European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 07, 2020

Ethnobotanical Uses Of Elaeocarpus Serratus By Meitei Community Of Manipur, India

Nikita Khoisnam[1], Rocky Thokchom[2], Ratnamala Thokchom[3], Guneshori Maisnam[4] , and Sapna Jarial[5]

[1,4,5]*School of Agriculture, Lovely Professional University, Jalandhar (144411), Punjab (INDIA)*
[2]*Institute of Agriculture, Visva-Bharati, Sriniketan-731236, West Bengal, India.*
[3] *Department of Horticulture and Soil conservation, Government of Manipur, India*

E-mail:nikita.25685@lpu.co.in[1]

Author Note
Nikita Khoisnam, Assistant Professor, Department of Agricultural Economics and Extension, School of Agriculture, Lovely Professional University, Jalandhar (144411), Punjab (INDIA)
GuneshoriMaisnam, Assistant Professor, Department of Agricultural Economics and Extension, School of Agriculture, Lovely Professional University, Jalandhar (144411), Punjab (INDIA)
Sapna Jarial,Assistant Professor, Department of Agricultural Economics and Extension, School of Agriculture, Lovely Professional University, Jalandhar (144411), Punjab (INDIA)
Rocky Thokchom. Ph.D, Department of Horticulture and Postharvest Technology; Institute of Agriculture, Visva-Bharati, Sriniketan-731236, West Bengal, India.
Ratnamala Thokhom, A.O (Incharge) Department of Horticulture and Soil conservation, Government of Manipur, India

Contact: nikita25685@lpu.co.in

ABSTRACT: Manipur is extremely rich in underutilised minor fruit crops of immense horticultural and medicinal properties. Meitei, the major ethnic community of Manipur has the unique traditional knowledge of consuming the underutilised minor fruit in a varietal way. This community has a unique way of consuming Elaeocarpus serratus fruits in raw and in the traditionally processed form from time immemorial viz. Ambon (sauce), Chorphon Akangba (dried fruit slices and flaxes), Chorphon Heingan (candy), Chorphon Atingba (fermented fruit wine), Chorphon Achar (pickle) and Chorphon Takkhieba (beverage powder/and churang). They consumed the raw unripe fruit in a different form and also with some leafy green vegetables over a long period of time. The tradition knowledge of eating this underutilised minor fruits are handed down from one generation to another orally with a believed to have got direct medicinal benefit by this mode of eating. In this study, the traditional processes of Elaeocarpus serratus fruits and its medicinal values were documented.

Key words: Meitei, underutilised, minor fruit, Elaeocarpus serratus, unique traditional knowledge, medicinal.

1. INTRODUCTION

In India, Manipur is extremely rich in underutilised minor fruit crops of immense medicinal properties[16] and most of them are found in the Tarai region in the foothills of Himalayas and the North-Eastern region. *Meitei* is the majority ethnic group of Manipur with a long history of preserving their rich heritage[2]. In Manipur, the community is restricted mainly in six valley districts of the state. The community has the traditional knowledge of eating minor and underutilized plant as medicine from time immemorial[15]. The people living in the rural and hilly area have the advantage of long lifespan and healthy as compared to those living in big cities and towns, which may be attributed to the local vegetables and fruits having medicinal properties and consumed by the people here[16]. The protective foods are being searched in these novel crops are now viewed with greater emphasis than in the past in recognition of their role in fulfilling the nutritional security. These novel crops will also help rural sectors in mitigating the malnutrition and hence enabling them a quality life[20] and also have a significant role in domestic market and for their export[19] to improve their livelihood. In, North-east India, especially in Manipur limited efforts has been made to explore the ethnobotanical uses of minor and underutilized fruit crops[9]. However, Singh and his co-workers reported 39 plants belonging to 29 genera and 23 families of underutilized fruit crops consumed for medicinal purposes[16].

