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Ethnobotany of wild and semi-wild edible plants of the Madurese Tribe in Sampang and Pamekasan Districts, Indonesia

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Abstract. *Al Yamini TH, Djuita NR, Chikmawati T, Purwanto Y. 2023. Ethnobotany of wild and semi-wild edible plants of the Madurese Tribe in Sampang and Pamekasan Districts, Indonesia. Biodiversitas 24: 947-957.* This study aimed to inventory, identify, and characterize the diversity of wild and semi-wild edible plants (WSEPs) utilization; analyze and determine the highest importance of WSEPs based on socio-cultural, economic, and ecology; and analyze the sustainable management of WSEPs. This study was carried out in Sampang and Pamekasan Districts. The qualitative data collection was obtained by open, semi-structured, and structured interviews, while quantitative data were assessed using the pebble distribution method (PDM). Data were analyzed using the Index of Cultural Significance (ICS), Use Values (UVs), Local User's Value Index (LUVI), economic valuation, and important value index (IVI). The Madurese utilized 122 plant species belonging to 47 families of WSEP. The Madurese in Pamekasan District used more plant species (90 species of 30 families) than Sampang District (84 species of 20 families). These plant species were used as sources of carbohydrates, fruits, vegetables, seeds, spices, and beverages. The dominant plant families used are Anacardiaceae, Fabaceae, and Myrtaceae. Accem (*Tamarindus indica*) is the species with the highest ICS, UV, and LUVI values in both districts. Accem and tarebung (*Borassus flabellifer*) had the highest economic value. These plant species are also suggested to be maintained their species availability in their habitat.

Keywords: Diversity, edible plants, food plants, ICS

INTRODUCTION

Wild and semi-wild edible plants (WSEPs) are food plants that grow without human intervention or are not cultivated. These plants produce food sources such as staple foods, fruits, vegetables, or even spices for local communities (Sujarwo et al. 2016). The utilization of WSEPs is still practiced by local communities in various parts of the world today and is one way to support their lives (Ju et al. 2013; Sujarwo et al. 2014; García-Herrera et al. 2014). WSEPs has an important role in improving food security, especially during the lean season, increasing food diversification, and as a source of additional nutrients that are beneficial for health (Bacchetta et al. 2016). Based on the study's results, the content of micronutrients such as vitamins and minerals in some WSEPs is higher than nutrients in cultivated plants. For example, the folic acid content in purslane plants (*Portulaca oleracea*) is higher than in other cultivated plants (Addis 2013; Ranfa et al. 2014).

Currently, the utilization of WSEPs, an ancestral tradition, is increasingly abandoned (Cruz et al. 2013). Furthermore, socioeconomic changes, globalization, and modern lifestyles have led to the erosion of local knowledge on plant use in the community (Ju et al. 2013; Shrestha 2013; Wiryono et al. 2017; Ojelel et al. 2019). Consequently, this can threaten the sustainability of biological biodiversity and lead to weakened food security and increased environmental degradation (Addis 2013). Furthermore, the high rate of land conversion for housing and industry is increasing all the time (Amente 2017; Duguma 2020), especially on Madura Island. It is feared that this could threaten the existence of WSEPs plant species in nature and reduce the local knowledge of the Madurese community regarding the utilization of WSEPs species.

Madura is one of the islands that is administratively part of East Java Province, but the Madurese tribe that inhabits it has a different culture from the Javanese ethnic group. Madura Island is divided into West Madura and East Madura (Hefni 2008). West Madura, which consists of Bangkalan and Sampang districts, has a topography with high rainfall, while East Madura, which consists of Pamekasan and Sumenep districts, has low rainfall (Sigit et al. 2016). The difference in geographical conditions between West Madura and East Madura drives the Madurese to have a different culture of food plant utilization.

Madurese people have local knowledge about using plant resources to meet their needs. Local knowledge of the Madurese community that has been widely known is the utilization of plant species diversity as traditional medicinal materials (Zaman et al. 2013). However, local knowledge about using WSEPs in Madura as a food source has never been disclosed.

