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Mysore J. Agric. Sci., 56 (2) : 1-472 (2022)

CONTENTS

Mysore J. Agric. Sci., 56 (2) : 1-13 (2022)

Extraction of Betel Leaf Essential Oil for the Sustainable Solution to Betel Business in West Bengal for Effective Economic Gain : A Review

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ABSTRACT

The southern part of West Bengal produces very high quality of betel leaves not only ideal for domestic consumption but also for export with distinct cultivar producing highest amount of leaf essential oil. A small betel-vine of 3 decimal land could generate a monthly income of Rs.10,000-12,000. The main constraint of betel business is high perishability of the leaves. Several measures are recommended by the scientists for preservation of betel leaves. The extraction of betel leaf essential oil is the most adaptable solution to the perishability problem with a shelf life above 3 years with diverse application and high return. The coastal Bengal faces recurrent cyclones in summer causing havoc devastation of betel-vines and leaf-piles becomes the birth place of diverse pathogens. In betel export *Salmonella* infection and presence of high level of pesticide causes rejection of consignments. These declined betel mote creates environmental pollution by animal consumption and gets access to the food chain and local aquifers causing ecological imbalance even death. In such a condition the community based extraction facility of BLEO could be developed by the state horticulture department with involvement of local unemployed youth. Diverse oil extraction methods are available and could be selected according to the space, resource and demand of the market. Oil could be extracted from partially rotten and disease-stuck leaves leading to maximum utilization of waste leaves. The trader-cum-exporters could set up commercial oil extraction facility in pack-house adjoining area or local market or kishan mandi to reap the benefit of excess produce. The agri-marketing department and exporters could promote the marketing of this fragrant essential oil. The involvement of public and private sector could facilitate the large-scale utilization of the leaves with employment generation and high economic gain.

Keywords : Betel leaf, Essential oil, Perishable leaf, Shelf-life, Betel-business, *Salmonella* infection

BETEL creepers originated in South East Asian countries and grown widely in Asia. The cultivation practises are unique and in tropical hot areas the plant is propagated asexually without the intervention of sexual reproduction and association between male and female reproductive organs. In comparatively cooler region such as China, the male and female plants are grown separately and sexual reproduction could be operative. In such places the plant improvement programme may shift towards hybridization or pedigree selection. In the southern part of West Bengal of India the plant is mainly grown in an indigenous green-house structure called 'Pan baroj' in an asexual mode with stem cuttings. The adoption and popularization of this baroj cultivation is an example of indigenous agro-innovation. This baroj based cultivation produces high quality leaf produce enriched with different volatile and non-volatile compounds with high market demand (Mondal, 2021a). The qualitative diversity in chemical profile has given rise to different cultivars. Most popular cultivars of West Bengal produces highest amount of essential oil in comparison to other Indian cultivars. The recovery of essential oil is highest from 'Meetha' and 'Bangla' betel cultivars. This betel leaves could be chewed directly or aromatic oil could be extracted from the creeper. This plantation crop has enormous export potential in addition to domestic consumption. Due to perishable nature the storage of excess produce is difficult and extraction of betel oil could be an alternate strategy of income

The Mysore Journal of Agricultural Sciences

generation and efficient exploitation of this high-value creeper.

Taxonomy, Propagation Techniques and Economics

Piper genus is a pan-tropical aromatic plant with diverse uses in pharmaceutical and medicinal sector. This genus is very rich in essential oil (EO) loaded with different volatile and non-volatile compounds. The different compounds are found in leaf, stem, petiole, seed, root, fruits and inflorescence. This *Piper* genus covers nearly 1457 species out of which about 130 species were chemo-metrically identified (Salehi *et al.*, 2019). The essential of (EO) of *Piper* exhibits six main groups of compounds, monoterpenes, sesquiterpenes individually or both in combination, phenylpropenoid, benzenoid or non-terpenoid groups.