For centuries, ethnobotanical knowledge of underutilised minor fruit crops were practiced but its credentials started very lately. Most of this documentation was mostly based on the record or listing of species plant parts used and its uses[1, 8, 14, 15, 16]. Rathore reported availability of insufficient information on the nutritive value of wild underutilised minor fruit crops in India[12]. The uses of the species wise and its detailed information is necessary to explore its spread out uses not only its medicinal values but also from horticultural aspects as well as religious and cultural importance. In the present study, the in depth ethnobotanical uses of *Elaeocarpus serratus* by *Meitei* community are given.

Elaeocarpus serratus belongs to Elaeocarpaceae family usually evergreen having spread canopy with small to medium size of tree (10-12 m). Leaves are obovate oval, acute at the base and obtuse-rounded apex, margin have shallowly crenate serrate with incisions dents; at the lower face pale olive green or drying brown in colour. Before senescence the leaves turn red. Flowers are usually 4-8 cm long, racemes axils from past and present leaves are slightly shorter, pedicels as sepals are long, 4-6 mm sepals, and acute, lanceolate, fine-pilose or glabrous, petals are white in colour with 5-6 mm having a broad cuneate base, 25-35 filaments. Fruit are found as drupe, 3-4 cm long, have bluntly pointed ovoid, dull, smooth, greenish yellow colour, pulp are usually light to dark green in colour, copious acid, edible; stone ovoid oblong in shape, thick and bony, strongly tubercle, one celled, one seeded. Species is indigenous to Sri Lanka[6] and distributed wild in the Indo-Malaysian region.

2. METHODOLOGY

The present investigation was carried out in association with 'The Department of Horticulture and Soil Conservation, Manipur' with 'Institute of Agriculture, Visva-Bharati, Sriniketan, West Benagal' in 5 Districts of Manipur namely Imphal East, Imphal West, Bishunupur, Thoubal and Kakching. At least twenty respondents each from the Districts were studied. Thus, in total 100 respondents were selected. 'Questionnaire' were made, and information was collected through 'Random Sampling' during several fieldworks between 2016-2017 on the traditional horticultural and medicinal uses of *Elaeocarpus serratus* by the

community of *Meitei*. The information were collected from the local people of the study area and analysis of the data were done and documented.

3. RESULTS

From the extensive field survey and interviewing the respondents of the study areas, it was revealed that *Elaeocarpus serratus* was found to be the most important underutilised minor fruit crops which were used by *Meitei* community due to its abundant availability and its easy uses. It is generally cultivated and widely grown naturally. *Elaeocarpus serratus* is known as *Chorphon* in *Meiteilon*, the language of *Meitei* community. The different parts of the plant were found to be consumed raw or processed and also used as traditional medicine, and can be prepared by following different techniques. The results obtained after analysis of data on the preference of processed products of *Elaeocarpus serratus (Chorphon)* are shown below:

Table.1: Preference of consuming the processed product of *Elaeocarpus serratus (Chorphon)* among the Districts of Manipur.

Processed Product	**Imphal East (n= 20)**		**Imphal West (n= 20)**		**Bishnupur (n= 20)**		**Thoubal (n= 20)**		**Kakching (n= 20)**		**Total Districts (N= 100)**	
	F	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**
Ambon	1	5	0	0	2	10	0	0	1	5	4	4
Chorphon Akangba	5	25	4	20	4	20	3	15	6	30	22	22
Chorphon Heingan	1	5	3	15	1	5	2	10	3	15	10	10
Chorphon Atingba	2	10	4	20	8	40	4	20	4	20	22	22
Chorphon Achar	7	35	6	30	4	20	8	40	5	25	30	30
Chorphon Takkhieba	4	20	3	15	1	5	3	15	1	5	12	12
Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**	**100**	**100**

*F= Frequency, P= Percentage

As observed from the table1, it was depicted that majority of the respondents from (35%) Imphal East, (30%) Imphal West and (40%) Thoubal had preferred Chorphon Achar, whereas in (40%) Bishnupur preferred Chorphon Atingba and (30%) Kakching preferred Chorphon Akangba. When taking all the Districts together it was found that majority of the respondents preferred Chorphon Achar (30%) which was followed by Chorphon Akangba and Chorphon Atingba (22%).

