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KERALA KARSHAKAN

English journal

The First English farm journal from the house of Kerala Karshakan

AGRI PHOTOVOLTAIC

SCOPE AND IMPORTANCE IN
AGRICULTURE SECTOR OF KERALA

INSIDE

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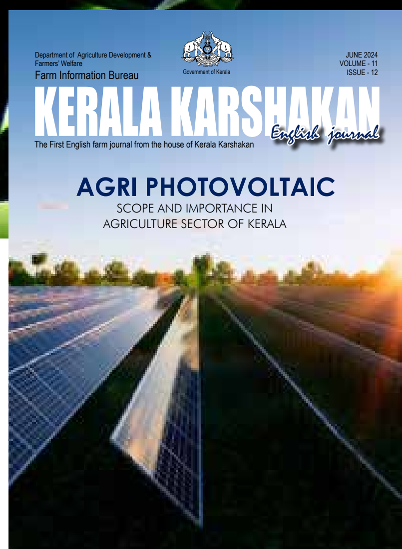

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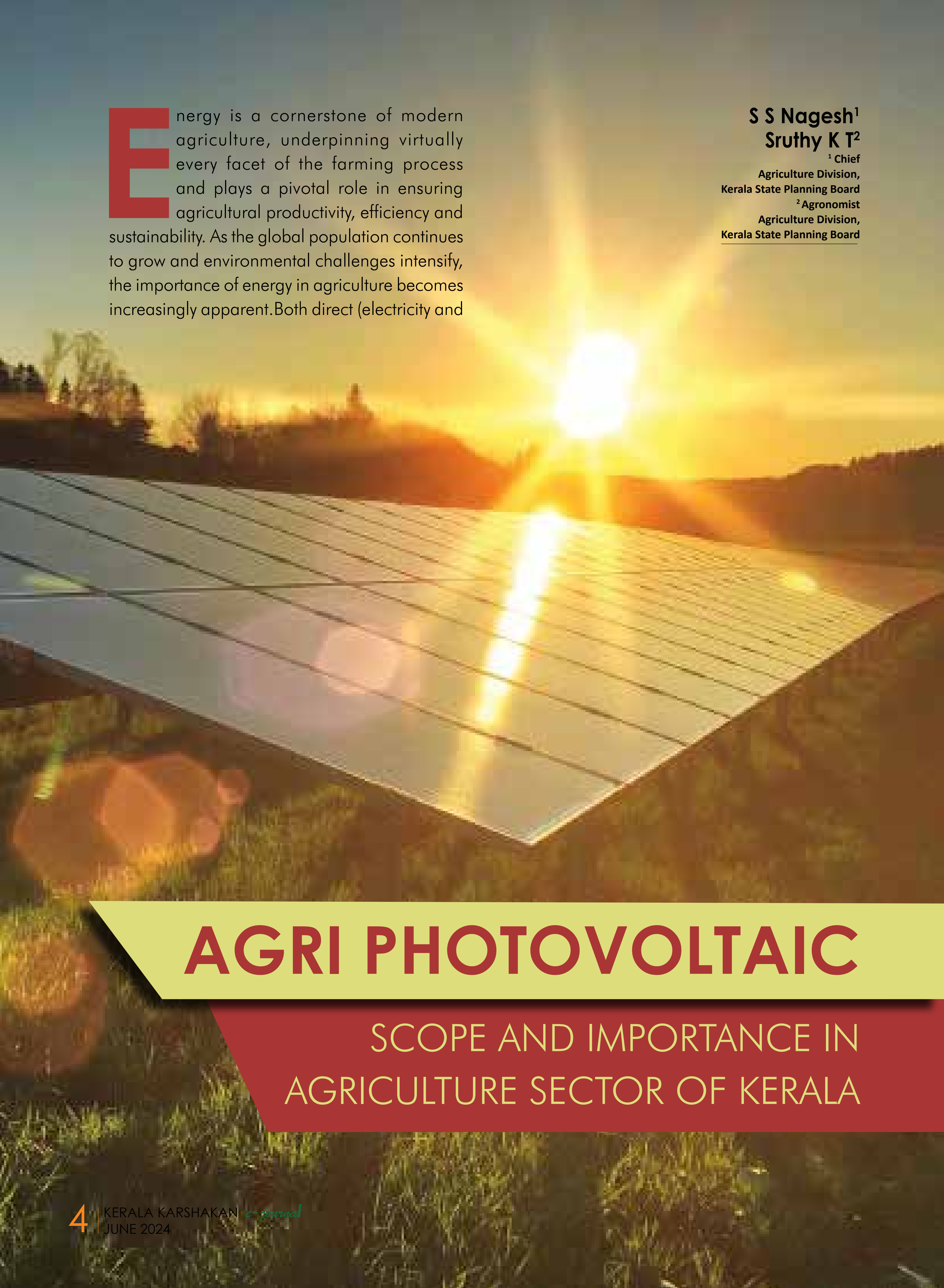

AGRI PHOTOVOLTAIC

SCOPE AND IMPORTANCE IN AGRICULTURE SECTOR OF KERALA

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Energy is a cornerstone of modern agriculture, underpinning virtually every facet of the farming process and plays a pivotal role in ensuring agricultural productivity, efficiency and sustainability. As the global population continues to grow and environmental challenges intensify, the importance of energy in agriculture becomes increasingly apparent.Both direct (electricity and

fuel) and indirect energy use in Indian agriculture have increased over the years.The direct energy use in the form of electricity in India's agriculture sector increased from 28.75 percent in 2009–10 to 37.10 percent in 2019–20(The Economic Times, 2024). Coming to the Kerala scenario, As per the 19th Electric Power Survey by Central Electricity Authority, there will be an increase of 25 per cent agricultural consumption of energy in the State by 2026-27.Electrical Energy consumption in Kerala during 2018–19 to 2022-23 is depicted in Figure 1.Kerala faced a 5.83 percent growth in electrical energy consumption from 2018–19 to 2022-23.

Kerala uses hydel, solar, wind and thermal power to produce electricity and the electricity demand of the State is met mainly through generation from Kerala State Electricity Board Limited (KSEBL), Central Generating Stations (CGS), Independent Power Producers (IPPs), Power Exchangesand Traders.According to the Economic Review 2023 by Kerala State Planning Board, total installed capacity of power in the State as on March 31st2023 is 3514.81 MW. Of which, hydel contributed the major share of 2,173.57 MW (61.84 per cent), while 734.42 MW was contributed by solar power (20.90 per cent), 536.54 MW (15.27 per cent) from thermal and 70.28 MW from wind (2 per cent).

Under this context, the potential for utilizing readily available resources such as solar energy increases dramatically.Solar energy stands out as a prominent and highly favorable renewable energy source due to its abundant availability, versatility and environmental benefits. Harnessing energy from the sun's rays, solar power offers a sustainable alternative to traditional fossil fuels which helps to mitigate greenhouse gas emissions and reduce reliance on finite resources. One of its key advantages lies in its widespread accessibility with solar panels beingdeployable in diverse settings from remote rural areas to urban rooftops. Moreover, solar energy systems can be tailored to meet varying energy needs ranging from small-scale residential installations to large utility-scale solar farms. With its capacity to generate clean renewable electricity while minimizing environmental impact, solar energy emerges as a cornerstone of the transition towards a more sustainable and resilient energy future.

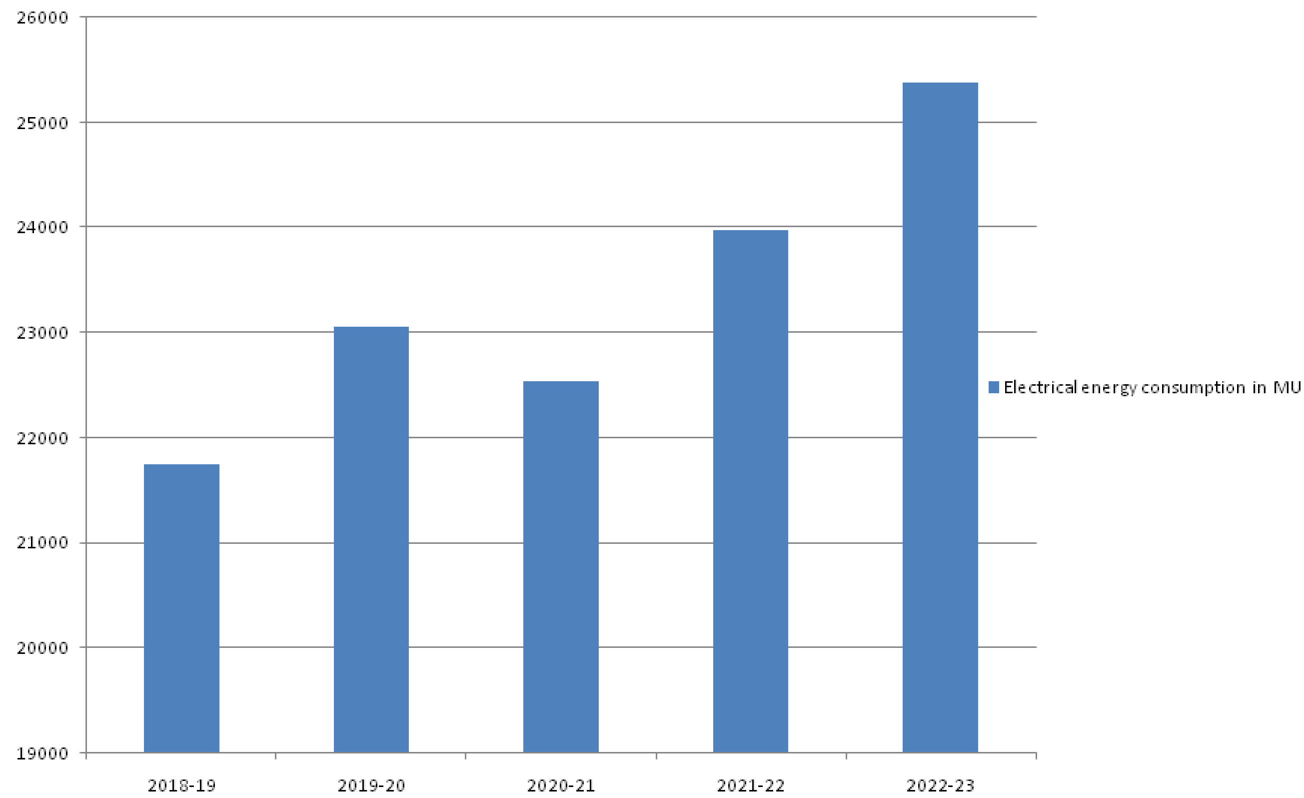

Figure 1.Electrical energy consumption in Kerala from 2018–19 to 2022-23
Source: KSEBL

Kerala aims transition to 100 per cent renewable energy by 2040 and net carbon neutrality by 2050.Sosignificant advancements in the renewable energy field are required if long-term sustainable energy is to be achieved. Kerala receives annual average solar insolation over 5.5 KWh/sq.m/day which indicates a good potential and favoring energy policies for various solar energy harvesting methods such as roof top solar photovoltaic plants, grid connected plants in wasteland, decentralized wind-solar hybrid plants, off grid solar plants etc.(Ganesh and

Agrivoltaic plant at Cochin International Airport (Credit CIAL)
Source: Agrivoltaics in India Overview of projects and relevant policies, NSEFI,2023

Ramachandra, 2012).

Agri Photovoltaic Importance and Benefits in Agriculture Sector

Solar energy can be harnessed in agriculture sector in many ways, such as using solar panels to power irrigation systems or to generate electricity for farm operations. According to Tariq et al., 2021 Solar spraying machines, solar greenhouse heaters, solar crop dryers, solar water pumps, animal ventilation and solar irrigation are a few examples of applications of solar photovoltaic systems. Groundmounted solar photovoltaic (PV) systems are installed on land used only for solar energy production. It's possible to co-locate solar and agriculture on the same land which could provide benefits to both the solar and agricultural sector through Agriphotovoltaic systems. Agriphotovoltaic (Agri-PV) is an innovative approach, it is a mixed system associating solar panels and crop at the same time on the same land area in light of the future requirements for both electricity and food. It involves the installation of solar panels above or alongside agricultural fields, providing dual benefits of renewable energy generation and agricultural productivity enhancement. Certain crops that thrive in shade may benefit from better growing conditions that Agri-PVmay offer. These consist of tubers, tomatoes and leafy greens. Agri-PV encompasses various configurations, including floating solar farms on water bodies, solar panels mounted on elevated structures above crops, and ground-mounted systems within agricultural fields. These systems can be tailored to suit different geographical, climatic, and agricultural contexts.