Piper betle is a sun-loving tropical creeper, it requires high rainfall and shady place for producing quality leaves. The plant prefers clay soil with good drainage with nearly neutral pH. As the betel leaf is consumed raw, the organic cultivation by application of Farm yard manure (FYM), mustard cake and bio-fertilizers provide toxin-free best produce. Stem cuttings with 2 nodes having 5-6 leaves are used as sett (propagule) for planting. The vines are propagated by terminal stem cutting or setts about 30-45 cm long. Setts obtained from the top portions of the vines are easy to root and hence best for planting. On an average 1,50,000 setts are required for planting one hectare. The usual row spacing of 60 cm and plant to plant spacing is 11.1 cm is maintained in southern parts of West Bengal (Dasgupta and Sarkar, 2017). Within 2-3 months of planting the baroj becomes ready for leaf plucking. Usually 5-6 leaf from lower part of the main stem were collected first and then after 25 days the leaf collection may be done from main and lateral stems. For export market betel is harvested at three weeks' interval and for local market at two weeks' intervals. Harvested leaves were washed cleaned and graded according to their size and quality. Then they were packed after cutting a portion of the petiole and rejecting the damaged leaves. For cleaning and washing clean, microbial contamination free water was used. Handling workers were also trained to sanitize their hands following proper personnel hygiene.

The creeper is bestowed with diverse array of secondary metabolites and has presented excellent chemotypic range to the tropics. This plant is grown in covered hut like structure in Northern and Eastern India and as a natural creeper with a support plant in Southern India. This creeper is native to Asia and is associated with the cultural heritage and auspicious to the people of South East Asia. In India this plant is grown vegetatively for production of betel leaves and several cultivars and landraces show huge demand in domestic and export market. This heart-shaped leaf is propagated for 15-20 million Indian and 2 billion foreign consumers annually. The crop provides Rs.6000-7000 million of national income per year and at the same time leaves worth Rs.30-40 million is utilized in global export (Das *et al.*, 2016). The leaves are not only used directly for chewing purposes but due to antioxidant, anti-inflammatory, anti-apoptotic, anti-cancer and anti-microbial properties, the leaf essential oil (1-3 %) is used in medicine, stimulant, antiseptic, tonic and other ayurvedic formulations. The Global Betel Leaf Oil Market Size is projected to grow at a CAGR of 3.1 per cent in terms of value during the forecast period from 2021-2028 (Dataintelo, 2020). The increasing demand for betel leaf oil in developing nations is expected to drive the growth of this market over the next few years. Factors such as changing food habits, rising disposable incomes and growing awareness about personal grooming are also driving this oil market.

Business Status of Betel Leaf

Betel leaves are precious agro-resource of the country. The climatic condition of Bengal produces finest quality of betel leaves with remarkable market demand. This fragrant leaves has a consistent domestic market but has huge potential in export sector. In 2020-21 financial year 9289 MT betel leaves (HS code 14049040) was exported from India

amounting Rs.11, 850 lakhs Indian currency. Maldives, United Arab Emirates, Thailand, Bangladesh, Malaysia, European countries, Australia, USA and Canada imports huge amount of betel leaves (Anonymous, 2021). In the last three years export statement of India it has been noticed that Indonesia, Morocco, Iran, Taiwan, Namibia, Israel are few countries who started importing betel leaves from India in 2020-21 financial year after the occurrence of Corona pandemic. The inclusion of these new international buyers in Indian export portal is an encouraging disclosure for the betel farmers and traders of India though Sri Lanka, Bangladesh, Nepal, Arab Emirates, South Africa shows a negative trend in the import of betel leaves in last financial year but has not discontinued import revealing an interesting export scenario for the betel leaf traders. The agro-climatic condition of India favours quality leaf production and effective display of different ecotypes or cultivars in the global market could attract more buyers.

Pertinent Problems of Betel Business

The betel leaf cultivation has several advantages. A medium sized well-maintained baroj of 3 decimal land could ensure a monthly income of approximately Rs.12,000 for a farmer. Most of the betel farmer of south Bengal maintains betel baroj along with rice and vegetable, fish and prawn cultivation. This specialized cultivation of betel is taken up as family cultivation and that reduces labour cost to a great extent (Mondal *et al.*, 2020a). The high perishability of the betel leaves are main constraint of betel business. The preservation of the leaves in zero energy cool chamber or 4°C cabinet of refrigerator could only increase the shelf life of extracted betel leaves for a week. De-petiolation, midrib removal were adopted by farmers for preservation of leaves (Madan *et al.*, 2014). The process of sun or shade drying was also adopted by some traders. The direct exposure to sun causes quality deterioration of leaves and shade drying sometime invites pathogen infection with less consumer preference. Bleaching or curing of betel leaves in closed curing chamber specially designed to generate temperature in the range of 60-70°C or in galvanized iron chamber is widely adopted by some betel traders. In Uttar Pradesh the bleached Banarasi cultivar of betel has high demand in national and global market (Pandey *et al.*, 2018). Chemicals such as sodium-bi-

