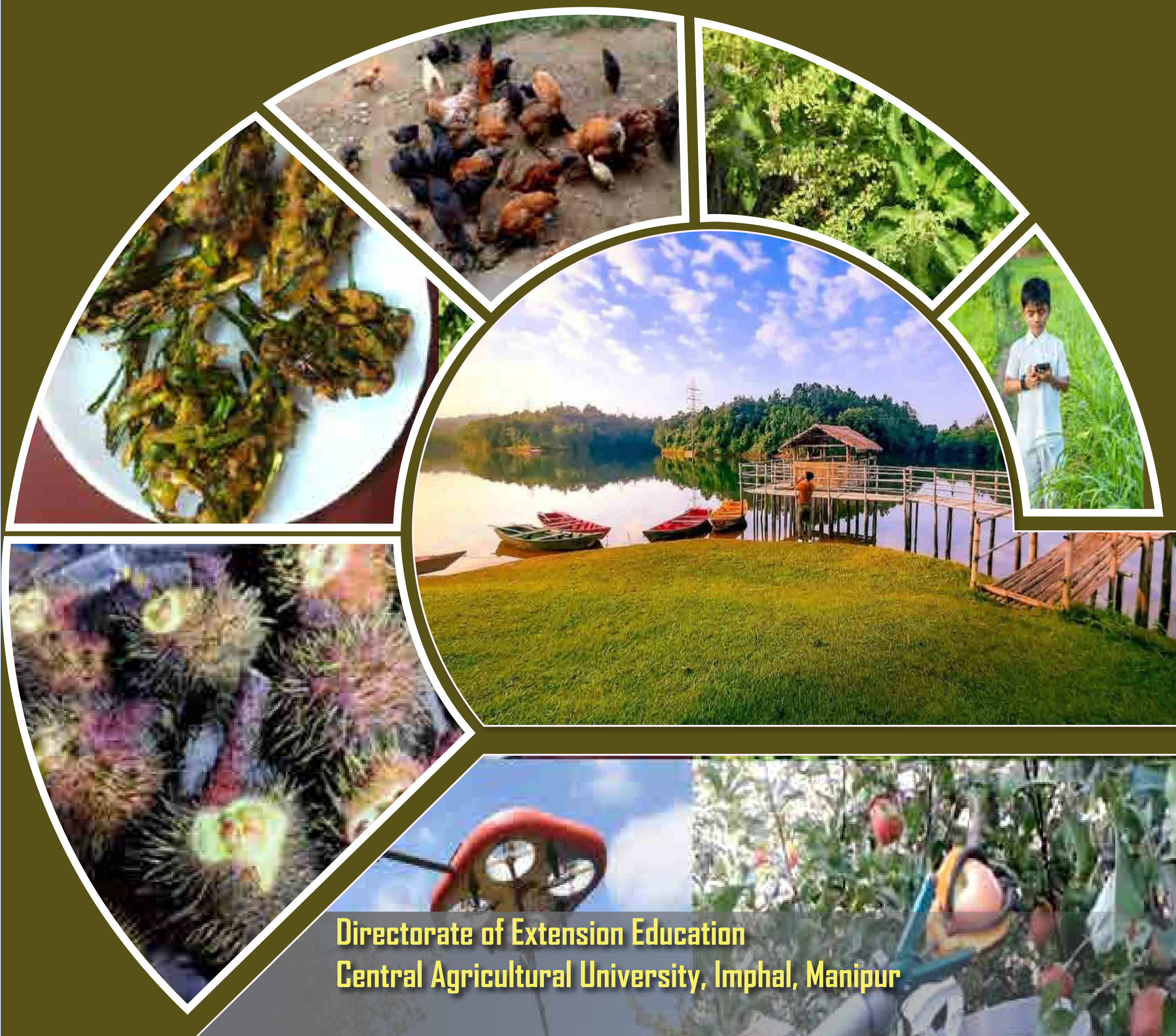

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From the Editor's Desk

Prof. Ph. Ranjit Sharma
Director (Extension Education)

As we gather at the CAU Regional Agri Fair 2025–26, we celebrate the spirit of innovation, collaboration, and progress that defines our agricultural community. This fair serves as a vibrant platform for knowledge exchange, showcasing the remarkable achievements and technological advancements that are shaping the future of agriculture in the North Eastern Region.

In this special edition of CAU Farm Magazine (Vol. 13, No. 3), we highlight the latest advancements, best practices, and success stories that are transforming the face of farming in our region. The magazine is proud to be part of this important event, showcasing the hard work and dedication of our farmers, scientists, and extension workers. It features articles on cutting-edge technologies, sustainable practices, and innovative approaches that are improving crop yields, enhancing livelihoods, and promoting environmental stewardship.

I extend my heartfelt appreciation to the farmers, who are the backbone of our agricultural progress. Their resilience, innovation, and unwavering commitment to nurturing the land continue to inspire us all. The success of every agricultural endeavour begins with their tireless efforts, and we salute their invaluable contribution to ensuring food security and prosperity for our nation.

I also convey sincere thanks to all participants, researchers, students, and collaborating institutions for their active involvement and enthusiasm. Their contributions enrich the fair with fresh perspectives, scientific insights, and innovative ideas that drive agricultural growth and sustainability.

As we move forward, let us continue to strengthen partnerships among farmers, researchers, policymakers, and industries to build a more resilient and self-reliant agricultural ecosystem. Together, through shared knowledge and collective effort, we can realize the vision of a prosperous and sustainable farming future for the North Eastern Region and beyond.

(Prof. Ph. Ranjit Sharma)
Chief Editor

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CULTIVATING RESILIENCE: CLIMATE-SMART CROPS SECURING NORTH-EAST INDIA'S FARMS

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Introduction

Across the world, climate change is rewriting the rules of farming. From prolonged droughts in Africa to heat waves in Europe and erratic monsoons in South Asia, farmers everywhere are struggling to protect their crops from an increasingly uncertain climate. Agriculture, the backbone of rural livelihoods, is under growing pressure. India, with its vast and diverse farming systems, stands at the frontline of this crisis. Rising temperatures are shrinking wheat yields in the north, erratic monsoons delay sowing in central India, unseasonal rains damage pulses in the west, and cyclones ravage coastal paddy fields in the east. Amid these nationwide challenges, the North Eastern Hill (NEH) region also faces its own paradox of plenty, where heavy rains bring both devastating floods and crippling dry spells. The region's farmers are predominantly small and marginal landholders, with average holdings of just 1.5 hectares, and they rely largely on monsoon-fed agriculture. Rice alone occupies more than 60% of the cultivated land, followed by maize, pulses, oilseeds, fruits, and vegetables. But climate variability threatens both productivity and livelihoods, trapping many farmers in cycles of risk. Against this backdrop, the adoption of climate-resilient crops and smart practices is rewriting the story of agriculture in the North-East India.

Rising to this challenge, climate-resilient crop varieties have emerged as a game-changing innovation in agricultural science. These plants, specially developed or naturally selected, are equipped to withstand drought, floods, extreme heat, salinity, and emerging pest pressures that often devastate traditional crops. Unlike conventional varieties that falter under stress, climate-resilient crops and their associated practices are designed to adapt to shifting conditions, ensuring stable yields and safeguarding food security in the face of climate uncertainty. This is the story of how the North-East, with its fragile hills and valleys, is proving that with the right seeds, smart science, and the spirit of its farmers, agriculture can not only survive but also flourish in the age of climate change.

Rice: From Heritage to Resilience

Rice has always been the heartbeat of the North-East. From the lush valleys of Assam to the hills of Mizoram and Sikkim, it is the food that sustains life and the crop that ties culture with livelihood. But in recent decades, unpredictable floods, erratic rains, and sudden droughts have made rice cultivation increasingly risky. Farmers often face the painful choice of replanting after floods or watching crops wither during a dry spell. The good news is that science and tradition together are rewriting this story. Across the region, a new generation of rice varieties is offering hope — plants that can survive floods, withstand drought, grow faster, and even fetch higher prices in the market.

Assam has taken the lead with some remarkable breakthroughs. The state's Agricultural University gifted India its first high-yielding purple rice, **Labanya**, rich in antioxidants and capable of yielding nearly five tonnes per hectare. Farmers have embraced it not just in Assam but in 18 states across the country. For flood-prone areas of the Brahmaputra valley, varieties like **Swarna Sub-1, Ranjit Sub-1, and Bahadur Sub-1** have proven lifesavers, staying alive even when submerged in water for two weeks. Farmers facing delays in transplanting due to floods are finding comfort in **Gitesh**, a variety that accepts seedlings aged anywhere between 30 and 60 days, while the short-duration **Luit** helps farmers escape floods altogether by maturing in just 90 to 100 days.

In neighbouring Arunachal Pradesh, when heavy rains submerged nursery beds for almost a week, **Swarna Sub-1** bounced back once the waters receded, while **Gitesh** allowed staggered planting even after floodwaters delayed transplanting. Farmers here have also seen success with **Luit**, which escapes both early and late floods and has given handsome profits in trial villages.

Manipur, where rice is deeply linked with tradition, has witnessed both indigenous wisdom and modern science at work. The hardy indigenous variety **Maza**, cultivated by Mao tribes, is valued for surviving droughts, though its yield is low. To meet modern needs, scientists of ICAR, Manipur and CAU, Imphal have also developed **RC-Maniphou-12**, a short-duration variety that avoids late-season drought, and **CAU-R5 "Emoinu Phou"**, known for tolerating both floods and drought. Perhaps the most exciting story is the release of **RC Manichakhao-1**, India's first semi-dwarf, high-yielding black rice. With yields up to five tonnes per hectare and rich anthocyanins, this variety combines resilience with high market value, promising a new income source for farmers.

Mizoram presents another striking case. Here, an experiment compared local rice with new introductions and found that the variety **Gomati** produced an astonishing 152 percent more yield, while **RCM 9** and **PNR 546** also doubled farmer harvests. Yet researchers learned a valuable lesson: Mizo farmers were reluctant to adopt high-yielding varieties that did not taste like their traditional rice. Among the new varieties, PNR 546 won the most hearts thanks to its fine, aromatic grains and shorter maturity period, while RCM 9 matched local preferences closely.

Nagaland's farmers, who often rely on upland and deep-water rice, are now supported with drought-tolerant options like **Shahsarang-1** and **IR64-Drought**, which provide security when rains fail. In Tripura, the varieties **Tripura Nabin** and **Gomati** are already popular among farmers for being stress-tolerant, pest-resistant, and moderately drought-tolerant. Adding to this, ICAR's Tripura Centre has recently released **TRC 2020-14**, a medium-slender grain variety that stabilizes yields in the humid subtropical climate.

Sikkim, where rice must adapt to hilly terrains and organic farming systems, has its own set of climate-resilient options. The trio of **Sikkim Dhan-1, Sikkim Dhan-2, and Sikkim Dhan-3** serve different ecologies — from lowlands to uplands — and are tailored for organic cultivation under heavy rains and steep slopes.

Maize, Pulses and Oilseeds: Staples That Withstand

The hilly landscapes of the North-East are home to farmers who have, for centuries, relied on rice as their staple crop. Yet, in these fragile rainfed uplands, rice alone often fails to provide the stability or nutrition needed for growing populations. Erratic rainfall, acidic soils, and recurring droughts have made it clear that diversification is the only way forward. Today, maize, pulses, soybean, and groundnut are stepping in — not only to complement rice but also to restore soil fertility, enrich nutrition, and bring farmers better returns.

Among cereals, maize has quickly risen as a champion crop across Meghalaya, Nagaland, and Mizoram. Its ability to thrive under rainfed conditions and its multiple uses as food, fodder, and feed, make it invaluable. In Meghalaya, hybrids like **HQPM-1, Vivek 9 and Vivek 21** have gained popularity. These hybrid maize varieties are rich in nutrition and stand strong under drought, suiting the rainfed hills perfectly. Nagaland's acidic soils, once a barrier to productivity, now support **RCM-76 and RCM-77**, hybrids bred by the ICAR Research Complex for the North-East. These hybrids maintain yield stability even on marginal lands. In Mizoram, where shifting cultivation and erratic rainfall dominate, short-duration hybrids like **Bio-9681** provide the flexibility farmers need, maturing quickly before weather turns hostile.

Just as maize strengthens cereal options, pulses are reshaping nutrition and soil health. By fixing nitrogen, they enrich soils while providing protein-rich diets. For areas prone to drought, pigeonpea has emerged as a resilient ally. In Arunachal Pradesh, **UPAS-120 and ICPL-88039** are now grown successfully in shifting cultivation systems, their drought tolerance ensuring reliable harvests even when rains fail. A more recent breakthrough from ICRISAT, **ICPV 25444**, is especially exciting. Insensitive to both heat and day length, this pigeonpea matures in just 125 days — a perfect match for the warmer, stressed climates now common in the region. Tripura too has tapped into pulse resilience, promoting **blackgram varieties PU-31 and T-9**, which not only withstand erratic weather but also resist major diseases, giving farmers confidence against uncertainty.

Soybean, once almost absent from these hills, is now finding its place as a crop of high promise. Traditionally, it had little area here due to lack of good varieties and poor practices. But with the introduction of **DSb-19**, farmers have discovered a crop that is both climate-smart and nutritionally rich. Beyond yield, soybean adds immense value by enriching soil with biological nitrogen, reducing the dependence on fertilizers, and fitting easily into crop rotations without disturbing rice or maize. In Nagaland, where uneven rainfall often causes terminal drought in soybean, farmers tested a simple yet effective adjustment:

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advancing the sowing date. Using the variety **JS 335**, they shifted planting from June to May and witnessed remarkable results. By escaping late-season drought, soybean found a renewed role in the region's upland systems.

Groundnut is another oilseed slowly reshaping the food basket of the North-East. Traditionally absent in hilly uplands, it has emerged as a profitable diversification crop, especially where rice or maize alone cannot sustain farmers. The introduction of **ICGS-76** has been a breakthrough. This variety thrives in degraded acidic soils, matures in about 120 days, and withstands bud necrosis disease as well as mid-season drought. More importantly, groundnut has enriched local diets with vegetable protein and edible oil, while improving cropping intensity and land productivity in areas once locked in mono-cropping of rice or maize.

Horticulture: Diversifying Resilience and Income

For decades, the farmers of the North-East have relied on rice and maize as their mainstay crops. But changing weather patterns, erratic monsoons, and prolonged dry spells have compelled them to look beyond traditional grains. Today, fruits, vegetables, and spices are offering not just nutritional diversity but also resilience against climatic stress. With the introduction of improved varieties, farmers are witnessing higher yields, better incomes, and sustainable farming practices.

In the lush hills of Meghalaya, **Kufri Megha**, a monsoon-hardy potato, has emerged as a reliable option for rain-soaked uplands. Alongside it, **Sweet Charlie**, a strawberry variety resistant to late blight, has reshaped the horticultural landscape by thriving even in disease-prone environments. Manipur's uplands are now dotted with plantations of drought-tolerant pineapples such as **Queen** and **Kew**, while Nagaland proudly cultivates the fiery **Naga King Chilli (Raja Mircha)**, renowned worldwide for its heat, alongside hardy banana varieties like **Grand Naine**.

Tripura, known as India's second-largest rubber-producing state after Kerala, is also moving ahead with climate-smart innovation. The newly released rubber clone **RRII 417** has shown remarkable adaptability to the monsoon fluctuations of the region. Trials reveal that more than 80% of trees reach tapping girth within just seven years. This breakthrough is part of India's broader strategy to boost domestic rubber production and reduce import dependence, offering Tripura farmers a stable and profitable crop option.

Vegetables too are finding new champions. In Sikkim, where tomatoes flourish both in greenhouses and open fields throughout the year, the variety **Arka Abhed** has steadily replaced the once-popular but disease-prone Romeo. Resistant to ToLCV, bacterial wilt, and both early and late blight, Arka Abhed performs reliably across all seasons—summer, kharif, and rabi. Farmers have welcomed the variety for its resilience and profitability, and many households have already benefitted from this shift, making tomato cultivation a cornerstone of Sikkim's horticultural economy.

In Nagaland, where cabbage is cultivated on a large scale, local varieties often struggle under the stress of unpredictable rainfall and prolonged drought. Farmers have now turned to **Rareball cabbage**, a resilient variety that responds well to climate-smart practices such as raising seedlings in polypropylene trays and using mulching for moisture conservation. The variety has shown better productivity and stronger resistance to pests and diseases, giving farmers both confidence and greater financial stability.

Conclusion

Farming in North-East India is changing story. Farmers are now learning that any challenge can be used to their advantage in a field that is turning rice fields into flood-resilient, drought-tolerant spaces, verifying that maize, pulses, oilseeds and fruit can nourish as well as provide financial security. Climate-resilient crops should be seen as not only new seeds but a new hope. They produce consistent harvests as weather alters, shield the soil, and make it marketable at a higher price. With these crops and simple smart methods, farmers are able to cultivate more and with little risk and nourish their families, have a brighter future.

Ultimately, it is made clear that, with the right sort of seeds, the right sort of knowledge and the power of our farmers, not only will agriculture be able to cope with the changes of climate within the North-East, but will actually thrive under its conditions.

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HIDDEN GREENS OF MANIPUR: REVIVING UNDERUTILIZED VEGETABLES FOR NUTRITION AND TRADITION

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Introduction

The term "underutilized vegetable" refers to those plant species that are traditionally consumed only in certain regions or by specific communities. Although they often possess significant nutritional, agricultural, and economic potential, these vegetables are rarely exploited or produced on a wide scale. Across our country's many agroclimatic zones, differing environmental conditions lead to a wide diversity of crops, which in turn shapes people's food choices. Food preferences vary greatly depending on whether one lives in the plains, hills, or valleys. In the North Eastern hill region of India, especially in Manipur, nestled in the Eastern Himalayas, the ethnic communities are richly diverse, and so are their eating habits. Both valleydwellers and hilldwellers possess indepth traditional knowledge about edible plants and herbs. These include raw leaves, young flowers, and tender stalks, which they incorporate into their diets. Many of these practices are ageold, consuming raw plant parts not just for flavour, but for their medicinal or healthpromoting effects. Among such underutilized plants are those that are used to prepare palatable and nutritious meals in local Manipuri cuisine.

Some examples include winged bean (*Psophocarpus tetragonolobus*, locally known as *Tengnoumanbi*), sword bean (*Canavalia gladiata*, locally known as *Tebi*), rhizome of lotus (*Nelumbo nucifera*, locally known as *Thambou*), arrowhead (*Sagittaria sagittifolia*, locally known as *Koukha*), fermented and non-fermented bamboo shoots (*Dendrocalamus giganteus*, locally known as *Usoi/Soibum*), and foxnuts (*Euryale ferox*, locally known as *Thangjing*).

(a)Wing Bean (*Tengnoumanbi*)

(b)Foxnuts(*Thangjing*)

(c) Ginger Lily (*Loklei*)

(d) Chameleon Plant (*Toningkhok*)

(e) Hooker chives (*Maroinappakpi*)

(f) Water mimosa (*Esing-ekaithabi*)

(g) Chinese chives (*Maroinakkupi*)

(h) Fermented Bamboo shoot (*Soibum*)

(i)Banana Inflorescence (*Laphutharo*)

(j) Broad Bean (*Hawaimubi*)

(k) Bamboo Shoot (*Usoi*)

(l) Sword Bean (*Tebi*)

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Some indigenous and minor vegetables used in preparation of delicacies by the Meitei's:

(a) Winged bean (*Tengnoumanbi*)

(b) Foxnut (*Thangjing*)

(c) Ginger Lily (*Loklei*)

(d) Chameleon plant (*Toningkhok)*

(e) Hooker chives (*Maroinappakpi*)

(f) Water mimosa (*Esing-ekaithabi*)

(g) Chinese chives (*Maroinakkupi*)

(h) Broad Bean (*Hawaimubi*)

(i) Bamboo Shoot (*Usoi*)

(j) Sword Bean (*Tebi*)

Different uses of underutilized vegetables in local cuisine of Manipur:

Singju : *Singju* is a traditional salad from Manipur, rooted in the Meitei community, though people from other communities across the state enjoy it as well. It consists of finely chopped raw vegetables mixed with seasonings such as salt, red chili, roasted sesame (or perilla) seeds, and chickpea flour. There are two main varieties:

- **Vegetarian version**: served during rituals, festal ceremonies, or religious occasions.
- **Nonvegetarian version**: typically includes fermented fish (known locally as *ngari*) and is more common in everyday home meals.

This dish is often paired with regular meals but is also eaten as an afternoon or evening snack. Because it embraces whatever seasonal greens are available, there are many recipe variations. Common vegetables used include lotus stem, unripe papaya, winged bean, cabbage, sword bean, banana flower, water parsley, pea tips, water mimosa, and stink bean, among others.

Eromba: *Eromba* is among the most beloved dishes of Manipur. It is similar to a chutney: boiled vegetables are mashed together with chilies, potatoes, and fermented fish (locally called *ngari*). Depending on taste and creativity, various vegetables can be used, examples include stink beans, fermented bamboo shoots, or broad beans. Fresh herbs such as Chinese chives, coriander, lemon basil, and chameleon plant are often added for garnish to boost flavor. There is also a vegetarian version of *Eromba*. In place of fermented fish, ingredients like roasted sesame seeds, fried chickpea flour (besan), mashed fried chilies, chives, and onions are used to create the dish's distinctive taste.