Integrating solar panels with agriculture

optimizes land use, especially in areas with limited available land for both energy generation and farming. Agri-PV promotes sustainability by utilizing renewable energy sources to power agricultural operations, reducing dependence on fossil fuels and mitigating greenhouse gas emissions, conserving natural resources and preserving biodiversity in agricultural landscapes. It offer climate resilience by providing shade to crops, reducing water evaporation and minimizing temperature fluctuations which can mitigate the impacts of climate change on agricultural productivity. By diversifying income streams, Agri-PV can enhance the economic viability of farms, providing additional revenue through electricity generation and potential incentives or subsidies for renewable energy production.

As per discussed, this systems provide shade to crops, reducing heat stress and optimizing photosynthesis leading to increased crop yields and improved quality. The shade provided by solar panels reduces water evaporation from the soil contributing to water conservation and improved irrigation efficiency. Apart from this, it protect soil from erosion, compaction and excessive moisture loss thereby preserving soil fertility and promoting healthier plant growth. By generating renewable energy on-siteAgri-PV systems offer farmers greater energy independence, reducing reliance on external energy sources and stabilizing energy costs.

Crops and lay out under Agri- PV system

For these settings, the ideal crops with characters likeshade loving, low growing, spreading and with no negative effects on the solar power plant's ability to operate efficiently are preferred especially spices, vegetables and medicinal plants. According to Santra, P et al., 2017, for an agri-voltaic system, low-growing crops—ideally those that are less than 50 cm tall, that can withstand some shade and use less water are chosen and the variety of crops like coriander, fenugreek, fennel, cucurbits, cluster bean, cabbage, cauliflower, peas, cow pea, onion, garlic, chilli, aloevera, senna ,ashwagandha etc. fits well to Agri- PV system.

A comprehensive overview of 22 operational projects and 3 upcoming pilot projects in agri photovoltaic in India by National Solar Energy Federation of India (NSEFI), 2023 states that there are mainly 3 types of plant layout for Agri- PV systems

1. Panels positioned on the ground that enable interspace farming. Currently the largest and most advanced example of this kind in India is the Agrivoltaic site in the Cochin International Airport where over 20 different vegetables viz. yam, long yard bean, drumstick, mountain ginger, turmeric, cabbage, cauliflower, snake gourd, bitter gourd, bottle gourd, ash gourd, blonde cucumber, eggplant, tomato, pumpkin and okra are cultivating. The edges of the area are also further beautified by curry leaf trees, drumstick trees, buddha bamboo, small mango trees as well as euginia and alamanda flowers.
2. Panels that are slightly raised, allowing crops to be grown in the spaces between and partly beneath them. A little greater land usage is possible and the crops that thrive in shade can be planted in the area beneath the panels. These systems are implemented, for instance, at the GIPCL facility next to Amrol and the CAZRI research site in Jodhpur.
3. Fully elevated panels, that allow farming and cultivation with small machinery under all parts of the site.

By connecting the Agri-PVsystem to the grid via a net metering system, it is possible to deliver photovoltaic generated electricity and farmers can generate revenue annually. If not, farmers' fields can run solar photovoltaic pumping systems using off-grid agri-voltaic systems.In addition to receiving payment for the electricity they create from photovoltaic cells, farmers can also profit from growing suitable crops. Installing an agri-voltaic system in a farmer's field can overall enhance the land equivalent ratio.

It is more difficult to develop huge solar grids in the area due to space constraints in Kerala. For this reason, the State Government has begun to encourage rooftop solar through initiatives and policy changes. Under this program, consumers can receive up to a 40 percent subsidy for rooftop solar panels and consumer will always receive a return on investment that is at least doubled. Various activities under Soura scheme of the Urja Kerala Mission is an ambitious programme to install over 1000 MW of solar photovoltaic systems in Kerala. The Agency for New and Renewable Energy Research and Technology (ANERT) in the State is handling solar photovoltaic programmes including installation of solar photovoltaic grid-tie power plants, off-grid systems promotion in remote hamlets etc. The Indian Government launched the KisanUrja Suraksha evamUthaanMahabhiyaan (KUSUM) Schemeaimed at ensuring energy security for farmers in India.

Challenges

Agri-photovoltaic (Agri-PV) systems offer a promising integration of renewable energy generation with agricultural practices, but there also present several challenges that need to be addressed for widespread adoption and effectiveness. Factors such as dust accumulation on solar panels, vegetation growth beneath the panels and potential damage from weather events necessitate frequent inspections and cleaning which can be labor-intensive and costly especially for installations at greater heights.Cost considerations and research gap on suitable crops for Agri-PV systems also present barriers to Agri-PV implementation. Another challenge is the irregular power supply associated with solar energy generation. The intermittent nature of solar energy production can pose logistical challenges for farmers particularly in regions with unpredictable weather patterns or limited sunlight hours.

Conclusion

Agri photovoltaic represents a promising synergy between renewable energy and agriculture. The main potential advantage of an agri-voltaic system is that it can double farm income by increasing farmland's revenue through the sale of power generated by photovoltaic cells and crop yield.In order to successfully implement agrivoltaics, a coordinated approach from all stakeholders, such as financial organizations, policymakers, farmers, private developers and knowledge institutes are needed. Moreover, there is a research lacuna regarding the identification and cultivation of crops suited to thrive under Agri-PV systems. While certain shade-tolerant and low-growing crops have been identified as potential candidates, there remains a need for comprehensive research to assess the agronomic performance, yield potential, and economic viability of different crop varieties under varying Agri-PV configurations. Bridging this research gap is crucial for informing crop selection decisions and maximizing the synergies between renewable energy production and agricultural productivity within Agri-PV systems.

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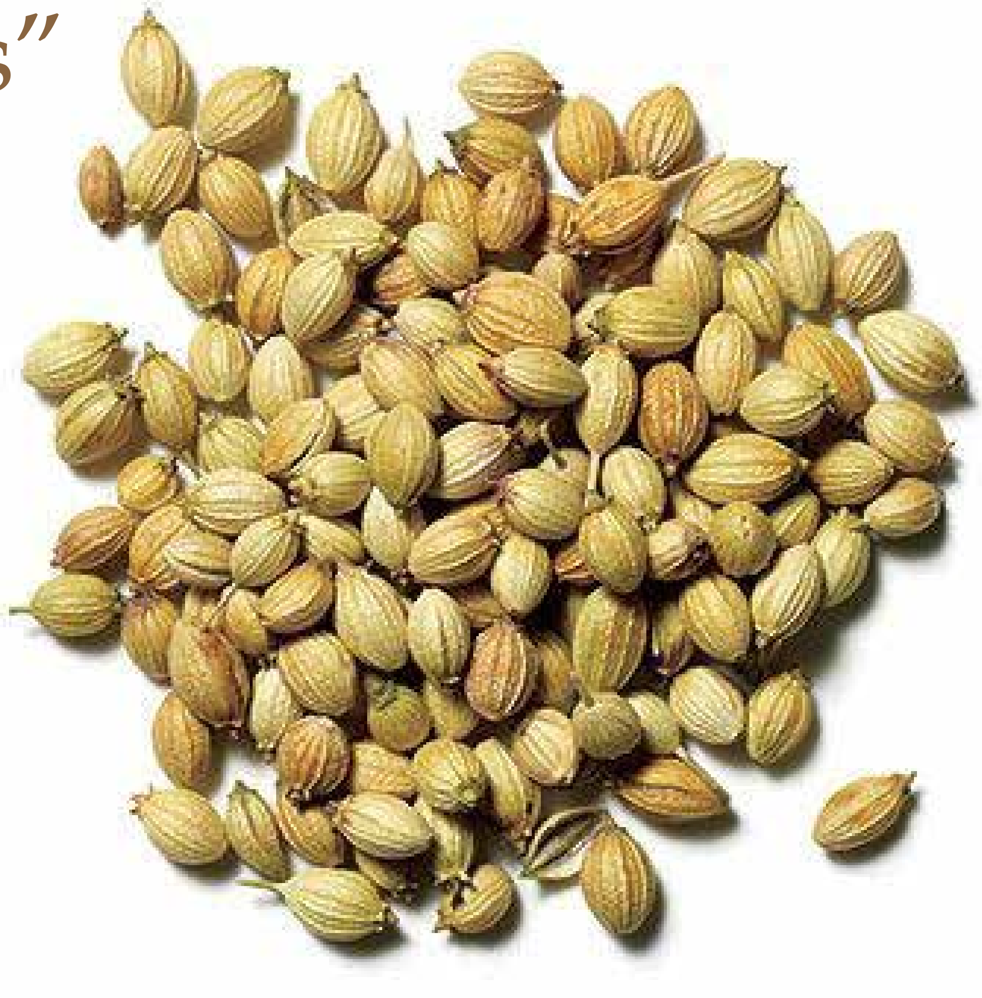
The Coriander, also known as cilantro, has a rich history dating back to 5000 BC and is even mentioned in the Bible in Exodus 16:31. The use of its seeds in burials was recorded as far back as 1550 BC. Throughout history, coriander has been utilized by various civilizations, including the Romans, Greek physicians like Hippocrates, and Chinese cultivators since the fourth century. Its presence in India and Europe can be traced back to ancient times. The name 'coriandrum' is derived from "koros," meaning bug, referring to the disagreeable

Summer Splendor: Exploring Coriander's Role in Ancient Cultures and Modern Wellness"



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fetid smell of the leaves. Coriander *(Coriandrum sativum)*, a member of the Apiaceae family, is an annual herb. While its leaves are known as cilantro, its fruit (seeds) are typically referred to as "coriander." A coriander crop typically matures in 40 to 45 days. Although all parts of the plant are edible, the fresh leaves and dried seeds are the most commonly used in cooking.

Coriander holds a significant place in the realm of spice crops, imparting distinctive flavors to various culinary delights. It manifests as a slender-stemmed, compact herb, typically reaching heights of 25 to 50 cm, adorned with numerous branches and umbrella-like clusters. The leaves, arranged alternately, are compound, contributing to the plant's overall appeal. This annual herb stands between 30 to 100 cm tall, boasting bright-green foliage and upright stems. Its flowers form short-stalked umbels, featuring 5 to 10 rays in hues of pale mauve or white. The seeds, spherical and finely ribbed, exhibit a yellow-brown hue, measuring approximately 5 mm in diameter, adorned with five longitudinal ridges. Maturation occurs around three months after planting. Initially, the harvested plants emit a somewhat disagreeable scent, which dissipates upon drying, giving way to a pleasant fragrance. Coriander is classified into two types based on fruit diameter: 3–5 mm (Coriandrum sativum L. var. vulgare) and 1.5–3 mm (C. vulgare L. var. microcarpum).

Chemical Composition:-

Coriander seeds boast approximately 1% volatile oil content. The aroma of coriander is primarily attributed to the alcohol d-linalool, with a desirable content of 60% or higher. Additionally, the oil contains constituents such as d-α-pinene, β-pinene, α-terpinene, geraniol, borneol, decylaldehyde, and acetic acid. Notably, essential oil extracted from smaller coriander fruits exhibits superior flavor and yield. Compared to oils within the same group, coriander oil demonstrates enhanced stability.

Health Benefits of Coriander

Coriander boasts an essential oil content ranging from 0.03% to 2.6%, containing various beneficial

compounds. Among these are monoterpenes, limonene, α-pinene, γ-terpinene, p-cymene, citronellol, borneol, camphor, coriandrin, geraniol, dihydrocoriandrin, coriandrons A-E, flavonoids, and essential oils. It serves as a stomachic, spasmolytic, and carminative, possessing significant bioactive properties. Notably, different parts of the plant, including seeds, leaves, flowers, and fruits, exhibit a wide range of health benefits:

Promotes Healthy Vision: Coriander leaves are rich in Vitamin A, Vitamin C, Vitamin E, and carotenoids, contributing to improved vision.

Supports Immunity: Abundant in Vitamin C, Vitamin E, and Vitamin A, coriander leaves enhance the immune system's efficiency, aiding in white blood cell function and iron absorption.