TABLE 1

Export statement of major betel leaf importing countries of the world

Country	2018-19		2019-20		2020-21		% share in 2020-21
	Quantity in MT	Rs. in Lacs	Quantity in MT	Rs. in Lacs	Quantity in MT	Rs. in Lacs	
Maldives	910.95	2717.88	833.28	2521.46	734.72	2862.13	20.77
United Arab Emirates	1493.62	4849.31	603.99	1965.61	489.98	1702.98	12.36
Thailand	0.48	0.29	1.93	4.19	836.00	1564.27	11.35
Bangladesh	12256.56	3257.94	9401.17	2382.99	5595.35	1192.81	8.66
USA	269.04	869.35	136.09	616.21	198.21	1176.06	8.54
Indonesia	0.00	0.00	0.00	0.00	817.00	959.57	6.96
Sri Lanka	663.30	1455.76	1273.64	2939.19	199.71	788.97	5.73
UK	147.60	447.62	104.61	364.00	143.12	765.14	5.55
Singapore	9.89	19.83	20.56	41.02	186.22	383.36	2.78
Canada	97.16	181.89	114.54	281.37	89.03	360.28	2.61
Other	1515.9	3627.68	1513.68	2596.44	862.29	2023.27	14.69
Total	17364.50	17427.55	14003.49	13712.48	10151.63	13778.84	100.0

The Mysore Journal of Agricultural Sciences

carbonate and tartaric acid could assist in storage of leaves. The washing of leaves with sodium-hypochlorite before packaging could reduce the number of spores of some pathogen. Treatment with ozonated water and dipping of fresh leaves in bark extract of *Terminelia arjuna* could control betel leaf pathogens including deadly *Salmonella* strains (McLauchlin *et al.*, 2019). Treatment with benzyl adenine (BA) with vented polybag, ice-bag storage also increases shelf life. The processes mentioned above are time consuming, labour intensive and ensures slight increase in shelf life. The most promising alternative is the use of excess betel leaf for essential oil extraction. This extracted oil has huge potential in natural life style industry. Even

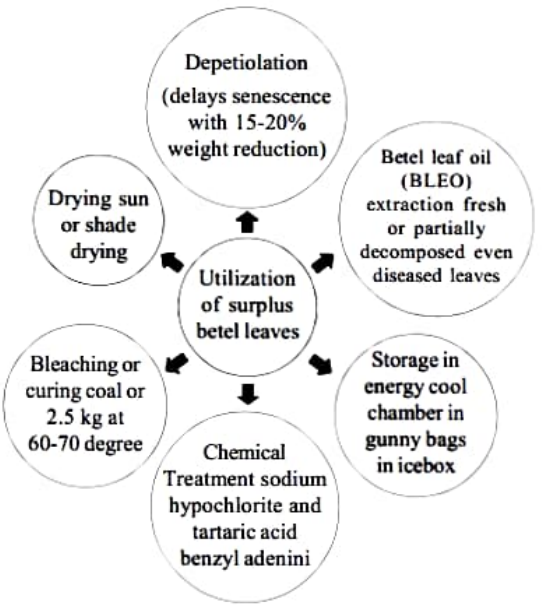

Fig. 1 : The different measures taken for post-harvest shelf life increase or utilization of unsold betel leaves

the partially rotten leaves or infected leaves could be utilized for oil extraction. The other techniques mainly ensure the consumption of betel as masticatory or mouth fresheners but the betel leaf oil extraction could increase its applicability and diverse utilization with enhanced shelf life. The collection and extraction of betel leaf essential oil (BLEO) could be a low cost solution to different problems faced by betel traders including disease infestation and environmental pollution. The cost of betel oil is much higher than the raw leaves. The inclusion of oil extraction facility will be an additional defence to the normal fresh leaf export.