Paknam: *Paknam* is a pancakestyle dish where ingredients like hooker chives (*Maroinapakpi*), young banana flower (inflorescence), peas (in flour form), wild coriander, fermented fish, salt, chili and various spices are mashed together. Pea flour (besan) is added to bind the mixture thoroughly. This blend is then wrapped, first in one or two layers of turmeric leaves, and finally in banana leaves. Once wrapped, it is cooked by placing it on a hot griddle (pan) and pressing it down (often with a weight). After about 30 to 45 minutes of this pressing and cooking, it releases a characteristic aroma, signaling that it is done. An alternate method is to place the sealed *paknam* inside a small tiffin box, steam it (for example in a pressure cooker up to three whistles), and then give it a final roast on the pan until lightly browned. A variation of *paknam* uses *kanglayen* (tree mushrooms) where mushrooms replace or are added to the vegetable mix, giving a different flavor and texture.

Khoukha Bora / Koukha Kanghou **(Arrowhead fritters /fried):**

Arrowhead, locally known as Koukha *(botanical name Sagittaria sagittifolia)*, is a tuber that thrives in swamps, marshes, and flooded rice fields. Its edible, round tubers are encased in thin, scalelike membranes. Because of its texture and taste, *Koukha* is highly prized in Manipur, where it appears on many menus in local markets, hotels, and homes. In Manipuri cooking, it is prepared in multiple ways. One way is stirfrying the sliced or chopped tuber (known as *koukha kanghou*) with spices, herbs, and sometimes fermented fish. Another popular method is making fritters (*koukha bora*), where the tuber is diced or mashed, mixed into a batter, and fried until crispy.

Kangshu: *Kangshu* is a traditional Manipuri dish commonly eaten as a side. Its key ingredient is peruk (Indian pennywort, *Centella asiatica*), which is first cooked in a pressure cooker for about two whistles. Once tender, the *peruk* is drained, squeezed to remove extra water, and then chopped or mashed. Boiled or roasted dried yellow peas are added to the mix. Red chilies, salt, and *ngari* (fermented fish) impart the characteristic flavor. There are also variations of *Kangshu*. For example, when fresh bamboo shoots are used instead of pennywort, the dish is called *Ushoi kangshu*. Another version, *Uthummana kangshu*, uses *Wendlandia paniculata*. Like the original, these alternatives also include peas, fermented fish, and chilies. Finally, fresh herbs like coriander are often added just before serving to give an extra layer of aroma and taste.

(a)Yongchak Eromba

(b)Laphu tharo Paknam

(c)Soibum Eromba

(d)Nakuppi Bora

(e)Chagem Pomba

(f)Maroi Thongba

Some of the local cuisines of Manipur prepared from underutilised vegetables

(a) *Yongchak Eromba*
(b) *Laphutharo Paknam*
(c) *Soibum Eromba*
(d) *Nakuupi Bora*
(e) *Chagem Pomba*
(f) *Maroi Thongba*

Kangsoi: *Kangsoi* (also called *Kangshoi* or *Chamthong*) is a staple in Manipuri households, often eaten daily. It is a light vegetable stew where various boiled greens and seasonal vegetables are cooked in water, then flavored with fermented fish (*ngari*), dried fish, chilies, salt, and aromatic herbs such as Chinese chives and Hooker chives (*Maroinapakpi*). Many underutilised wild or wetland plants are incorporated into *Kangsoi*. Some examples are *Yellang* (*Polygonum orientale*), *Kengoi* (*Persicaria posumbu*), *Yerum keirum* (*Stellaria media*) and others. Because of its simplicity and adaptability, *Kangsoi* has many versions. It can be purely vegetarian, using only vegetables and herbs, or nonvegetarian, when fermented or dried fish is added. It features minimal oil (often none), letting the fresh taste of greens and mild spices shine. *Kangsoi* is valued both for its nutrition and its soothing, subtle taste, often served with rice, or alone like a soupy curry.

Ooti: *Ooti* is a classic, vegetarian dish deeply rooted in Manipuri daily cuisine. It is cooked regularly in almost every household and is especially popular during festivals or feasts. The basic version is prepared with dried yellow peas (soaked overnight), fresh or nonfermented bamboo shoot (known locally as *Usoi*), chives (Chinese chives), salt, red chilies, and a small amount of sodium bicarbonate (or cooking soda). One variant, called *Ooti Ashangba* or Green *Ooti,* uses rice and green leafy vegetables like colocasia/taro leaves, giving the dish a green hue. When making *Ooti*, stirring throughout is generally avoided once certain ingredients are added. This helps preserve a smooth texture and maintain the distinct flavour.

Chagempomba: *Chagempomba* (also spelled *Chagem Pomba*) is a distinctive and traditional dish of the Meitei community in Manipur. It is made by combining broken or cut rice (known locally as *chagem*) with a rich mix of seasonal greens, dried fish, fermented fish, fermented soybean (*hawaijar*), salt, chili, bay leaf, turmeric powder, mustard oil, Chinese chives, and other herbs. A wide variety of underutilised vegetables are commonly included, examples are water mimosa, mustard leaves, pea tips, broad beans, and stink beans. The dish is cooked until it forms a thick, hearty curry-like consistency. The name *Chagempomba* derives from "*chagem*," the Manipuri term for cut or broken rice, which is an essential component. Because of its strong, pungent flavour (thanks especially to fermented soybean and fish) and its use of many aromatic herbs and leaves, its aroma and taste are quite distinct. It is an important traditional dish of the Manipuris, prepared by mixing varieties of vegetables, dried fish, fermented fish, salt, chili, turmeric powder, bay leaf, mustard oil, Chinese chive, cut rice (tukra in Hindi), and fermented soybean. Some vegetables commonly used in the preparation of *Chagempomb*a include water mimosa, mustard leaf, pea tips, stink bean, broad bean, and pea. Cut rice (*chagem* in Manipuri) and fermented soybean are compulsory ingredients in *Chagempomba*. The dish derives its name from *chagem*, the Manipuri term for cut rice, highlighting its integral role in the recipe.

The following table gives insight into some of the list of underutilized vegetables consumed by Manipuri people as raw or cooked along with their scientific names, uses as a delicacy and health benefits (Jain *et al.*, 2011 & Yumnam *et al.*, 2012).

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TABLE: COMMON UNDERUTILIZED VEGETABLES OF MANIPUR, THEIR DIETARY USES AND HEALTH BENEFITS

Sl. No.	Scientific Name	Local name	Family	Dietary uses and preparation	Medicinal Values
1	*Allium hookeri*	*Maroinapakpi*	Liliaceae	Leaves are used in *Paknam* and in other Manipuri dishes also .The roots are also used in fish curry.	Aphrodisiac
2	*Allium tuberosum*	*Maroinakuppi*	Liliaceae	Leaves are used in preparing fritter and can be used in different Manipuri dishes.	Aphrodisiac and diuretic.
3	*Alpinia nigra*	*Pullei*	Zingiberaceae	Rhizome used in eromba (used in religious ceremonies, symbolic of Manipuri New Year)	Carminative, aphrodisiac, tonic, diuretic, expectorant, appetizer and analgesic. Skin infections
4	*Alocasia indica*	*Yendem*	Araceae	Whole plant can be used in *eromba* and *kangsoi* preparation.	Purify blood
5	*Amomum aromaticum*	*Namra*	Zingiberaceae	Rhizome as a constituent in the preparation of *eromba*.	Powder is taken to control high blood pressure.
6	*Canavalia cathartica*	*Tebi*	Papilionaceae	Young pods are used in *singju, eromba, chagempomba* preparation.	Anthelmintic or vermifuge.
7	*Cardamine hirsuta*	*Chantrukmana*	Brassicaceae	Whole plant except root is used in *singju*.	Diuretic, paste is applied on cut and injuries
8	*Centella asiatica*	*Peruk*	Apiaceae	Whole plants except root is used in preparation of *kangshu, simple boil* or eaten as raw.	Expectorant and against cold & gastric.
9	*Colocasia esculenta*	*Lam paan*	Araceae	Corm and leaf cooked eaten as *ooti*.	Extract is tonic, given in cough and diabetes.
10	*Cycas pectinata*	*Yendang*	Cycadaceae	Young shoot is used in preparation of *kangshu*	Against dysentery.
11	*Elsholtiza blanda*	*Lomba*	Lamiaceae	Leaves and dried inflorescences are used in *singju* and *eromba* as raw.	Antipyretic, expectorant, against high blood pressure and menstrual disorder

12	*Euryale ferox*	*Thangjing*	Nymphaeacea	Fruit cooked eaten or raw in *eromba*.	Raw fruit eaten against diabetes; leaf petiole paste applied on burns and boils.
13	*Hedychium coronarium*	*Lok-lei*	Zingiberaceae	Rhizome is used in preparation of *eromba*.	Paste of rhizome is eaten against cough, fever; leaf extract is given against throat complaint.
14	*Houttuynia cordata*	*Toningkhok*	Saururaceae	Leaves are used in *singju* and *eromba* as raw	Anti-diuretic, against cholera &dysentery
15	*Ipomoea aquatica*	*kolamni*	Convolvulaceae	Shoot cooked eaten and used in preparation of *singju*.	Boiled leaf extract is used as ear-drop to treat ear-ache; leaf paste is applied on insect bite.
16	*Musa paradisiaca*	*Laphu*	Musaceae	Young pseudo-stem is used in preparation of *eromba*. Banana flower is used in preparation of *paaknam* and *singju*.	Easy movement of bowel and against dysentery, diarrhoea, Cholera
17	*Nelumbo nucifera*	*Thambal*	Nelumbonaceae	Young leaves are eaten as raw and lotus rhizome is one of the important ingredients in preparation of *singju*.	Paste of petiole is applied on boils and burns.
18	*Neptunia oleracea*	*Esing-ekaithabi*	Fabaceae	Shoot cooked as *eromba* or eaten raw as *singju*.	Eaten raw in dysentery and intestinal infections.
19	*Oenanthe javanica*	*Komprek*	Apiaceae	Shoot and leaf is one of the best and preferred species used in the preparation of *singju*.	Boiled in little water and the filtrate is used as ear-drop to cure ear-ache.
20	*Parkia roxburghii*	*Yongchak*	Fabaceae	Young inflorescences and tender pods are used in *singju*. Mature pods are used in *eromba*.	Carminative & against piles
21	*Persicaria posumba*	*Kengoi*	Polygonaceae	used in preparation of *Kangsoi*	Eaten to cure diabetes, piles and intestinal disorder.
22	*Polygonum barbatum*	*Yelang*	Polygonaceae	Used in preparation of *Kangsoi* and *eromba*.	Paste is taken to treat stomach disorder and dysentery.

23	*Psophocarpustetra gonolobus*	*Tengnoumanbi*	Papilionaceae	Young pods are used in preparation of *singju,eromba, chagempomba.*	Expectorant
24	*Sagittarias agiltifolia*	*Koukha*	Alismataceae	Used in preparation of bora,eromba	Paste along with honey is given in cough.
25	*Sesbannia grandiflora*	*Chuchurangmei*	*Papilionaceae*	Young pods and tender twigs are used in preparation of *singju* and *eromba.*	Expectorant, antipyretic & against diabetes
27	*Trapa natans*	*Heikak*	*Lythraceae*	Fruit cooked eaten or as raw, petiole eaten as eromba and singju	Nutrition & tonic
28	*Vanguerias pinosa*	*Heibi*	Rubiaceae	Young leaves used preparation of *singju.*	Anthelmintic or vermifuge
29	*Viola pilosa*	*Huikhong*	*Violaceae*	shoots is used in preparation of *Kangshu*	Cooked and eaten to cure cough, running nose and stomach ulcer.
30	*Wendlandia glabrata*	*Pheija*	Rubiaceae	Young shoots are used in preparation of *singju* as raw and cooked in preparation of *eromba*	Expectorant & against dysentry.

Conclusion:

In Imphal, Manipur, the famed **Ema Keithel** (Mother's Market) - a marketplace run exclusively by women - features a variety of underutilised foods. This unique market, wholly operated by women vendors, embodies the region's commitment to gender balance and serves as a powerful emblem of women's empowerment. Across both rural and urban sectors, women sellers drive microeconomic activity, earning a livelihood with dignity. These women deal not only in familiar vegetables like cabbage, cauliflower, beans, carrots, okra, and eggplant, but also in indigenous plant species that are not widely known outside their communities. These wild or semiwild plants, harvested from meadows, riverbanks, marshes, and field edges, are sources of affordable income with minimal inputs. Many of these lesser known vegetables are also used medicinally, part of a tradition of local knowledge passed down through generations. It is likely that people living in rural or forest regions live longer, in part because of their routine physical activity and regular consumption of these wholesome, medicinal vegetables. These "edible medicines" may play a significant role in reducing lifestylerelated illnesses, such as diabetes, heart disease, and cancer, compared to rates in more urbanised settings (Phurailatpam *et al*, 2014).

HOARY BASIL – A PROMISING BIOTHERAPEUTICS

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Hoary Basil commonly known American Basil or Lemon Basil (scientific namei*: Ocimum americanum* L.) is an aromatic plant belonging to the family *Lamiaceae* and is valued for its culinary and medicinal uses. It is a small, erect, and much-branched aromatic annual herb that grows to a height of 30–60 cm. The stem is quadrangular in shape, covered with fine hairs and numerous glandular trichomes that contribute to the plant's characteristic aroma. Leaves are arranged oppositely along the stem, ovate-lanceolate in shape with toothed margins, and are also covered with fine hairs. When crushed, the leaves release a distinct lemony fragrance due to the presence of volatile essential oils. The plant bears small, bilaterally symmetrical (zygomorphic) flowers arranged in terminal spikes, which are typically white to pale lilac in colour. The fruit is a dry nutlet containing mucilaginous seeds that swell and form a gelatinous coating when soaked in water.

Distribution and Habitat

Hoary Basil thrives in warm tropical and subtropical climates and demonstrates remarkable adaptability to varying environmental conditions. It is native to Africa and South Asia but has become widely naturalized in many parts of the world, including Southeast Asia, Australia and the Pacific Islands. In India, it is commonly found in both semi-arid and humid regions, growing abundantly along field margins, wastelands and gardens. The species prefers well-drained sandy loam soils rich in organic matter, with a neutral to slightly alkaline pH. It is highly tolerant of full sun exposure and exhibits moderate drought resistance, making it well-suited for cultivation in regions with erratic rainfall patterns. Although it performs best under warm and humid conditions, the plant can also withstand brief periods of water stress due to its robust root system and presence of glandular trichomes, which reduce water loss by transpiration. These ecological adaptations contribute to its success as a hardy aromatic herb in diverse agro-climatic zones.

Propagation

Ocimum americanum is primarily propagated through seeds, which are sown directly in prepared seedbeds or nursery trays. The seeds exhibit high germination rates and sprout readily within 10–15 days under optimal temperature (25–30°C) and moisture conditions. Light irrigation during germination is crucial to maintain soil moisture without waterlogging, which can impair seedling emergence. Seedlings are typically transplanted to the main field when they reach a height of 10–15 cm to ensure better establishment and uniform plant spacing. It can also be propagated through stem cutting where the non-flowering tender stems of 10-15 cm is selected just below a leaf node where the lower leaves are stripped off leaving only a pair of leaves at the top. The cutting should be kept in the cool temperature with high humidity under indirect sunlight. Rooting is observed after 2-4 weeks of planting. Coarse sand is the best medium for rooting of cuttings.

Agro-climatic Requirements

This species thrives best in warm tropical and subtropical climates, making it well-suited for cultivation in regions with abundant sunlight. It prefers sandy loam soils enriched with organic matter and good drainage to promote healthy root development. The ideal soil pH ranges between 6.0 and 7.0, as extreme acidity or alkalinity may limit nutrient uptake and essential

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oil accumulation. While the crop exhibits moderate drought tolerance, regular irrigation is recommended during dry spells, especially in the vegetative phase, to maximize biomass and essential oil content.

Harvesting

The aerial parts, including leaves, stems and flowering tops, are harvested at full bloom, which coincides with the peak concentration of essential oils in the glandular trichomes. Harvesting is usually done 60–75 days after sowing, depending on climatic conditions and growth rates. Early morning or late evening harvests are preferred to minimize volatile oil losses due to high daytime temperatures. Post-harvest handling involves shade drying of plant material or immediate distillation to preserve the quality and yield of essential oils.

Traditional and Ethnomedicinal Uses

Hoary basil is culturally significant in traditional medicine systems like Ayurveda and Unani. It's diversified uses includes i) Decoction for treatment of coughs, bronchitis, asthma etc ii) Infusion for treatment of indigestion, diarrhea iii) Leaf pastes for wounds, burns, and skin infections iv) Used as a febrifuge in tropical regions v) Essential oil derived from it acts as a natural insecticide and is used as mosquito repellent etc.

The therapeutic effects of the plant are attributed to the presence of various phytochemical composition as listed:

Essential Oils

The aerial parts of *O. americanum* yield essential oil rich in monoterpenes and phenylpropanoids. Major constituents identified through GC-MS includes Camphor, Limonene, Linalool, Eugenol, Methyl chavicol, l β-caryophyllene.

Flavonoids

Major flavonoids identified from *Ocimum americanum* include rosmarinic acid, luteolin, and apigenin. These compounds are potent antioxidants that scavenge free radicals, inhibit lipid peroxidation, and protect cellular components from oxidative stress. Flavonoids also exhibit anti-inflammatory and neuroprotective activities, contributing to the herb's therapeutic versatility.

Phenolic Compounds

Caftaric acid and chlorogenic acid are the major phenolics present in this plant species. These phenolic acids possess antimicrobial, hepatoprotective, and anti-diabetic properties by modulating oxidative and inflammatory pathways.

Alkaloids

Alkaloids are present in small quantities and are believed to enhance the overall bioactivity of the plant. They may contribute to the analgesic and antimicrobial effects observed in traditional medicine.

Triterpenoids

Triterpenoids such as ursolic acid and oleanolic acid have been detected in this plant species. These compounds are known for their anti-inflammatory, antimicrobial, and anticancer properties. They also exhibit hepatoprotective and cardioprotective effects in experimental studies.

Polysaccharides

Polysaccharides like xylose, galactose, and rhamnose are present in the plant matrix. These exhibit immunomodulatory activities, enhancing innate and adaptive immune responses.

PHARMACOLOGICAL ACTIVITIES

Antioxidant Activity

Extracts of *Ocimum americanum* have demonstrated significant free radical scavenging activity, primarily attributed to the presence of bioactive compounds such as flavonoids and phenolic acids. These phytochemicals act as potent antioxidants by neutralizing reactive oxygen species (ROS) and reactive nitrogen species (RNS), thereby preventing cellular damage induced by oxidative stress. Studies conducted both in vitro and in vivo have shown that methanolic and aqueous extracts of Hoary Basil effectively reduce oxidative stress markers, including lipid peroxidation, protein carbonyl content, and DNA fragmentation. The antioxidant activity is largely associated with key phenolic constituents like rosmarinic acid, caffeic acid, and flavonoids such as luteolin and apigenin, which possess the ability to donate hydrogen atoms and electrons, chelate metal ions, and upregulate endogenous antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). This suggests that *O. americanum* may have therapeutic potential in mitigating oxidative damage linked to chronic diseases such as diabetes, cardiovascular disorders, neurodegeneration, and cancer.

Antimicrobial Activity

The essential oils derived from *Ocimum americanum* have exhibited broad-spectrum antimicrobial activity against a range of pathogenic microorganisms. Notably, these oils demonstrate significant inhibitory effects against gram-positive bacteria such as *Staphylococcus aureus* and gram-negative bacteria including *Escherichia coli* and *Pseudomonas aeruginosa*. In addition, antifungal properties have been observed against opportunistic pathogens like *Candida albicans* and other *Candida* species. The antimicrobial efficacy is primarily attributed to the presence of bioactive volatile compounds such as camphor, eugenol, limonene, and linalool, which disrupt microbial cell membranes, increase permeability, and lead to leakage of intracellular contents. Studies have further shown that these essential oils interfere with quorum sensing mechanisms and biofilm formation, which are critical for bacterial virulence and persistence. These findings strongly support the traditional use of *O. americanum* in the treatment of skin wounds, respiratory tract infections, and gastrointestinal ailments caused by microbial pathogens.

Anti-inflammatory and Analgesic Effects

Camphor and linalool, two major constituents of the essential oil of *Ocimum americanum*, have been identified as key bioactive compounds responsible for its anti-inflammatory properties. Preclinical studies using arthritic rat models have demonstrated that administration of these compounds significantly reduces inflammatory responses. Camphor exhibits its effects by modulating inflammatory mediators such as prostaglandins and cytokines, inhibiting cyclooxygenase (COX) and lipoxygenase (LOX) pathways, which are pivotal in the synthesis of pro-inflammatory eicosanoids. Linalool, on the other hand, has been reported to attenuate leukocyte infiltration and suppress oxidative stress in inflamed tissues by enhancing endogenous antioxidant enzyme activities like superoxide dismutase (SOD) and catalase (CAT). Together, these compounds mitigate edema formation, joint swelling, and cartilage degradation in experimental arthritis, suggesting their potential as natural anti-inflammatory agents for managing chronic inflammatory conditions

Hypoglycemic and Hypolipidemic Potential

Studies conducted on diabetic animal models have demonstrated that extracts of *Ocimum americanum* significantly reduce blood glucose levels and improve lipid profiles, highlighting its potential antidiabetic and hypolipidemic properties. The antihyperglycemic effect is largely attributed to the presence of flavonoids and triterpenoids, which enhance insulin secretion, improve glucose uptake by peripheral tissues, and inhibit key carbohydrate-hydrolyzing enzymes such as α-amylase and α-glucosidase. These compounds also modulate oxidative stress and inflammatory pathways, thereby protecting pancreatic β-cells from damage caused by reactive oxygen species (ROS). Furthermore, treated animals showed a marked decrease in total cholesterol, triglycerides, and low-density lipoprotein (LDL) levels, along with an increase in high-density lipoprotein (HDL), suggesting a cardioprotective effect. The dual action on glycemic control and lipid metabolism supports the ethnomedicinal use of *O. americanum* in managing diabetes and its associated complications.