May Help Manage Blood Sugar Levels: Antioxidants present in coriander stimulate insulin secretion, aiding in the regulation of blood sugar levels.

May Lower Bad Cholesterol: Regular consumption of coriander leaves can reduce LDL (bad) cholesterol and elevate HDL (good) cholesterol levels.

Fortifies Bone Health:
Coriander leaves contain essential minerals like calcium, manganese, magnesium, and phosphorus, along with anti-inflammatory properties, promoting bone health and alleviating arthritis-related pain.

Enhances Gut Health:Rich in fiber, coriander leaves aid in digestive issues like stomach upset, diarrhea, bowel spasms, and nausea.

Promotes Skin Health:
With its iron, Vitamin E, and Vitamin A content, coriander fights free radicals, acts as an antimicrobial, antiseptic, and antifungal agent, and soothes and cools the skin.

Protects Your Brain:
Coriander extract exhibits neuroprotective properties, guarding brain cells against damage and enhancing memory. Its anti-inflammatory properties may mitigate inflammation-related brain degeneration.

Fights Infections:
Coriander's antimicrobial properties combat foodborne illnesses, with compounds like Dodecenal showing efficacy against Salmonella infections. Coriander seeds and oil are also effective against urinary tract infections and food-related diseases.

Easily Incorporated into Diet: Fresh coriander leaves, seeds, and powder are readily available and can be added to a variety of dishes, salads, marinades, and condiments, providing convenient access to its myriad health benefits. By incorporating coriander into your diet, you can harness its numerous medicinal properties to enhance overall health and well-being.

Cultivation practices of Coriander:-

Soil :-
Well-drained silt or loamy soils are ideal for cultivation. For rain fed cultivation, clayey soil with a pH ranging from 6 to 8

is preferred.Coriander thrives in temperatures between 20 to 25 °C.

Climate :-

Optimal conditions include cool, relatively dry, and frost-free climates.

Season : -

Ideal planting times are June to July and October to November.

Field Preparation :-

Prepare the finely tilled field .Apply Farm Yard Manure (FYM) at a rate of 10 tons/ha before the final Ploughing. Create beds and channels for irrigated crops. Sow split seeds at a spacing of 20 x 15 cm. Apply pre-emergence herbicide Fluchloralin (700 ml in 500 liters of water per ha). Germination typically occurs within 8-15 days.

Seed Treatment :-

For rainfed crops, pre-sowing seed hardening treatment with Potassium Dihydrogen Phosphate (10g/lit of water for 16 hours) is recommended. Treat seeds with Azospirillum (3 packets/ha).Control wilt disease by treating seeds with Trichoderma viride (4 g/kg of seed).

Seed Rate :-

10 - 12 kg/ha for irrigated crops.

5 kg/ha for rainfed crops.

Sowing :-

Split seeds before sowing to

improve germination rates.
Seeds require 14 days to germinate.

Manuring :-

Basal application: FYM (10 t/ha); N (10 kg), P (40 kg), K (20 kg) for both rainfed and irrigated crops.

Top dressing :- Apply 10 kg N/ha 30 days after sowing for irrigated crops.

Irrigation :-

First irrigation immediately after sowing, followed by another on the third day, and subsequent irrigations at 7-10 day intervals.

Apply pre-emergence herbicide Fluchloralin (700 ml in 500 liters/ha).

Thin plants 30 days after sowing to maintain 2 plants per hill.

Subsequent weeding is needed.

Induce drought tolerance in rainfed crops by spraying CCC @ 250 ppm one month after sowing.

Plant Protection :-

Aphids are controlled by spraying Methyl demeton 20 EC or Dimethoate 30 EC.

Powdery mildew is treated with Pseudomonas fluorescens, Wettable sulfur, or Dinocap.

Wilt is controlled with Pseudomonas fluorescens.

Grainmold is combated by spraying Carbendazim 0.1% 20 days after grain set.

Harvest :-

For coriander seed, harvest when fully ripe but still green and drying fruits are. Dry, thresh, winnow, and clean the plants.

For leaves, harvest when plants are 30-45 days old. Off-season coriander

productions:-

The Off-season coriander production is a growing trend in agriculture, driven by the increasing demand for fresh herbs year-round and the desire for more sustainable and locally sourced produce. Several methods and technologies are employed to facilitate off-season coriander cultivation, ensuring consistent supply and quality.

Green house Cultivation:

Greenhouses provide a controlled environment for year-round coriander production by regulating temperature, humidity, and light conditions.

In a greenhouse setting, the yield of coriander can vary widely depending on factors such as the greenhouse type (e.g., polyhouse, shade net house), the use of advanced technology (e.g., hydroponics, aeroponics), and the cultivar used. Yields can range from 2 to 10 times higher compared to traditional outdoor cultivation.

Hydroponic Systems:

Hydroponic cultivation allows for precise control of nutrient delivery and environmental factors, resulting in optimized growth rates and yields.

Indoor Cultivation and Artificial **Lighting:**

Indoor cultivation with artificial lighting, such as LED grow lights, allows for year-round coriander production regardless of external conditions.

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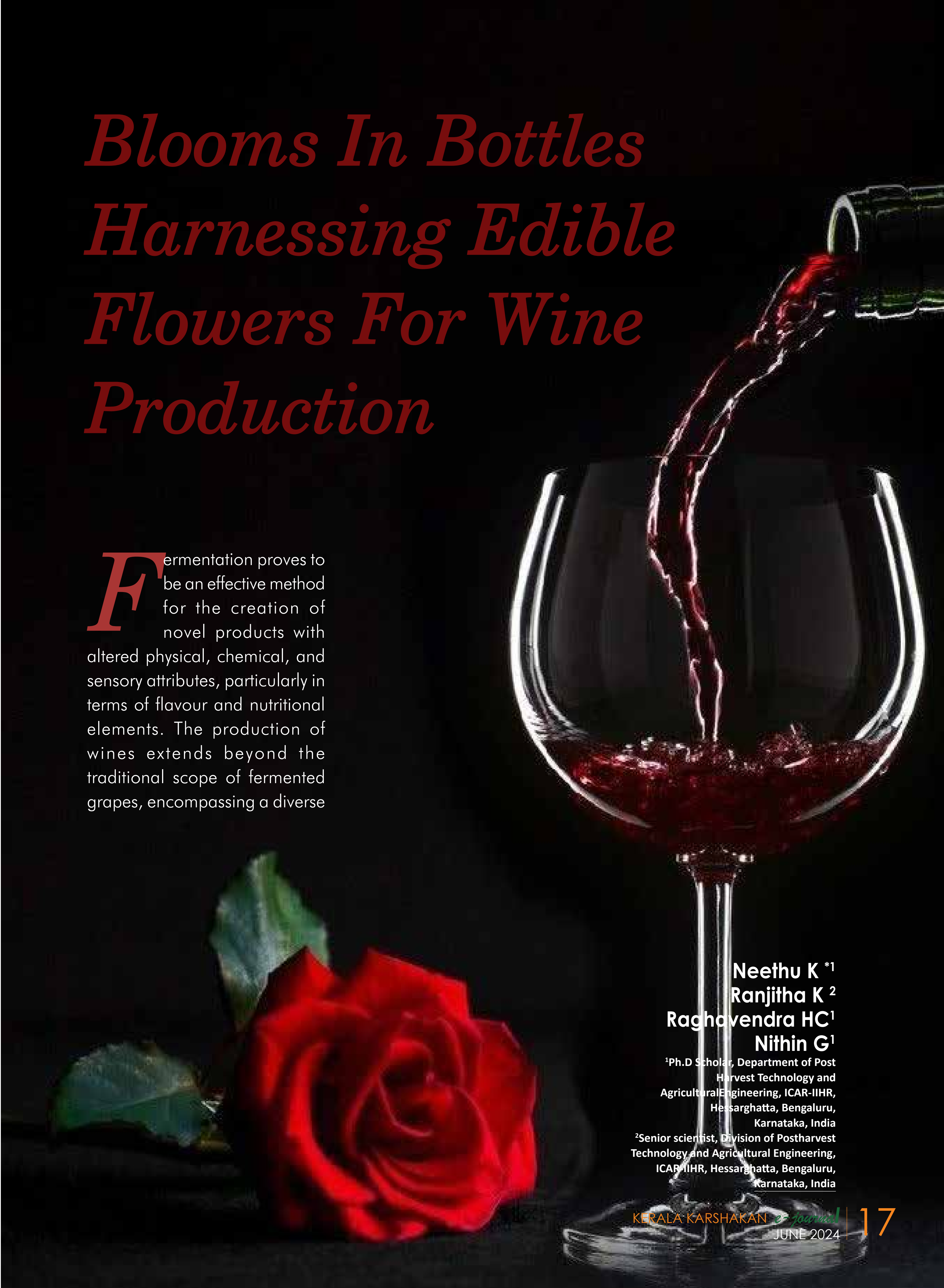

Blooms In Bottles Harnessing Edible Flowers For Wine Production

Fermentation proves to be an effective method for the creation of novel products with altered physical, chemical, and sensory attributes, particularly in terms of flavour and nutritional elements. The production of wines extends beyond the traditional scope of fermented grapes, encompassing a diverse

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array of crops. The future of wine market is anticipated to be bright due to the relaxation in wine policy brought out in several states, including Kerala. Besides the conventional fermentative substrates such as grapes, other fruits, honey etc., edible flowers also can be used as excellent raw materials for production of wines. Wine production from flowers has been documented since time immemorial; and this art has progressed into anorganized small scale industry in countries like Japan, China and some parts of India. Besides reducing postharvest losses of these perishables, value addition of flower crops for human consumption is a strategy that boosts their economic value.

Some of the potential flowers for wine making include rose *(Rosa damascena)*, jasmine (Jasminum spp), mahua *(Madhuca indica)*, rhododendron *(Rhododendron arboretum)*, shankupushpam *(Clitoriaternatea)* and hibiscus *(Hibiscus rosa sinensis)*.These flowers are used as either major ingredients or to enhance the aroma of other wines, owing to their richness in aromatic volatile components.The pleasant fragrance of floral wines is attributed to the diverse array of volatile compounds they contain.Floral wines with rich history in Indian subcontinent, and suitable for tropical conditions are given in the following sections

Rose wine

Rose has a pleasant aroma and offers health benefits and medicinal properties, making

Rose wine

it suitable for developing functional foods and beverages like rose wine. The good quality Damascus rose petals (Desi Gulab) are used for the production of this exotic wine and it can be consumed by both vegetarian and non-vegetarian people. Apart from the use in production of wine, rose flowers can also be used as a flavour enhancer in dealcoholized wines. Rose flower extract is reported to be an aroma enhancer of dealcoholized Merlot red wine. The rose flower extract found to be the best in improving the volatile composition especially, ethyl octanoate, isoamyl octanoate, linalool, and geraniol, and aroma intensity with improved sensory properties.

Jayashree Yadav, an entrepreneur based in Pune, has innovated a new method for crafting 'rose wine' using distinctive ingredients and roses. Having secured a patent for her technique, she is in the process of establishing a winery in the vicinity of Pune.

Mahua wine

Mahua, scientifically known as *Madhuca indica* is a multipurpose tree belonging to the Sapotaceae family. This species serves as a comprehensive solution for fulfilling the essential needs of food, fodder, and fuel. It is a large tree of Indian origin, predominantly cultivated on unproductive lands in the northern and central regions

Mahua wine

of the country. Although not cultivated commercially as a flower crop in Kerala, mahua is grown as an underutilized tree crop in fields.Mahua flowers are used as a fermenting initiater in many Ayurvedic medicines.The consumption of mahua flowers

Roselle wine

on day to day basis can provide nutritional benefits to human body because of its fleshy petals loaded with sugars and these flowers are rich source of vitamin A and C.

The white coloured mahua flowers are subjected to preliminary treatments such as sorting, washing and crushing before juice extraction. Juice extraction is done using hydraulic press at a pressure of 1500–2000kg/square inch and collected in stainless steel vessels. 500 ppm KMS addition obtained mahua flower juice with least browning. Juice is ameliorated with sugar and acid to obtain 20°Brix TSS and 0.5% acidity and supplied with *Saccharomyces cervisiae* to initiate fermentation. Optimum temperature for the fermentation is 16°C, it resulted in higher content of alcohol (9.9%) and ascorbic acid (0.9 mg). whenherbs such as lemon, cinnamon, raw mango, and mint were incorporated into mahua flower wines, an enhancement in both aroma and overall acceptability were observed. Nevertheless, the wine treated with lemon stood out as superior in comparison to the other treatments.