Export Obstacle of Betel Leaves

Mainly betel export is influenced by two major determinants, the *Salmonella* infection and pesticide residue in the leaf. The importers of European countries were very sensitive about *Salmonella* and other pathogen infection (Fakruddin *et al.*, 2017). In case of export to European countries and USA the Indian betel growers required to follow standard procedure mentioned in the betel leaf export advisory and the consignment needed phyto-sanitary certification from APEDA recognized laboratory cum pack houses. In several betel consignment infection was detected in past and the importing country destroys the whole infected consignment or forces the exporter to arrange for the return of the consignment to the exporting country using own cost. In export business that leads to huge burden for the exporters as they could not make any profit from the deal and also faces export ban for several years. The importing countries such as USA, Canada are also very critical about the maximum residual level (MRL) of pesticides, insecticides. A small deviation from the standard level may lead to export rejection (Mondal *et. al.*, 2020b). In such a condition total organic approach or integrated semi-organic mode could be adopted by the orchard owners to comply with international phyto-sanitary standards. A random sampling of 25 g betel leaves (at least 5 sampling) from exporting farms requires *Salmonella* testing before final packing. In case of betel as the leaf is consumed the MRL level is also very significant in export compliance. Since the leaves are highly perishable. An alternative marketing strategy is required by the betel leaf exporters to mitigate any export failure. If the export consignment fails to satisfy the phyto-sanitary standard the huge amount of unsold fresh betel leaves would be a burden as it is not very easy to increase the daily domestic market demand of the leaves instantly. The stacking of huge amount of leaves causes environmental hazard

TABLE 2

Disease and Pests of Betel-vines and recommended bio-control agents

Diseases	Causal organism	Treatment	Reference
Anthracnose leaf spot	*Colletotrichum capsici*	Tobacco leaf extract + cow urine	Chakrabarty, 2018
Bacterial leaf spot	*Xanthomonas axonopodis belticola*	Streptocycline 500 ppm + Copper oxy chloride 0.3 per cent	Kavya, 2018
Foot rot, leaf rot, wilt	*Phytophthora parasitica*	*Trichoderma harzianum* mixed mustard oil cake @ 500 kg/ha in 4 doses	Hedawoo and Makode, 2020
Foot rot, leaf rot, wilt	*Sclerotium rolfsii*	*Trichoderma harzianum* (5 g of culture in barley grain) and garlic-clove extract (1:1), 15 per cent in combination	Rahman *et al.*, 2021
Salmonellosis	*Salmonella typhimurium, S. enterica, S. paratyphi, S. gallinarum, S. bongori*	Vinegar (1.5% for 10 min.), sorbitol, ethanolic extract of *Terminelia arjuna*	Fakruddin *et al.*, 2017
Leaf curl and holes	*Spodoptera litura*	Pheromone trap @ 4-5 per acre	Rebecca *et al.*, 2021
White fly leaf withering	*Singhiella pallida*	Blue trap @10-20 per acre, 15 cm above crop canopy	Milenovic *et al.*, 2019

and becomes breeding ground for diverse pathogens. In such a state extraction of the betel leaf oil could be a better and viable alternative for exporters.

Domestic Constraints of Betel Cultivation

The eastern India experiences recurrent heavy cyclone at the end of summer season. The speed of storm ravages the betel orchards every year before monsoon. The leaves including the whole plants get damaged. The partial rotting of these damaged vines causes environmental pollution (Mondal, 2021b). The infected betel motes heaped in rural areas becomes breeding ground for bacterial and fungal contaminants. The financial losses created by these damaged orchards were surpassed with rapid environmental pollution including contamination of both land and water-bodies. In such a case the rapid utilization of the lodged plants may reduce the environmental problem. De-petiolation or bleaching of leaves could save some leaves. In a new approach the shifting of the damaged creepers to a commercial oil extraction facility could save the farmers from economic loss as well as reduce the rural health problem. The central and the state horticulture department provides a nominal compensation to the baroj owners by direct benefit transfer and the farmers at least obtains the mental strength to continue betel cultivation under super-cyclone hit regions. The recurrent occurrence of storm in each year with a nominal compensation may not convince and restrain the poor farmers to continue cultivation. In such conditions the extraction of BLEO from the betel creepers could generate moderate income especially meeting up the loss in completely damaged baroj. In partially damaged baroj the oil extraction could provide an additional advantage by reduction in the purchase of propagating material. Study indicates that in partially damaged baroj the farmer utilizes the stem cutting of their own baroj for further restoration of their own baroj.