Toxicological Aspects

While *Ocimum americanum* is generally regarded as safe when used in traditional doses for culinary and medicinal purposes, certain chemotypes of the plant have been found to contain relatively high concentrations of methyl eugenol and estragole—two phenylpropanoid compounds that have raised toxicological concerns. Both methyl eugenol and estragole have demonstrated hepatotoxic and carcinogenic potential in animal studies, particularly when administered in high doses or over prolonged periods. The European Food Safety Authority (EFSA, 2015) has classified these compounds as potentially genotoxic and carcinogenic based on their ability to form reactive metabolites that can bind to DNA and induce mutagenic effects. Therefore, excessive or long-term consumption of *O. americanum* extracts or essential oils rich in these constituents should be avoided. Special caution is advised for vulnerable groups such as pregnant and lactating women, infants, and individuals with pre-existing liver conditions, as the safety data in these populations is limited. It is recommended to use only standardized preparations with controlled levels of methyl eugenol and estragole to minimize potential risks while retaining the herb's therapeutic benefits.

Way forward

There is increasing global interest in developing standardized extracts and essential oils from *Ocimum americanum* for diverse applications in the pharmaceutical, cosmetic, and nutraceutical industries. This is largely due to its rich phytochemical composition and broad-spectrum bioactivities, including antioxidant, antimicrobial, and anti-inflammatory properties. To fully realize its commercial and therapeutic potential,

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future research should prioritize several key areas. First, clinical validation of pharmacological effects is essential to substantiate preclinical findings and establish efficacy, safety, and appropriate dosage regimens in humans. Second, comprehensive chemotype screening and selection are necessary to identify and propagate varieties with desirable traits and low concentrations of potentially harmful constituents such as methyl eugenol and estragole, thereby ensuring consumer safety. Third, emphasis must be placed on sustainable cultivation practices, including eco-friendly agronomic techniques, organic production methods, and optimized harvesting strategies to ensure consistent yield and quality of essential oils without compromising environmental health. Addressing these research priorities will enable the safe and effective utilization of *O. americanum* as a high-value aromatic and medicinal crop in modern industries.

Conclusion

Ocimum americanum (Hoary Basil) stands as a promising multipurpose herb with culinary, aromatic, and medicinal applications. Its rich phytochemistry underpins antioxidant, antimicrobial, and anti-inflammatory effects validated in traditional and preclinical studies. Strategic research and safety assessments will expand its utility in modern phytotherapy.

EDIMENTALS: INTEGRATING ORNAMENTALS AND EDIBLES FOR SUSTAINABLE LANDSCAPES

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1. Introduction

Ornamental plants are cultivated primarily for their aesthetic value, contributing to the beautification of gardens, parks, and urban landscapes. They include a diverse range of trees, shrubs, climbers, grasses, and flowering plants valued for their foliage, flowers, fruits, fragrance and form (Adams *et al*.,, 2012). Beyond their visual appeal, ornamental plants play crucial roles in ecological balance, cultural practices, and even psychological well-being. However, many ornamental plants can be edible and serve a dual purpose in both enhancing aesthetic appeal and providing nutritional and medicinal benefits. The recent resurgence of interest in edible ornamental plants—coined "edimentals"—reflects a shift toward multifunctional landscapes that serve both visual and nutritional needs. This concept aligns with the broader practice of foodscaping or edible landscaping, which integrates edible species into ornamental beds to promote sustainability, biodiversity, and food security (Schmitzer *et al*., 2022).

2. Edimentals

Edimentals are species cultivated for dual purposes: they enhance garden aesthetics while providing edible yields, including edible flowers, leaves, roots and fruits (Table 1). Notable examples include *Tropaeolum majus* (nasturtium), *Calendula officinalis*, Chrysanthemums, chamomile, begonia etc. which are valued for both vibrant flowers or foliage and flavour. Northeast India, recognized as a biodiversity hotspot, harbours numerous potential edimentals such as *Hibiscus sabdariffa*, *Rhododendron arboreum*, *Oxalis* sp. etc., traditionally used for both decoration and food. Edimentals are rich in antioxidants, vitamins and minerals, and bioactive compounds such as flavonoids and alkaloids

TABLE 1. LIST OF EDIMENTALS WITH THEIR EDIBLE PARTS AND USES

Sl. No.	Plant Name	Botanical Name	Edible Parts	Culinary/Medicinal Uses
1.	Hibiscus	*Hibiscus rosa-sinensis, H. sabdariffa*	Petals, calyx, leaves	Tea, syrup, jam, chutney, curry
2.	Rose	*Rosa spp.*	Petals	Gulkand, desserts, syrups, tea
3.	Clitoria / Butterfly Pea	*Clitoria ternatea*	Flowers	Herbal tea, natural dye
4.	Marigold	*Tagetes spp.*	Flowers	Garnish, salad, medicinal uses
5.	Calendula / Pot Marigold	*Calendula officinalis*	Flowers	Tea, soups, salads
6.	Safflower	*Carthamus tinctorius*	Flowers and seeds	Herbal tea, medicinal uses and oil extraction from seeds
7.	Niger	*Guizotia abyssinica*	Seeds	Roasted seeds and oil extraction
8.	Sunflower	*Helianthus annus*	Flower and seeds	Herbal tea and seed oil
9.	Snapdragon	*Antirrhinum majus*	Flowers	Garnish (mild flavor)
10.	Chrysanthemum	*Chrysanthemum spp.*	Flowers	Tea, salad, traditional medicine
11.	Dendrobium Orchid	*Dendrobium chrysanthum*	Flowers	Garnish, herbal medicine (TCM)
12.	Water Lily	*Nymphaea sp.*	Flowers, seeds, tubers (select species)	Salads, curries, medicinal preparations
13.	Lotus	*Nelumbo nucifera*	Flowers, seeds, roots	Soups, pickles, sweets, snacks
14.	Oxalis / Wood Sorrel	*Oxalis sp.*	Leaves, flowers	Tart flavor in salads (moderation advised)
15.	Ornamental Curcuma	*Curcuma alismatifolia, C. longa*	Rhizome, flowers (few species)	Curries, pickles, herbal remedies
16.	Garlic Vine	*Mansoa alliacea*	Leaves, flowers	Garlic-flavored seasoning, medicinal tea
17.	Lavender	*Lavandula spp.*	Flowers	Baked goods, tea, syrups
18.	Chamomile	*Matricaria chamomilla*	Flowers	Herbal tea, calming tonic
19.	Pansy / Viola	*Viola tricolor, V. odorata*	Flowers	Garnish, desserts, drinks
20.	Basil (Purple/Ornamental types)	*Ocimum basilicum*	Leaves, flowers	Culinary herb, garnish
21.	Nasturtium	*Tropaeolum majus*	Leaves, flowers, seeds	Salads, peppery flavour, pickled seeds
22.	Dahlia	*Dahlia sp.*	Tubers	Starchy vegetable, mild flavour
23.	Chinese pinks	*Dianthus chinensis*	flower	Herbal tea and cake or as a decoction
24.	Cosmos	*cosmos sulphureus* (orange) and *Cosmos caudatus*	petals and young leaves	Decoctions or tea
25.	Daylily	*Hemerocallis sp.*	Buds, flowers, tubers	Soups, stir-fries
26.	English daisy	*Bellis perennis*	Flower	Spicy and bitter flower is used in salad, cake, porridge and as a decoction.
27.	Morning glory	*Ipomoea carica*	Flower	Soup, decoction

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28.	Tulip	*Tulipa sp.*	Petals (select varieties only)	Salad garnish (ensure chemical-free)
29.	Begonia	*Begonia sp.*	Flowers, leaves	Tart salads, cooling drinks
30.	Geranium	*Pelargonium × hortorum*	Flowers, leaves	In jam or ice cream, baked goods, flavouring honey or made into syrup.
31.	Cornflower	*Centaurea cyanus*	Flowers	Garnish, colourful salads
32.	Borage	*Borago officinalis*	Flowers, leaves	Beverages, salads, cooling properties
33.	Lily (edible types)	*Lilium brownii*, *L. lancifolium*	Bulbs, flowers (cooked only)	Soups in East Asian cuisine
34.	Bougainvillea	*Bougainvillea* sp.	Colourful bracts and flowers	Herbal tea
35.	Jasmine	*Jasminum sambac*	Flower	Tea infusion for scented tea

3. BENEFITS OF EDIMENTALS

3.1 Environmental Sustainability and Biodiversity

Incorporating edimentals into landscapes, gardens and urban spaces, creates a multifunctional ecosystems that support pollinators, enhance soil health and reduce the need for chemical inputs. These plants contribute to biodiversity conservation by providing habitats and food sources for various insects, birds, and microorganisms, thus maintaining ecological balance. Cultivating edimentals encourages sustainable land use practices, such as organic gardening and permaculture, which minimize environmental degradation and promote resource efficiency. Moreover, their dual value as both aesthetic and nutritional resources aligns with sustainable development goals, fostering resilient ecosystems and improving food security while enhancing the cultural and ecological richness of landscapes.

3.2 Nutritional and Phytochemical Value

Studies on ornamental edible flowers (e.g., begonia, nasturtium, calendula, rose, daylily, marigold) demonstrate rich antioxidant activity, phenolic and flavonoid content, and essential minerals such as K, Ca, Mg, Fe (Carboni *et al.*, 2025). Furthermore, ornamental plant extracts are gaining attention as natural colorants, antimicrobials, and nutraceuticals (Lekshmi *et al.*, 2023). Phenolic acids, flavonoids, anthocyanins and carotenoids are abundant in edible flowers. These compounds underlie the flowers' antioxidant and anti-inflammatory effects (Janarny *et al.*, 2021; Lekshmi *et al.*, 2023). Minerals and vitamins (K, Ca, Fe, vitamins A, C, E) are significant contributors to the health value (Mlcek et al., 2021).

4. APPLICATIONS IN CULINARY AND FUNCTIONAL FOODS

Edimentals find wide applications as:

4.1 Culinary delights:

Edible ornamental plants offer not only visual appeal but also unique flavours, fragrances, and nutritional benefits, making them a valuable addition to gourmet cuisine. (Matyjaszzczyk and Smiechowska, 2019) Vibrant flowers such as *Nasturtium* (*Tropaeolum majus*), *Calendula officinalis*, and *Viola* are often used as garnishes in salads, soups, and desserts, enhancing both aesthetics and taste. Herbal infusions made from *Clitoria ternatea* (butterfly pea) and *Hibiscus sabdariffa* produce antioxidant-rich teas with vibrant hues and therapeutic properties. Petals of *Rosa* spp. and *Lavandula* (lavender) are incorporated into flavoured oils, vinegars, and syrups for culinary innovation. Candied flowers like violets and pansies add elegance to confectioneries, cakes, and pastries. Additionally, several edimentals are processed into value-added products such as jams (*Rosa* hips), herbal beverages (*Jasmine*, *Chamomile*), and natural food colorants (*Marigold*, *Safflower*). These applications reflect the growing interest in edimentals as functional ingredients in modern gastronomy and wellness-focused diets. Garnishes, salads, herbal teas, and desserts.

4.2 Functional ingredients:

Edible ornamentals are rich in bioactive compounds that make them valuable as functional ingredients in the food, nutraceutical, and cosmetic industries.

These plants contain diverse phytochemicals such as flavonoids, anthocyanins, carotenoids, and phenolic acids, which confer health-promoting properties including antioxidant, anti-inflammatory, antimicrobial, and cardioprotective effects. For example, *Clitoria ternatea* flowers are used as natural colorants and memory-enhancing herbal supplements due to their high anthocyanin content, while *Hibiscus sabdariffa* calyces are incorporated into beverages for their blood pressure-lowering effects. Extracts of *Calendula officinalis* and *Lavandula* are utilized in herbal teas, syrups, and skincare formulations for their soothing and healing properties. Moreover, dried petals of *Tagetes* (marigold) serve as sources of lutein, a carotenoid beneficial for eye health, and are used as natural additives in functional foods. These applications underscore the potential of edimentals as sustainable and multifunctional resources for health and wellness industries.

4.3 Value-added products:

Edible ornamentals offer immense potential for developing diverse value-added products that cater to culinary, nutraceutical, and cosmetic markets. The vibrant petals of *Rosa* spp. are processed into rose water, essential oils, jams, and syrups, widely used in gourmet foods and skincare. *Hibiscus sabdariffa* calyces are utilized for preparing herbal teas, natural colorants, and refreshing beverages with antihypertensive properties. *Calendula officinalis* flowers are incorporated into salves, ointments, and herbal infusions for their anti-inflammatory and wound-healing properties. *Clitoria ternatea* is a popular source of anthocyanin-rich powders and liquid extracts, used as natural blue colorants in confectionery and functional drinks. Dried petals of *Tagetes* (marigold) yield lutein, which is added to eye-health supplements and poultry feed for yolk pigmentation. These value-added products enhance the economic viability of edimentals, promoting their utilization beyond ornamental gardening and contributing to sustainable livelihoods and wellness-focused industries.

5. EDIMENTALS IN SUSTAINABLE LANDSCAPING

Incorporating edimentals into urban gardens, vertical farming systems, and agro-ecological designs supports:

5.1 Biodiversity conservation

Edimentals play a crucial role in conserving biodiversity by integrating ornamental and edible plant species into sustainable landscapes and agroecosystems. Many edible ornamentals such as *Hibiscus sabdariffa*, *Rhododendron arboreum* and *Clitoria ternatea* are native or endemic to biodiversity-rich regions like Northeast India. Cultivating these species in home gardens, urban green spaces, and community landscapes not only enhances aesthetic value but also supports *in-situ* conservation of genetic resources.

5.2 Pollinator attraction

Edimentals play a dual role in enhancing garden aesthetics and supporting ecological functions by attracting diverse pollinators. Many edimentals such as *Calendula officinalis* (pot marigold), *Tropaeolum majus* (nasturtium), and *Rosa* sp. produce vibrant flowers rich in nectar and pollen, serving as foraging sites for bees, butterflies, hoverflies, and other beneficial insects. The presence of these plants in home gardens, agroecosystems, and urban landscapes contributes to pollinator biodiversity, ensuring the reproductive success of both ornamental and food crops in the vicinity. Additionally, *Clitoria ternatea* and *Hibiscus rosa-sinensis* are particularly favoured by native bee species and hummingbirds, respectively, in tropical regions. By integrating such species into functional landscapes, edimentals promote ecosystem services like pollination and biological pest control, while also contributing to the conservation of declining pollinator populations globally.

5.3 Food security in urban areas

Edible ornamentals, or edimentals, offer innovative solutions for enhancing food security in urban landscapes. With rapid urbanization and limited arable land, integrating these multifunctional plants into city spaces combines aesthetic value with nutritional benefits. Rooftop gardens, vertical walls, balconies, and community parks can host edimentals such as *Tagetes* (marigold), *Clitoria ternatea* (butterfly pea), *Hibiscus sabdariffa* (roselle), and *Nasturtium*, enabling city dwellers to grow nutrient-rich foods in compact spaces. These plants provide fresh, pesticide-free flowers, leaves, and fruits rich in vitamins, minerals, and bioactive compounds, supplementing urban diets and addressing micronutrient deficiencies. Beyond nutrition, edimentals contribute to urban biodiversity, improve air quality, and foster community engagement in gardening initiatives. Promoting edimentals in urban agriculture aligns with global sustainable development goals (SDGs) by linking urban greening with health, well-being, and resilient food systems.

6. SAFETY AND AGRONOMIC CONSIDERATIONS

6.1 Pesticide and Contaminant Management

As edible ornamentals are consumed directly or used in culinary preparations, ensuring their safety from chemical residues and contaminants is crucial. Conventional ornamental plants are often subjected to heavy pesticide applications for aesthetic perfection, but such practices are unsuitable for edimentals intended for human consumption. Adoption of integrated pest management (IPM) strategies, including the use of biopesticides, neem-based formulations, entomopathogenic fungi, and beneficial insects, can help minimize pesticide reliance. Additionally, cultivation in controlled environments such as polyhouses and vertical farms reduces exposure to air pollutants and heavy metals often encountered in urban settings. Regular monitoring of soil and irrigation water quality is also important to avoid the accumulation of contaminants like lead, cadmium, or arsenic in edible plant parts. Educating growers and consumers about safe production practices, organic certification, and postharvest washing techniques further enhances food safety in edimental systems. Edimentals must meet food safety standards, necessitating organic cultivation practices and accurate species identification to avoid toxic substitutes (Lekshmi *et al.*, 2023).

6.2 Toxicity Awareness

While edible ornamentals provide nutritional and therapeutic benefits, it is essential to recognize that not all ornamental plants are safe for consumption. Many garden species contain toxic compounds such as alkaloids, glycosides, or oxalates that can cause adverse health effects if ingested. For instance, while *Hibiscus sabdariffa* and *Calendula officinalis* are widely recognized as safe, plants like *Lantana camara* and *Nerium oleander* are highly toxic and must be excluded from edible landscapes. Even within safe species, overconsumption of certain parts (e.g., oxalic acid in *Oxalis* sp.) can pose risks such as kidney stone formation. Awareness of edible and non-edible parts, proper identification, and moderation in consumption are critical to prevent accidental poisoning. Public education campaigns, labelling in nurseries, and adherence to food safety standards can promote responsible use of edimentals while ensuring consumer safety.

7. Discussion

Edible ornamentals, or edimentals, are emerging as promising components of sustainable horticulture, offering dual benefits of aesthetic appeal and nutritional value. Rich in bioactive compounds such as flavonoids, anthocyanins, carotenoids, and phenolic acids, these plants exhibit antioxidant, anti-inflammatory, and antimicrobial properties, supporting their use as functional foods and nutraceuticals (Mlček and Rop, 2011). Species like *Clitoria ternatea* and *Hibiscus sabdariffa* have been documented for their health-promoting effects, including memory enhancement and blood pressure regulation, respectively (Rop et al., 2012). Moreover, integrating edimentals into urban landscapes enhances biodiversity and supports pollinators, aligning with sustainable development goals. However, the risk of pesticide residues, heavy metal accumulation, and misidentification of toxic species necessitates awareness and adoption of safe cultivation practices such as organic farming and integrated pest management. Future research should focus on profiling phytochemicals in underutilized species, developing value-added products, and evaluating their health effects through clinical studies to establish edimentals as vital contributors to nutrition and wellness.

8. Conclusion

Edimentals redefine the boundary between ornamentals and edibles, offering a compelling model for sustainable, biodiverse, and productive landscaping. Their aesthetic richness, ecological function, and nutritional benefits make them well-suited for modern foodscaping initiatives. Adoption and rigorous study of edimentals will further support sustainable gardening and urban resilience.

EVALUATING ORGANIC FOLIAR NUTRITION STRATEGIES FOR SUSTAINABLE GARDEN PEA (PISUM SATIVUM L.) PRODUCTION

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The garden pea (*Pisum sativum L.)* is one of the most important leguminous vegetables cultivated in India, known for its nutritional richness, including proteins, essential amino acids, vitamins, and minerals. Beyond its dietary role, the pea crop is a crucial component of sustainable agriculture as it enriches soil fertility through symbiotic nitrogen fixation, thereby reducing the dependence on chemical nitrogen fertilizers. Globally, and particularly in India, the increasing demand for pulses and vegetables has led to intensified cultivation practices. Unfortunately, this has also resulted in heavy reliance on inorganic fertilizers, which, though effective in boosting yields in the short term, have serious consequences for soil health, microbial diversity, and long-term sustainability.

In recent years, the paradigm of agriculture has been shifting towards sustainable and environmentally friendly practices. Organic inputs are increasingly recognized as critical tools to restore soil fertility and improve crop productivity. Among these, liquid organic manures such as Panchagavya and Jeevamrutha have gained popularity. Panchagavya, a traditional fermented product derived from cow dung, urine, milk, curd, and ghee, is known for its abundance of nutrients, growth-promoting hormones, and beneficial microorganisms. Jeevamrutha, an indigenous preparation promoted under Zero Budget Natural Farming (ZBNF), contains cow dung, urine, jaggery, pulse flour, and soil, enhancing soil microbial activity and nutrient cycling. These formulations not only enhance nutrient uptake but also stimulate physiological processes such as photosynthesis, flowering, and seed development. Despite their potential, the adoption of such organic foliar sprays in commercial vegetable production remains limited due to the lack of scientific validation in diverse agro-ecological conditions. Therefore, this study was designed to compare the effects of Panchagavya and Jeevamrutha foliar sprays at different concentrations with the conventional RDF on the growth, yield, and economic returns of garden pea under the Eastern Himalayan conditions of Manipur.

The field experiment was conducted during the rabi season of 2023–24 at the Experimental Farm of the College of Agriculture, Central Agricultural University, Imphal, Manipur, located at 24°.45'N latitude, 93°.54' E longitude, and an altitude of 774 m above mean sea level. The experimental site is characterized by a subtropical climate with mild winters, receiving 141.62 mm rainfall during the cropping period. The mean daily maximum and minimum temperatures were 26.2°C and 6.4°C, respectively. The experiment was laid out in a Randomized Block Design (RBD) comprising eight treatments replicated three times. The treatments included Jeevamrutha and Panchagavya applied as foliar sprays at 3%, 5%, and 7% concentrations, recommended dose of fertilizer (RDF: NPK 20:60:40 kg/ha), and control (water spray). Seeds of garden pea variety Namdhari NS 1100, which matures within 85 days and is resistant to powdery mildew, were sown at 30 cm × 10 cm spacing. Pre-sowing seed inoculation with *Rhizobium leguminosarum* was carried out to enhance nodulation. Standard cultural practices including irrigation, weeding, and plant protection measures were uniformly adopted across treatments.