The Madurese community is one of the tribes with local wisdom on utilizing WSEPs. Local knowledge and wisdom about utilizing WSEPs is a form of adaptation strategy to Madura Island's dry and less fertile environmental conditions, so they can only depend partially on the agricultural sector (Sigit et al. 2016). Therefore, the Madurese people need efforts to fulfill their needs, especially food fulfillment, by utilizing the species of WSEPs found in their environment. In addition, the problems faced by the Madurese community are the low level of food security and the high poverty rate. This condition creates an excellent urgency for further study to make these resources available for future generations and food sovereignty and security, especially in the Sampang and Pamekasan Districts. This study aims to (i) inventory, identify and characterize the diversity of species and utilization of WSEPs utilized by the Madurese community in Sampang and Pamekasan Districts; (ii) analyze and determine the species of WSEPs that have the highest importance value, including economic value, ecological value, and socio-cultural value; and (iii) analyze the sustainable management and development of WSEPs.

MATERIALS AND METHODS

Study area and period

This research was conducted from July 2021 to June 2022. Data collection through interviews and plant sampling was conducted in two districts, namely Sampang District (7°2'24.72 "S, 113°14'21.84 "E) and Pamekasan District (7°6'18.36 "S, 113°31'30.72E) (Figure 1). From each section, six villages were selected based on different topographic conditions, ranging from the southern coastal area to the northern part towards the mainland. Villages in Sampang Regency are Dharma Camplong, Apaan, Samaran, Tambak, Gunung Rancak, and Karang Penang Oloh. The selected villages in Pamekasan Regency include Bunder, Lembung, Proppo, Pakong, West Waru, and Pegantenan.

Sampang and Pamekasan districts have a varied topography, ranging from lowlands to highlands. The altitude of the research site in Sampang Regency ranges from 6-216 meters above sea level, with rainfall ranging from 707-2,504 mm. This district has two seasons: the dry season in May-October and the rainy season in November-April. Meanwhile, Pamekasan Regency has an altitude ranging from 2-320 meters above sea level, with rainfall ranging from 838-1,777 mm. This regency has two seasons: the rainy season in December-April and the dry season in May-November.

Data collection procedures

Qualitative and quantitative data were collected by conducting open-ended, semi-structured, and structured interviews by visiting the homes of key informants and regular informants directly. Key informants were selected using a purposive sampling method based on the research objectives. The selection of ordinary respondents used a combination method between snowball sampling and purposive sampling by considering (i) respondents who have used and are currently using wild plants as food obtained from nature; (ii) respondents who know the species of wild plants as food, how to use and process them. In addition to interviews, another method used was field observation with local informants in their natural habitat to collect plant specimens. The data collected included the diversity of WSEPs species, harvesting locations, parts used, habitus, frequency of use, preference level, market price, and other uses of WSEPs besides food ingredients. Quantitative data collection of plant importance values was calculated using the Pebble Distribution Method (PDM) referring to Sheil et al. (2004).