Traditional horticultural processed product

Ambon

Green unripe horticultural mature fruits were used to prepare the traditional *'Ambon'* or sauce.

Procedure: Green unripe horticultural mature fruits free from disease and bruises were plucked and wash it thoroughly in clean running water and then keep it for a while for air

drying on a clean banana leaf. Further, the fruits were either cut into few slices or boiled as a whole in an earthen pot until it attains smooth texture. Salt, sugar and chilli powder were added in the crushed cooked fruit and cooked further for some minutes and the '*Ambon*' is prepared. It is traditionally prepared and served in big feast like '*Usop*', *Chakouba*, etc. It is oil free and enhanced the digestion process after the heavy meal and keeps our digestive system healthy.

Chorphon Akangba

It is traditionally prepared dry fruit slice or flakes.

Procedure: Unripe fruit slices or flakes are well mixed with salt and sundried on the banana leaf on '*Phoura* or *Yangkok'*, a large flat bamboo craft for drying purpose. In bright sunlight, it takes around 4 to 5 days to get the desirable dry stage for consumption. This dried product improved digestion if taken after the meal.

Chorphon Heingan

It is a traditionally prepared fruit candy.

Procedure: Fruit slices were steamed in earthen pot for 10 to 15 minutes. After steaming the steamed fruits was allowed to cool down to normal temperature and the slices were separated. The slices were exposed to open air under the shade on the banana leaf on '*Phoura* or *Yangkok'* for whole night. This was followed by dipped treated in hot sugar syrup for about 2 days (osmotic dehydration process). The process was facilitated with stirring at regular interval. After this, the draining off of the syrup was done for several hours before consumption. Consumption of it strengthens the digestive system and regulates the bowel movement.

Chorphon Atingba

It is a traditionally prepared fermented fruit wine.

Procedure: Mature unripe or ripe fruits can be used for wine preparation. An earthen pot of about 15 to 20 litre capacity is required for the preparation of wine. Nowadays instead of aluminium pots earthen pot has taken its place. First, thoroughly washed 5 to 6 kg of *Elaeocarpus serratus* and put into the earthen pot for cooking. Then the cooked fruit is to be spread over a *Phoura* or *Yangkok* for suitable cooling set it aside in dim light; then mixed up the fruit with *Hamei* (Fig.1) @ 40-50 gm/1 kg of fruit. The two components should be mixed thoroughly and kept it for fermentation process. Then pour the mixture inside the earthen pot which was earlier cleaned then and dried under fire. The earthen pot has to been kept in the sunlight for about 3-4 days during summer with its mouth covered with a clean cloth. In case of preparation during winter time, the mixture has to be fitted or pour in a basket made of bamboo then wrapped with the leaves of Teak (*Tectona grandis* L. f.) or *Ficus hispida* Linn. or Banana (*Musa paradisiaca* Linn.) or Giant taro (*Alocasia indica* Schoot.), etc internally then baked under direct sunlight for about 5-6 days after the mouth is fully covered with a clean gunny bag or coarse cloth and leave it for fermentation. During this process of fermentation, three stages of taste have to be checked i.e alkaline taste then sweet taste and bitter taste for about two days comprehensive during the entire period of fermentation. Finally, the sweet and the bitter ones are filtered and is known as '*Chorphon Atingba'*. Low nourishment of foods, loss of appetite, etc. can be regulated by consuming this drink ('*Chorphon Atingba'*) before the meal.