Roselle wine

Roselle *(Hibiscus sabdariffa)* is a flower crop that's often overlooked but contains numerous beneficial compounds, making it a promising ingredient for functional foods. In various traditional medicinal practices, *H. sabdariffa* extracts have been utilized across different regions to address a wide range of ailments. In Kerala, the plant is known by local names such as 'Pulivenda', 'Mathippuli' and 'Meenpuli' and its fruit can serve as a substitute for tamarind in cooking. The petals surrounding the fruit are suitable for making wine. The process involves extracting juice from the calyx using distilled water at 30°C for an hour, followed by pasteurization at 50°C for 30 minutes. This juice is then supplemented with sodium metabisulphite (60 mg/L), brewing sugar, and yeast nutrient (1 g/L) to initiate fermentation, which occurs in contact with the calyxes over about 6 days. After primary fermentation, the wines are transferred to secondary fermentation vats and kept at specified temperatures until day 40.

Rhododendron wine

Rhododendron belonging to the family Ericaceae is the national flower of Nepal, while in India, specifically in the State of Uttarakhand, it is designated as the State tree.

The nectar of *Rhododendron arboreum* is utilized in the production of wine and has been found to be beneficial in addressing diarrhea and dysentery. While there isn't a fixed recipe for rhododendron wine, it can be crafted using methods similar to the preparation of conventional flower wines.

Mature flowers are picked from the tree and graded after removing stigma and anthers followed by cleaning and washing. Juice extraction is done using grinders/blenders and subjected to boiling. The Total Soluble Solids (TSS) of the juice is adjusted to 22°Brix and then inoculated with yeast and yeast nutrients. Stir the must every day until the intense fermentation stops, which should take 7 to 10 days. A secondary fermentation tank with a fermentation trap is filled with the strained liquid. After 30 days, wine is racked, and then it is done again after another 30 days. Once clear, it is bottled and kept in a cool, dark area. After six months, it is safe to drink, but a year later, it has much improved quality. The initial taste of the wine is light and floral, followed by a subtle and lively aftertaste.

Theproduction of flower winespresents a promising avenue for both culinary and medicinal exploration. Through traditional practices and modern methods, these wines harness the bioactive compounds inherent in flowers, offering unique flavours and potential health benefits. The example of H. sabdariffa wine production in Kerala showcases the versatility of this flower, from its culinary use as a tamarind substitute to its application in winemaking. Further research and experimentation in this field hold the potential for expanding our understanding of floral resources and their integration into functional food development.

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ORGANIC PLANT BREEDING

AN ECO-RIENDLY CONCEPT

During the green revolution, production and productivity in agriculture increased with the use of high-yielding seeds, fertilizers, chemical control, and irrigation facilities. However, the excessive use of fertilizers and chemicals to achieve higher yields has resulted in residual effects that pose various issues for animals, humans, and the environment.

Therefore, there is a need to shift from chemical-based agriculture to organic-based agriculture. This transformation is exemplified by the case of Sikkim state in India, which has embraced organic agriculture by avoiding synthetic chemicals in crop cultivation. While organic farming may yield lower crop quantities, the higher prices for organic produce compensate for this.

There are many differences between conventional and organic farming systems. Organic farming concentrates on most aspects such as soil quality, nutritional quality, biodiversity, and less environmental pollution. However, there is a yield gap between these two systems. The crop yield under organic conditions is very low. Therefore, breeders are working on breeding activities tailored for organic conditions, aiming to develop varieties that can yield more in organic farming systems, a concept known as organic plant breeding.

ORGANIC PLANT BREEDING

Organic plant breeding is a specialized branch of plant breeding that focuses on developing new plant varieties suitable for organic farming system. It is a holistic approach that concentrates not only on the final product of the crop but also on the complete procedure of plant growth and development.

BREEDING GOALS

1. Breeding for quality: When aiming for improved quality in breeding, one consideration is the development of plants that contribute to human health. Apart from enhancing nutritional content, such as increasing protein levels, breeding for secondary metabolites can enhance resistance to human diseases.

2.Adaptation to local climate: Since organic farming relies exclusively on organic supplements for crops, it is essential to breed crops that can thrive under the specific climate conditions of their local environment.

3.Nutrient efficiency: It is essential to breed crops that exhibit high nutrient efficiency and strong responsiveness to the natural nutrients provided.

4.Resistance to pests and diseases: Cultivating resistant genotypes is the most efficient and suitable approach for managing diseases and pests, especially given the strict prohibition of synthetic chemicals in organic agriculture.

5. Resistance to mechanical weed control: In organic farming, the primary method for weed control is manual weeding. Therefore, it is beneficial to breed crops that exhibit traits such as early vigor, larger canopy coverage, strong nutrient competitiveness with other crops, and the ability to outcompete weed growth. These characteristics help crops to withstand mechanical hand weeding while maintaining their yield.

6.Yield stability: It is essential for the yield to remain consistent and at the same level as that of conventional varieties. Farmers typically prioritize comparing yields, making it crucial for the crop to deliver both stability and a yield that matches conventional varieties.

CRITERIA FOR ORGANIC PLANT BREEDING

Organic plant breeders must carefully choose their varieties while adhering to the organic conditions stipulated in this standard. It is mandatory for organic plant breeders to transparently disclose the breeding techniques they employ. This transparency enables farmers to make informed choices about the varieties they select, considering the specific techniques and tools used in the plant breeding program. Organic plant breeding takes a holistic approach, valuing all living entities, including plants, for their intrinsic worth and respecting the integrity of life, beyond their utility to humans and animals. The natural reproductive capacity of a plant variety is upheld as a fundamental principle. Organic plant breeders may seek plant variety protection, but organic varieties cannot be patented. For annuals, a minimum of one generation must be grown under organic conditions. Biennial plants and perennials should undergo at least two generations of organic cultivation. In addition, land designated for conversion to organic status must remain under conversion for two years. There are some breeding techniques that are not suitable for organic plant breeding. These include genetic engineering, CMS hybrids without restorer genes, protoplast fusion, and mutation induction. Genetic engineering is a technique at deoxyribo nucleic acid (DNA) level, which is completely prohibited because of the intervention in the plant's genetic makeup, which destroys its connection with its natural environment. Therefore, organic plant breeders are not allowed to use genetically modified organisms (GMOs) in the development of cultivars. Techniques at the cellular level are also prohibited because there is no direct interaction between plants and their growing environment.

TECHNIQUES IN ORGANIC PLANT BREEDING

1.Variation induction techniques

Combination breeding: Combination breeding involves crossing two genotypes of the same species. Various generations are propagated and selected after crossing. It is widely used to create variation in breeding lines under organic conditions.

Crossing varieties or species: When there is insufficient genetic diversity within a crop to make breeding improvements, it becomes necessary to consider crossbreeding between two distinct species. This can involve related crops or even wild species although the complexity of the process may vary.

Bridge crossing: To overcome the inherent crossing barriers between two plant species that are initially incompatible, such as wild type A and cultivar B, a strategy known as introgression can be employed. This involves the transfer of desirable traits from the wild type through the use of a third plant, wild type C, which is compatible with both species A and B. The process begins by crossing wild type A with wild type C. Subsequently, plants carrying the desired traits are selected from this cross and then crossed with target cultivar B to introduce the desired traits into the cultivar.

Backcrossing: Crossing different species can produce offspring with too many wild traits, which prevents direct selection for desirable traits. In these cases, repeated backcrossing with a well-adapted cultivar may eliminate some wild-type traits, finally producing a genotype that is highly similar to the cultivar.

F_1 hybrid development: Crossing of two homozygous inbred lines to obtain F_1 hybrids. However, the disadvantage is that the multiple inbreeding of parental lines leads to plants that would not survive under organic conditions.

2.Selection techniques

Phenotypic selection: Phenotypic selection is a crucial component of all breeding programs. This process involves choosing the best-performing individual plants or their offspring, which are then cultivated in the field and assessed based on pre-established breeding goals. The interaction between a plant and its specific soil and climatic conditions is a fundamental requirement for the development of locally adapted crops. It is important that all selection stages occur within organic growing conditions.

Shuttle breeding: Changing the environment during the selection process is an attempt to increase the adaptability of varieties, by alternately testing the breeding material at two or more different locations.

Change in sowing time: Change in sowing time (early or late spring, early or late autumn) is usually carried out to select criteria such as day length insensitivity, lower demands for flower formation or yield, and quality stability at varying growing periods.

3.Maintenance and multiplication techniques include generative propagation and vegetative propagation.

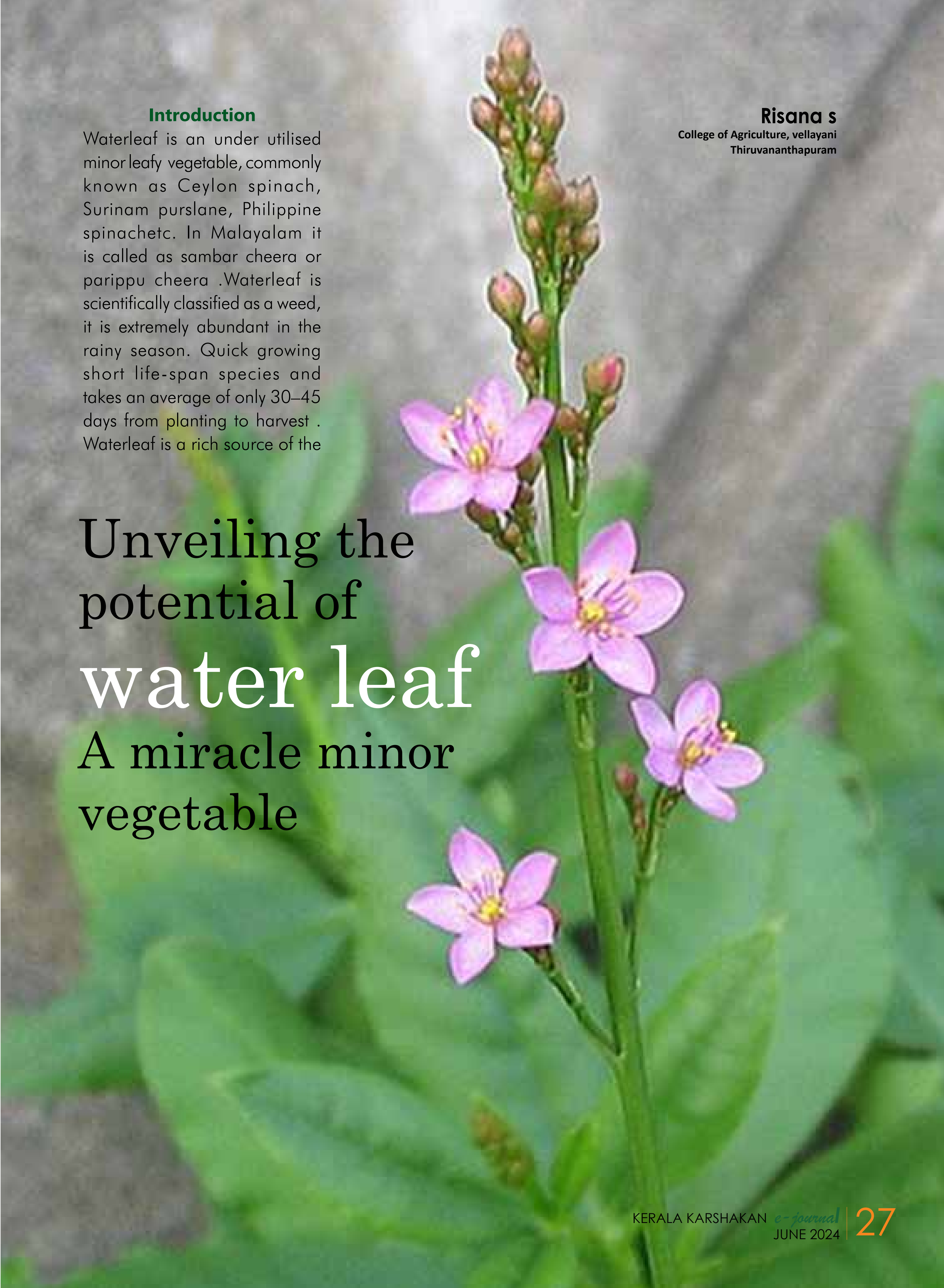
PARTICIPATORY PLANT BREEDING

Participatory Plant Breeding (PPB) programs were initially developed in developing countries to cater to the needs of small-scale, low-input farmers in challenging environments not typically addressed by commercial breeding companies. It engages various stakeholders, including breeders, farmers, consumers, extension specialists, vendors, industry representatives, and rural cooperatives, in collaborative plant breeding research.