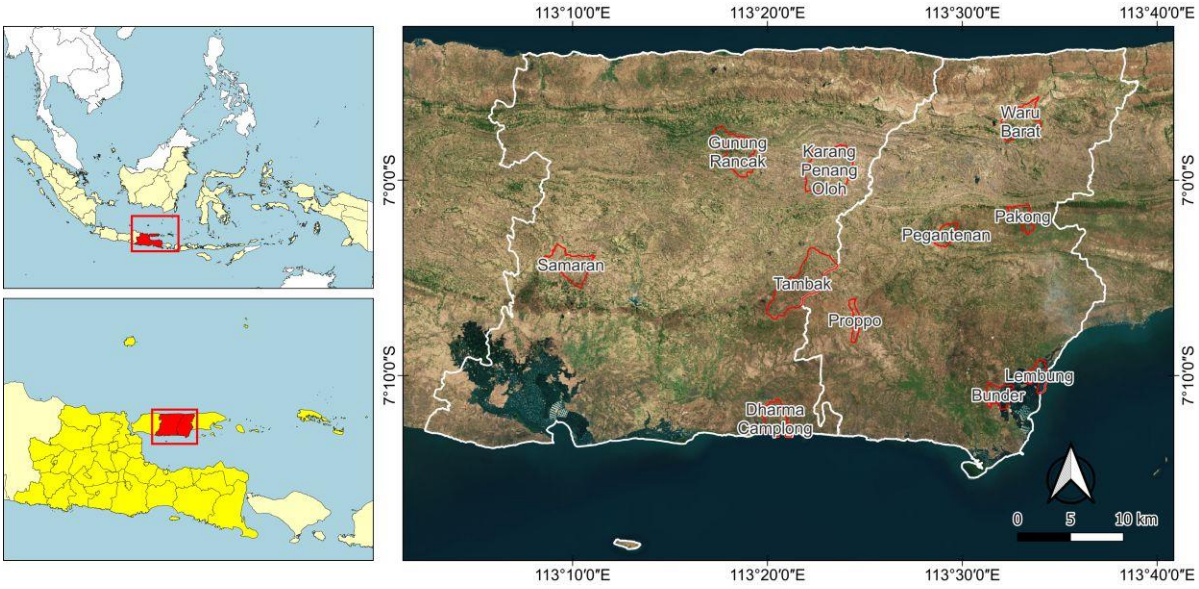

Figure 1. The map shows the sites of studies areas, Sampang and Pamekasan districts, East Java Province shown in red, indicate the sub-districts of the research location

Herbarium-making is carried out for plant species that could not be identified during field observations. The herbarium-making process was based on standard methods (Das 2020). First, specimens were dried and then carried out the identification process using plant identification books by matching the morphological characteristics of specimens with morphological traits in the book "Plants for Human Consumption" (Kunkel 1984) and "Flora of Java" (Backer and Van den Brink 1968). The plant identification process was carried out at the Integrated Laboratory of Trunojoyo University, Madura. The scientific names obtained were verified with two websites Global online sites Biodiversity Information Facility (GBIF) (https://www.gbif.org/) and plant of the world (https://powo.science.kew.org/).

Data analysis

Analysis of Importance Value

Ethnobotanical quantitative data were analyzed using several approaches, namely the Index of Cultural significance (ICS), Use Values (UVs), and Local User's Value Index (LUVI). The formulas used are as follows:

Index of Cultural Significance (ICS)

Index of Cultural significance (ICS) is used to determine the importance of each plant species that refers to Turner (1988):

$$ICS = \sum_{i=1}^{n} (q \times i \times e)ni$$

Where; q is the quality value which is the use number of a plant species, i is the intensity value which is the value of the intensity of utilization of beneficial plant species, and e is the exclusivity value which is the value of the level of exclusivity or preference.

Use Values (UVs)

Use value is analyzed using a calculation that refers to Phillips et al. (1994) as follows:

$$UV = \Sigma U / N$$

Where; U is the number of uses mentioned by informants for a plant species, and N is the total number of informants interviewed for a plant species. If a plant obtains a high UV value, it indicates many usage reports for the plant, while a low score shows fewer use reports cited by informants.

Local User's Value Index (LUVI)

Data on the local importance value of a plant species was analyzed using calculations that refer to (Sheil et al. 2004). The formula used is:

$$LUVI = Gij = \Sigma kategori{=}jGij = RWj \times Rwij$$

Where; I is the species, J is the use, Gij is the individual value, RWj is the weight given to the broad class of use to which the specific j belongs, Rwij is the relative weight within the category j for the uses of species i that qualify as members of j.

Importance Value Index (IVI)

Data on the importance value index of a plant species was analyzed using calculations that refer to (Ismail et al. 2017). The formula used is:

$$IVI = RF + RD + Rdo$$

Where; RF is relative frequency, RD is relative density, and RDo is relative dominance. Data on the importance value index of a plant species is used to determine the conservation strategy by comparing the IVI with the ICS value (Table 1).

Economic valuation

The economic valuation of WSEPs species uses a direct approach using market prices. The parameters used to calculate the economic value are the amount harvested per tree or hectare, the frequency of harvesting in one year, and the total harvest per household per plant species.

RESULTS AND DISCUSSION

Diversity of wild and semi-wild edible plants

Madurese people utilize about 122 species from 47 families of WSEPs (Table 6). The number of WSEPs species differs in the research locations, where in Sampang District, there are 84 species belonging to 20 families. In Pamekasan District, there are 90 species belonging to 30 families of WSEPs. The most diverse species found belongs to the Anacardiaceae family, consisting of 26 species, including its varieties, followed by the Fabaceae family, with nine, and Myrtaceae, at eight.