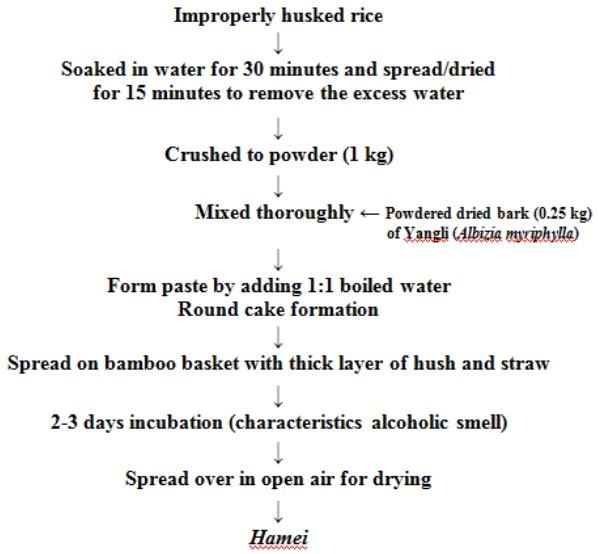

Fig.1 -Flow chart for *Hamei* preparation[7].

Chorphon Achar

It is a traditional raw fruit pickling and preserved in spicy mustard oil.

Procedure: Fruit slices are first treated with *Meitei Thum* (Traditionally prepared salt plate.) and dried in '*Yangkok*' to extract moisture from the fruits. To the drained slices, a partially ground mixture of spices including mustard seeds, asafoetida, a slice of *Meitei Thum*, coriander seeds, cumin seeds, fenugreek seeds, turmeric powder and chilli powder were added and thoroughly mixed. The whole admixture is filled into a clean jar and covered with previously cooked and cooled mustard oil and covered the jar air tight. The jars were kept in sunlight every day for several hours up to about 2 to 3 weeks before consumption (ChitraMani & Kumar, P. (2020); Sharma, M., & Kumar, P. (2020); Chand, J., & Kumar, P. (2020); Naik, M., & Kumar, P. (2020); Kumar, P., & Naik, M. (2020); Kumar, P., & Dwivedi, P. (2020); Devi, P., & Kumar, P. (2020); Kumari, P., & Kumar, P. (2020); Kaur, S., & Kumar, P. (2020); Devi, P., & Kumar, P. (2020); Sharma, K., & Kumar, P. (2020); Kumar, S. B. P. (2020); Devi, P., & Kumar, P. (2020); Chand, J., & Kumar, P. (2020).

Chorphon Takkhieba

It is a traditionally prepared beverage powder/and *Churang*.

Preparation: Unripe fruit slices are spread on the banana leaf on '*Phoura* or *Yangkok'* and kept in bright sunlight for drying. In bright sunlight, it takes around 7 to 10 days for fully dried. The dried fruit slice is put in a wooden/stone mortar (*Shumban*) pounded with the help of a wooden mallet (*Shuk*) and thus the obtained powder mass is called '*Chorphon Takkhieba.'* This beverage powder/and *Churang* can be consumed directly or with water to improve appetite, to relief stomach disorder and chest pain. It has a long shelf life in this form and can be enjoyed in any season (Kumar, P. (2019); Kumar, D., Rameshwar, S. D., & Kumar, P. (2019); Dey, S. R., & Kumar, P. (2019); Kumar et al. (2019); Dey, S. R., & Kumar, P. (2019); Kumar, P., & Pathak, S. (2018); Kumar, P., & Dwivedi, P. (2018); Kumar, P., & Pathak, S. (2018); Kumar et al.,2018; Kumar, P., & Hemantaranjan, A. (2017); Dwivedi, P., & Prasann, K. (2016). Kumar, P. (2014); Kumar, P. (2013); Kumar et al. (2013); Prasann, K. (2012); Kumar et al. (2011); Kumar et al. (2014).

Traditional methods of raw consumption

With salt and dry chilli flakes.

Meitei community of all ages and sexes are very fond of consuming raw *Elaeocarpus serratus* fruits and young tender leaves from the time immemorial. Unripe fruits are consumed with salt and dry chilli flakes after heavy lunch. It is believed to improve the digestion process. Many were reported to consume it by wrapping it with salt and chilli flakes in mature mustard leaves. Mustard leaf improved the taste as well as it avoids the sensitiveness of teeth while consuming sour acidic *Elaeocarpus serratus* fruit. The astringent fruits are used in the treatment of dysentery and diarrhoea.