The data on green pod yield (kg/ha) of garden pea as influenced by organic foliar nutrition application have been given in the Table. The data showed that different level of Panchagavya and Jeevamrutha application had significant effect on green pod yield of garden pea. The maximum green pod yield per hectare was obtained with the application of recommended dose of fertilisers (2493 kg/ha), which was statistically at par with the treatments foliar application of Panchagavya @7% (2385 kg/ha) and Jeevamrutha @ 7% (2085 kg/ha) respectively. Conversely, control (water spray) yielded the minimum number of green pods at 1564kg/ha. It might have resulted in transport of assimilates thereby better balanced supply with cation and anions of potassium, nitrate nitrogen respectively enhance the other nutrient availability at critical stage could have induce more flowering, reducing in flower shedding and increased transportation of

photosynthates from source to sink and in later stage, more assimilates are produced than used in growth and development, excess assimilates are diverted to storage compounds resulting increased green pod and grain yield of garden pea. These results are in close conformity with Kumbar *et al.* (2015), Rabade *et al.* (2022), Sridhara *et al.* (2022), Singh *et al.* (2023) and Baban (2011).

Economic evaluation revealed that while RDF gave the highest gross and net returns, the cost of chemical fertilizers increased the overall cultivation expense. Panchagavya @7% however, provided the highest B:C ratio (1.74), suggesting better profitability relative to input cost. This finding is particularly important for small and marginal farmers, as it highlights the potential of low-cost organic inputs to improve both productivity and income. These results corroborate earlier studies on the effectiveness of Panchagavya and Jeevamrutha in pulses and vegetables. The highest cost of cultivation, gross income and net returns were associated with RDF. It may be due to more amount of chemical fertilizer requirement compared to other treatments. Similar results of higher cost of cultivation are well documented by Purohit *et al.* (2023). Highest benefit cost ratio was observed with the application of 7% Panchagavya. This may be attributed to higher green pod yield and grain yield resulting from application of appropriate nitrogen, phosphorous and potassium nutrients with appropriate timings of application as compared to other treatments. The results are in conformity with the findings of Amareswari *et al.* (2015).

The present investigation underscores the effectiveness of organic foliar sprays in enhancing the growth, yield, and profitability of garden pea. While RDF achieved the maximum yields, its higher input cost makes it less feasible for resource-poor farmers. Among organic treatments, Panchagavya @7% proved most effective, recording high yield attributes and the best benefit-cost ratio, thereby demonstrating its suitability as a sustainable and economical alternative. The adoption of such organic inputs can reduce dependency on chemical fertilizers, restore soil health, and contribute to long-term sustainability in legume-based farming systems. Further multi-location studies are recommended to validate these results under diverse agro-climatic conditions and to promote wider adoption.

TABLE EFFECT OF DIFFERENT DOSES OF FOLIAR APPLICATION OF ORGANIC FERTILIZER ON GREEN POD YIELD AND ECONOMICS OF GARDEN PEA UNDER MANIPUR SITUATION

Treatments	Green pod yield (kg/ha)	Total cost of Cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Jeevamrutha @3%	1564	59269	109459	50190	0.85
Panchagavya @3%	1718	59389	120252	60863	1.02
Jeevamrutha @5%	1820	59989	127434	67445	1.12
Panchagavya @5%	1940	60189	135754	75565	1.26
Jeevamrutha @7%	2085	60709	145940	85231	1.40
Panchagavya @7%	2385	60989	166956	105967	1.74
RDF	2493	66743	174538	107795	1.62
Control (water spray)	1286	58189	90044	31855	0.55
S.Em. (±)	135	-	-	-	-
C.D.(P=0.05)	407	-	-	-	-

Note: RDF @ N:P:K 20:60:40 kg/ha : Jeevamrutha and Panchagavya foliar applications were applied at 20, 40 and 60 DAS

Foliar application of natural fertilisers on garden pea

View of the experimental field

SEED TREATMENT FOR MANAGING BACTERIAL PATHOGENS IN AGRICULTURE

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Seed treatment is one of the most effective and eco-friendly methods to protect crops from harmful pathogens. The main purpose of seed treatment is to control seed-borne and soil-borne diseases, improve seed germination, and ensure healthy field stand.

Seeds are the primary carriers of many pathogens, especially bacteria, fungi, and viruses. If untreated, infected seeds can introduce diseases into new fields and cause heavy yield losses. Once the pathogen enters the soil or plant system, management becomes difficult and costly. Hence, seed treatment acts as the first line of defense by reducing the initial infection source.

The practice not only protects seedlings during the most vulnerable stages of growth but also supports sustainable farming by reducing the need for repeated pesticide sprays. In addition, seed treatment helps in achieving uniform germination, strong plant stand, and improved productivity. Modern methods also combine seed treatment with biofertilizers and growth-promoting microbes, which enhance plant growth and resistance against stress. With increasing emphasis on sustainable agriculture, seed treatment has become an important component of Integrated Pest Management (IPM) approches. Seed treatment is considered as a cost-effective, environmentally safe, and reliable strategy for ensuring food security by reducing losses caused by seed borne bacterial pathogens.

Importance of Seed Treatment

Seed treatment is a vital practice in agriculture that ensures healthy crop establishment and minimizes early-stage losses caused by pathogens and pests. Since many bacterial and fungal diseases are transmitted through seeds (**Bacterial Blight of Rice** *(Xanthomonas oryzae and loose smut of wheat)*, treating seeds before sowing is a proactive measure to prevent disease outbreaks. It provides the first line of defence for seedlings, which are particularly vulnerable during germination and early growth stages. Moreover, seed treatment contributes to improved crop yield, quality, and sustainability by reducing the need for excessive chemical applications in the field.

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Advantages

1. Protects seeds against bacterial, fungal, and viral diseases
2. Enhances seedling vigor and survival
3. Cost-effective compared to foliar sprays
4. Reduces environmental contamination
5. Promotes uniform germination and better yield
6. Compatible with modern farming technologies

Disadvantages

1. Risk of seed damage if not properly treated
2. Limited duration of protection
3. Resistance development due to chemical overuse
4. Costly for small-scale farmers
5. Health and safety concerns while handling chemicals
6. Some treatments restricted by regulations

Methods of Seed Treatment

Seed treatment methods are broadly divided into physical, chemical, and biological approaches. These techniques aim to eliminate seed-borne pathogens, improve germination, and promote healthy crop growth.

1. Physical Seed Treatment

Physical methods are eco-friendly alternatives to chemical use (Jindal *et al.*, 1991; Elwakil, 2003).

- **Hot Water Treatment:** A traditional and widely used method where seeds are soaked at 50–55°C for a specific time (10–30 minutes). It effectively controls several seed-borne diseases such as black rot in crucifers and bacterial wilt in tomato, though improper temperature may damage seed viability (Floyd, 2005; Muniz, 2001).

- **Dry Heat Treatment:** Involves heating seeds with hot air or solarization. It is effective in inactivating certain fungi, viruses, and insects, and is widely used in vegetable seeds (Luthra, 1953).

- **Aerated Steam Treatment:** Seeds are exposed to hot, humid air under controlled conditions, which kills pathogens without severely affecting germination. This method is suitable for large-scale commercial use (Tapke.,1926).

- **Radiation Treatment:** Techniques such as gamma rays, UV light, or microwaves are sometimes used to reduce microbial load. However, care is needed because higher doses can damage seeds (Bhaskara Reddy *et al.*, 1995).

2. Chemical Seed Treatment

Chemical methods are the most commonly practiced due to their quick action and wide availability.

- **Fungicides & Insecticides**: Chemicals such **as** streptomycin (100–200 mg per litre of water as foliar spray), copper oxychloride (2.5 g per litre of water as foliar spray), and sodium hypochlorite (0.5–1.0% solution for seed soaking) are commonly used to suppress bacteria and fungi. In addition, some commercial formulations combine fungicides and insecticides for broad-spectrum protection for example, Carbendazim 12% + Mancozeb 63% WP (SAAF) as a fungicide mixture, or Triazophos 35% + Mancozeb 50% WP which provides both insecticidal and fungicidal action

- **Seed Soak in Fungicides:** Seeds are immersed in aqueous fungicide solutions to control seed-borne fungi and improve germination. For example, Carbendazim 50% WP **@** 2 g per litre of **water** – effective against seed-borne fungi such as *Fusarium* and *Alternaria*.

- **Use of Antibiotics:** In some cases, antibiotics are used against bacterial seed infections, but they may cause phytotoxic effects such as bleaching and stunted seedlings.

- **Soaking in Inorganic Chemicals:** Seeds are soaked in mineral solutions like calcium chloride, zinc sulfate, or boric acid, which help improve germination, seedling vigor, and stress tolerance. Calcium chloride at 1–2% solution is known to improve germination and increase tolerance to environmental stresses, while zinc sulfate at 0.05–0.1% solution promotes seedling vigor and helps in correcting zinc deficiency during early growth. Similarly, boric acid at 0.2% solution improves pollen viability, fruit set, and early seedling establishment. Typically, seeds are soaked in these solutions for 6–12 hours, depending on the crop and chemical used, and then shade-dried before sowing. (Mariappan *et al.*, 2013).

3. Biological Seed Treatment

Biological methods involve coating or inoculating seeds with beneficial microorganisms that protect plants and enhance growth.

- **Microbial Inoculants:** Species such as *Rhizobia* (for legumes), *Azospirillum*, *Pseudomonas, Bacillus*, and *Trichoderma* improve nutrient uptake, fix nitrogen, and suppress pathogens.
- **Biopriming:** A combination of seed hydration (soaking) and inoculation with biological control agents. The seeds are soaked for a specific period, then mixed with the agent, allowing the beneficial microbes to colonize the seed surface during germination.
- **Systemic Acquired Resistance (SAR):** Triggered by prior infection or chemicals like salicylic acid, leading to activation of defense proteins that protect plants against future pathogen attack.
- **Induced Systemic Resistance (ISR):** Stimulated by non-pathogenic microbes like PGPR (*Pseudomonas* and *Bacillus*), which prime plants to respond faster and stronger when exposed to pathogens.
- Natural/Organic Treatments: Eco-friendly seed treatments use biocontrol agents like *Trichoderma harzianum* or *Pseudomonas fluorescens* (4–10 g/kg seed) to protect against pathogens and boost vigor. Neem oil or leaf extracts (5–10 ml/kg seed) help reduce seed-borne infections and repel insects, while traditional practices such as soaking seeds in cow urine or compost tea also improve germination and early growth. These methods reduce chemical dependence and support sustainable crop production.

Management of Seed-Borne Bacterial Diseases

1. **Bacterial Blight of Rice (*Xanthomonas oryzae*)**

- Hot Water reatment: Soak seeds at 52–54°C for 10–15 minutes.
- Chemical Treatment: Use Streptomycin (0.1%) + Copper oxychloride (0.3%), or Sodium hypochlorite (1%).
- Biological Treatment: Coat seeds with *Pseudomonas fluorescens* (4–10 g/kg seed) to reduce infection.

2. **Bacterial Wilt (*Ralstonia solanacearum*) – Tomato & Potato**

- Hot Water Treatment: Soak tomato seeds at 50°C for 30 minutes.
- Chemical Treatment: Dip seeds in 0.5% Bleaching powder or a mixture of copper sulfate (0.1%) + Streptomycin (0.1%).
- Biological Treatment: Treat seeds with *Pseudomonas fluorescens* (4–10 g/kg seed) to improve germination and seedling vigor.

3. **Black Rot of Cabbage (*Xanthomonas campestris*)**

- Hot Water Treatment: 50°C for 25–30 minutes.
- Chemical Treatment: Use Sodium hypochlorite (1%) or Mercuric chloride (0.01%).
- Biological Treatment: Seed coating with *Pseudomonas fluorescens (add dose)*

4. **Halo Blight & Common Blight of Beans** *(Pseudomonas syringae, Xanthomonas axonopodis)*

- Hot Water Treatment: 55–56°C for 10–15 minutes.
- Chemical Treatment: Use Streptomycin + Copper oxychloride, or Sodium hypochlorite (1%).
- Biological Treatment: Apply *Bacillus subtilis* or *Trichoderma* as seed coating.(dose ?)

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5. **Bacterial Canker of Tomato** *(Clavibacter michiganensis)*

- Hot Water Treatment: 52–54°C for 25 minutes.
- Chemical Treatment: Soak seeds in 1% Bleach solution (15 min) or Streptomycin (100 ppm for 30 min).
- Biological Treatment: Seed treatment with *Bacillus subtilis* increases resistance.

Conclusion

Seed treatment is an essential practice for preventing seed-borne diseases and ensuring healthy crop establishment. Physical, chemical, and biological methods each play an important role, but their combined use offers the most effective and sustainable results. By reducing early pathogen load, improving germination, and promoting strong seedlings, seed treatment acts as the first line of defense for crops and contributes to higher yield and sustainable agriculture.

GOAT FARMING AS A PROMISING ENTREPRENEUR FOR THE FARMERS OF PEREN DISTRICT, NAGALAND

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Livestock plays an important role in Indian economy for small holder farmers by providing animal origin protein source in the form of meat and milk for family consumption and also serves as a source of additional income. About 20.5 million people depend upon livestock for their livelihood. The contribution of livestock to the national economy is about 4.9 % of total GDP and 25.6 % of total agriculture GDP, the share to total exports is about 11.54 % (apeda.gov.in). Goat is considered as one of the most important among the livestock and its contribution towards meat and milk is 13.72 percent and 2.95 percent as per 20th livestock census. Goat slaughtered around 103.60 million during the year 2019-20. Goat and sheep meat export 7111 million tones which is about 0.22 percent share in total meat export (Livestock production statistics of India 2020). Goat is also considered as one of the most important livestock next to pigs in NE region, the population of goat is 5408245 in North-east which is 3.7 % of the total goat population of India. Goat population in Nagaland is only 31602 as per 20th livestock census which is the lowest among the seven NE states.

The College of Veterinary Sciences and Animal Husbandry, Jalukie, Peren, Nagaland took up a project to boost up the farmers income through goat farming especially at Peren district of Nagaland by selecting two villages i.e. Jalukie–B and Old Jalukie. The selected villages consist of 1070 household number at Jalukie–B with human population of 5456 and Old Jalukie is 507 with population of 1447.The source of income of these villages were mainly backyard livestock rearing and agriculture crops. Among the livestock rearing the common livestock were pig, goat, cattle, buffalo, sheep and poultry mainly chicken, duck, Muscovy duck, geese, Japanese quail and turkey etc. System of goat rearing in this region was mainly free range system, open with temporary enclosure and semi intensive system.

Popularization of profitable goat farming for sustainable livelihood especially among the women group is needed since initial investment is very less in comparison to other livestock. This project will also help farmers to integrate goat farming as one component under integrated farming system which will be suitable for the region and also enhance their income generation.

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The farmers rear livestock mainly for household purpose which required intervention for commercialization of the surplus livestock production. Large scale livestock farming can be achieved only by scientific farming and introduction of elite breeds this will not only improve their livelihood but can also change the concept of backyard livestock keeping. In order to initiate a change, we started our project with 20 number of beneficiary.

Target of the project

The selected farmers were given training, they were advice to construct low cost shed with locally available materials, slatted flooring. Training on scientific management in regards of balanced feeding, breeding, vaccination, deworming, curative health care, culling etc. were provided to the farmers with the target of profitable goat farming which means 3 kidding in 2 years with less than 5% mortality from birth to sale. Aiming a profitable goat farming, selected farmers were given 3 goats each 2:1 ratio of male and female, total of 60 numbers of goat along with concentrate feeds, mineral mixture and anthelmintics drugs were distributed.

Fig.1: Distribution of 60 numbers of goats to 20 beneficiary at Jalukie –B and Old Jalukie, Peren district of Nagaland

System of goat rearing

The farmers usually rear goats under free range and semi-intensive system. The reason for not adopting goat intensive farming may be due to economically weaker condition of the farmers. The farmers are instructed to make their goat sheds with slatted type of floor which is suitable for NE region because of high humidity and heavy rainfall. The floor is elevated approximately 3–3.5' (0.9–1.05 m) above the ground to facilitate cleaning and to avoid possible of water logging. The advantage of slatted flooring is mainly to limit the direct contact with the excreta which prevent from various parasitic infestation and respiratory diseases. Bamboo slats or wooden slats 3" thick and 1" wide (7.5 cm and 2.5 cm respectively) may be used as flooring materials which are laid one after another leaving about 1 cm gap in between. The roofing is tin sheets to protect the goats from rain and heat. The walls of the shed are with bamboo or timber which provides adequate ventilation.

Feeding

Commonly farmers fed the animals with household kitchen waste, jackfruit leave, neem leave, maize leave, grasses, *Melastoma Melabatricum* (Indian rhododendron) rice polish, broken rice etc.

Health care and management

The goats were vaccinated against viral diseases like Foot and Mouth Disease (FMD) and Peste des petits ruminants **(PPR)** diseases. Routinely deforming is done every 3 months, minerals mixture is provided along with the feed as per requirement.

Outcome of the project

After about one and the half years the farmers shows increase in the number from 60 to 80 numbers and many does are pregnant. Some of the progressive beneficiaries are mentioned below:

Table no. 1. Beneficiary details of goat farmers

SN	Name of beneficiary	Name of Village	Income from goat farming (Rs.)	Beneficiary photograph
1.	Shri Peiding, having 2.0 acres land at foot hill with fishery cum other components integrated farming.	Old Jalukie	35000 to 40000 additional income from goat farming annually (value for 9 nos. of goats)	

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2.	Shri. Zierang having 1.0 acres land with integrated farming.	Old Jalukie	25000 to 30000 additional income from goat farming annually (value for 5 nos. of goats)	
3.	Smt. Neyen having 2.0 acres land with integrated farming.	Old Jalukie	25000 to 30000 additional income from goat farming annually (value for 5 nos. of goats)	
4.	Smt. Rebecca having 3.0 acres land with integrated farming of piggery cum poultry.	Jalukie –B	20000 to 25000 additional income from goat farming annually (value for 4 nos. of goats)	

Suggestions:

- There should be common browsing area in their respective villages.
- Construction of livestock shed should be away from homestead areas.
- Plantation of locally available trees and fodders which can be used as goat feed.
- Record keeping of the goat farm
- Avoid continuous inbreeding
- Observe sanitation of livestock shed areas.
- Restrict visitors into livestock shed areas
- Isolation of sick animals
- Vaccination and deworming should be done regularly.

Conclusion

Goat farming has gained popularity amongst the farmers of Peren district, Nagaland as it requires less investment, less labour intensive and quick proliferation than other animal husbandry. It provides an excellent source of subsidiary income. Goat farming is an ideal option for people who want to earn money through sustainable practices.

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IMPROVED BACKYARD POULTRY PRODUCTION FOR LIVELIHOOD AND NUTRITIONAL SECURITY IN NAGALAND

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The livestock sector is vital for rural livelihoods and socio-economic upliftment of the majority of tribal people in Nagaland. It provides milk, meat, eggs, draught power and manure. Livestock also plays an integral part in socio-cultural practices among tribes and provides self-employment opportunities. Further, it ensures food and nutritional security, especially dietary protein requirements.

Livestock farming in Nagaland is largely characterized by traditional age-old backyard farming system, where most of the households rear 2-3 numbers of pigs and 15-30 numbers of desi birds. These animals are primarily raised for meat and egg purposes, but they are sold to meet emergency household's needs such as medicine, clothes, and school fees.

The per capita availability of eggs in Nagaland during 2016–17 to 2022–23 remained much lower than the all-India average (Table-1). This shortfall is attributed by several factors: a continuous decline in poultry population (Fig 1), the absence of indigenous registered layer breeds, confinement solely on backyard farming, and the inherently low annual egg yield of desi birds. Similarly, total meat production in the state has shown a declining trend (Fig 2). Interestingly, per capita availability of meat in Nagaland was higher than the all-India average (Table 2). This paradox is explained by the large-scale import of meat animals from other states. This highlights the challenge of meeting the growing demand for eggs and meat in the state.

Backyard poultry farming can be a viable alternative to piggery, as it provides both meat and eggs. Further, it serves as an important affordable animal protein source (FAO, 2013). Eggs, in particular, are an essential part of a balanced diet, being rich in vitamin D, carotene, calcium, iron, and phosphorus. Therefore, backyard poultry also plays a vital role in improving the livelihoods and nutritional security of women, children, the elderly, and the chronically ill (Kumaresan *et al.,* 2008).

The productivity of traditional backyard poultry farming with desi birds, in terms of meat and eggs, remains much lower than that of commercial poultry. At the same time, consumer preference for local chickens and eggs is high, owing to their taste, texture, and flavour (Sapcota *et al.,* 2002). With the growing human population and rapid industrialization, the demand for sustainable animal-source foods will continue to rise. Therefore, promoting backyard poultry farming with improved germplasm represents an appropriate intervention to bridge the gap in egg and meat demand while enhancing livelihood and nutritional security in Nagaland.

TABLE 1: PER CAPITA AVAILABILITY OF EGGS DURING 2016-17 TO 2022-23 (FIG IN NUMBER/ANNUM).

Year	Nagaland	All India
2016-17	19	68
2017-18	19	73
2018-19	18	79
2019-20	18	86
2020-21	18	90
2021-22	16	95
2022-23	16	101

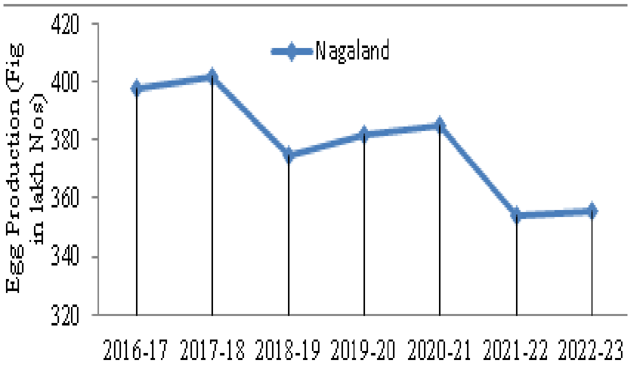

Fig.1: Trends of total eggs production (Statistical Handbook of Nagaland, 2021 Govt. of Nagaland).