Extraction of Betel Leaf Essential Oil (BLEO)

The concentrated moisture free extract of the plant part that retains the natural essence of a cultivar is regarded as essential oil. The volatile and non-volatile chemical components present inside betel leaves are used for oil extraction. The climatic condition of South 24 Parganas is suitable for the cultivation of commercially desirable cultivars. The shade and

TABLE 3

The production loss of Yaas super-cyclone affected gram panchayat (GP) of Kakdwip region of West Bengal covering finest betel-vines

Affected Gram Panchayat	Total area under coverage (Ha.)	Crop damage area in Ha. (100%)	Production loss (in MOTE)	Monitory value (Rs. Lac)
Bapuji	62	62	41850	6947.1
Madhusudanpur	30	30	20250	3361.5
Netaji	40	40	27000	4482
Pratapadityanagar	292	1	14175	2353.05
Rabindra	89	60	40500	6723
Ramgopalpur	49	45	30375	5042.25
Total	299	258	174150	28908.9

protected atmosphere inside betel baroj encourages production of different bio-molecules related to taste and aroma enhancement of betel leaves. Eugenol, chavicol, hydroxyl-chavibetol, safrole, stearaldehyde, linalool are some of the recognised compound present and detected in betel leaf oil. The sweet fragrance of 'Meetha' cultivar is due to the presence of anethole and estragole under volatile fraction of the oil. Different trace compounds also remain present in specific landraces giving identity to that cultivar. Bangla, Meetha, Sanchi, Kali Bangla, Bagerhati, Jhalpata cultivars are prevalent in South Bengal (Karak *et al.*, 2016). The traditional asexual cultivation for a long period of time undocumented exchange of stem cuttings generated redundancy problem. The flexibility in propagules exchange and use of unidentified cultivar creates constraint in baroj management. The betel creeper shows seasonal variation in deposition of different aromatic compounds. In winter the deposition of different compounds is highest and becomes minimum in monsoon (Mondal, 2021a). The different parts of betel plant also store diverse chemicals. Though industrially only leaf based oil extraction is being practised by the traders. The chemotyping of the extracted oil could be advantageous to identify the proper utility of the BLEO in industry. Distinct chemotyping of BLEO on varietal, morphological, geographical, seasonal basis could provide detailed idea about exact utilization of the extracted oil.

TABLE 4

Piper betle cultivars with leaf essential oil chemo-marking

Chemotype	Volatile Biomarker	Reference
Sagar Bangla,	Chavicol	Guha and Nandi, 2019
MeethaKapoori, Bangla, Selan,	Eugenol Sanchi Sanchi	Karak *et al.*, 2018
Sirugamani	Germacrene D	Preethy *et al.*, 2017
Meetha	Estragole, anethole	Mondal, 2021a
Phillipine, Malaysian, Nepalese	Chavibetol	Sarma *et al.*, 2018
Maghai	Benzodioxole	Das *et. al.*, 2018
Kali Bangla, Manikdanga, Bangla, Ghanagete, Bagerhati	Eugenol acetate	Guha and Nandi, 2019
Sanchi	Stearaldehyde	Karak *et al.*, 2018
Bogor, Boyolali, Makassar	4-allyl phenyl acetate,	Aligiri *et al.*, 2018
Vietnameze betel rhizome	Alpha-cadinol	Thanh and Nguyen, 2019