Chorphon Asuba.

It is a way of consuming of unripe, tide firmness, raw fruit flesh by pounding it with salt and chilli flakes in small wooden/stone mortar (*Thuksu*) with a wooden mallet (*Khon*).

The respondents were asked about their preference on consuming the raw product of *Elaeocarpus serratus (Chorphon)* among the different Districts and the results thus obtained are depicted in the table 2 below:

Table.2: Preference of consuming the raw product of *Elaeocarpus serratus (Chorphon)* among the Districts of Manipur.

Raw Consumption	**Imphal East (n= 20)**		**Imphal West (n= 20)**		**Bishnupur (n= 20)**		**Thoubal (n= 20)**		**Kakching (n= 20)**		**Total Districts (N= 100)**	
	F	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**	**F**	**P**
With salt and dry chilli flakes	12	60	9	45	7	35	15	75	4	20	47	47
Chorphon Asuba	8	40	11	55	13	65	5	25	16	80	53	53
Total	20	100	20	100	20	100	20	100	20	100	100	100

*F= Frequency, P= Percentage

From the above result, it can be concluded that majority of the respondents preferred to consume raw Chorphon in the form of Chorphon Asuba.

Other Uses

Tender young leaves are used in curries to enhance taste and boost digestion. For the treatment of diarrhoea and dysentery this fruits are locally prescribed. The leaves are used as an antidote to poison.

4. DISCUSSION

Manipur is extremely rich in underutilised minor fruit crops of immense medicinal properties[16]. Underutilised minor fruit crops hold immense promise and required to be acknowledged and exploited for their potential importance[5]. By adding value addition to the underutilised fruits it increases not only the demand of local marketing but its export[19]. In India, from the various research works[1, 10, 13, 16, 18] it can be observed that the uses, consumption, processing, utilization for medicinal value of underutilised minor fruit crop differs in different community and places. Our *Meitei*, community also has the unique traditional knowledge of consuming this fruit crop in a varietal way. Perusal of present survey indicates the way of consuming and utilisation of *Elaeocarpus serratus* by *Meitei* community. Traditional knowledge of these fruit crops has the prospective of transforming into commercial opportunity, providing practical leads for development of the products and its processes form in horticulture. The traditional knowledge of consuming and processing of this fruit crop was transferred from one generation to another orally. Oral tradition gets disorder and threatens the loss of valuable information about many specific plants due to

deterioration of many languages in tropics and sub-tropics. Ethnobotany is one of the important scientific studies of a regional plant and its practical uses through its local culture and people traditional knowledge[4]. Preservation of the traditional knowledge by documentation is the great challenges of a rich heritage community. This preservation is of immense importance in future research as well as it become a medium of introducing a community to the whole world. Therefore, it is vital to document the folk knowledge of this minor fruit crop for its optimum utilization and conservation. In the present study we give importance in the detailed ethnobotanical study on *Elaeocarpus serratus* mainly focusing on is consumption and horticultural processing. Rather than of listing various plant species without any specific information in the society, it's more important to know more specifically about a particular plant species of the local region. Specific study about particular individual species will be helpful for the researchers and extension workers to identify threats and its conservation status of many endangered and rare plant species. In recent years people are already taking keen interest on traditional medicine especially based on underutilised minor fruit plants. *Elaeocarpus serratus* is a unique plant species which is of immense importance in terms of horticultural, medicinal and cultural values. It has some potential in the treatment of AIDS, diabetes and cancer[3]. The fruit juice can help in increasing the appetite in patients by stimulating secretion from the taste buds[17]. Fruits contain rich amount of plant acids and tannin. The bark of this plant is used in treating hemorrhages, ulcers and biliousness[11]. Various species of Elaeocarpus have also been broadly studied because of their diverse pharmacological performance like analgesic, anti-inflammatory, antimicrobial, antifungal, anti-diabetic, anti-oxidative, antiviral, antitumor, antihypertensive, anti-anxiety and antidepressant activities[3]. The present surveys provide a sense of pride among the *Meitei* community to treasure and safeguard their traditional horticultural processing knowledge for future applications. Interactions between researchers and locals also brought about understanding among the *Meitei* community need to value and document their traditional knowledge before this practice of orally handing down their traditional knowledge is lost. Further, this survey may be a double-edged sword, as this survey helps in mutual sharing of knowledge, wherein the knowledge shared by the locals is complemented by sharing of various awareness tips for conservation and sustainable development from the researchers who interact with the local peoples. And also through local extension agents, promotion of the underutilized minor fruits species uses and health benefits awareness can be spread far and wide. Thus, making it commercial and increase their productivity for competing with other crops and to develop technologies suitable for specific processing purposes, development of products and storage of fresh and processed products from the concern authorities through the information collected.