Table 1. Classification of conservation strategies based on IVI and ICS scores

Comparison category		Conservation strategy
IVI	ICS	
High	Low	Assessing and developing other potentials
High	High	Maintaining the availability of species
Low/moderate	High	Cultivating species
Low/Moderate	Low	Cultivating, studying, and developing another potential

Notes: IVI is the importance value index, and ICS is an index of cultural significance

The highest plant species diversity in Sampang District was found in Gunung Rancak Village. This village is located at the highest point in Sampang Regency, 216 meters above sea level. The number of WSEPs species found was 45 species belonging to 22 families. This village's highest types of WSEPs come from the Anacardiaceae family, with as many as three species: *Mangifera odorata,* and *Mangifera lalijiwa,* and ten *Mangifera indica* varieties, namely pao re'dere', pao kangsel, pao gentong madhu, pao kedhe', pao kocor, pao ote, pao dudul, pao teke', pao paka' madhu and pao carang. The most diverse WSEPs species in Pamekasan District was found in Bunder Village. This village is located in the lowlands with an altitude of 2 meters above sea level. The number of species found was 46 species belonging to 30 families. The most prominent family is Fabaceae consisting of as many as five species, namely *Tamarindus indica, Erythrina variegata, Leucaena leucocephala, Sesbania javanica,* and *Macroptilium lathyroides*. The second most prominent family, Anacardiaceae, consists of three species, namely *Lannea coromandelica, M. lalijiwa,* and three *M. indica* varieties, namely pao golek, pao jenali, and pao tepong. The third largest family is Amaranthaceae, with three species: *Suaeda maritima, Amaranthus hybridus,* and *Amaranthus viridis*.

Based on the number of species most utilized by the Madurese community in both Sampang and Pamekasan Districts, it shows that topographic conditions at the research site do not affect the number of species used by the community. However, topographic conditions affect the diversity of species utilized by the community. That is because a plant species requires appropriate conditions and environmental factors to grow well in its habitat. For example, *S. maritima* only grows in coastal areas with high soil salinity levels and is not found in other areas. Therefore, the availability of species in nature affects the level of utilization of plant species in a community.

In addition, several plant species are only utilized in one district. For example, plant species used only in Sampang District include *Aegle marmelos, Annona reticulata, Ardisia elliptica, Psidium guajava, Bidens pilosa, Ocimum tenuiflorum, Antidesma ghaesembilla, Ampelocissus arachnoidea, Protium javanicum,* and nine local mango varieties. Plant species in Pamekasan Regency are 25 species such as *Cleome rutidospema, Wrightia pubercens, Murraya koenigii, L. coromandelica, Phyllanthus reticulatus, Garcinia dulcis, Cyperus rotundus, Hellenia speciosa, Trichosanthes costata, Trianthema portulacastrum,* and four local mango varieties.

The high number of usage plant species in Pamekasan Regency is due to the drier environmental conditions with low rainfall. This condition causes people in this district to be unable to depend entirely on cultivated plants' food needs, so people also use more wild plants as an additional food source.

Growth form, part of use and habitat

The WSEPs habitus utilized by the Madurese community are trees, herbs, shrubs, and vines. Based on the interview, it was found that the Madurese community most widely uses the tree habitus. The percentage of species with tree habitus is 56%, herbaceous 21%, shrubs 12%, and vines 11% (Figure 2A). The Madurese community most widely utilizes plants with tree habitus because they can provide food throughout the season, especially during the dry season, where other plants with habitus herbs and shrubs do not grow.

Madurese people utilize six plant parts, namely fruit 80 species, leaves 36 species, seeds ten species, tubers ten species, sap two species, and shoot two species. The most utilized plant part is fruit (Figure 3). Fruit contains sugar, starch, water, vitamins, and minerals, which are beneficial for humans if consumed (Rejman et al. 2021). Fruit generally has a sweet or sour taste and is one of the healthy foods. Fruit is usually eaten as fresh fruit or processed into other foods such as salad, jam, and candied, for example, the fruits of *Phyllanthus acidus* and *Antidesma bunius*.

Based on interviews and surveys at the research site, WSEPs species grow in several habitat types: moorland, yard, garden, rice field, and salt pond (Figure 2B). WSEPs species are most commonly found in moorland habitats. Moorland is the most dominant land on Madura Island, so many WSEPs species are found in this habitat (47%). The proportion of moorland area in Sampang District is 58.8%, and in Pamekasan District is 73.6% (Hefni 2008).