Industrial Utility of Extracted BLEO

The research carried out in this recent era shows multiple advantage of extraction of BLEO. All the varieties cultivated in West Bengal shows much higher recovery of betel leaf essential oil (BLEO) than the cultivars raised in other states of India. Although the recovery of essential oil is quiet less in betel but it is very expensive from commercial

point of view. Two kilo betel leaves could produce 4 ml of BLEO and cost of 10ml crude BLEO is approximately Rs.1800. Although the shelf life of betel leaves is only 2-3 days under ambient temperature but BLEO could be stored intact for more than 3 years. It is being detected that betel oil could be extracted from partially decomposed leaves as well. This oil has multi-purpose application taking from medicinal, cosmetic, food industry to packaging sector. The betel leaf essential oil (BLEO) has several medicinal and cosmetic uses. The oil has insecticidal, fungicidal property and could be included in IPM or organic cultivation system (Hossain *et al.*, 2020). The domestic and export agro-concern only prioritised betel leaf production and sell but prospect lies in other morphological components of the plant. The petiole, rhizome, root part shows equal prospect in essential oil extraction. The betel leaves remaining inside the extractor machine could be utilized for production of bio-compost. In this approach the domestic and export loss of betel leaves could be minimized along with cleaning of environmental waste. In rural areas the betel heaps not only acts as an infection ground but the cattle and other domestic animal gets infected and even the diseases affects human and enters the food chain. The *Salmonella* infection is very severe infection and betel based disease transmission disturbs the ecological balance.

TABLE 5

Application of piper betel oil in diverse industry sector

Field / Area	Application	Reference
Livestock rearing and management	4 per cent betel oil increases carcass weight, reduces bacterial infestation in broiler	Lodang *et al.*, 2019
Packaging material	BLEO combined maize blended film	Hiremania *et al.*, 2021
Food preservative	Could keep apple juice extract by reducing microbial contamination	Basak, 2018
Processing industry	Very effective for scombroid fish coating for better preservation	Ariyani *et al.*, 2018
Mosquito repellent	*Aedes aegyptii* mosquito control	Dante *et al.*, 2018
Natural micro-emulsion	Control *Aspergillus flavour* in tomato paste	Basak and Guha, 2017
Cosmetic industry	*Piper betle* and *Acacia catechu* a natural colorant lipstick, rouge, eye shadow	Randive *et al.*, 2020
Eco-friendly dish-wash	40 ml of betel leaf extract, 10 g of lime, 20 g of gambier and distilled water	Chandra *et al.*, 2020
Edible fibre in cut-fruit, vegetable business	Addition of 0.2 per cent BLEO in carboxy methyl cellulose (CMC) increases physical property of the film	Utama *et al.*, 2018
In-vitro plant protection	In commercial flower micro-propagation 100 % BLEO could substitute autoclaving	Taghizadeh *et al.*, 2016
Antimicrobial textiles	The prospect of naturally extracted oil in micro-encapsulation of textiles	Gundewadi *et al.*, 2021
Bio-fungicide	Could treat powdery mildew, *Sclerotium rolfsii*, *Fusarium oxysporum* f.sp. *vasinfectum* and *Rhizoctonia solani*	Lister *et al.*, 2020
Bio-pesticide	*Aphis gossypii, Amrasca biguttula, Helicoverpa armigera* and *Pectinophora gossypiella*	Ibrahim *et al.*, 2017

Several scientists are concentrating on the reduction of post-harvest loss of different crops. In jack fruit (*Artocarpus heterophyllus*) the matured, ripened fruit bulbs are eaten raw. The 40 per cent un-ripened bulbs are processed to yield deep-fried chips but 59-60 per cent of the matured, un-ripened fruit bulbs get wasted. Those waste bulbs were used to produce a novel food item named jack-peel rind chews (JPR chews) that was accepted by the consumers with a good score from health perspective with relatively variable response regarding palatability. The product showed storage stability of more than six months. This alternative organic raw material was comparable to papaya based Tutty-fruity flavour in food items of bakery and confectionary industry (Ray *et al.*, 2021). This finding proved beneficial for rural income generation especially involving women self-help group satisfying waste to wealth generation. In this paper in the same way the urgency of extraction of betel leaf essential oil (BLEO) from the un-sold un-utilized as well as partially decomposed leaves is discussed with a similar objective of waste to wealth generation.

Community Based Oil Extraction Facility

The BLEO extraction could generate an end product with high storage life and multi-dimensional application. In the erratic weather condition and glut season the utilization of the damaged as well as the excess betel plants in oil extraction could assist the poor farmers to mitigate their loss. The application of other post-harvest technologies could only keep the leaf intact for few days or slight increase of shelf life of the plant produce. Whereas, extraction of oil could only act as measure of damage control faced by the farmers at periodic intervals. In betel business also the establishment of oil extraction facility could assist the betel traders to regulate their business with economic gain. The public and private sector partnership could be established by linking betel farmers with betel traders for both fresh produce supply and BLEO extraction in cases of emergency.