REFERENCES

[1] Bandyopadhyay S & Mukherjee S K, Wild edible plants of Koch Bihar district, West Bengal, *Nat Prod Reliance*, 8(1) (2009) 64-72.

[2] Census of India, Manipur Population Census data. Office of the Registrar General & Census Commissioner, India Ministry of Home Affairs, Government of India, New Delhi, 2011. (https://www.census2011.co.in/census/state/manipur.html)

[3] Dahanayake N, Some underutilised fruit crops of Sri Lanka. *Int J Sci Res* , 5(2) (2015) 1-7.

[4] Hamilton A, Curriculum development in applied ethnobotany. In: *Curriculum development in applied ethnobotany*, edited by Shinwari Z K, Hamilton A & Khan A A from May 2 to 4, 2002 at Nathiagali, Abbotabad, WWF - Pakistan, 91–95.

[5] Jallikop S H, *Taxonomy, growth habit and adaptability of some underutilised fruits. In*: National symposium on underutilised horticultural crops from June 8 to 9, 2006 at Indian Institute of Horticultural Research, Banglore. *Abstract: 4*.
[6] Jayasuriya A H M & Rajapakse R M T, Plant genetic resources activities in Sri Lanka, In: *Sixth Meeting of South Asia Network on Plant Genetic Resources* (SANPGR), edited by Mal B, Mathur P N, Rao V R & Jayasuriya A H M, held at PGRC, Peradeniya, Sri Lanka, from December 9 to 11, 2002, (IPGRI South Asia Office, New Delhi, India), 2004, 22–38.
[7] Jeyaram K, Singh T A, Romi W, Devi A R, Singh W M, Dayanidhi H, Singh N R & Tamang J P, Traditional alcoholic beverage, *Yu* of *Meitei* communities of Manipur, *Indian J Traditional Knowledge*, 8 (1) (2009) 115-121
[8] Kikim A & Yadava P S, Phenology of tree species in subtropical forests of Manipur in north eastern India, *Trop Ecol*, 42 (2001) 269-276.
[9] Kotoky R, Pathak M G & Kanjilal P B, Physiochemical characteristics of seed oils of some Litsea species found in the North-East India. *Nat Prod Reliance*, 6 (2007). 297-300.
[10] Kour S, Bakshi P, Sharma A, Wali, V K, Jasrotia A & Kumari S, Strategies on Conservation, Improvement and Utilization of Underutilized Fruit Crops, *Int J Curr Microbiol App Sci*, 7(03) (2018) 638-650.
[11] Pullaiah T, *Encyclopedia of World Medicinal Plants* Vol.2, Regency Publication, New Delhi, 2006, 852-853.
[12] Rathore D S, Overcoming malnutrition through non traditional fruits, *Indian Hort*, 45 (2001) 9-11.
[13] Shiva B V, Bhargav & Nimbolkar P K, Under-Exploited and Nutritionally Rich Wild Fruits of Telangana, *Int J Curr Microbiol App Sci*, 6(6) (2017) 2682-2694.
[14] Singh AV, An account of the indigenous plants used by the Meiteis of Manipur as food, *J Phytol Res*, 21(1) (2008) 33-40.
[15] Singh H B, Singh R S, Sandhu J S, *Herbal medicine of Manipur*, A colour Encyclopedia, Daya publishing House, New Delhi, 2003.
[16] Singh S R, Phurailatpam A K, Wangchu L, Ngangbam P & Chanu T M, Traditional medicinal knowledge of underutilized minor fruits as medicine in Manipur. *Int J Agric Res*, 4 (8) (2014) 241-247.
[17] Sriti K, Manjari S K, & Kanti C C, Correlation between phytochemical screening, antibacterial and anthelmintic activities of *Elaeocarpus serratus*, *Int Res J Pharm*, 2(9) (2011) 133-136.
[18] Srivastava A, Bishnoi S K & Sarkar P K, Value Addition in Minor Fruits of Eastern India: An Opportunity to Generate Rural Employment, In: *Fruits for Livelihood: Production Technology and Management Practices*, edited by Dutta A K & Mondal B, (Agrobios, Jodhpur, India), 2017, 395-417.
[19] Srivastava R P & Sanjeev K, *Fruit and vegetable preservation principles and practices*, (International Book Distributing Co. Limited, Lucknow), 2002, 363-364.
[20] Swaminathan M S, Enlarging the basis of food security, In: *The role of underutilized species*. International workshop held at the M. S. Swaminathan Research Foundation, Chennai, India, from February 17 to 19, 1999.
[21] ChitraMani, P. K. (2020). Evaluation of antimony induced biochemical shift in mustard. Plant Archives, 20(2), 3493-3498.
[22] Sharma, M., & Kumar, P. (2020). Biochemical alteration of mustard grown under tin contaminated soil. Plant Archives, 20(2), 3487-3492.