The "participatory" aspect of PPB means that all participants can influence key stages of the breeding and selection process. They work as co-researchers, contributing to goal-setting, breeding priorities, making crosses, screening germplasm entries, conducting adaptive testing, and leading seed multiplication and dissemination efforts. The fundamental idea behind PPB is that joint efforts can achieve more than individual actions focused on specific objectives. PPB has gained significant attention in breeding programs for organic farming systems, primarily because of the unique requirements of organic farmers and the limited attractiveness of the small organic market for commercial plant breeders.

CONCLUSION

Organic plant breeding is a system focused on developing crop varieties that thrive under organic farming conditions while promoting soil and human health by avoiding chemical inputs. Although organic varieties may initially yield less, this can be improved through organic breeding methods. These varieties are safe for both human consumption and the environment. Organic plant breeding serves the needs of organic farmers by providing cultivars suited to their farming systems and contributes to sustainable agriculture by reducing reliance on external inputs.



Unveiling the potential of water leaf
A miracle minor vegetable

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Introduction

Waterleaf is an under utilised minor leafy vegetable, commonly known as Ceylon spinach, Surinam purslane, Philippine spinachetc. In Malayalam it is called as sambar cheera or parippu cheera .Waterleaf is scientifically classified as a weed, it is extremely abundant in the rainy season. Quick growing short life-span species and takes an average of only 30–45 days from planting to harvest . Waterleaf is a rich source of the

essential nutrients like Calcium, Phosphorus, Iron, and Vitamin C and low in calories and sugar.. It is also a good source of Vitamin A, Thiamine, Riboflavin and Niacin. Generally, it's a good idea to try to eat three to four servings of vegetables per day. A waterleaf rich diet is recommended for stroke and heart disease patients because, like most vegetables its completely cholesterol free and fibre rich . The edible leaves are soft, succulent, and highly nutritious herbaceous annual and perennial plant with light green edible leaves.

Origin and distribution

Waterleaf originated from tropical Africa, widely grown in West Africa, Asia, Mexico, the Caribbean, Central America, and South America.

Nutrient content

Every 100 grams of waterleaf contains approximately Calories: 25,Protein: 2.4 grams,Fat: 0.4 grams, Carbohydrates: 4.4 grams and Fibre: 1.0 grams.

Uses

- Waterleaf is an excellent source of calcium and phosphorus, both of which are essential for healthy bones. The two elements appear to work together. They are especially good for helping women over 60 who are already suffering from osteoporosis.
- Maintaining sufficient levels of vitamin A is essential for healthy eyes.
- Rich in antioxidants and has been implicated in the management of diabetes, jaundice, cancer, stroke, obesity and measles .
- Waterleaf is an excellent dietary source of iron. Iron deficiency can range from mild to severe. Those who experience milder symptoms benefit the most from shifting to an iron-rich diet
- A diet rich in vitamin C reduces the risk of developing Alzheimer's disease and slows age-related cognitive decline. Waterleaf is an excellent source of vitamin C, with about 31 mg for every 100 grams of vegetable matter.
- Leaves, tender stems and

flowers of this leafy vegetable are used in a number of recipes for cooking and in salads, soups, stews, stir fries, and pizza.

Species diversity

Belongs to Purslane family (Portulacaceae), a group of edible plants with cosmopolitan distribution, The genus Talinum comprises of 15 species, of which only five species have been reported in India. Talinum triangulare (Jacq.) and *Talinum fruticosum popularly* known as waterleaf .Of the five different Talinum species reported in India, T. triangulare is closely related to Talinum paniculatum and Talinum portulacifolium. The former differs from the other species by certain morphological traits including paniculate inflorescence borne on a triangular peduncle and flower sepals being prominently veined.

Botanical description

Waterleaf is an erect perennial herb species with swollen roots and obtuse-angular, hairless, and succulent stems, which can grow to 3–10 feet in height. Stem branches have two lateral and basal buds. The leaves are arranged spirally and more clustered at the top of the stem. The leaf blades are usually spoon-shaped, succulent, and occasionally indented at the apex . Its light-green stems are smooth and have an erect growth habit, and the cross-sections of mature stems have a cylindrical shape, tapered at each end . Waterleaf has pink-colored flowers, which are bisexual and primarily self-pollinate with limited outcrossing. The inflorescences are triangular. Fruit ripening occurs about two weeks from flowering .The fruits are light-green, ellipsoid capsules, which are dehiscent with many seeds that are dark brown and break open .

Propagation

Waterleaf is usually propagated by seeds or vegetative cuttings. The seeds often have low germination due to poor seed

waterleaf soup

Waterleaf stew (sambar)

viability or seed dormancy and should be pregerminated. Seedlings can be transplanted to the field when 3 weeks old .As a result of the difficulty in establishing the crop using seeds, vegetative propagation is encouraged .Vegetative cuttings are taken from the mature stem in 5-to-8-inch segments and can be directly planted, without rooting, 2 inches deep on raised beds. Waterleaf is frequently intercropped with other vegetable crops; however, it can also be cultivated solely.

Soil and climatic requirements

Waterleaf is tolerant of a range of temperatures, moisture levels, and soil types. The appropriate soil pH for optimal growth and yield ranges from 6.1 to 7.5. Waterleaf can withstand some flooding stress. It thrives well in humid conditions, with rich compost, or acidic well-drained soil, under partial shade. But can also grow under direct sunshine and in fully exposed places, on pore sandy soils or elevations. The plants of this crop can adapt to varying climate conditions and low soil fertility .

Fertilizer application

Currently, there is no fertilizer recommendation available for waterleaf.

Harmful effects

Waterleaf is extremely nutritious. However, it is also high in oxalate. The main concern when it comes to eating too much waterleaf stems from its oxalate content. Up to 50 percent of the soluble (dissolves in water) oxalate can be removed through blanching or cooking. Cooking can also remove lectins from waterleaf. Lectins are generally harmless, but they can interfere with the body's ability to absorb micronutrients like calcium, iron, and zinc.

Harvesting

Waterleaf grows vigorously in favourable conditions, and harvest can start 3 to 4 weeks after planting . The shoots can be harvested at an interval of 1 to 2 weeks for up to 2 months. After about four harvests, the plant yield declines. Waterleaf can be harvested either by hand or with a sharp knife . Plant quality and freshness is best when harvested in the early morning, when transpiration is minimal. The leafy produce of this crop is highly perishable and may start wilting a few hours after harvest.

ceylon spinach pilao

Post harvest Management

It is as an ingredient in stew and soup with other seasonings like onions or chili peppers, or boiled as a vegetable . Waterleaf can be prepared with fish, ground melon, chicken, beef, or tofu to give different flavours. Waterleaf can be mixed into cookies to make veggie cookies. Leaves and young stems are often used as a softener in cooking fibrous vegetables or thickener in sauce in the southern region of Nigeria. The cooking of waterleaf should be on a low heat at 5–10 minutes to minimize denaturing. Waterleaf can be preserved by freeze-drying, solar drying, or oven drying.

Waterleaf stir-fryPulao

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UNVEILING THE MAGIC OF PHOTOSELECTIVE NETTING IN FRUIT CULTIVATION

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Modern agriculture is experiencing an increasing need to protect crops from their cultivation environment due to global climate changes and the resulting extreme climatic events, on the other hand, there is a need to meet rising market demands for better product quality, reduced chemical applications, food safety and sustainability of the production processes. Netting is an effective method used to protect crops from excessive solar radiation, environmental hazards and pests. The different types of nets include anti-hail nets, shade nets, exclusion nets and photoselective nets. Anti-hail nets are used to prevent the damage caused by hailstorms and winds, shade nets protect crops against extreme solar radiation and exclusion nets are used to protect crops from pests.

Photoselective nets

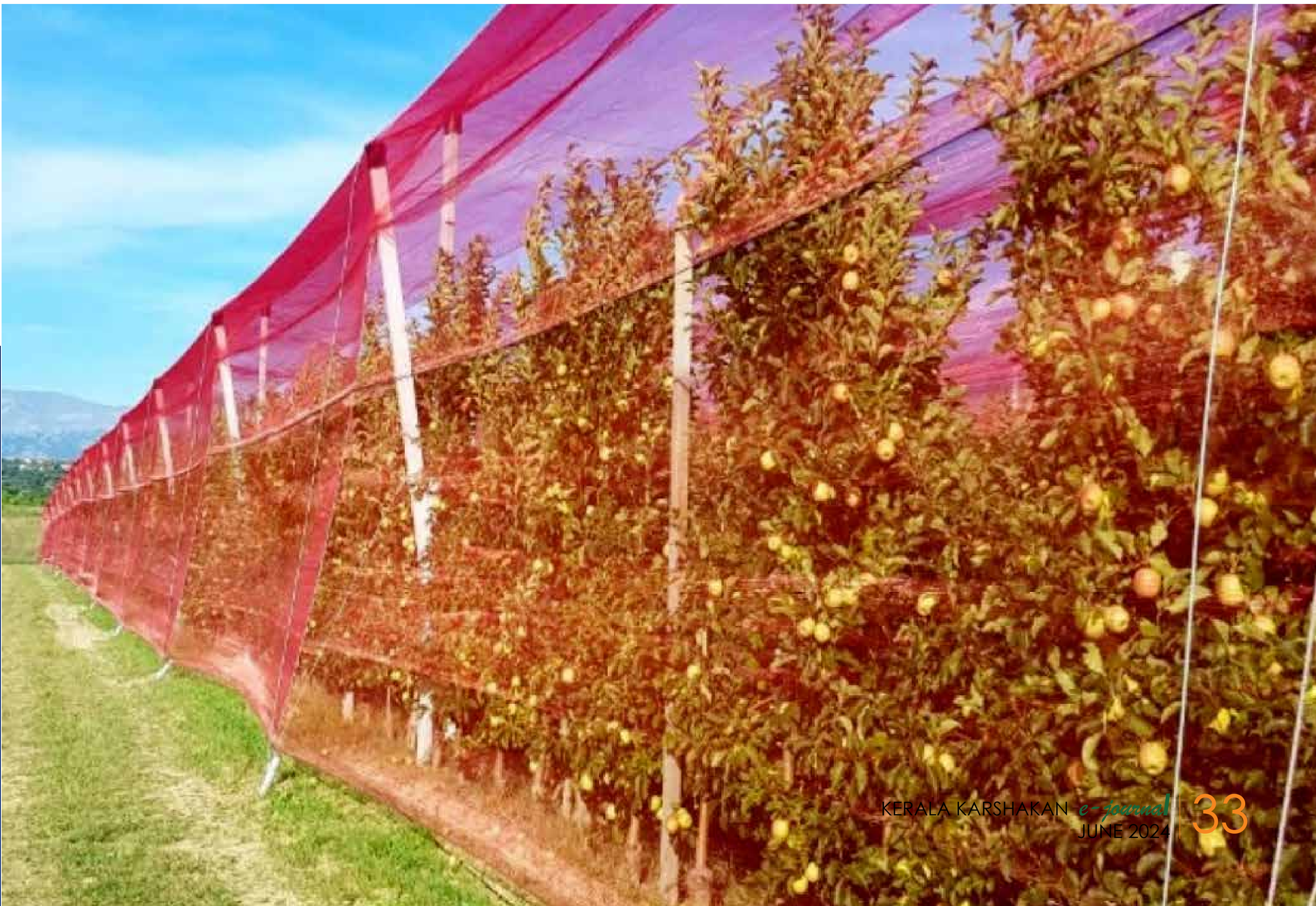
Photoselective nets are plastic nets into which various chromophores as well as light-dispersive and reflective elements are added during manufacturing. It is designed to screen spectral bands of solar radiation and transform direct light into scattered ones. This spectral manipulation aims to promote light-regulated physiological responses, while the light scattering improves the penetration of the spectrally modified light into the inner plant canopy, thus increasing the efficiency of light-dependent processes.