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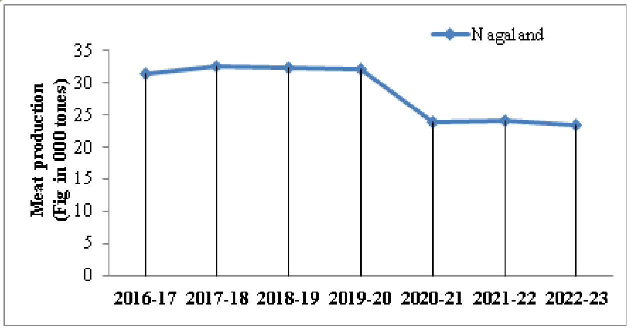

Fig. 2: Trends of total meat production (Statistical Handbook of Nagaland, 2021 Govt. of Nagaland).

Table 2: Per Capita Availability of Meat During 2016-17 to 2022-23 (figures in Kg/Annum)

Year	Nagaland	All India
2016-17	15.04	5.72
2017-18	15.37	5.86
2018-19	15.16	6.15
2019-20	14.93	6.45
2020-21	11	6.52
2021-22	10.99	6.82
2022-23	10.53	7.1

Backyard Poultry Production System

Poultry in backyard systems are usually reared in small units of 10–20 birds per household, primarily for family consumption, with surplus male birds sold for additional income. This system is characterized by the rearing of native, indigenous, or improved birds with low or no input, relying largely on scavenging for natural feed. The birds also consume household waste and insects, thus utilizing resources not directly useful to humans or livestock. Management typically involves minimal supplementary feeding, simple night shelters, and limited healthcare practices.

According to FAO (2014), backyard poultry production can be classified into four systems: (1) small-scale extensive scavenging, (2) scavenging, (3) semi-intensive, and (4) small-scale intensive systems. Similarly, Rajkumar *et al.* (2021), in the context of India, categorize backyard poultry into (1) the traditional backyard system, (2) semi-intensive farming, (3) small-scale intensive farming, and (4) native chicken farming.

In Nagaland, the majority of households traditionally rear native chickens or desi birds. These birds grow slowly and lay fewer eggs than commercial broilers and layers but are widely accepted by rural and tribal communities. Moreover, prophylactic health care and biosecurity measures are rarely practiced in this system, leading to sporadic disease outbreaks and high mortality rates.

Backyard Poultry Production with Improved Germplasm

The productivity of backyard poultry production systems can be enhanced either by introducing improved germplasm in Nagaland (Table 3) or by adopting better management practices. Improved poultry germplasm, owing to its similarity in phenotypic appearance to desi birds—particularly their multi-coloured plumage is well accepted by poultry farmers in many parts of the NEH region of India including Nagaland. In addition, these birds exhibit faster growth rates and therefore produce more meat and eggs than native chickens. They are also hardy, have better liveability, show relatively higher disease tolerance, and produce brown eggs with a greater egg mass than indigenous chickens. These traits make them highly suitable for backyard farming with improved germplasm compared to traditional systems with desi birds (Singh *et al.,* 2022).

Dual purpose two improved poultry varieties—ICAR-Debendra and CARI-Nirbheek are under trials in Jalukie, Peren, Nagaland under the ICAR-NEH scheme by the College of Veterinary Science and Animal Husbandry, CAU (Imphal), Jalukie, Peren. So far, the performance of these poultry varieties has been encouraging under both backyard and semi-intensive systems. Farmers have reported the onset of egg production as early as four months in backyard systems, while growth performance has also been promising.

Fig 4: ICAR- Debendra and CARI-Nirbheek poultry varieties reared under the Semi Intensive production system.

TABLE 3: GROWTH AND EGG PRODUCTION PERFORMANCE OF IMPROVED BACKYARD POULTRY GERMPLASM.

SN	Improved Backyard Poultry Germplasm	Type (egg/meat/dual)	Body weight female	Body weight male	Egg production	References
1	Vanaraja	Dual	1,613 gram at 20 weeks age	2,216 gram at 20 weeks age	137 eggs per hen per yea	Singh *et al.*, 2021
2	Srinidhi	Dual	981 gram at 20 weeks age	2,288 gram at 20 weeks age	202 eggs per hen per year	Singh *et al.*, 2022
3	Rainbow rooster	Dual	1,650 gram at 20 weeks age	-	163 eggs per hen per year	Singh *et al.*, 2022

CHALLENGES IN BACKYARD POULTRY FARMING

- Non-availability of improved poultry germplasm suited to local agro-climatic conditions.
- Disease outbreak and biosecurity threats.
- Lack of skill: Backyard poultry farming is traditionally practiced by farmers; however, rearing improved poultry germplasm with flocks of more than 50 birds requires scientific management practices in order to realize their full genetic potential.

CONCLUSION

Backyard poultry farming with improved germplasm and better management practices has immense potential to enhance food security, generate income, and support vulnerable communities. The introduction of improved poultry germplasm can revolutionize this sector by increasing productivity while retaining native traits, particularly benefiting small and marginal farmers of Nagaland. However, challenges such as disease outbreaks and lack of skills hinder the realization of its full potential.

Fig 5: ICAR- Debendra and CARI-Nirbheek poultry varieties reared under the backyard production system in Jalukie, Peren, Nagaland.

ACKNOWLEDGEMENTS

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DYNAMICS OF HONEY PRODUCTION IN INDIA: AN ANALYTICAL PERSPECTIVE

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Introduction

Honey is described as a viscous syrupy fluid made by honeybees from plant nectar and there is no natural alternative to honey. Honey has been utilized in various ways to treat wide range of diseases since time immemorial. Beekeeping or apiculture is the art of raising and harvesting bees for the purpose of collecting honey and other beekeeping products such as bees wax (Cadwallader *et al.,* 2011). India has a long history of honey and bees (Debjani, 2023) and it is regarded as the "land of honey" (Shree *et al.,* 2017). Indian bees are generationally familiar with the local fauna and flora, so the pollination cover by bees is wider (Devidayal, 2023). In the last 10 years, an increase of 16.9 per cent in the number of colonies and an increase of 8.81 per cent in honey production has been achieved. In terms of honey production, China stood first with 461,000 tonnes followed by Turkey with 118297 tonnes and Iran producing 79535 tonnes and India producing 74204 tonnes (worldpopulationreview, 2025)

India produces many varieties of honey, including eucalyptus, lychee, sunflower, and multi-floral Himalayan. Approximately 1,33,200 Metric Tonnes (MT) of honey are produced in India annually (Press Information Bureau, 2022). Uttar Pradesh is India's largest honey-producing state, contributing over 30 per cent to the nation's honey output. Other leading honey-producing Indian states include Gujarat, Punjab, Bihar, and Madhya Pradesh. Based on honey export data, India's honey export has surpassed 107963.21 MT of natural honey to the world for the worth of Rs. 1470.84 crore/177.52 USD million during 2023-24. The prime markets for honey export from India include the USA, Saudi Arabia, the United Arab Emirates, Bangladesh, and Canada (Eximpedia, 2024) where 17 states of India are currently participating in exporting natural honey to various countries across the world. The global honey has soared during the COVID-19 pandemic, as it is increasingly favoured as a healthier alternative to sugar and an effective immune-enhancing supplement, highlights the significant export potential in India. This paper makes an attempt to assess the performance in natural honey production and export from India. Therefore, an attempt has been made to investigate growth trends in production and Export of honey from India and to determine the instability of the production and export of honey in India.

Data And Methodology

The time series data from the last 20 years *i.e.* 2004-2023 for production of natural honey and 10 years *i.e.,* 2014-2023 for export quantity of natural honey were collected. The data for the production of honey in Nort-East India for 8 years (2015-2022) were also obtained.

The data were collected from Agricultural Processed Food Product Export Development Authority (APEDA), Government of India, National Bee Board (NBB), National horticultural Board (NHB) and Department of Agriculture & Farmers Welfare.

Methodology

Compound growth rate

The growth rate in production and export of honey in India was calculated by applying Compound Annual Growth Rates (CAGR).

CAGR was estimated by using the following model.

$$\text{Log } Y = \alpha + \beta_t + e \;\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where,

Y = Dependent variable (Exported quantity)

t = Time

α = Constant

β = Coefficient that determined the Growth rate

From equation (1) CAGR was computed as follows:

$$\text{CAGR} = (\text{Antilog of } \beta_2 - 1) * 100$$

Where,

β_2 = coefficient

Instability indices

The instability in production and export of honey in India were calculated using Cuddy-Della Valle Instability Index (CDVI). This index is the modification of coefficient of variation (CV) to accommodate for trend which is commonly present in time series economic.

Instability index = C.V *√(1-R^2)

Where,

C.V. = Coefficient of variation of y the time series data

R^2 = adjusted coefficient of determination

Table1: Range of CDVI

Range	Index
0-15	Low instability
15-30	Medium instability
>30	High instability

Results And Discussion

Growth rates and Instability of honey production from India

The Compound annual growth rate (CAGR) showed a positive growth rate of 6.30 per cent per annum which indicated that there was a signifying an increase in the production of honey. The instability index of production was found to be highly instable with 30.26 and showed coefficient of variation with 44.92 per cent over a period of time (Table 2).

Table 2: CAGR and instability of production of honey in India

Year (2004- 2023)	Production (%)
CAGR	6.30
CDVI (Instability index)	30.26
CV	44.92

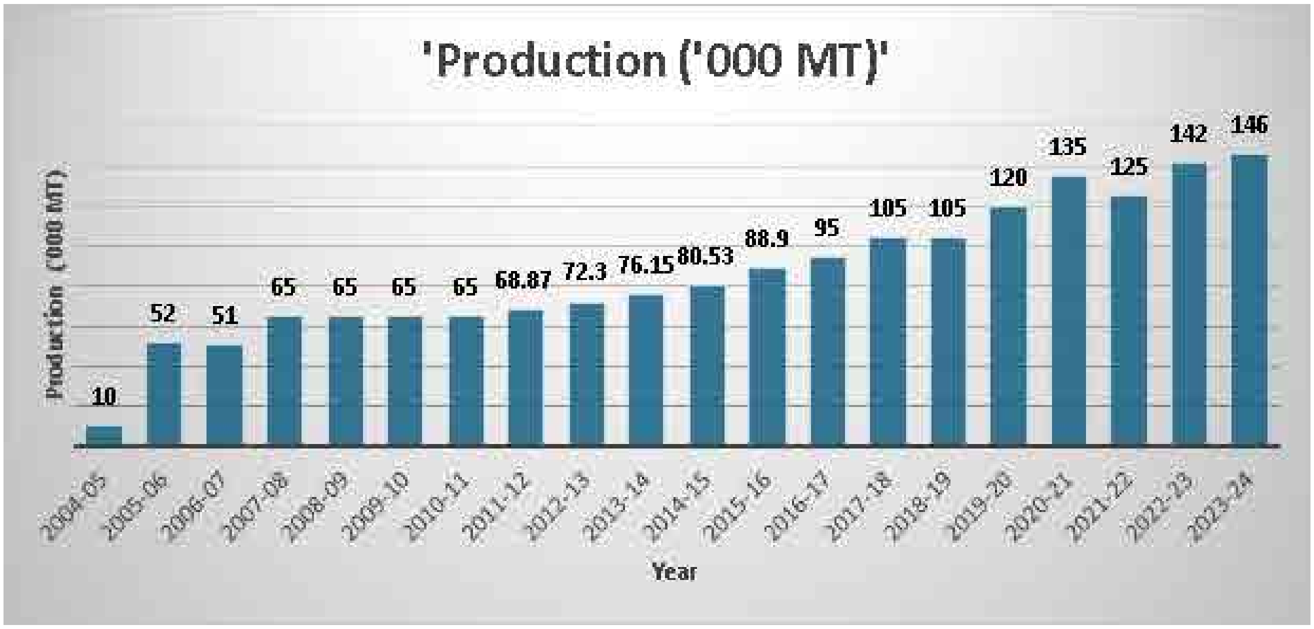

Fig.1: Production of Honey in India from 2004-05 to 2023-24

Growth rate and instability of export quantity of honey from India

Over a period of time the export quantity of honey showed a positive growth indicating increase in export quantity of honey at the rate of 2.23 per cent per annum (Table 3). The Cuddy-Della instability index for export quantity of honey was highly instable with the index of 43.24.

Table 3: CAGR and instability of export quantity of honey from India (2014-2023)

Year	Export Quantity (%)
CAGR	2.23
CDVI (Instability index)	43.24
CV	44.33

Fig.2: Export of honey in India from 2014-15 to 2023-24

Trends of Honey production in North-East India

The total production of honey in the North East Region (NER) was 3.4 ('000 MT) over the period of time. The growth rate of honey production in NER was 15.9 per cent per annum which was significantly higher compared to the all-India level but high instability was observed in production during the study period. Nagaland and Tripura show the highest CAGR for total production of honey with 14.39 per cent per annum. Despite having the highest CAGR for total production, Nagaland shows the highest instability for the same which may be attributed to paucity of money, lack of subsidy in apiculture, lack of continuous income generation and high capital input (Singh *et al.,* 2016). Instability index for production is low for Assam, Manipur and Tripura. Arunachal Pradesh, Meghalaya, Mizoram and Sikkim have a medium range of instability.

Table 4: Honey Production in North-East India from 2015 to 2022

State	Production ('000 MT)	CAGR (%)	CDVI
Arunachal Pradesh	0.12	8.86	24.19
Assam	1.23	2.04	13.43
Manipur	0.36	9.64	13.15
Meghalaya	0.25	5.24	22.47
Mizoram	0.22	3.59	20.51
Nagaland	0.61	14.39	31.56
Sikkim	0.43	3.59	18.91
Tripura	0.18	14.39	13.50
NER	3.4	15.9	123.3
All India	915.9	6.30	16.26

Conclusion And Way Forward

India's honey industry has seen positive growth in both production and exports, though it has also experienced significant instability. This instability is likely linked to environmental factors and beekeeping techniques. To address this, India needs a comprehensive strategy that involves educating beekeepers on modern techniques and technologies, improving on-ground practices, and implementing strategic market interventions. These efforts would reduce production and export instability, ultimately boosting India's competitive position in the global honey market.

WINES OF MANIPUR: CULTURAL HERITAGE, MICROBIAL ECOLOGY, AND BIOCHEMICAL PERSPECTIVES

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Introduction

Fermentation is one of humanity's most ancient food technologies, and in Northeast India it remains integral to diet, culture, and identity. Across the region, cereal-based fermented beverages form an important part of community life, with rice serving as the principal substrate. Among these, the traditional rice wine of Manipur, commonly called **Yu,**is particularly significant. Prepared and consumed across the Meitei community of the valley and among tribal groups in the hills, Yu is more than a drink: it is a cultural symbol offered in rituals, shared in festivals, and integrated into everyday hospitality. Its production is usually entrusted to women, reflecting gendered knowledge systems and intergenerational transmission of artisanal skills. In this way, Yu stands as both a dietary supplement and an intangible cultural heritage that embodies the continuity of Manipuri society.

The defining feature of Yu production is the indigenous starter culture called *Hamei*. These dried rice cakes harbor a diverse microbial consortium that initiates both saccharification of starch and alcoholic fermentation. Unlike controlled industrial fermentations that rely on monocultures, *Hamei* represents a naturally selected microbial ecosystem shaped by centuries of empirical refinement. The first systematic microbiological study of *Hamei* demonstrated its complexity: yeast species such as *Saccharomyces cerevisiae*, *Pichia anomala*, *Torulasporadelbrueckii*, *Candida tropicalis*, and *Pichia guilliermondii* were identified alongside others, confirming that fermentation is driven by a consortium rather than a single organism. This diversity not only influences ethanol yield but also shapes the flavor, aroma, and nutritional properties of Yu.

From a biochemical perspective, Yu exemplifies the dynamics common to rice wine systems worldwide. The simultaneous saccharification and fermentation process involves enzymatic hydrolysis of starch into fermentable sugars followed by yeast-mediated ethanol production. During this process, a broad spectrum of secondary metabolites emerges. Studies on other rice wines show that compounds such as higher alcohols (isoamyl alcohol, phenylethanol, n-propanol), organic acids (lactic, acetic, succinic), amino acids, peptides, esters, and phenolics accumulate during fermentation. These compounds contribute to the characteristic sensory qualities of rice wines and, in some cases, exhibit antioxidant or other bioactive properties. Although Yu itself has not been chemically profiled, it is reasonable to expect that similar metabolic pathways and products are at play, particularly since the microbial taxa identified in *Hamei* are known to produce such metabolites.

The nutritional and potential functional roles of rice wines add further dimensions. Research on Chinese and Korean rice wines demonstrates that fermentation increases free amino acids, γ-aminobutyric acid (GABA), and total phenolic content, which in turn enhances antioxidant potential. Animal studies have suggested that peptides and phenolics from rice wine may modulate inflammation and cardiovascular markers. While no such work has been carried out on Yu, these findings provide a framework for future exploration. Given that Manipur also cultivates pigmented rice varieties rich in anthocyanins and polyphenols, their use in wine-making could further enhance the bioactive profile of Yu.

Despite its promise, Yu remains scientifically underexplored. Household-level production introduces wide variability in rice cultivar, fermentation duration, water quality, and microbial load. Such variability affects not only sensory quality but also safety. Concerns about the possible formation of biogenic amines, contamination with spoilage organisms, or inconsistency in ethanol content are valid, particularly when no standardization or regulatory framework exists. Reviews of ethnic fermented foods from Northeast India emphasize that safety research on artisanal beverages remains limited, leaving a gap in quality assurance. This lack of systematic characterization not only hinders wider recognition of Yu but also constrains its potential valorization as a functional beverage in broader markets.

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At the same time, the cultural and economic stakes are high. With growing global interest in artisanal, probiotic, and natural fermented products, Yu represents an opportunity for both cultural preservation and sustainable entrepreneurship. Establishing Yu as a scientifically validated product would require interdisciplinary collaboration: microbiologists to map its microbial ecology, food chemists to analyze metabolites, nutritionists to assess health impacts, and policymakers to frame safety standards. Such efforts could enable Yu to evolve from a local household beverage into a documented heritage product with both cultural pride and commercial potential.

Biochemistry and Nutritional Aspects of Manipuri Rice Wine

The biochemical profile of Manipuri rice wine, known locally as Yu, has not yet been comprehensively studied in peer-reviewed literature. However, insights can be drawn from the verified microbial ecology of *Hamei* starter cultures and from the broader body of research on Asian rice wines. Together, these sources provide a strong foundation for inferring the major biochemical constituents, nutritional implications, and potential functional properties of Yu, while also underscoring the need for direct empirical studies.

Starch hydrolysis and sugar metabolism

The starting substrate for Yu is glutinous rice, which is rich in amylopectin and serves as the primary carbohydrate source. During fermentation, starch is hydrolyzed into glucose, maltose, and other fermentable sugars through the action of amylolytic enzymes. Although specific data on Manipuri starters are limited, analogous systems show that both molds and yeasts contribute to saccharification. Once sugars are available, yeast metabolismparticularly by *Saccharomyces cerevisiae* and related genera identified in *Hamei* (Jeyaram et al., 2008)converts them into ethanol and carbon dioxide via glycolysis and alcoholic fermentation. This process not only produces ethanol, the primary alcohol in Yu, but also fuels the generation of secondary metabolites that define the beverage's nutritional and sensory character.

Ethanol and higher alcohols

Ethanol concentrations in traditional rice wines typically range between 5% and 12%, depending on fermentation time, rice variety, and starter microbial load. In addition to ethanol, higher alcohols form an important class of metabolites. These include isoamyl alcohol, phenylethanol, isobutanol, and n-propanol, which are generated via amino acid catabolism through the Ehrlich pathway. Wang et al. (2022) demonstrated that rice cultivar selection directly influences the levels of higher alcohols, linking starch composition and amino acid availability to volatile alcohol profiles. These higher alcohols contribute to flavor and aroma but can also pose risks if produced in excess. For Yu, which employs diverse *Hamei* starters, the balance between ethanol and higher alcohols is likely variable, suggesting the need for detailed profiling to assess both sensory quality and safety.

Organic acids and pH regulation

Organic acids are critical not only for sensory balance but also for microbial stability. In rice wine fermentation systems, lactic, acetic, succinic, and malic acids are commonly detected. Xu et al. (2021) reported that organic acid accumulation occurs concurrently with ethanol production, shaping pH trajectories during fermentation. A stable acidic environment helps suppress spoilage organisms and supports the growth of acid-tolerant beneficial microbes such as lactic acid bacteria. In the case of Yu, where *Hamei* has been shown to carry both yeasts and bacteria, it is reasonable to infer that organic acid production contributes to both flavor complexity and preservation, although specific acid profiles remain unmeasured.

Amino acids, peptides, and γ-aminobutyric acid (GABA)

Protein degradation during fermentation releases free amino acids and small peptides, which serve dual roles as nutrients and flavor precursors. Xu et al. (2021) documented increases in free amino acids, bioactive peptides, and γ-aminobutyric acid (GABA) during traditional rice wine fermentation. These compounds can enhance umami taste, contribute to mouthfeel, and provide functional benefits such as antihypertensive or neuroprotective effects. Amino acids like leucine, isoleucine, and phenylalanine are also precursors for higher alcohols and esters, linking nitrogen metabolism to aroma production. Although such detailed profiling has not yet been conducted for Yu, the microbial diversity of *Hamei* strongly suggests similar pathways are active.