[23] Chand, J., & Kumar, P. (2020). Yield attribute shift of mustard grown under cadmium contaminated soil. Plant Archives, 20(2), 3518-3523.
[24] Naik, M., & Kumar, P. (2020). Role of growth regulators and microbes for metal detoxification in plants and soil. Plant Archives, 20(2), 2820-2824.
[25] Kumar, P., & Naik, M. (2020). Biotic symbiosis and plant growth regulators as a strategy against cadmium and lead stress in chickpea. Plant Archives, 20(2), 2495-2500.
[26] Kumar, P., & Dwivedi, P. (2020). Lignin estimation in sorghum leaves grown under hazardous waste site. Plant Archives, 20(2), 2558-2561.
[27] Devi, P., & Kumar, P. (2020). Concept and Application of Phytoremediation in the Fight of Heavy Metal Toxicity. Journal of Pharmaceutical Sciences and Research, 12(6), 795-804.
[28] Kumari, P., & Kumar, P. (2020). Trichoderma fungus in mitigation of rhizosphere arsenic: with special reference to biochemical changes. Plant Archives, 20(2), 3512-3517.
[29] Kaur, S., & Kumar, P. (2020). Ameliorative effect of trichoderma, rhizobium and mycorrhiza on internodal length, leaf area and total soluble protein in mung bean (Vigna radiata [L.] R. Wilazek) under drought stress. Journal of Pharmacognosy and Phytochemistry, 9(4), 971-977.
[30] Devi, P., & Kumar, P. (2020). Effect of bioremediation on internodal length and leaf area of maize plant cultivated in contaminated soil with chromium metal. Journal of Pharmacognosy and Phytochemistry, 9(4), 1408-1413.
[31] Sharma, K., & Kumar, P. (2020). Mitigating the effect of biofertilizers on morphological and biochemical level in pearl millet grown under mercury toxicity. Journal of Pharmacognosy and Phytochemistry, 9(4), 955-961.
[32] Kumar, S. B. P. (2020). Salinity stress, its physiological response and mitigating effects of microbial bio inoculants and organic compounds. Journal of Pharmacognosy and Phytochemistry, 9(4), 1397-1303.
[33] Devi, P., & Kumar, P. (2020). Enhancement effect of biofertilizers on germination percentage and plant height in maize grown under chromium toxic soil. Journal of Pharmacognosy and Phytochemistry, 9(4), 702-707.
[34] Chand, J., & Kumar, P. (2020). Biochemical shift of mustard grown under cadmium contaminated soil. Journal of Pharmacognosy and Phytochemistry, 9(3), 178-183.
[35] Kumar, P. (2019). Evaluation Of Internodal Length And Node Number Of Pea Treated With Heavy Metal, Polyamines And Glomus. Journal of the Gujarat Research Society, 21(10s), 518-523.
[36] Kumar, D., Rameshwar, S. D., & Kumar, P. (2019). Effect Of Intergated Application Of Inorganic And Organic Fertilizers On The Roots Of Chickpea. Plant Archives, 19(1), 857-860.
[37] Dey, S. R., & Kumar, P. (2019). Analysis of Available Nitrogen of Wheat Cultivated Soil Treated with Organic and Inorganic Source of Fertilizers. Int. J. Curr. Microbiol. App. Sci, 8(8), 2986-2990.
[38] Kumar, P., Siddique, A., Thakur, V., & Singh, M. (2019). Effect of putrescine and glomus on total reducing sugar in cadmium treated sorghum crop. Journal of Pharmacognosy and Phytochemistry, 8(2), 313-316.
[39] Dey, S. R., & Kumar, P. (2019). Cadmium induced biochemical shift in maize. Journal of Pharmacognosy and Phytochemistry, 8(1), 2038-2045.
[40] Kumar, P., & Pathak, S. (2018). Short-Term Response of Plants Grown under Heavy Metal Toxicity. Heavy Metals, 69.