Establishment of Public Sector Community Oil Extraction Facility

District or block level infra-structure facility for community based BLEO extraction could be

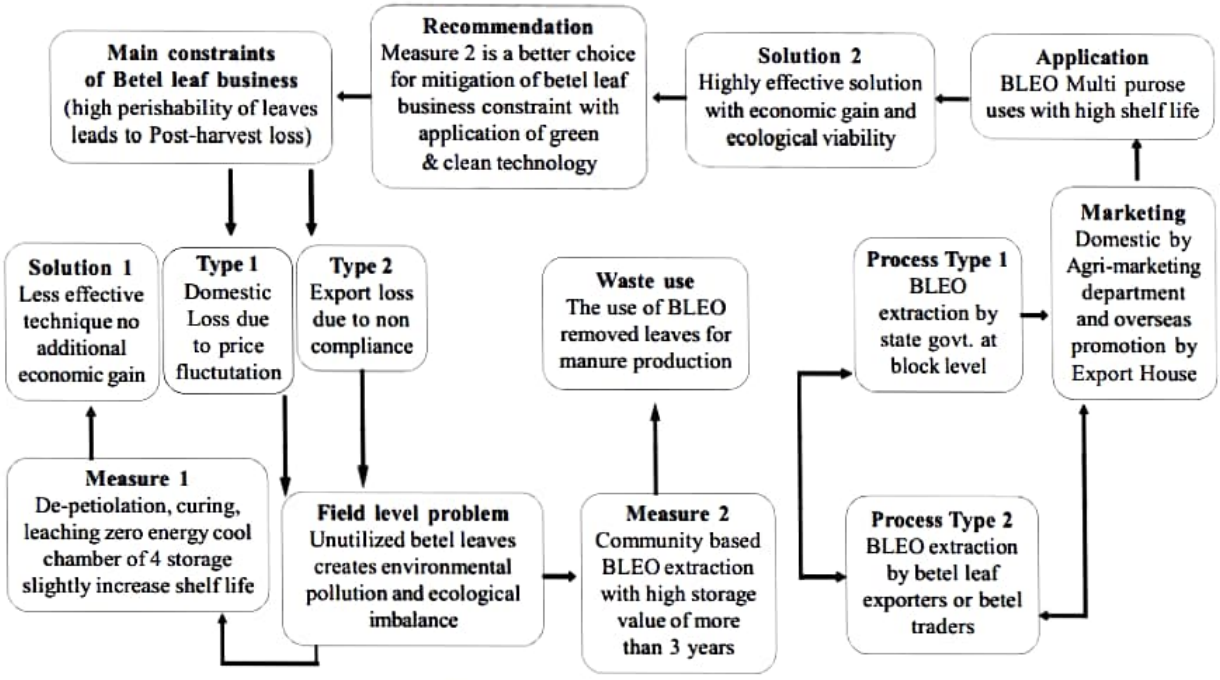

Fig. 2 : The outline of the community betel leaf oil extraction process

estalished by the state horticulture department. Initially a few model projects could be taken up in districts including maximum number of baroj. The state aided BLEO facility could extract huge amount of essential oil with involvement of local betel farmers. The product could be marketed by agricultural marketing department of West Bengal. Even the chemotypic labelling and cultivar specific oil extraction could get global customers according to their business needs. If the farmers get convinced about the financial gain of oil extraction, they may bring the damaged or intact leaves to oil extraction facility after the departure of super-cyclone. In different studies the morpho-anatomical diversity of betel oil was explored indicating the prospect of different parts of the plant in future oil extraction programmes (Shethi *et al.*, 2019). The aftermath of cyclone uproots the whole plants in some coastal vines and those plants could be completely utilized for community oil extraction and sequential compensation of the farmers. The women and rural unemployed community may be involved in this community improvement programme.