Phenolic compounds and antioxidant potential

Phenolic compounds are another important class of bioactives in rice wines. Derived from rice grains, especially pigmented varieties, phenolics include flavonoids, anthocyanins, and phenolic acids. Fermentation can increase their extractability and alter their chemical forms, enhancing antioxidant activity. Koay et al. (2022) reviewed evidence that rice wines often show elevated radical scavenging capacity compared to raw substrates. Similarly, Xu et al. (2021) observed significant increases in total phenolic content during fermentation, correlating with higher antioxidant potential. Given that Manipur cultivates pigmented rice varieties rich in anthocyanins, their use in Yu could enhance its bioactive profile, but direct studies are needed to confirm these effects.

Vitamins, minerals, and trace elements

Yeasts such as *Saccharomyces cerevisiae* are capable of synthesizing B-group vitamins, including thiamine, riboflavin, and niacin. While vitamin concentrations in Yu remain unmeasured, analogous rice wines have been shown to contain modest amounts of these micronutrients. Minerals such as magnesium, zinc, and iron can also leach into the beverage during fermentation, depending on the composition of rice and water used. Together, these nutrients suggest that Yu may provide more than ethanol-derived calories, although rigorous nutritional analyses are lacking.

Functional and biomedical perspectives

The potential health benefits of rice wines extend beyond their nutritional content. In animal models, Yang et al. (2022) reported that rice wine polyphenols and peptides attenuated inflammation and improved cardiac function in diabetic cardiomyopathy. Although no equivalent studies exist for Yu, these findings illustrate the possible functional implications of fermented rice beverages. The presence of lactic acid bacteria in *Hamei* raises the question of probiotic contributions, though survivability through the gastrointestinal tract has yet to be established. Overall, while empirical evidence specific to Yu is absent, broader rice wine literature points to antioxidant, anti-inflammatory, and digestive benefits as plausible areas for investigation.

Safety considerations and variability

The nutritional potential of Yu must be considered alongside safety concerns. Household fermentation, lacking standardization, introduces variability in microbial composition, ethanol concentration, and byproduct formation. Biogenic amines such as histamine and tyramine can accumulate in artisanal beverages if bacterial metabolism is unchecked, posing risks for sensitive individuals. Das et al. (2024) emphasized that safety assessment of ethnic fermented foods in Northeast India remains insufficient, necessitating microbiological monitoring and quality control. For Yu to be considered as a candidate for functional beverage development, comprehensive safety profiling must accompany nutritional studies.

Microbial Ecology and Cultural Context of Manipuri Rice Wine

Microbial ecology of *Hamei* starter cultures

The microbial ecology of Manipuri rice wine is defined by the traditional starter culture known as *Hamei*. Unlike industrial inoculants, which rely on purified strains of yeast or bacteria, *Hamei* is a naturally evolved, household-produced inoculum that reflects centuries of empirical refinement. It is typically prepared by mixing ground rice with water and occasionally herbal additives, shaping the mixture into small cakes, and allowing them to ferment and dry under controlled environmental conditions. These dried cakes can then be stored and later crumbled into steamed glutinous rice to initiate wine fermentation. The use of *Hamei* provides not only yeast and bacterial inocula but also a protective ecological framework in which multiple microorganisms coexist and function synergistically.

The most comprehensive study of *Hamei* to date was conducted by Jeyaram et al. (2008), who analyzed 54 samples collected from tribal households in Manipur. Molecular identification revealed that *Saccharomyces cerevisiae* was the dominant yeast, consistent with its well-established role in ethanol fermentation. However, other yeasts such as *Pichia anomala*, *Torulasporadelbrueckii*, *Candida tropicalis*, *Candida parapsilosis*, *Pichia guilliermondii*, and *Pichia fabianii* were also identified. This diversity underscores the ecological complexity of the starter, with each species contributing to biochemical transformation. *Torulaspora* species are known for ester production, influencing fruity aroma, while *Pichia* and *Candida* strains can generate organic acids and contribute to nitrogen metabolism. The coexistence of multiple yeast species suggests that Yu fermentation is a dynamic, multi-phase process rather than a monoculture-driven pathway. In addition to yeasts, *Hamei* likely harbors lactic acid bacteria, although fewer studies have profiled bacterial communities in Manipuri starters compared to other

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fermented foods of Northeast India. In other rice wine systems, lactic acid bacteria contribute to acidification, flavor complexity, and inhibition of spoilage organisms. Their presence would also be consistent with the dual saccharification and fermentation process observed in other Asian rice wines (Koay et al., 2022). Thus, while yeasts dominate ethanol production, bacteria probably play an important role in microbial succession, pH stabilization, and possibly probiotic potential.

Metabolic interactions during fermentation

The fermentation of Yu represents a classic example of microbial succession. At the onset, molds and bacteria may hydrolyze rice starch into fermentable sugars through the release of amylases and other enzymes. Yeasts then consume these sugars, producing ethanol and secondary metabolites. During this process, metabolic cross-feeding occurs: amino acids and peptides generated by proteolysis become precursors for higher alcohols and esters, while organic acids produced by bacteria influence yeast metabolism. Such interactions have been documented in rice wine systems beyond Manipur. Wang et al. (2022) emphasized how rice cultivar and microbial community structure shape the profile of higher alcohols, while Xu et al. (2021) observed dynamic changes in amino acid and phenolic concentrations during fermentation. Together, these findings imply that Yu fermentation is both complex and highly sensitive to substrate and ecological variation.

Cultural significance of Yu

Beyond microbiology, Yu occupies an enduring place in the cultural and social life of Manipur. It is consumed not merely as an alcoholic beverage but as a marker of identity and belonging. Among the Meitei community, Yu is traditionally offered in religious ceremonies, ancestral rites, and community feasts. Its preparation is entrusted primarily to women, whose knowledge of *Hamei* production and wine fermentation is passed from one generation to the next. This gendered dimension of production situates Yu within the broader context of women's roles in food security and cultural preservation in Northeast India.Yu also functions as a social equalizer. It is shared in festivals, consumed during marriage ceremonies, and offered to guests as a gesture of hospitality. Its ubiquity in social life has made it both a cultural necessity and, at times, a political subject, given the restrictions on alcohol in Manipur under state prohibition laws. Despite these restrictions, household brewing persists, reflecting the resilience of cultural practices in the face of regulation. For many families, brewing Yu is not merely about producing alcohol but about sustaining tradition, affirming identity, and maintaining community bonds.

Yu in the broader landscape of Northeast Indian fermentation

Yu shares commonalities with other rice-based beverages across Northeast India, such as *apong* in Arunachal Pradesh, *zutho* in Nagaland, *chhang* in Sikkim, and *jou* in Assam. These beverages also rely on indigenous starter cultures and employ glutinous or pigmented rice as substrates. Ethnographic and microbiological research across the region consistently highlights the dual importance of such beverages: they serve as food security strategies in environments where preservation is critical, and they embody cultural narratives that connect communities to their land and ancestors (Das et al., 2024). What distinguishes Yu is its centrality to Meitei identity and its reliance on *Hamei*, which has now been partially characterized at the molecular level. This makes Yu an important case study for linking cultural anthropology with microbial ecology.

Challenges of preservation and modernization

While Yu is deeply embedded in tradition, the lack of standardization poses challenges for its preservation and potential commercialization. Household-level variability in rice cultivar, water quality, starter preparation, and fermentation duration leads to differences in ethanol content, flavor, and microbial load. This variability not only complicates scientific characterization but also raises questions about safety, particularly in relation to microbial contamination and byproduct formation. Das et al. (2024) argue that ethnic fermented foods of Northeast India require systematic safety evaluations if they are to gain wider recognition or enter regulated markets. For Yu, this means that any attempt at valorization must balance authenticity with quality assurance.

Conclusion

The traditional rice wine of Manipur, commonly known as Yu, stands as a unique synthesis of ecology, chemistry, and culture, making it both a heritage food and a potential subject for modern scientific valorization. At its foundation, Yu is defined by the starter culture *Hamei*, a living microbial consortium dominated by *Saccharomyces cerevisiae* but also enriched with *Pichia*,

Torulaspora, and *Candida* species, whose metabolic interplay drives saccharification, ethanol production, and the generation of higher alcohols, organic acids, esters, peptides, and phenolics. This microbial diversity not only governs fermentation kinetics but also underpins the nutritional and sensory attributes of the wine, offering a biochemical richness that distinguishes Yu from industrial monoculture ferments. Biochemical studies from related rice wines show that fermentation enhances free amino acids, γ-aminobutyric acid, polyphenols, and antioxidant capacity, suggesting that Yu, too, may harbor bioactive properties linked to digestive support, metabolic modulation, and oxidative stress reduction, though these claims remain unverified due to the absence of direct metabolomic analyses. Culturally, Yu is inseparable from the identity of Manipuri communities: it is brewed by women as part of household knowledge systems, consumed in social gatherings, offered in rituals, and maintained as an anchor of cultural resilience despite state prohibition laws. Its persistence illustrates the deep interconnection between food, identity, and resistance, as brewing Yu is not only about producing alcohol but about preserving tradition, affirming belonging, and sustaining intergenerational continuity. At the same time, the artisanal nature of Yu introduces variability in microbial composition, ethanol content, and safety parameters, creating challenges for reproducibility and raising concerns over contaminants or biogenic amine formation. Addressing these gaps will require a multi-disciplinary approach that combines microbiological profiling, biochemical characterization, nutritional assays, toxicological screening, and socio-cultural documentation. Such work can generate evidence to support or refute local health claims, while also informing protocols for standardization, safety assurance, and potential commercialization. The broader significance of Yu lies in its potential to be positioned alongside other global rice wines such as Japanese sake or Korean makgeolli, not as an imitation but as a distinct cultural product with its own microbial and sensory identity. If supported by careful scientific validation, community-led entrepreneurship, and policy frameworks that safeguard authenticity while ensuring safety, Yu could evolve from a largely undocumented household tradition into a recognized functional beverage that contributes simultaneously to food heritage preservation, rural livelihoods, and the global market for probiotic and bioactive fermented foods. Thus, Yu embodies the promise of integrating traditional knowledge with contemporary science, highlighting how indigenous fermentation systems can inspire sustainable innovations that respect culture while meeting modern nutritional and health aspirations.

TRADITIONAL FISH FEED INGREDIENTS AND FEEDING PRACTICES AMONG FISH FARMERS IN SOUTH GARO HILLS, MEGHALAYA, INDIA

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Introduction

Aquaculture has become an increasingly important sector in Meghalaya, playing a vital role in ensuring food security, creating rural employment opportunities, and boosting income generation. The state's abundant rainfall, natural ponds, flowing rivers, and hilly terrain provide ideal conditions for freshwater fish farming. Among its districts, South Garo Hills stands out for its rich tradition of community-based aquaculture practices that rely heavily on indigenous knowledge systems.

In this region, fish farming is not merely a livelihood, it is a way of life. It contributes to household nutrition, economic stability, and cultural identity. However, due to limited access to commercial fish feed caused by challenging terrain, inadequate infrastructure, and high costs local farmers have long depended on traditional and locally available resources to sustain their fish ponds.

Background

Located in the southwestern part of Meghalaya, South Garo Hills is characterized by rugged hills, dense forests,

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and high annual rainfall. The region is dotted with natural water bodies, seasonal streams, and household ponds, which provide a conducive environment for freshwater aquaculture. The consistent rainfall helps maintain pond water levels year-round.

Fish farming is a key supplementary livelihood activity for small and marginal farmers in this remote district. Given that fish is a staple in the local diet, aquaculture also plays a significant role in addressing nutritional needs. Families often rear fish in backyard ponds using low-input methods, drawing on generations of traditional knowledge and locally sourced feed materials.

Due to the district's remote location and poor connectivity, commercial fish feed is often unavailable or prohibitively expensive. Consequently, fish farmers have developed indigenous, cost-effective feeding practices tailored to the local environment and economic conditions.

Locally Available Traditional Fish Feed Ingredients

In the absence of commercial feed, farmers utilize a range of locally available and inexpensive natural materials to feed their fish. The most commonly used traditional feed ingredients include:

Banana Leaves: Banana plants grow abundantly in the region and are readily accessible. Farmers harvested banana leaves and placed them directly into the ponds for feeding grass carp.

Grasses: Local grasses, including soft aquatic varieties, are harvested and used to feed herbivorous fish species.

Puffed Rice: Puffed rice, a common household item, is rich in carbohydrates and often used as supplementary fish feed. Leftover or surplus puffed rice is collected and scattered over the pond surface. While not nutritionally complete, it serves as an effective energy source when used in combination with other feed types.

Termites: Termites are a traditional and highly valued protein source for fish. Farmers collect them from nearby termite mounds and feed them to fish either alive or crushed. High in protein, termites are especially beneficial for fingerlings and juvenile fish. However, their collection is labor-intensive and seasonal.

Termites are a traditional and highly valued protein-rich feed resource used by fish farmers in South Garo Hills. Often referred to as a "natural protein supplement," termites play a critical role in traditional aquaculture systems, especially in the early stages of fish development. Local farmers typically collect termites from nearby termite mounds, especially during the rainy season when termite activity is high. Various collection methods are used, including the placement of partially burnt wood, cow dung, or straw bundles near mounds to attract termites, which are then gathered the following day. Once collected, termites are either fed live or lightly crushed before being scattered into the ponds. Farmers have observed that regular feeding with termites results in improved survival rates, faster growth, and better resistance to diseases. In polyculture systems, termites are often fed to carnivorous or omnivorous fish species which readily accept animal-based feed. Termites remain a vital component of traditional fish feeding practices due to their high nutritional value, local availability, and effectiveness in improving fish health and growth - especially in resource-limited rural aquaculture settings where commercial feeds are inaccessible or unaffordable.

Rice bran: Rice bran is a **widely used traditional fish feed ingredient** in many rural aquaculture systems across India, including regions like South Garo Hills, Meghalaya. Rice bran, a by-product of rice milling, is commonly available in rural areas and serves as a popular supplementary fish feed. It is rich in carbohydrates, fats, and moderate amounts of protein, making it a relatively balanced and energy-rich feed. Farmers often mix rice bran with water to form a moist mash or scatter it directly on the pond surface. Its ease of access, affordability, and nutritional value make it a favored choice among small-scale fish farmers in South Garo Hills.

Feeding Practices: Traditional Feeding practices in South Garo Hills are primarily guided by local knowledge and practical experience rather than scientific measurement. Typically, fish are fed once or twice a day usually in the early morning and late evening. During periods of feed scarcity, feeding may be reduced to a few times a week. There are no fixed feed ratios; instead, farmers estimate quantities based on the pond size, fish population, and feed availability. This intuitive approach is rooted in years of observational experience.

Feeds such as banana leaves are often submerged near the pond edges, tied to bamboo poles for gradual consumption. Puffed rice and termites are scattered across the pond surface to ensure easy access for the fish.

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Benefits and Limitations of Traditional Feed

Benefits

- **Low Cost**: Traditional feed ingredients are inexpensive or freely available, making them suitable for resource-limited, small-scale farmers.
- **Eco-Friendly and Sustainable**: These feeds are natural and biodegradable, with minimal environmental impact. They also promote the recycling of household and farm by-products.
- **Local Availability**: Most ingredients are accessible within or near the homestead, reducing dependence on external supplies.

Limitations

- **Nutritional Imbalance**: Traditional feeds often lack the full nutritional profile required for optimal fish growth, especially in terms of essential proteins, vitamins, and minerals.
- **Seasonal Availability:** Ingredients like termites and surplus puffed rice are seasonal or dependent on household waste, affecting feeding regularity.
- **Slower Growth Rates**: Compared to nutritionally balanced commercial feeds, traditional feeds may result in slower fish growth and lower yields, which can limit the profitability of fish farming.

Banana Leaves

Grass

Transition Towards Scientific Approaches

In recent years, fish farming in Meghalaya, including South Garo Hills, has begun to shift from purely traditional practices toward more scientific and commercial approaches. Recognizing the limitations of local feed availability and the growing demand for fish, KVK has introduced several initiatives to support sustainable aquaculture development training programme, fish fingerlings distribution, awareness programme and methods demonstrations.

Conclusion

The traditional fish feeding practices in South Garo Hills reflect the ingenuity and resilience of local communities in adapting to their environment. By utilizing readily available materials such as banana leaves, grasses, puffed rice, and termites, these farmers have sustained aquaculture in challenging conditions for generations. While such practices have limitations in terms of nutritional completeness and scalability, they remain an important part of the region's aquaculture heritage. Balancing traditional knowledge with modern scientific approaches will be key to ensuring the future sustainability and productivity of fish farming in the region.

Puffed Rice

Termites

Rice Bran

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THE SMART REVOLUTION: ARTIFICIAL INTELLIGENCE TRANSFORMING FOOD PROCESSING AND SUPPLY CHAINS

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1. Introduction

Artificial Intelligence (AI) is increasingly becoming a cornerstone of innovation in the food and agri-industry, ushering in what is often called the *Digital or Smart Revolution*. Broadly, AI encompasses a suite of technologies that enable machines to perform tasks requiring human-like intelligence, such as machine learning (learning from data), data analytics (deriving insights from vast datasets), computer vision (pattern and image recognition), and intelligent robotics (autonomous decision-making and action). Together, these systems are redefining how food is grown, processed, packaged, and delivered.

The growing global population projected to reach 9.7 billion by 2050 demands more food from fewer resources. Meanwhile, climate variability, supply chain complexity, and rising consumer expectations for safe and sustainable food pose immense challenges. AI offers powerful solutions to these issues by optimizing efficiency, reducing waste, and ensuring consistent quality across production systems. Through Big Data generated by sensors, machines, and digital networks, AI enables rapid, deep, and predictive analyses that guide real-time decisions - the defining feature of *Industry 4.0* or the *Smart Factory*.

Globally, several digital trends mark this transformation in the food sector:

- Automation and robotics in processing lines, reducing drudgery and increasing precision.
- Smart packaging and sensors, where IoT-enabled materials continuously monitor temperature, gas composition, and freshness.
- Precision processing and predictive analytics, using AI to optimise drying, fermentation, and blending parameters while forecasting shelf-life and market demand.
- Traceability and transparency, with block chain and AI ensuring farm-to-fork accountability and food safety.

The food and beverage industries worldwide are also witnessing unprecedented integration of cyber-physical systems and machine-vision technologies, ensuring quality inspection and operational efficiency. Studies show that the introduction of industrial robots in food manufacturing has resulted in nearly 25 % higher productivity compared to manual operations, alongside improved hygiene and uniformity. Expert systems and AI-driven control models now enable *self-adjusting processes* that minimize human error and resource use, leading to safer and more sustainable food production.

In the Indian context, particularly in the North-Eastern Region, AI adoption is in its nascent stage but carries transformative potential. The region's rich horticultural and fermented-food heritage (pineapple, orange, king chilli, *Hawaijar*) presents strong potential for AI-enabled grading, sorting, fermentation control and intelligent packaging systems- although documented applications are currently limited and warrant further R&D and pilot deployment. Start-ups and academic institutions are increasingly exploring AI in crop monitoring, predictive analytics, and postharvest processing. As computing power and data infrastructure expand, integrating AI with sensors like electronic noses and tongues, near-infrared hyperspectral imaging, and computer vision will enable the North-East's food sector to produce high-quality, globally competitive products.

In essence, AI represents a fusion of engineering, data science, and biological insight-transforming food systems from reactive to predictive, from manual to autonomous, and from conventional to sustainable. The dawn of this digital era signals a future where *every process in the food chain thinks, learns, and improves continuously*- ensuring that every bite we take is safer, smarter, and more sustainable.

2. The Role of AI across the Food Value Chain

Artificial Intelligence (AI) is revolutionising every stage of the food value chain - from raw material grading to final packaging and logistics. By combining machine

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learning (ML), computer vision, sensor fusion, and robotics, AI enables smart, self-optimising processes that ensure quality, safety, and efficiency throughout the food industry.

A. Raw-Material Assessment

The journey begins at the raw material stage, where computer vision systems coupled with deep learning models are transforming how fruits, vegetables, and grains are sorted and graded. AI-based inspection systems detect parameters such as colour, shape, size, texture, and surface defects, ensuring uniformity and consistency beyond what manual sorting can achieve.

For instance, Ismail and Malik (2022) demonstrated a deep-learning ensemble model capable of grading multiple fruits in real time with over 95% accuracy. Similarly, the *FruitVision* CNN model achieved near-perfect classification for apples, bananas, and guavas. In grains, multispectral and NIR imaging with ML algorithms helps classify broken or discoloured rice kernels.

AI-integrated vision systems now allow:

- Tomato sorting lines to identify blemishes or irregular sizes;
- Apple grading conveyors to automatically assign grades (A/B/C);
- Rice-kernel classifiers to separate damaged kernels in milliseconds.

a).Drone guided automatic fruits plucking devices

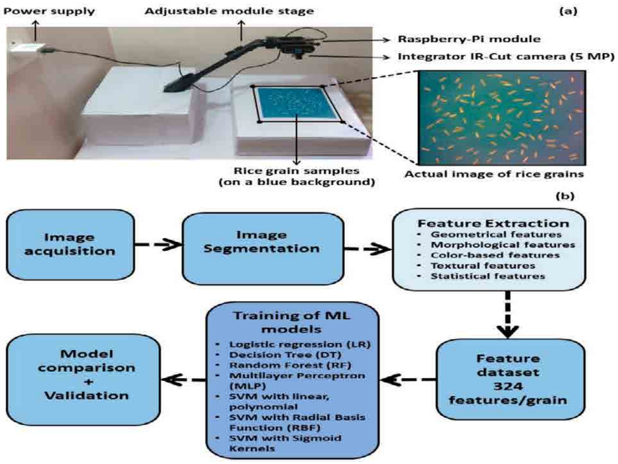
b. Automatic fruit plucking robotic arms

c. Sorting and grading through image processing

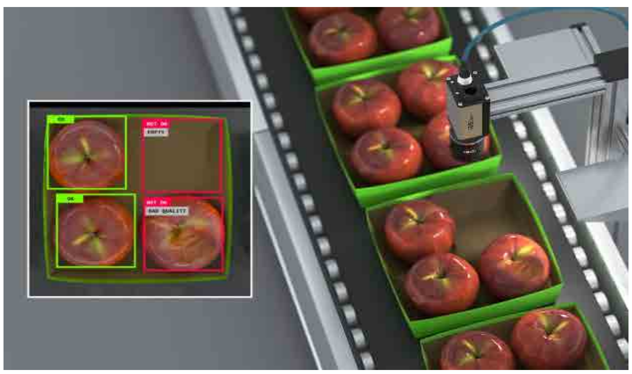
d. AI based sorting fruits (Apple)

e. AI based detection for imperfections, contaminants, or quality attributes

This technological leap improves efficiency, minimises waste, and standardises quality across large processing units.