[41] Kumar, P., & Dwivedi, P. (2018). Plant lectins, agricultural advancements and mammalian toxicity. Molecular Physiology of Abiotic Stresses in Plant Productivity, 360.
[42] Kumar, P., & Pathak, S. (2018). Nitric oxide: a key driver of signaling in plants. MOJ Eco Environ Sci, 3(3), 145-148.
[43] Kumar, P., Pathak, S., Amarnath, K. S., Teja, P. V. B., Dileep, B., Kumar, K., ... & Siddique, A. (2018). Effect of growth regulator on morpho-physiological attributes of chilli: a case study. Plant Archives, 18(2), 1771-1776.
[44] Kumar, P., & Hemantaranjan, A. (2017). Iodine: a unique element with special reference to soil-plant-air system. Advances in Plant Physiology (Vol. 17), 314.
[45] Dwivedi, P., & Prasann, K. (2016). Objective plant physiology. Objective plant physiology., (Ed. 2).
[46] Kumar, P. (2014). Significance of soil-root system and aquaporins for water homeostasis in plant-a review. Advances in Plant Physiology (Vol. 15), 15, 324.
[47] Kumar, P. (2013). Food Security and Nutritional Safety: A Challenge Ahead. Journal of Functional and Environmental Botany, 3(1), 12-19.
[48] Prasann, K., Biswapati, M., & Padmanabh, D. (2013). Combating heavy metal toxicity from hazardous waste sites by harnessing scavenging activity of some vegetable plants. Vegetos, 26(2), 416-425.
[49] Prasann, K. (2012). Feeding the future: crop protection today. Acta Chimica and Pharmaceutica Indica, 2(4), 231-236.
[50] Kumar, P., & Dwivedi, P. (2011). Future Habitat Loss: Greatest Threat to the Soil Microbial Biodiversity. Journal of Functional And Environmental Botany, 1(2), 82-90.
[51] Kumar, P., Singh, B. N., & Dwivedi, P. Plant Growth Regulators, Plant Adaptability And Plant Productivity: Areview On Abscisic Acid (Aba) Signaling In Plants Under Emerging Environmental Stresses. Sustaining Future Food Security In Changing Environments, 81.