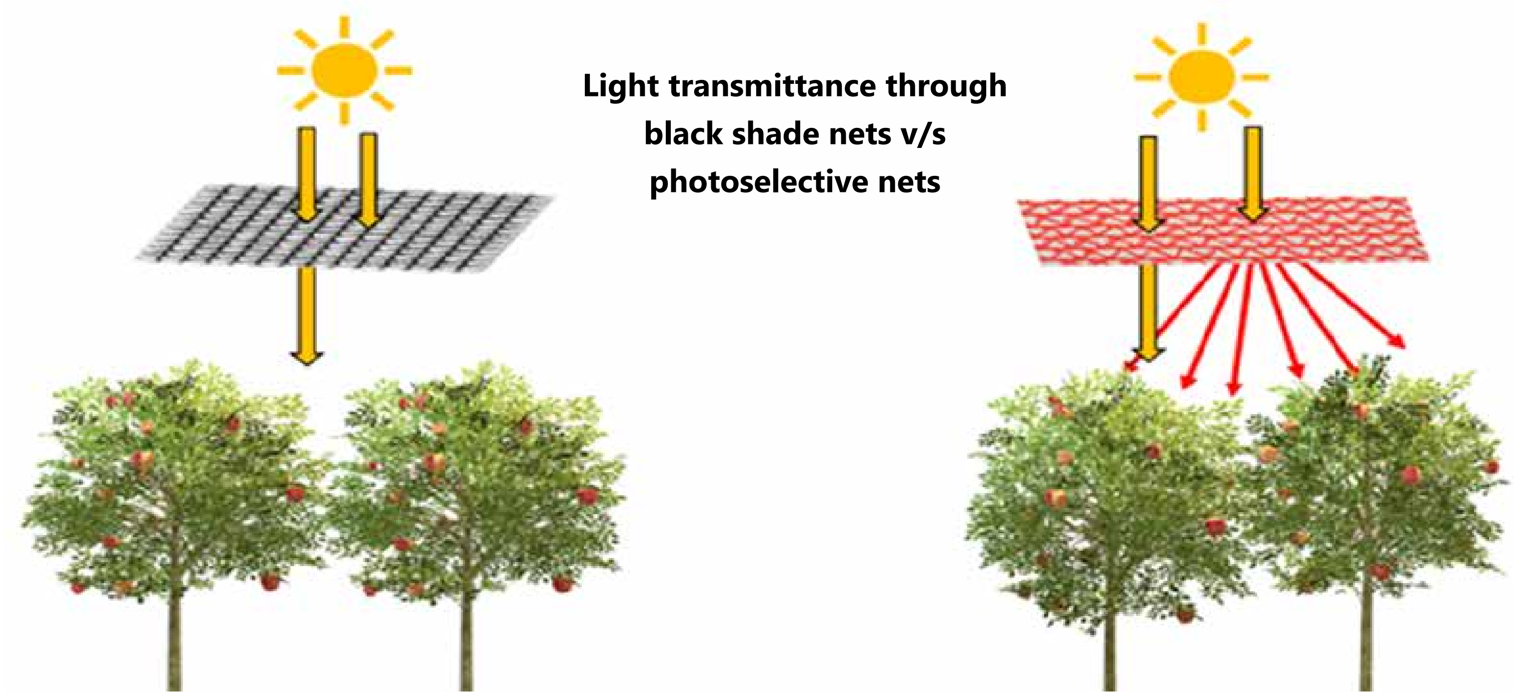
Photoselective netting technology was developed in 1996 by a joint R&D effort of the Agricultural research organization, Volcani Center along with Polysack Plastics Industries in Israel. Initially, it was known as ColorNets and later renamed as photoselective nets. It can be divided into two groups: "coloured photoselective nets and neutral photoselective nets". Coloured nets include red, green, yellow and blue nets which are visibly coloured and neutral nets including pearl, white and grey, absorb spectral bands shorter or longer than the visible range.

Principle

Photoselective nets have unique features when compared with black shade nets and transparent nets. Since the threads of black nets are entirely opaque, they do not modify the spectral quality of radiation, rather they decrease light intensity thus providing shade. Transparent nets will scatter the light in addition to the shading effect but do not spectrally modify it, while photoselective nets reduce the light quantity, scatter it and spectrally manipulate it.

Nets are composed of both holes and plastic threads. In the case of black nets, light beams reaching the black





Light transmittance through black shade nets v/s photoselective nets

threads are fully blocked. While light beams passing through the holes remain unchanged. The resulting light has the same composition as the natural light with only a reduction in its quantity. But in the case of photoselective nets, the fraction of light hitting the threads that come out of the net is both spectrally modified and scattered, while the fraction of light that passes freely through the holes remains unchanged in its quality. Thus, the plants are exposed to a mixture of modified and unmodified light.

Light quality modification

In general, the radiation spectrum relevant to plants ranges from 280 to 800 nm, which includes UV light, photosynthetically active radiation (PAR) and far-red radiation. Spectral photon irradiance can be altered by the colour and shading intensity of the photoselective nets. Different colours of a specific photoselective net are due to the absorption and reflection of light caused by the reflective fibres added to the net. The light-dispersive and pigmented material of the chromatic additives and the reflective fibres selectively filter solar radiation to promote specific wavelengths of light inside the nets. Photoselective shade netting has been developed to improve the percentage transmittance of PAR and allow the modification of the spectral light composition with different light scattering.

Blue shade net absorbs ultraviolet (UV) (100-400 nm), red (R) (640-680 nm) and far red (FR) (690-750 nm) spectral regions, while enriches blue (B) (420-460 nm) spectral regions. Red shade net absorbs ultraviolet (UV), blue (B) and green (G) (495-570 nm) spectral regions and enriches the red (R) and far red (FR) spectral regions. Yellow shade net reduces ultraviolet (UV) and blue (B) wavelengths and enriches green (G), yellow (Y), red (R) and far red (FR) wavelengths. White and pearl nets absorb ultraviolet (UV) wavelength and enrich blue (B), green (G), yellow (Y), red (R) and far red (FR) wavelengths. Pearl nets show higher scattering than others. Grey also scatters light to a smaller extent, while the black net does not scatter the light. So, the possibility of each net manipulating light quality is defined by the pigments that are embedded in the plastic material.

Plants will respond to the quality of the incident light. This response is mediated by a number of photoreceptors specific to different wavelengths. Photoselective nets can be used to change red to far-red light ratios that are detected by phytochromes, the amounts of radiation available to activate the blue/ultraviolet-A photoreceptors, the amount of blue light involved in phototropic responses mediated by phototropins and radiations at other wavelengths. These will influence the plant's growth and development.

Microclimate effects

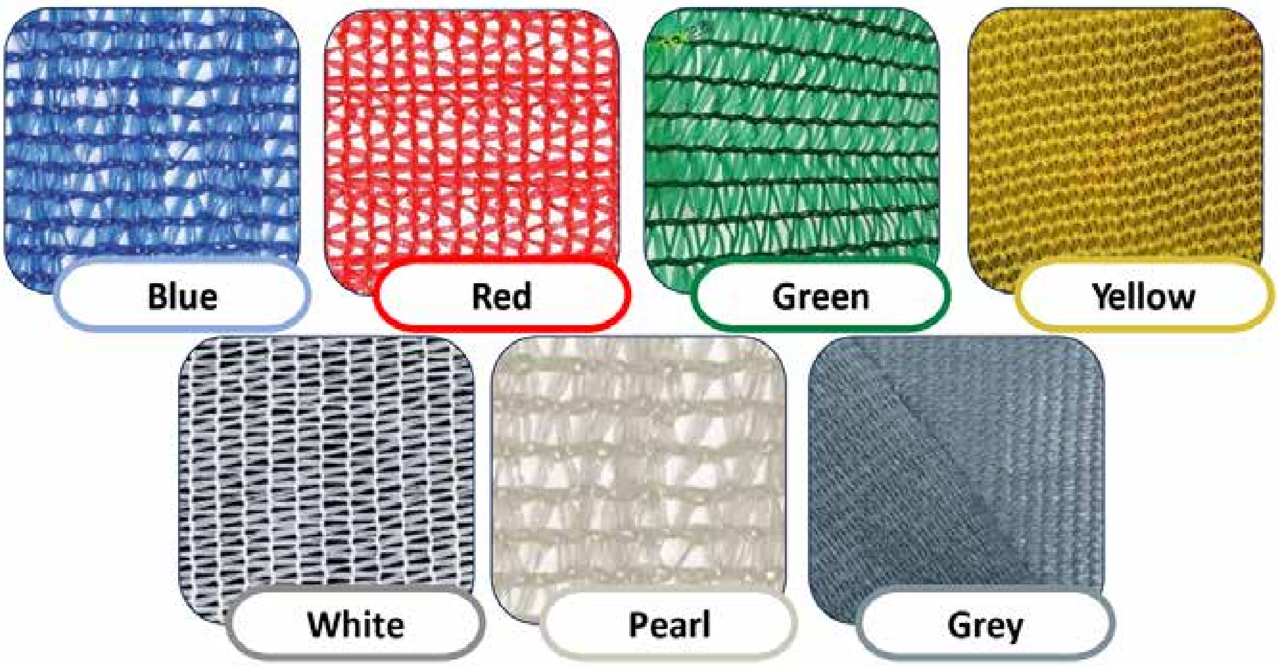
Photoselective nets can have a significant impact on the microclimatic factors surrounding crops such as photosynthetically active radiation (PAR), temperature, humidity and wind velocity.Photosynthetically Active Radiation (PAR) is the spectral range of solar radiation from 400 to 700 nm that photosynthetic organisms are able to use in the process of photosynthesis. PAR measurement is important in agriculture to evaluate the plant's growth. The PAR under the photoselective nets differs according to the shading intensity. Regardless of colour, nettings reduce the amount of radiation reaching crops underneath. Reductions in PAR, particularly in regions with high solar radiation, led trees being less prone to photo-oxidative stress.There is a reduction in temperature due to the shading effect.The reduction in wind speed is due to the resistance to airflow offered by the net. Increased humidity due to the presence of water vapour created by transpiration in plants and reduced wind speed.

Photoselective netting effects in fruit crops

The traits that respond differentially to photoselective netting include,

Photosynthetic efficiency: The effect of net application on the photosynthetic efficiency of fruit trees was reported in many cases. Studies conducted in different cultivars of apple and citrus using blue and red nets showed an increase in the photosynthetic rate. The increase can be explained by the shading effect, increase in red and blue light and reduction in stressful conditions. Under shade, leaves have a higher photosynthetic activity due to less stomata closing and less photo-inhibitory damage to photosystem II (PS II) caused by radiation exceeding the photosynthetic saturation point on clear days. When red and blue light were increased, plants exhibited improved photosynthesis due to the fact that chlorophylls a and b, have

Different types of photoselective nets



Crop	Cultivars	Net	Country	Effects	References
Apple	Fuji	Bluenets	Italy	Photosynthesis Fruit Size	Bastiaset al., 2012
	Fuji	Red net	Italy	Fruit weight Fruit colour	Corollaroet al., 2015
	Honeycrisp blue nets	Red and	USA	Fruit size, Sunburn incidence	Serra et al., 2020
	Honeycrisp blue net	Red and	USA	Sunburn incidence	Kalcsitset al., 2017
Avocado	Hass	Red, blue, white	South Africa	Yield Sunburn incidence	Tinyaneet al., 2018
Kiwi fruit	Hayward red and white	Blue, grey,	Israel	Fruit size	Basile et al., 2008
Citrus	Valencia	Red and pearl	Israel	Fruit weight Fruit size	Dovjiket al., 2022
Pomegranate	Mridula	Red net	India	Fruit weight Fruit size Fruit colour Sunburn incidence	Meena et al., 2016

a higher absorption potential in the blue and red regions. Another factor is stress, reduction in light and temperature stress increases the photosynthetic efficiency of fruit crops.

Fruit characters: Generally, the effect of the net on fruit size is related to their photosynthetic efficiency.Improved photosynthesis, increases carbohydrate availability for fruit development. Shading intensifies the natural thinning of fruitlets, which in turn affects the fruit size. Reduction in water stress also has a positive impact on the size of the fruit.Anthocyanins are the main pigments that impart colour to the fruits and there is an optimal temperature range for its synthesis. By alleviating temperature stress nets can achieve the effect on the accumulation of anthocyanin especially in warm areas. Likewise, light quality also has an important impact on colour development. Anthocyanin concentrations were also found to be highest in the treatment with blue and red light.