(i) a rice-kernel classification machine



(ii) a conveyor belt of apples being graded by a camera system (source: ids-imaging.us)

Figure 1. Raw Material Assessment (i) and (ii) using AI in food industries

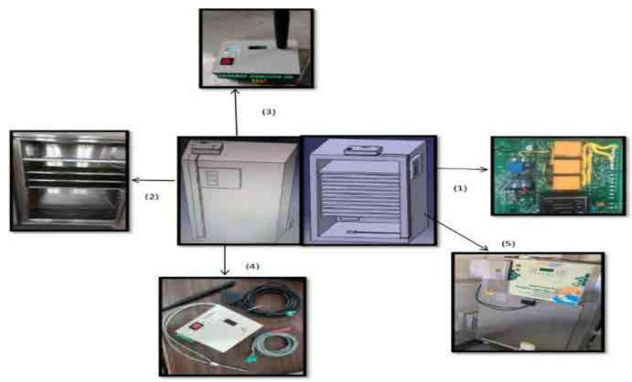
B. Food-Processing Automation and Robotics

Inside modern plants, AI-driven automation is reshaping drying, mixing, fermentation, extrusion, and packaging. Smart sensors and actuators constantly measure temperature, humidity, moisture, flow rates, and residence time, feeding real-time data to ML algorithms that automatically adjust process parameters for optimum quality.

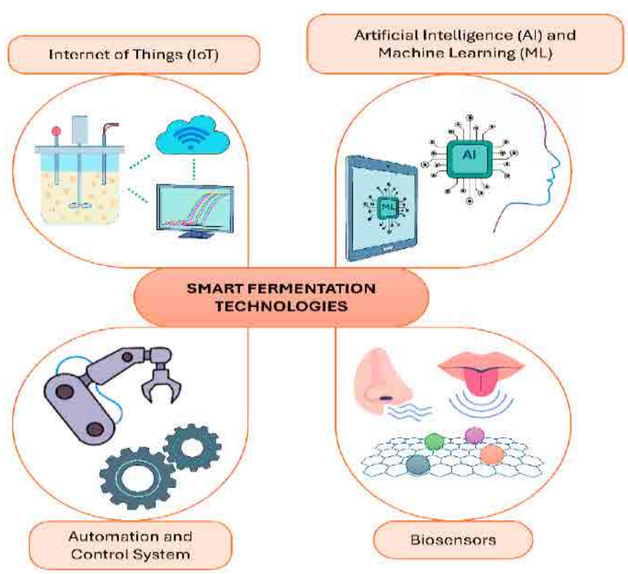
Robotic arms are increasingly deployed in material handling, tray loading, or packaging, reducing labour fatigue and ensuring consistency. Neural-network-based controllers fine-tune processes such as fruit-slice drying or fermentation aeration based on dynamic feedback.

E-nose and E-tongue sensors combined with AI algorithms enhance flavour monitoring and aroma profiling during dehydration or fermentation. AI-assisted cleaning systems—like Nottingham's *SOCIP* prototype—use fluorescence and ultrasonic sensors to detect microbial residues in food equipment, reducing cleaning time by 30-40 %.

(a) Robotic arm



(b) sensors and actuators in a dryer



c). Automatic fermentation with monitoring screens,

d) AI-assisted cleaning system

Figure 2. a). Robotic arm in a food-processing plant, b). Sensors and actuators in a smart dryer, c). Automated fermentation vessel with monitoring screens (Endress + Hauser QWX43 System, 2025). d). AI-assisted cleaning system with optical sensors and spray nozzles (SOCIP Prototype, University of Nottingham).

c. Quality and Safety Monitoring

Quality assurance and food safety are core domains where AI now plays a decisive role. Predictive models built on historical process data can anticipate spoilage, detect contamination, or flag equipment failure before product quality is compromised.

AI-powered computer-vision systems can identify micro-cracks in packaging films, measure browning in bakery items, or detect foreign particles. ML-driven shelf-life modelling has shown success in predicting deterioration in seafood, dairy, and cut fruits under variable temperature conditions.

Meanwhile, blockchain–AI integrations enable real-time traceability of food batches, from farm to fork. Such "smart-chain" analytics score risk at each supply node and help trace contamination within minute).

AI-based hygiene monitoring using CCTV with facial and object recognition now verifies whether staff follow safety protocols for example, wearing gloves, masks, and hairnets.

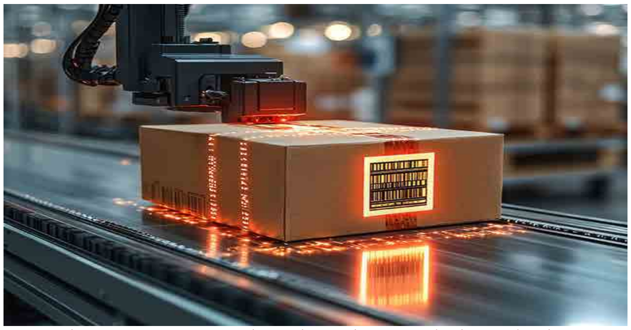
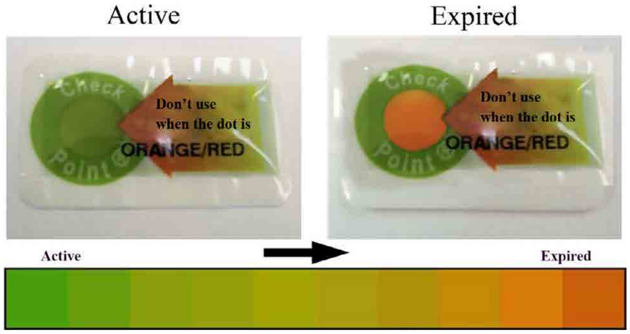


Figure 3. AI system detecting micro-cracks in packaging

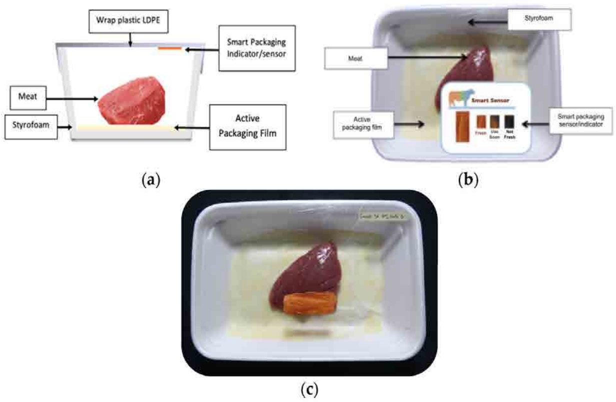
d. Packaging and Shelf-Life Prediction

AI is integral to intelligent packaging and dynamic shelf-life prediction. Embedded mini-sensors (for oxygen, CO_2, ethylene, humidity) send real-time data to ML models that estimate remaining freshness or predict spoilage onset.

At the packaging line, computer-vision inspection ensures seal integrity, label accuracy, and defect rejection. Some advanced systems already integrate predictive analytics with logistics data to manage cold-chain routing for perishable foods.



Application of an Intelligent Sensor and Active Packaging System



(a)Visual indicator as intelligent packaging with sensor strip

b) packaging line camera inspecting seal integrity

Figure 4.a). Intelligent packaging with sensor strip showing freshness indicator, and
b). Packaging line camera inspecting seal integrity.

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E. Product Development and Supply-Chain Optimisation

Beyond production, AI contributes to new product design, market prediction, and logistics management. Machine-learning algorithms analyse consumer preferences and sensory profiles to design products that match specific flavour or nutrition targets. In beverage and snack industries, adaptive neural-fuzzy models help executives predict the success of new product launches and plan inventory accordingly.

Across the supply chain, AI coupled with the Internet of Things (IoT) improves traceability and sustainability. Smart trucks with AI-linked temperature sensors select optimal routes and adjust conditions to reduce spoilage. Decision-support systems powered by Big Data now help forecast demand, optimise cold-storage use, and ensure on-time deliveries.

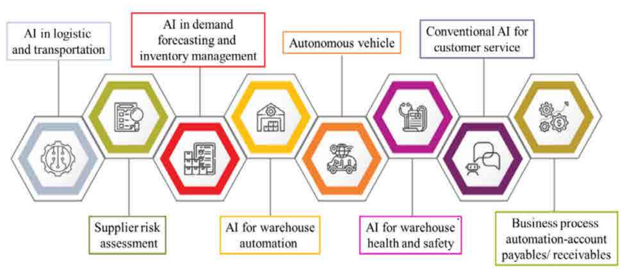

Figure 5. AI–IoT integration

AI's role across the food value chain demonstrates its versatility from grading raw materials and automating production to predicting spoilage, monitoring hygiene, and enhancing supply-chain intelligence. For India's North-East, such technologies could be game-changers for horticultural and fermented-food enterprises, ensuring efficiency, sustainability, and market competitiveness

Benefits of AI Adoption

Aspect	Impact of AI
Efficiency	Automation of repetitive tasks increases productivity and consistency.
Safety & Hygiene	Reduced human contact during processing lowers contamination risk.
Cost Optimization	Predictive maintenance minimizes downtime and energy use.
Traceability	Blockchain-linked AI ensures end-to-end transparency in supply chains.
Sustainability	Reduces waste, energy consumption, and enhances eco-efficiency.

AI also allows real-time decision-making. For example, AI-powered predictive models can suggest the best drying temperature for pineapple slices or the optimum blend of milk for yoghurt with consistent texture-all without manual trial and error.

5. Challenges and Ethical Considerations

While the advantages are compelling, several challenges must be addressed for widespread adoption in India's food sector:

- **Cost and Infrastructure:** Small processors and cooperatives often lack resources for advanced AI integration.
- **Data Quality and Availability:** Reliable datasets are essential for machine learning models to function effectively.
- **Skill Gap:** There's a growing need to train food technologists, engineers, and students in data analytics and AI applications.
- **Ethical and Social Impacts:** Automation may reduce manual jobs; hence, balanced technology adoption and upskilling are crucial.

Government support through Digital Agriculture Mission, Startup India, and Skill India initiatives can mitigate these challenges by building local innovation ecosystems

Conclusion

Artificial Intelligence is no longer a futuristic concept—it is already transforming the way we grow, process, and deliver food. Across the food value chain, AI has proven its potential in sorting, drying, cleaning, packaging, product development, and supply-chain management, offering unparalleled gains in precision, efficiency, and food safety. The integration of machine learning, robotics, and sensor-based analytics enables industries to automate complex unit operations, optimise resources, and ensure consistent quality even under constraints such as workforce shortages or environmental variability.

For India's food processing sector—and particularly for the North-Eastern region - AI presents a timely opportunity to leapfrog into a new era of *smart, green, and inclusive* food systems. With its high-value horticultural and fermented-food heritage, the region can benefit from AI-enabled grading, fermentation control, smart packaging, and real-time logistics optimisation.

As digitisation accelerates globally, AI stands out as the invisible yet indispensable ingredient in building resilient and sustainable food ecosystems. By bridging human expertise with intelligent technologies, AI empowers food technologists and engineers to enhance quality, minimise waste, and ensure that every product reaching the consumer is **safer, smarter, and more sustainable**—truly defining the smart revolution in food processing and supply chains.

DIGITAL EXPOSURE AND ITS IMPACT AMONG RURAL CHILDREN

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Introduction

Digital exposure among rural children has rapidly grown into a major aspect of their everyday lives, marking a significant shift from traditional forms of learning and interaction to digital education, entertainment and communication. Digital exposure has given children many benefits like watch educational videos, attend online classes, use learning apps and find information that goes beyond regular learning in the schools. Technology also allows them to connect with friends and relatives who live far away, explore creative hobbies such as photography, music and drawing, and stay informed about events happening in different parts of the world. This exposure not only expands their learning but also helps in developing digital literacy skills. At the same time, digital exposure also has some negative effects. Many rural children spend too much time on phones or watching TV without proper limits and guidance. This can cause problems like eye strain, less physical activity, disturbed sleep and difficulty in concentrating. Online games, social media and entertainment can distract them from studies and reduce outdoor play. In rural areas, where there are fewer playgrounds and activities, screens often become the main way children pass their time. Moreover, many parents in rural area may not be fully aware of these risks to guide their children toward healthy online habits. According to World Health Organization, excessive or unsafe digital exposure can harm physical health, mental well-being, cognitive development and social relationships. The American Academy of Child and Adolescent Psychiatry (AACAP) recommends specific screen time limits for children to promote healthy development.

Guidelines by age group

SN	Age Group	Recommendations
1	Infants (<18 months)	Avoid all screens except video chatting with relatives, always with an adult present.
2	Children (18–24 months)	If parents choose to introduce screens, it should be high-quality, educational programming, and parents must co-view.
3	Children (2-5 years)	Limit non-educational screen time to about 1 hour per week-day and up to 3 hours on week-end days. Prioritize interactive, creative, or educational content.
4	children (6 years and above)	No fixed time limits. Instead, focus on balance: screen use should not replace sleep, ex-ercise, schoolwork, or family/social interaction. Encourage healthy habits, critical thinking about media, and responsible digital use.

(Source: American Academy of Child and Adolescent Psychiatry, 2024)

Additional recommendations for all ages

- No screens during meals.
- No screens 30–60 minutes before bedtime.
- No TVs/devices in bedrooms.
- Parents should model healthy use and guide their children.

Why Digital Exposure is Rising in Rural Areas

Rural children spend more time on screens because of social, economic and environmental factors. In many rural areas, opportunities for physical recreation are limited with fewer playgrounds, sports clubs, libraries or community activity centres. This lack of alternative engagement leads children toward mobile phones and televisions as primary sources of entertainment. Affordable smart phones and low-cost internet packages have made digital access widespread. Parents in rural areas often work long hours in agricultural fields, markets or labour jobs, leaving children unsupervised for much of the day. In such cases, screens act as a form of childcare keeping children busy and indoors.

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According to Gayathri *et al.* (2023), the COVID-19 pandemic further accelerated this trend. Online classes introduced many rural children to prolonged device use for the first time and even after schools reopened, the habit continued and shifting more toward online games, streaming platforms and social media. Social isolation also plays a role as rural houses are often far from each others, making it harder for children to meet peers regularly. So, digital interaction through messaging apps or multiplayer games becomes a substitute for face-to-face communication. Cultural perceptions can also contribute, as many families view digital devices as a sign of modernity and progress which unintentionally encourage overuse. All these reasons make screens not only a source of fun but also the main way for rural children to learn, talk with others and passing time which lead to more daily screen use.

Positive Impacts of Digital Exposure on Rural Children

1. Access to Education: According to Gandhi and Umair (2025), digital devices provide rural children with valuable access to education by enabling them to attend online classes, watch educational videos and use interactive learning applications. These tools help them understand complex concepts in a simpler and more engaging way. Through digital platforms, children can access quality learning resources that were once limited to urban areas. This exposure not only improves their academic performance but also helps bridge the educational gap between rural and urban communities. It promotes equal opportunities for learning and personal growth.

2. Skill Development: Digital devices play an important role in skill development by allowing children to explore creative talents such as photography, drawing, music and storytelling through various mobile applications. These platforms provide interactive tools and tutorials that make learning fun and accessible. Engaging in such activities not only nurtures creativity but also builds confidence and problem-solving skills.

3. Global Awareness: Internet access enables children to gain global awareness by learning about different cultures, traditions and innovations from different part of the world. Through videos, articles and interactive platforms, they can explore diverse lifestyles and viewpoints beyond their immediate surroundings. This exposure helps them develop a broader understanding of the world and fosters respect for cultural diversity. Learning about global issues and advancements also encourage children for critical thinking and decision-making.

4. Social Connection: According to Reid *et al.*(2016), digital platforms enable children to stay connected with friends and relatives who live far away fostering strong emotional bonds despite physical distance. Through video calls, instant messaging and social media, they can share moments, exchange ideas and offer support to one another. Such interactions help reduce feelings of loneliness and isolation especially for children in remote areas. Staying socially connected also enhances their communication skills and emotional well-being.

Negative Impacts of Digital Exposure on Rural Children

1. Excessive Screen Time: In the absence of recreational facilities, children often spend long hours on mobile phones, tablets, laptops, computers and television. This shift from active play to screen-based entertainment reduces opportunities for outdoor activities and social engagement with peers. Lack of physical movement can slow their physical development and lower fitness levels.

2. Physical Health Impacts: Jayalekshmi *et al.,* (2025) stated that prolonged using of devices can cause eye strain, headaches and sleep disturbances. It may also lead to neck, back, or shoulder pain from poor posture. In some cases, it can affect the nervous system leading to fatigue or dizziness (Pandey and Vaishnav, 2023). Children's screen exposure increases sedentary time and the likelihood of choosing unhealthy foods which can contribute to obesity. This happens because screens promote a preference for snacks, fast food and sugary drinks while reducing interest in physical activity (Wang and Zhang, 2024).

3. Cognitive and Developmental Impacts

- **Short attention span**: Fast-paced screen content with quick scene changes and constant visual effects can make children to expect nonstop excitement. This makes harder for them to focus on slower-paced activities like reading books, doing

puzzles, drawing, writing, gardening and playing board games. Over time, their attention on tasks may decrease leading to restlessness and difficulty in completing work.

- **Reduced problem-solving skills**: Reduced hands-on and imaginative play due to excessive screen time can limit opportunities for children to explore, experiment and solve problems on their own. Activities like building, crafting or role-playing help children to develop creativity and critical thinking skills. When these are replaced by passive digital entertainment, children may struggle to think independently or find solutions in real-life situations.
- **Academic decline**: Excessive time spent on entertainment screens can significantly reduce the time children spend on studying and completing homework. Constant exposure to engaging digital content may also lower their concentration, making it harder to focus during lessons or retain information. As a result, academic performance can decline with reduced motivation to learn and weaker grasp of key concepts.
- **Language delays**: Passive video watching does not provide the interactive communication needed for healthy speech and language development. Without opportunities to respond, ask questions, or engage in dialogue, children may develop slower vocabulary growth and weaker conversational skills which can lead to noticeable delays in overall language proficiency.

4. Emotional and Mental Health Impacts

- **Addictive behavior**: Addictive behaviour can develop as games and social media give reward that trigger repeated engagement through likes, points and achievements. This constant reinforcement making it difficult for children to limit screen time.
- **Irritability and mood swings**: Prolonged and unstructured screen use can cause irritability and mood swings which can disturb children ability to control their emotion. Excessive screen time can make children more frustrated, impatient and easily upset.
- **Social withdrawal**: Social withdrawal occurs when individuals increasingly favour virtual interactions over direct or in-person communication which limits their opportunities to develop interpersonal skills. This change can make children feel lonely and weaken their real-world social connections.
- **Body image and peer pressure issues**: Exposure to idealized media content can create unrealistic beauty standards that leading to body dissatisfaction and low self-esteem.
- **Behavioral problems:** Anitha *et al.*(2021) stated that prolonged exposure to fast-paced digital content can over stimulate the brain and making it harder for children to regulate energy and attention which leading to hyperactivity. According to Ray and Jat (2010), excessive screen use with violent content may normalize aggression, reduce empathy and increase frustration, often resulting in conduct problems such as defiance, rule-breaking and frequent conflicts with others.

5. Social and Cultural Impacts

- **Loss of traditional activities**: Increased screen use has reduced children's participation in local games, crafts and cultural practices which limit the opportunities to engage with their heritage. This decline can weaken cultural bonds and hinder the development of traditional skills.
- **Urban cultural influence**: Greater exposure to global media can introduce urban cultural influences that shape children's lifestyle aspirations and values. This shift may lead them to adopt modern trends while gradually moving away from traditional norms and practices.

Guidelines for parents to reduce screen time of children

- ❖ Make a daily routine with fixed limits for screen time. Use timers to monitor and guide screen use. This helps children understand boundaries and build healthy digital habits.
- ❖ Set a good example by limiting own screen time during family time, it allows for more real interaction. Children learn by imitating adults, so showing balanced use of digital technology helps them use it carefully.
- ❖ Engage children in alternatives like outdoor play, sports, art, music and reading. Plan at least 60 minutes of active play every day for children.
- ❖ Keep screens out of bedrooms, dining areas and study spaces which help children focus better and spend quality time with family. Avoid screen time 1–2 hours before bedtime and ensure children follow age-appropriate sleep schedules.

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- Watch digital content with younger children and talk about what they see. This helps them understand better, ask questions and stay safe from harmful content.
- Reduce the screen usage gradually rather than stopping suddenly. Parents can start by cutting 15–20 minutes each week, allowing children to adjust without feeling stressed or resistant.
- Teach children about digital safety including how to protect their privacy, avoid cyber bullying and interact respectfully with others.