Coconut production and processing of other plant part is directly related to the reform of rural house holds of different districts of Karnataka. A study on ball copra production from coconut in the Tomakuru, the largest district of Karnataka, reveals that abiotic stress factors play significant role in the processing of copra along with high commission to the middleman for selling of the copra (Lokesh and Sharif, 2021). The Coconut and copra production is negatively regulated by the shortage of rainfall in equivalence to fresh betel leaves and betel leaf oil production scenario that depends largely on the pre-monsoon erratic super-cyclones that hit the Eastern India. In glut condition in monsoon and high market fluctuation controls the betel leaf business in a similar way. The direct linkage of farmers and government agencies or private industries may reduce the level of middle man interference elevating farmer's income.

Private Sector Oil Extraction by Betel Traders

In a similar fashion the betel traders could set up a betel leaf oil extraction facility (BLOEF) in baroj adjoining region or in vicinity to pack-house / phyto-sanitary laboratory complex or in kishan-mandi area for rapid availability of excess and unutilized leaves. The oil extraction facility in baroj adjoining area will facilitate the maximum utilization of waste or rejected materials. The attempt may be initiated as joint venture among the betel traders / exporters. The export rejected consignments could be directly utilized for oil extraction in this facility. As leaves are cleaned and packed before export, the oil extraction could be initiated without wasting time. In addition to that partially damaged leaves, even infected leaves could be utilized for BLEO extraction (Amaresh *et al.*, 2017). The temperature and pressure generated during the extraction process could kill the pathogens and the crude oil remains pure and free from contamination. An initiative could be taken to integrate local small vendors with these mass extraction facilities to mitigate major loss of this perishable leaf. The continuous interaction and transaction of the exporters with international buyers opens up the provision of getting potential buyers. Additionally, the traders

TABLE 6

Different Extraction Process for BLEO recovery with water as solvent

Process	Time (Minute)	Oil Recovery	Reference
Simple Hydro-distillation	265	0.50 (% v/w)	Preethy *et. al.*, 2017
Super Critical Carbon dioxide	210	7.32 (% v/w)	Aziz *et. al.*, 2016
Microwave Distillation	50	1.41 (dry w/w)	Hemalatha, 2017
Ultra-sound hydro distillation	90	0.25 (% w/v)	Hans, 2017
Cold Compressed oil	180	0.71 (w/v)	Tongnuanchan and Benjakul, 2014

could showcase their product in buyers and sellers meet or could negotiate with other essential oil producing companies for selling of the oil. Both the above mentioned ventures either taken by government or industry or public private partnership could control the fluctuating betel trade and secure economic growth and environmental sustainability.

Future Line of Work

In this study it is being suggested to consider betel leaf loss as an important agro-industrial constraint and to mitigate the problem in a holistic manner. The previous publications highlighted the design and development of small scale betel oil extraction facility on individual farmer centric approach. In a venture taken by Indian Institute of Technology (IIT), Kharagpur a betel leaf oil extractor was developed for efficient oil extraction exceeding the performance of normal Clevenger apparatus based extraction. The institute is popularising the oil extractor with efficient design for individual betel farmers for income generation. In this paper the prospect of community based public or private sector oil extraction is being discussed and proposed with involvement of all the stakeholders. The idea conceptualized in this paper may uplift the baroj economy with stability of betel leaf business of West Bengal.

The problem could be considered in a bidirectional approach including the angle of farmers and traders. The amalgamation of farmers with traders could lead to a systematic solution to the problem. The loss is dealt under domestic and export arena.

In case of domestic market the involvement and leadership role of state horticulture department could strengthen the local economy. In a community approach extraction related training, commercial installation facility development, storage, operational facility and logistics could be taken care by the state government.

District or block level facility could be developed involving local betel farmers or unemployed youth or female members of betel household.

The marketing of the oil could be facilitated by agri-marketing department in collaboration with state horticulture department.

The involvement of fresh betel traders and exporters in this oil extraction could lead to a profitable solution with a fixed market for the BLEO. The establishment and maintenance of a BLEO facility in pack-house or betel baroj adjoining area or kishan mandi area and storage and marketing of the same by betel exporters or traders could be an excellent solution to the betel waste management ensuring clean and green maintenance of the environment with healthy vines and noteworthy economic gain.

The active involvement of fresh betel traders in this venture could ensure better maintenance of machinery, storage, record keeping, fixed market, logistic benefit, product diversification and global recognition.

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