Pest and disease infestation: Photoselective nets can acts as a physical barrier against bigger insects. Even though the holes of the nets are large enough for free passage of aphids, whiteflies and thrips, their penetration and the incidences of these pests-borne viral diseases were markedly lower under the Yellow and Pearl nets.

The Yellow net attracts these pests, causing them to remain on top of the net for extended periods (an arrestment response), thus reducing the efficacy of viral transmission. Pest protection by the Pearl net is related to the repellency due to its light reflective capacity. Even though photoselective netting does not provide full pest control, it can be incorporated into integrated pest management strategies.

Physiological disorders – sunburn: The application of nets reduces sunburn occurrence. Sunburn is a physiological disorder caused by the strong intensity of solar radiation and it is manifested as browning necrosis and photooxidative burns.

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FPOs have emerged as a crucial institutional mechanism for enhancing the bargaining power of smallholder farmers, promoting collective action, and improving access to markets, finance, and technology. While FPOs have gained traction in

FARMER PRODUCER ORGANISATION (FPO)FORMATION

OPPORTUNITIES AND POSSIBILITIES FOR THE LIVESTOCK SECTOR IN INDIA

the agriculture sector, their application in the livestock sector remains relatively underexplored. This paper explores the potential opportunities and possibilities for the formation of Farmer Producer Organisations (FPOs) in the livestock sector in India. This paper examines the literature on FPOs, analyzes the current state of the livestock sector in India, and identifies the challenges and opportunities for FPO formation. Drawing on empirical evidence and case studies, it discusses the potential benefits of FPOs for livestock farmers, including enhanced productivity, income stability, and access to value chains. Furthermore, the paper provides recommendations for policymakers, practitioners, and stakeholders to foster the development of FPOs in the livestock sector, thereby contributing to the sustainable growth and inclusivity of the sector.

Keywords: Farmer Producer Organisation (FPO), Livestock Sector, India, Collective Action, Smallholder Farmers, Market Access, Institutional Mechanism

Introduction:

Livestock plays an important role in Indian economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. Livestock provides livelihood to two-third of rural community. It also provides employment to about 8.8 % of the population in India. India has vast livestock resources. The livestock sector plays a crucial role in India's rural economy, providing livelihoods to millions of smallholder farmers and contributing significantly to food security, nutrition, and poverty alleviation. However, despite its importance, the sector faces various challenges, including fragmented production systems, limited access to markets and finance, low productivity, and inadequate infrastructure. In recent years, there has been growing recognition of the need to strengthen institutional support and promote collective action among livestock farmers to address these challenges effectively. Farmer Producer Organisations (FPOs) have emerged as a promising model for achieving these objectives in the agriculture and allied sector. FPOs are member-based organizations formed by farmers to collectively engage in production, processing, marketing, and other agricultural activities. While FPOs have been successfully implemented in crop

farming, their potential in the livestock sector remains largely untapped. This paper aims to explore the opportunities and possibilities for FPO formation in the livestock sector in India, drawing on existing literature, empirical evidence, and case studies.

Literature Review:

The literature on FPOs highlights their role as an effective institutional mechanism for promoting the interests of smallholder farmers, enhancing their bargaining power, and facilitating their integration into markets. Studies have shown that FPOs can contribute to increased productivity, income stability, and poverty reduction among member farmers. Moreover, FPOs have been found to improve access to inputs, technology, credit, and extension services, thereby enhancing the overall competitiveness and sustainability of agricultural production systems. While most of the existing literature focuses on FPOs in the context of crop farming, there is a growing recognition of their potential relevance to the livestock sector.

Current State of the Livestock Sector in India:

The livestock sector in India is characterized by its vastness, diversity, and importance in rural livelihoods. With a large population of cattle, buffalo, sheep, goats, and poultry, India ranks among the top livestock-producing countries globally. However, the sector faces numerous challenges, including low productivity, inadequate infrastructure, lack of market linkages, and limited access to finance and technology. Smallholder farmers, who constitute the majority of livestock producers in India, often operate in isolation and face difficulties in accessing markets and value chains.

Challenges and Opportunities for FPO Formation in the Livestock Sector:

Despite the potential benefits of FPOs, their formation and functioning in the livestock sector are hindered by several challenges. These include the dispersed nature of livestock holdings, lack of awareness and capacity among farmers, regulatory constraints, and limited access to institutional support. However, there are also significant opportunities for promoting FPOs in the livestock sector. These include the growing demand for livestock products, increasing emphasis on value addition and quality assurance, availability of government schemes and programs, and the emergence of new technologies and business models. By leveraging these opportunities and addressing the underlying challenges, FPOs can play a transformative role in the livestock sector, empowering smallholder farmers, enhancing their livelihoods, and contributing to sustainable development.

Case Studies and Empirical Evidence:

Livestock-based Farmer Producer Organizations (FPOs) in India are playing a crucial role in organizing small and marginal farmers involved in livestock rearing, facilitating access to markets, technology, and finance, and improving their socio-economic conditions. Here are some notable livestock-based FPOs in India:

Karnataka Milk Federation (KMF): KMF is one of the largest dairy cooperatives in India, operating under the brand name "Nandini." It comprises numerous dairy farmer cooperatives and milk unions across Karnataka. KMF helps organize dairy farmers into FPOs, providing them with access to milk processing facilities, marketing channels, and veterinary services.

Amul Federation: Amul is a well-known dairy cooperative federation based in Gujarat. It consists of thousands of village-level dairy cooperatives known as "Dairy Cooperative Societies" (DCS). These DCSs are essentially livestock-based FPOs that collect milk from local farmers, processes it into various dairy products, and market them under the Amul brand.

Sahyadri Farms: Sahyadri Farms is a farmer-owned cooperative in Maharashtra, primarily focused on horticulture and dairy farming. It operates as an FPO, empowering small and marginal farmers to collectively market their produce, including milk, vegetables, and fruits. Sahyadri Farms provides farmers with training, technology, and market linkages.

Tamil Nadu Livestock Development Agency (TNLDA): TNLDA is a government agency in Tamil Nadu dedicated to promoting livestock development and dairy farming. It supports the formation of livestock-based FPOs, offering them technical assistance, breed improvement programs, and access to subsidized inputs and credit.

Kamdhenu Dairy Farmers Producer Company Limited: Kamdhenu Dairy is a farmer-owned producer company based in Bihar. It operates as an FPO, engaging in milk procurement, processing, and marketing activities. Kamdhenu Dairy provides training and extension services to its member farmers, focusing on improving milk productivity and quality.

Gokul Dairy: Gokul Dairy is a cooperative dairy federation in Maharashtra, comprising numerous village-level dairy cooperatives. It operates as an FPO, procuring milk from local farmers, processing it into various dairy products, and marketing them under the Gokul brand. Gokul Dairy also provides veterinary services and extension support to its member farmers.

The above successful examples of FPOs in the livestock sector provide valuable insights into their potential impact and effectiveness. These Case studies from various parts of India demonstrate how FPOs have enabled livestock farmers to overcome challenges, access markets, add value to their products, and improve their incomes. These case studies highlight the importance of collective action, capacity building, institutional support, and market linkages in the success of FPOs. By replicating and scaling up these experiences, policymakers, practitioners, and stakeholders can promote the widespread adoption of FPOs in the livestock sector, unlocking their full potential for inclusive growth and development.

SWOT analysis of Livestock Sector and Way forward to form Livestock Cooperatives/ FPOs

Analyzing the livestock sector through a SWOT (Strengths, Weaknesses, Opportunities, and Threats) framework can provide valuable insights for forming livestock cooperatives. Here's a general SWOT analysis followed by potential strategies for forming livestock cooperatives:

Strengths:

Diverse Livestock Resources: Countries often have diverse livestock species, providing opportunities for a variety of products,

Local Livelihoods: Livestock farming is a significant source of income and employment for rural communities,

Cultural Importance: Livestock farming often holds cultural significance and traditions in many societies.

Growing Demand: Increasing populations and changing dietary preferences drive demand for livestock products,

Value Addition: Livestock products have multiple value-added opportunities like processing into dairy, meat, and leather products.

Weaknesses:

Low Productivity: Many livestock farmers face challenges in achieving optimal productivity due to factors like poor breeding, nutrition, and healthcare,

Fragmented Markets: Lack of organized marketing channels leads to price fluctuations and exploitation by middlemen,

Limited Access to Inputs: Farmers may face challenges in accessing quality feed, veterinary services, and credit,

Infrastructure Gaps: Inadequate infrastructure for cold storage, transportation, and processing hinders the value chain,

Environmental Concerns: Livestock farming can contribute to environmental issues such as greenhouse gas emissions and land degradation.

Opportunities:

Cooperative Formation: Collaborative efforts through cooperatives can improve bargaining power and access to resources,

Value Chain Integration: Cooperatives can integrate backward into input supply and forward into processing and marketing, capturing more value,

Technology Adoption: Leveraging technology for better breeding practices, healthcare, and market access can enhance productivity,

Export Potential: Meeting international standards and certifications can open up export opportunities for livestock products,

Diversification: Exploring niche markets such as organic, specialty, or value-added products can diversify income streams.

Threats:

Market Competition: Livestock farmers face competition from imports and large-scale industrial farming,

Disease Outbreaks: Epidemics and pandemics in livestock pose significant risks to the sector's stability and profitability,

Policy Uncertainty: Changes in regulations, trade policies, and subsidies can affect the operating environment,

Climate Change impacts: Erratic weather patterns and natural disasters can impact feed availability and animal health,

Social Perceptions: Concerns about animal welfare, environmental impact, and health implications of livestock products can influence consumer preferences.

Way Forward to Form Livestock Cooperatives/FPOs:

In today's agricultural landscape, Farmer Producer Organizations (FPOs) are increasingly recognized for their potential in facilitating access to crucial markets, services, and technologies for small-sized farmers. However, we observe quite an untapped potential in the livestock sub-sector where these organizations can display even more effective roles. Going forward, an innovative and multifaceted strategy is needed to strengthen and promote FPOs' growth in the livestock industry. A consolidated approach involving local, regional, and national stakeholders can aid in areas like technology upgrade, financial assistance, infrastructure development, policy advocacy, and training initiatives, eventually driving the growth of FPOs and making them a driving force behind sustainable livestock production and rural development.

The livestock sector plays a pivotal role in the agricultural economy, particularly in rural areas where livelihoods primarily depend on rearing animals. However, there is an urgent necessity for interventions to improve the quality of livestock and augment the income of the individuals involved. A significant section of these livestock farmers works independently, not linked with any cooperative group. Such farmers often engage in livestock farming for subsistence instead of commercial profit.

Their methods lean more towards traditional practices, which often lack scientific rigor and are unsustainable in the long term. These circumstances underline the urgency for awareness and intervention efforts such as mass sensitization of livestock farmers through Educational Campaigns.

Subsistence livestock farmers should be the target of extensive educational campaigns where they receive basic and advanced knowledge on livestock farming. This could range from maintaining proper hygiene for animals to their regular check-up schedules. In addition, Science backs many effective farming practices which significantly boost the livestock health and product quality. Awareness about these methods needs to reach these independent farmers to further improve their practices and make them sustainable. Furthermore, appropriate capacity building of livestock farmers is highly anticipated. Practical and hands-on training is just as necessary as theoretical knowledge. Implementing regular training sessions where experienced experts instruct these farmers on sustainable farming methods can prove invaluable.

Furthermore, resource mobilization entails pooling resources among farmers, allowing for the investment in common infrastructure, technology, and input procurement. Achieving market linkages calls for the establishment of partnerships with buyers, processors, and retailers with the aim of ensuring fair prices and market access for cooperative members. On the other hand, policy advocacy involves advocating for supportive policies and incentives from government agencies, all to promote the formation and sustainability of livestock cooperatives. Additionally, collective networking efforts involve collaboration with a varied array of stakeholders such as research institutions, NGOs, and financial institutions, which allows us to leverage our expertise and valuable resources. Within the co-operatives, we aim to explore opportunities for value addition through looking into the possibilities of processing, packaging, and branding of livestock products. This enables the capture of more value along the supply chain.