Conclusion

Digital exposure has brought both opportunities and challenges to the lives of rural children. It has expanded their access to education, skills and information but it has also increased risks related to health, attention and social interaction. The key lies in creating a balanced approach using technology as a means of learning, creativity and connection while ensuring it does not replace the physical activity, human interaction and real-world experiences that are vital for healthy childhood development. With proper use, digital exposure can become a powerful tool to empower rural children and prepare them for a brighter future.

MEAN AND VARIANCE: FOUNDATIONS FOR UNDERSTANDING DATA IN FARM SCIENCES

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Introduction

The concepts of mean and variance are fundamental to understanding any dataset. Whether evaluating crop yields, milk production, or fish weight, these measures provide insights into both the central tendency and the variability of data. While the mean (commonly referred to as the "average") is widely understood, the concept of variance—or its square root, the standard deviation (SD) is equally crucial. This article aims to explain the logic behind mean and variance in simple terms, focusing on their interpretation and significance rather than on detailed mathematical calculations. Through everyday examples and applications in agriculture, veterinary, and fisheries sciences, we will see how these measures complement each other in providing a complete understanding of data.

1. Understanding the Mean

The mean is a measure of central tendency that represents the "typical value" of a dataset. In other words, it tells us the balancing point of the data. Mathematically, for n observations $x_1, x_2, x_3, \ldots, x_n$, the mean ($\bar{x}$) is:

$$\bar{x} = \sum_{i=1}^{n} x_i$$

Suppose a cow produces 6, 8, and 10 liters of milk over three days. To find the mean daily yield, we add up the quantities and divide by the number of days:

$$\bar{x} = \frac{(6+8+10)}{3} = \frac{24}{3} = 8 \text{ Liters}$$

This tells us that, on average, the cow produces 8 liters of milk each day. However, this single number does not reveal how consistent the production is across days. Were all days close to 8 liters, or did some days have much lower or higher outputs?.

In cases where two varieties share an identical mean yield (for instance, 20 Q/Ha), the selection process for adaptation becomes challenging, given their equivalent performance based on average yield. To answer this, we need to look beyond the mean

2. Understanding Variance

Variance measures how far individual observations are from the mean. It tells us the spread of the data. If all values are the same, the variance is zero because there is no deviation from the mean. A high variance means that the data points are

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scattered far from the mean, indicating inconsistency. Mathematically, variance (σ^2) is defined as:

$$\sigma^2 = \frac{\sum(x_i - \bar{x}_i)^2}{n}$$

Continuing with the milk example, the daily milk outputs are 6, 8, and 10 liters, with a mean of 8 liters. Let's find how far each day's production is from the mean: Day 1: 6 - 8 = -2 liters, Day 2: 8 - 8 = 0 liters, Day 3: 10 - 8 = 2 liters. We square these deviations to avoid negative values: 4, 0, 4. The variance is the average of these squared deviations:

$$\sigma^2 = \frac{4+0+4}{3} = \frac{8}{3} = 2.67\ L^2$$

The variance here is about 2.67 (in squared liters). While this number is not as intuitive as the Mean, its Square Root, known as the standard deviation (SD) is easier to interpret:

$$\sigma = \sqrt{2 \cdot 67} \approx 1 \cdot 63L$$

This means that daily milk production typically varies by about 1.6 liters from the mean of 8 liters. So, we can expect a yield ranging between 6.4 Liters to 9.6 Liters. If the variance (and hence SD) were zero, it would mean the cow produced exactly 8 liters every day.

3. When Are Mean and Variance the Same?

Although mean and variance usually differ, certain data patterns or distributions can make them numerically equal. For example, in a Poisson distribution often used to model event counts like disease cases the mean and variance are mathematically equal. In most real-life farm data, however, variance provides distinct information about reliability that the mean alone cannot reveal.

4. Why Mean alone can be misleading?

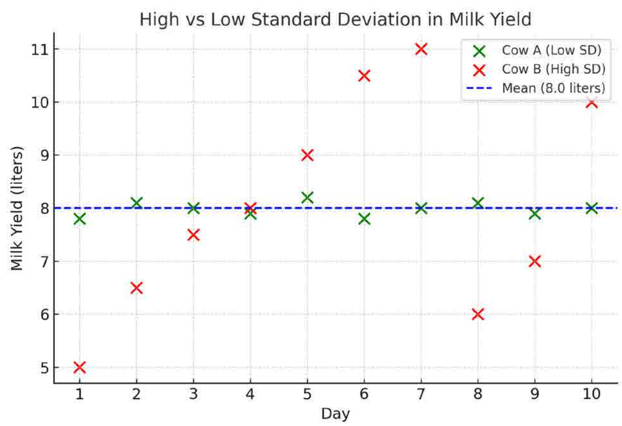
To see why mean alone can mislead, consider a food delivery example. Company A takes 28, 30, and 32 minutes to deliver, while Company B takes 15, 30, and 45 minutes. Both have the same mean of 30 minutes, but Company A has an SD of just 2 minutes, whereas Company B's SD is about 12 minutes. Looking only at the mean suggests they are equally good, but variance tells us Company A is far more consistent.

Another illustration is income distribution. Suppose the average income in two countries, X and Y, is ₹10 lakh. In Country X, most people earn close to this value, with incomes ranging between ₹9 and ₹11 lakh, leading to an SD of about 0.7 lakh. In Country Y, incomes range from ₹1 lakh to ₹30 lakh, resulting in an SD of around 9 lakhs. While the mean suggests similar wealth, variance reveals that Country Y is far less equal and much more unpredictable.

5. Why Mean and Variance Matter Together

The mean shows the central value of a dataset, while variance and SD reveal the spread and consistency. In decision-making, both are essential. A dataset with a slightly lower mean but low variance may be preferable because it ensures predictable outcomes.

For instance, a farmer might choose a crop variety that consistently yields around 4.5 tons per hectare with minor fluctuations (low SD) rather than another that averages 4.8 tons but varies dramatically due to weather sensitivity (high SD). Similarly, in fisheries, a batch of fish that weighs uniformly around 500 grams (low SD) is far better for packaging and pricing than a batch with the same mean but large variations.



6. Applications in Farm Sciences

The true value of mean and variance lies in how they help us interpret real-world phenomena. In farm sciences be it agriculture, veterinary, or fisheries data often reflect natural variability, which is influenced by genetics, environment, management, and random factors. Simply knowing the average yield, growth, or production is rarely sufficient for drawing meaningful conclusions. Variance complements the mean by revealing whether an outcome is stable and dependable or erratic and unpredictable, which is vital for scientific decisions and research planning.

In agriculture, for instance, researchers often test multiple crop varieties under field conditions. Two rice varieties might both have an average yield of 4.5

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tons per hectare. However, if Variety A has a standard deviation of just 0.3 tons while Variety B varies by 1.2 tons, it indicates that Variety A consistently performs well across plots, while Variety B's performance fluctuates widely. For farmers, a slightly lower but stable yield is often more desirable because it reduces risk, especially when weather conditions or soil fertility vary. Variance thus helps agronomists recommend varieties that offer reliability rather than just higher averages.

In veterinary sciences, milk yield studies illustrate the importance of variance. Suppose two buffalo breeds show the same mean daily milk production of 8 liters. Breed X, with an SD of 0.5 liters, shows that most animals produce between 7.5 and 8.5 liters consistently. Breed Y, with an SD of 3 liters, may produce anywhere between 5 and 11 liters, which complicates production forecasting for dairy farmers. Veterinarians and animal breeders use variance to identify which breeds or feeding regimes provide predictable outcomes, which is essential for supply chain planning and farmer income stability.

In fisheries, variance provides a clear picture of market readiness. A fish farm may report an average harvest weight of 500 grams per fish, but if individual fish vary between 300 and 800 grams, grading and pricing become challenging. A pond where fish weights cluster tightly around 500 grams (low SD) is easier to market and fetches better prices, as buyers prefer uniformity. Fisheries scientists often evaluate feeding schedules, stocking density, and water quality by looking not only at mean growth rates but also at how variable these outcomes are across a population.

Across these disciplines, mean and variance together allow researchers to move from just describing outcomes to evaluating the reliability and risk factors associated with them. For assistant professors or researchers from non-statistical backgrounds, understanding this relationship means being able to interpret experimental results more accurately, identify stable interventions, and communicate findings effectively to farmers, policymakers, and industry stakeholders.

Conclusion

Mean and variance are more than just mathematical tools; together, they form the foundation of data interpretation. The mean tells us what is typical, while variance shows how stable or unpredictable that typical value is. For agriculture, veterinary, and fisheries sciences, where decisions are often made under uncertainty, these two measures help in identifying reliable crop varieties, consistent animal breeds, and uniform fish stocks. By appreciating both the center (mean) and the spread (variance), we gain a deeper understanding of data that can guide better scientific and practical decisions.

PERFORMANCE OF ARKA ANAND F1 BRINJAL UNDER SOUTH GARO HILLS

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Background

Brinjal (*Solanum melongena* L.), native to India, is a commonly cultivated crop with significant genetic

diversity in terms of plant type, fruit shape, size, colour, and yield. However, local varieties, though preferred for specific traits, often underperform in yield compared to improved hybrids.

Intervention

To address this, Krishi Vigyan Kendra (KVK), South Garo Hills initiated awareness and demonstration programs to introduce improved brinjal hybrids, specifically Arka Anand F_1, developed by ICAR-IIHR, Bengaluru. Awareness was created through various extension activities including film shows, Kisan Gosthi, Mera Gaon Mera Gaurav programme etc.

Capacity Development and Demonstration

Under the NEH programme of ICAR-IIHR, Arka Anand F_1 was demonstrated on 1 hectare of farmers' field, comparing its performance with the local brinjal variety. Regular field visits, farmer-scientist interactions, and group discussions were conducted to monitor crop performance and acceptability in the market.

Results & Impact

Yield Performance

Significant improvements observed in growth, yield-contributing traits, and marketable produce. Arka Anand F_1 demonstrated a 37.35 % increase in yield compared to local brinjal varieties.

Economic Impact

Parameter	Arka Anand F_1	Local Variety
Net Income (Rs./ha)	₹ 3,85,027/-	₹ 2,43,035/-
Benefit-Cost Ratio	2.59	2.14

Result

Adoption of Arka Anand F_1 led to a substantial 58.4% increase in net income, making it a highly profitable option for brinjal cultivation in the region.

Social Impact

Farmers in the region have shown strong confidence in the technology and are eager to adopt the technology. They have expressed satisfaction with the initiatives undertaken by the Krishi Vigyan Kendra, South Garo Hills, in uplifting the socio-economic status of the farming community.

Performance of Arka Anand F1 Brinjal at farmer's field

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WILD FAGACEOUS NUT SPECIES FROM SUB-TROPICAL FOREST AREA OF KYRDEMKULAI, MEGHALAYA – POTENTIAL LOCAL DIETARY SOURCE FOR NUTRITIONAL SECURITY

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Introduction

Meghalaya has rich source of biodiversity with dense forest area of 17,927 km^2, but the potential of the existing flora is still under-utilized. Indigenous fruits play a significant role in food and livelihood security of people in the developing nations. These fruits, usually collected from the wild provide an alternative source of nutrition and generate cash income in times of hardship of the rural poor and the tribal's (Deshmukh and Shinde, 2010). Some of the wild fruits are reported with richer nutritional value than the commercial cultivated fruits. In the recent times, consumption of wild fruits has decreased due to improvement and hybridization in commercially-cultivated fruits. In the modern society, the younger generations are in denial to even consume the local seasonal fruits because of dilution in the traditional knowledge and change in consumption habit, negligence and ignorance.

Importance

Nuts are important part of human nutrition and health, as a source of protein, carbohydrate, vitamins, minerals, dietary fibre and phytonutrients. The utility of fagaceous nut has been minimal in the country as a whole. Even in the Kashmir valley, the profile of the fruit industry has been long dominated by apples (Pandit *et al*., 2013). Diversifying fruit industry is a necessity for addressing the social problem of health and nutrition insecurity especially in women and child, poverty reduction, unemployment and conservation of the rare species. Besides, it is an important to develop local-based food habit, especially for the rural population. In Meghalaya, fageceous nuts are under-exploited in the region even though the existence of local diversity in the rich forest area of the state. These nuts are available during the winter dry months in the region. These under-utilized nuts have tremendous potential which can be popularized for commercialization with proper value addition.

Distribution

The Fagaceae family including beeches, chestnuts and oaks comprises of eight genera with about 927 species (Christenhusz and Byng, 2016). These flowering trees are mostly deciduous in temperate regions, but appear as evergreen trees and shrubs in the tropics. They are genetically very diverse group and distributed throughout the world including North-eastern India. In India, fagaceous nuts are mainly grown in the orchards and in wild throughout the Himalayas up to Assam and Meghalaya at altitudes of 2000 to 3000 m ASL for edible nuts (Pandit *et al*., 2013). Northeastern states is a transition zone of the Fagaceae members and have floral affinity with Greater Himalaya, Central Himalaya and Lesser Himalaya (Singh and Singh, 2016). A total of 35 species were recorded from Northeastern states. The genus Quercus (14 species), Lithocarpus (11 species) and Castanopsis (9 species) were reported. Among the NE states, Arunachal Pradesh recorded 30 species, followed by Assam (27 species), Meghalaya (24 species), Sikkim (19 species), Nagaland (15 species), Manipur (12 species), Tripura (5 species) and Mizoram (4 species) (Singh and Singh, 2016).

Challenges and prospects

Increase in urbanization and commercial exploitation of forests and waste lands have led to a threat in the existence of indigenous crops. Increase in climate catastrophe and unpredictability in the present day cannot guarantee food security in state of emergencies. Cultivation of commercial varieties can be taxing with respect to resources like water, nutrients and agronomic management. Fagaceous nuts can be grown and produced without pesticides, entirely organically (Pandit *et al*., 2013). These nuts can be grown easily in foothills where other fruit crops cannot be grown, (Pandit *et al*., 2013) and can be potential resources for the economy, environment and nutritional security.

Moreover, it is high time and urgent requirement for diversification of daily diet based on locally available and easily cultivable food. It is a positive sign that in the recent times, the under-utilized crops are beginning to take its place as an important component in the area of science, technology and research (Devi *et al.*, 2018). These nut species are propagated through seeds and possesses vast genetic variability and heterogeneity for important traits. There is an urgent need to characterize and evaluate the available germplasm for the identification of area/state specific quality genotypes for commercial horticulture. The information will also help in preserving the genetic resources of these nut species and will provide primary information for further studies like selection of desirable trees, biochemical, physiology and molecular characterisation of the existing races in the region.

Local diversity and utility

Four fagaceous species *viz.*, *Castanopsis tribuloides (Sm.) A.DC*, *Castanopsis purpurella (Miq.) N. P. Balakr (Syn. Castanopsis hystrix* A.DC.)., *Castanopsis indica (Roxb. ex Lindl.) A.DC.* and *Lithocarpus fenestratus var. khasiana A.DC* (The Herbarium, Royal Botanical gardens, Kew; Hooker, 1890) were identified from the sub-tropical forest area of Kyrdemkulai, Meghalaya. According to villagers, the local names of these species are Soh-ot-saw, Soh-ot-rit, Soh-ot-langkhraw and Soh-ot-dieam, respectively (Table 1). These nuts are usually found in the wild forest areas and not cultivated. The locals collect the nuts, consume raw or roasted. They are also sold in the local markets like Umsning, Iewduh, Bara Bazar, Shillong (Singh and Singh, 2016). The locals of Kyrdemkulai area don't have record or knowledge on other medicinal properties of these nut trees. However, Singh and Singh (2016) reported medical property of *C. indica*, its leaf decoction is used to treat stomach disorder, skin infection, resin for curing diarrhoea, bark paste to control chest pain and anti-cancer activity of ethanolic bark extracts of *C. indica*. Bark paste of *Castanopsis tribuloides* is applied to cure snakebites (Joshi *et al.*, 2011), and leaves are used as fodder (Prasad Pokharel *et al.*, 2021). Other utility includes firewood and timber (Aye *et al.*, 2012). *C. tribuloides* bark extract also demonstrated remarkable antipyretic activity in recent studies (Hasan *et al.*, 2022). The variability for important traits at intra and interspecies level is discussed as follows:

Table 1: Wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya

Species	Specimen reference	Local name	Nuts Availability	Local utilities	Market
Castanopsis purpurella (Miq.) N. P. Balakr.	http://specimens.kew.org/herbarium/K000832670	Soh-ot-saw	October-December	Consumed raw/roasted	Local markets, Umsning, Iewduh, Bara Bazar, Shillong
Castanopsis tribuloides (Sm.) A.DC	http://specimens.kew.org/herbarium/K000832662	Soh-ot-rit	October-December		
Castanopsis indica (Roxb. ex Lindl.) A.DC.	http://specimens.kew.org/herbarium/K000832671	Soh-ot-langkraw	October-December		
Lithocarpus fenestratus var. khasiana A.DC	http://n2t.net/ark:/65665/3d33d97ce-0efb-432c-8df3-fb9682081df8	Soh-ot-dieam	August-December	Not consumed; Eaten by wild animals	

Conclusion

Alternative utilities and traditional knowledge of locally potential wild species need to be explored to increase the value of these local nuts. The preliminary information provide knowledge for future studies like selection of the desirable types, biochemical, physiology and molecular characterisation of the existing races in the region which will serve as reservoir of genetic resource, genetic improvement, conservation and utilization of these nuts in a more extensive manner. This will in turn help to achieve food and nutrition security by making food basket more diverse, safeguarding the existing diversity and to achieve sustainable development based on the use of available genetic wealth, promotion and also conservation of these species.

Castanopsis perpurella (Miq.) N.P.Balakr. | Castanopsis tribuloides (Sm.) A.DC. | Lithocarpus fenestratus var. khasiana A.DC | Castanopsis indica (Roxb. ex Lindl.) A.DC.

Figure 1: Fruit and bur of wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya

Figure 2: Branch and leaf of wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya (L-R): Castanopsis perpurella, Castanopsis tribuloides, Lithocarpus fenestratus, Castanopsis indica

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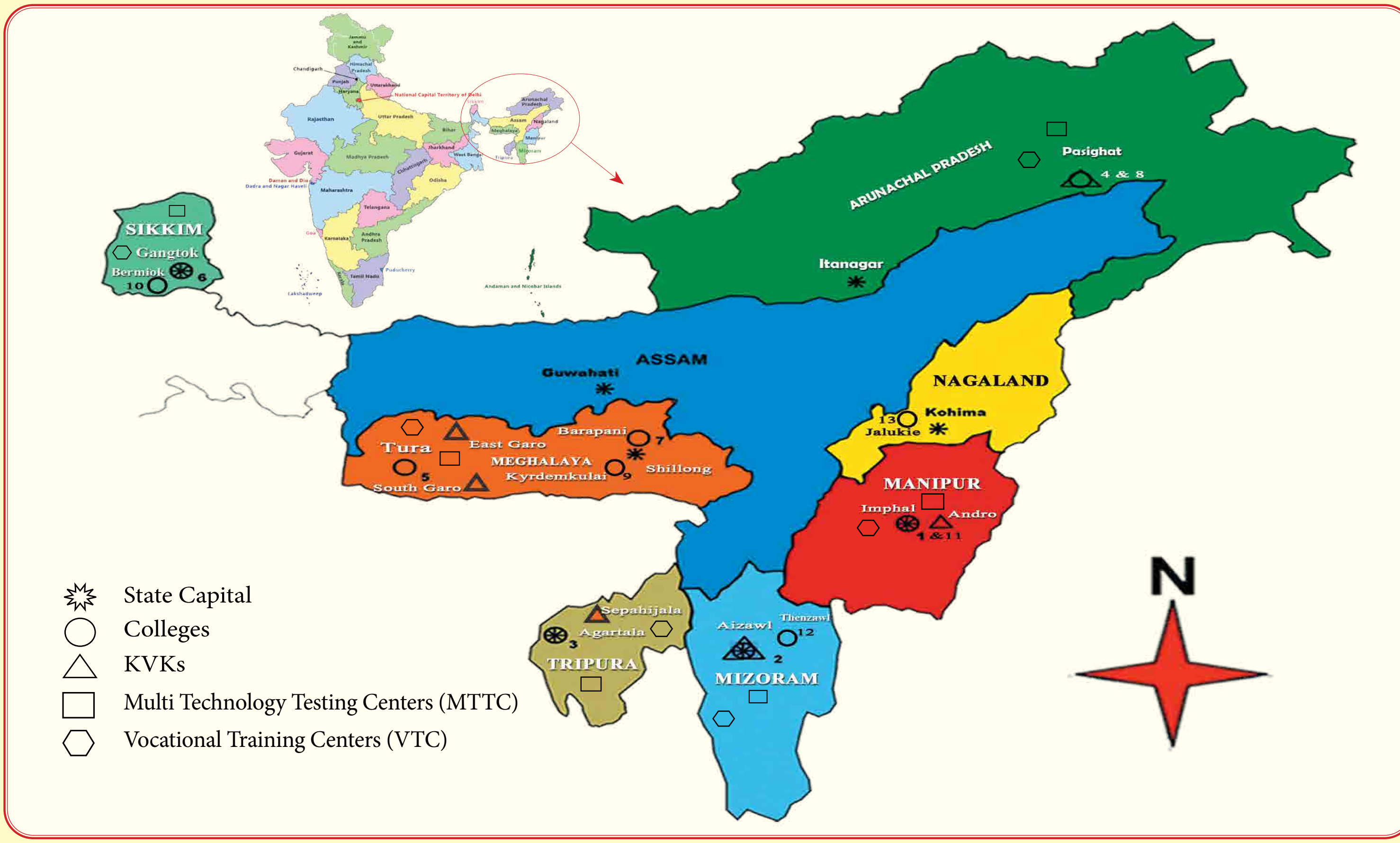

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