With respective to risk management, it is important for us to develop contingency plans and insurance mechanisms as a safeguard and to mitigate possible risks. These risks may stem from devastating disease outbreaks, unwieldy price volatility, and detrimental climate-related disasters. As part of our support system, we provide workshops, directions in skill training, and educational materials. All of these working in tandem to help farmers enhance their skills, ultimately growing knowledge and productivity. Sustainability initiatives are at our core, with a significant effort on our part to promote sustainable farming techniques alongside approved animal welfare practices. These endeavors are to safeguard the environment and bolster livestock health. Our efforts will continue in facilitating access to affordable credit, allowing farmers the prospects to fund necessary enhancements and expansions.

Additionally, conducting public awareness campaigns will ensure that the public is educated about the benefits of supporting local livestock cooperatives, complemented by equality practices that are designed to ensure that all members have an equal say in decision making, irrespective of their contribution or involvement level. Finally, social responsibility initiatives coordinated by us will help the wider community and lay emphases on the environment, ultimately underscoring our cooperative's commitment to social improvement. The creation of farmer support groups provides significant assistance to independent farmers through shared knowledge, mutual support and access to crucial resources. Formed as cooperatives and farmer group institutions, they offer indispensable services like superior quality feeds, financial aid, and veterinary services. Facilitating memberships to these cooperative groups or even forming new ones in distant, unexplored locales is a promising strategy to uplift independent farmers.

The role of government is paramount in enhancing the situation for small-scale subsistence farmers by executing appropriate policy interventions and financial support. Necessary changes in policy, such as favorable subsidies or incentives for employing scientific farming practices, can facilitate a conducive environment for these farmers. Besides, extending financial support can serve as an impetus, spurring more farmers to embrace advanced and scientifically sound practices.

Assessing these factors and harnessing the strengths while counteracting weaknesses and threats, livestock cooperatives can acquire a central role in boosting the living standards of smallholder farmers. For promoting sustainable undertakings in the livestock sector, such cooperatives are indispensable. The rising surge of small, self-reliant livestock farmers who utilize traditional methods out of sheer necessity can't be overlooked. It becomes essential to integrate them into this development chain through proper awareness creation and relevant training channels. Their role could be transformative in actualizing a sustainable, eco-friendly and efficient livestock sector. By progressively leading them towards scientifically-informed farming practices, we serve a dual purpose: fortifying livelihoods and transmuting the rural economy towards comprehensive growth and development. In this way, they could become integral parts of a holistic, sustainable future in the livestock sector, serving the broader good.

Recommendations:

Based on the analysis presented in this paper, several recommendations can be made to foster the formation and growth of FPOs in the livestock sector in India:

Awareness and Capacity Building: Conduct awareness campaigns and capacity-building programs to educate livestock farmers about the benefits of FPOs and train them in organizational management, marketing, and value addition.

Policy Support: Create an enabling policy environment by simplifying regulations, providing incentives, and integrating FPO promotion into existing government schemes and programs.

Access to Finance and Technology: Facilitate access to finance, credit, and technology for FPOs through targeted schemes, partnerships with financial institutions, and technology transfer initiatives.

Market Linkages: Strengthen market linkages for FPOs by developing infrastructure, promoting value addition, and facilitating partnerships with agribusinesses, retailers, and exporters.

Institutional Support: Provide institutional support to FPOs through dedicated extension services, technical assistance, and networking opportunities with other stakeholders in the livestock value chain.

Conclusion:

The formation of Farmer Producer Organisations (FPOs) holds immense potential for transforming the livestock sector in India by empowering smallholder farmers, enhancing their livelihoods, and promoting sustainable development. By leveraging collective action, market linkages, and institutional support, FPOs can address the challenges faced by livestock farmers and unlock new opportunities for growth and inclusivity. However, realizing this potential requires concerted efforts from policymakers, practitioners, and stakeholders to create an enabling environment and support the formation and growth of FPOs across the country.

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Cinnamomum malabatrum

Earning with Evergreen Edana Experience of an Enterprising farmer

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Cinnamon, known for its aromatic and flavorful bark, is popular worldwide as a spice and holds significance in both traditional and modern medicine. The essential oil of cinnamon is responsible for its distinct aroma and taste, with cinnamaldehyde being the main component, accompanied by various other constituents such as eugenol. Only a select few species of Cinnamomum are cultivated commercially for their spice production. The bark of cinnamon is widely used in culinary applications as a condiment and flavoring agent. It possesses carminative, astringent,

stimulant, and antiseptic properties. Cinnamon aids in controlling vomiting, relieving flatulence, and has been found to be beneficial in cases of diarrhea and abnormal uterine bleeding or hemorrhage. Additionally, there have been reports suggesting that the consumption of cinnamon may help in reducing blood sugar and cholesterol levels. Cinnamon is considered as the hardiest of spices and can tolerate wide range of soil and climatic conditions. It requires an average temperature of 27 to 30°C and rainfall between 2000-2500mm.

The Cinnamon Family

The economically important genus *Cinnamon* comes under the family Lauraceae. It is distributed in India, Srilankaand consists of around 250 species comprising evergreen trees and shrubs. Among them the most important dollar earning species is *Cinnamomum verum* or *Cinnamomum zeylanicum*, the true cinnamon.The thin soft bark is the economic important part.

Srilankan/Cylone Cinnamon (*Cinnamomum verum*) is popularly known as Dalchini in market and is common in Srilanka and in Kerala, the southern state of the India. The dried inner bark yields the 'true cinnamon' of commerce. Cinnamon quills are the popular grade in trade and sometime chips are also been marketed. There are two regular cutting seasons in South India, which synchronize with two monsoons. The bark can be extracted during rainy season when humidity is high as it is easily peelable.

The peeled barks are placed one over the other and packed together. Peeled and rolled slips are piped and bundled for drying.The piped slips are called quills'. The smaller quills are inserted into larger ones to form compound quill. Drying is also one of the important stages of cinnamon processing as it adds to the quality of the final product. The yield varies with type of variety and age and at an age of 10-11 years, 225 to 300 kg quills/ha can be expected. The bark is thinner, sweeter and less bitter as compared to China cinnamonCinnamon species is easy to propagate by seeds. But due to high heterogenisity, vegetative propagation methods are tried and air layering was found highly feasible. The first cinnamon planation in Kerala was in Anjarakandy in Kannur.The plantation, spanning over 200 acres, is located on the banks of the Anjarakandy River. It was established in 1767 by the East India Company and was considered as the largest cinnamon plantation in Asia.

Chinese Cassia/Cinnamon (*Cinnamomum cassia*)is referred as'Cassia' in international commerce.Thethicker bitter bark is also popular in market and used as a spice for flavoring foods and as a natural traditional remedy throughout

the world. Cinnamon possesses many specific functional properties such as antioxidant, anti-inflammatory, antimicrobial, and acaricidal activities.

Indian Cassia/Cinnamon *(Cinnamomum tamala)*,also known as Bay leaf in market, Indonesian Cassia *(Cinnamomum burmannii)*, Saigon/ vietnamesecinnamon *(Cinnamomum loureirii)* are the other traded cinnamons. Among the economically useful related taxa. C. camphora L. is important as a source of camphor. The wild species of cinnamon *(C. malabatrum, C. macrocarpum, C. riparium, C. heynianum, C. travancorium* and *C. micolsonianum)* are in danger of extinction because of indiscriminate bark extraction.

Edana(*CinnamomummalabatrumBurn.* F) is a species under Cinnamon family and exists as wild in moist deciduous evergreen forest in Western Ghat of Kerala. It is known as *Edana or Vayana* or *Elavangam* or *theralior Kattu Karuvain* Kerala. It is the most abundant species in south Indian forest with great variability. It is highly heterozygous and more complex and there are occurance of many other subspecies within the species *malabatrum*. The leaf oil contains high amount of eugenol and used in perfumery and confectionery.The species was abundant in western ghat and the destructive removal made it to the verge of extinction. The morphological similarity and characteristic fragrance have identified distinguish clusters of cinnamon species. *Cinnamomum malabaricum* is considered as the oldest spice having sweet fragrance and warm taste. The leaf has hot spicy aroma and is used in many traditional culinary preparations in Kerala. It is sometimesused as substitute or adulterant in Tejpat leaf.

The peculiar phenotypic features of C. *malabatrum* are trinerved leaves with outer nerve reaching the confluenceing tip. The leaves are broad and long; leaf length varies from 20-28 cm and width 5 to 8 cm.The tree is an evergreen plant with a height of 2-3m . The leaves have three central libs from base reaching leaf apex. Sometimes the two outer ones end below middle.

The tree was mentioned under the name *Kattukaruvain* the seventeenth century treatise *Hortus Malabaricus*, (garden of Malabar) that deals with the flora of Western Ghats region, covering the Indian states of Kerala, Karnataka, and Goa. The leaves are fragrant, elliptical, glabrous, andlarge sized.The major constituents of essential oil are eugenol, linalool, caryophyllene, bezyl benzoate, humulene and cinnamaldehyde.

Edana leaves are widely used in

preparation of *Kumbilappam*, also known as therali appam, a traditional snack from Kerala that is steamed and made with rice flour and jaggery,sometimes with jackfruit and sometimes without. It is wrapped in *edana* or *therali* leaves. These leaves are folded into a cone shape, and the dough is filled inside and covered with the remaining leaf corners. The final cooked product has a distinct aroma of *vazhanaela* or *edanaela*, which is highly appreciated by a wide range of people and has a year-round demand. During the *Attukal Pongala* festival in Thiruvananthapuram, Kerala, the sweet dish Therali appam is offered to the goddess Attukal Bhagavathi. The *theralileaves* are sold in local markets during festive seasons, as they impart a unique flavor and fragrance to the dumpling when steamed.

The Scent of Success- Experience of Mr. Shaji,Pachakkad,Thrissur

Mr. Shaji is a rubber farmer from Pachakad, Athirapilly panchayath in Thrissur. In addition to his rubber farming, he also operates a bakery unit. Some of his favourite products include Peanutchikkies, Sesame chikki, jack fruit candies,kumbilappamandchakka ada steamed product with jack fruit. The kumbilappam with jackfruit has consistently been a top selling item throughout the year. As the market continued to expand, Mr. Shaji identified a high demand for the long and fragrant leaves of the edanatree, which he used to gather from wild trees in homesteads or from the nearby forest periphery. The Jackfruit Ada dish is traditionally prepared by wrapping it in Edana leaves with a single fold. This steam-cooked delicacy includes a mixture of rice flour, jackfruit, and jaggery, resulting in a unique aroma that adds to its appeal.

Mr. Shaji has observed variations in the flavor and aroma while using wild leaves of Edanagathered from different locations. Furthermore, the shape and size of the leaves also differ.The edana leaves, which he found in the outskirts of the forest area, are large in size and have a mild soft aroma. This was selectively utilized in Kumbilappam/therali andchakka ada to impart the unique flavour. Then he started collecting unique types and conserved it in his farm.

Mr. Shaji carefully handpicked seedlings from the roadside near the forest, focusing on areas with bird's nests. The seeds had been consumed by birds, resulting in an abundance of seedlings near the nests. After collecting them, he planted the seedlings in poly bags for several months. Only the ones with a distinct aroma and optimal leaf size were chosen to be planted in his farm.Currently, he has approximately 200 plants that are four to five years old, planted at a spacing of three meters.He utilizes the leaves for his own purposes in the bakery unit. Some nearbybakery units purchase leaves from him, and he charges one rupee per leaf. Based on his experience, he can gather around 300 broad leaves from a single four years old Edana tree.

As a resourceful farmer, he keeps a record of all his activities. This meticulousness has transformed him into a true entrepreneur, as he maintains records of the expenses incurred and the profits earned while conducting business. He sells Kumbilappam, consisting of 50g dough, for fifteen rupees. For jackfruit ada, made with 80g dough, he charges twenty rupees.Mr. Shaji selectively collects well-fleshed jackfruits from the local area and stores them in a freezer. Using an electrical steamer with a capacity of 1000 numbers of adas at a time, he can prepare the product in just two hours. He employs nearby female workers who are skilled in the fast and efficient folding of leaves. Mr. Shaji primarily focuses on wholesalers who distribute his products in a chain network to bakeries in the metro cities. He is confident that the special kumbilappam will enter the export market by next year.

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