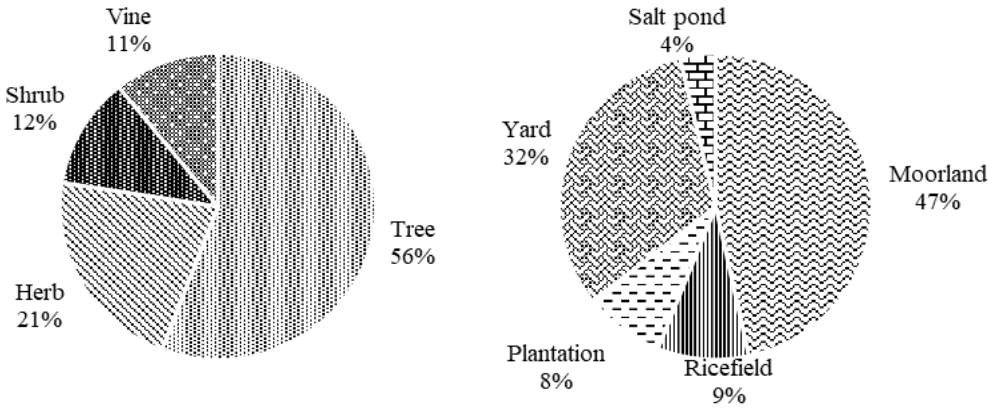

Figure 2. The percentage of plants' growth form (A) and the percentage of plants' habitat (B) used by the Madurese Tribe in Sampang and Pamekasan Districts, Indonesia

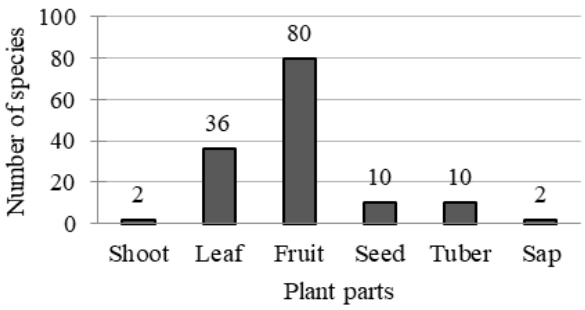

Figure 3. Number of plant parts used by the Madurese community in Sampang and Pamekasan Districts, Indonesia

Mode of use

Source of carbohydrates

The primary sources of carbohydrates for Madurese are rice and corn. However, Madurese also utilizes 11 other species as carbohydrate sources, *Pachyrhizus erosus, Colocasia esculenta, Dioscorea hispida, Dioscorea esculenta, Amorphophallus variabilis, C. rotundus, Dioscorea alata, H. speciosa, Amorphophallus paeoniifolius, Rhizophora stylosa,* and *Eleocharis dulcis*. Most of the carbohydrates source come from tubers such as *D. alata*. These tubers are usually processed before consumption, such as by boiling. In addition, some tubers must be processed in a particular way, soaking and drying to remove the poisonous content, for example, *D. hispida*. The tubers of this plant contain hydrogen cyanide compounds that have toxic properties if they enter the body (Lokman et al. 2017; Estiasih et al. 2022). The tubers of *H. speciosa* and *A. variabilis* are only taken for their starch to be processed into porridge and are known to treat gastric pain. This plant is also used as a medicine to treat diabetes by people in South India (Ramya and Dhamotharan 2019). The fruit of *R. stylosa* is used as a substitute for rice by chopping, drying, and steaming.

Source of vegetables

Madurese people utilize 42 species of plants as vegetables, *S. maritima, Pluchea indica, Cleome rutidosperma, Wrightia pubescens, Marsdenia brunoniana, E. variegata, L. coromandelica, Paederia foetida, B. pilosa, Morinda citrifolia, P. oleracea, A. hybridus, A. viridis, T. portulacastrum, M. lathyroides,* and *S. javanica*. Plant species used as vegetables by coastal communities are *S. maritima* and *S. portulacastrum*. These plants have a salty taste, and people can distinguish plants that have a very salty taste from the color of the stems and leaves. For example, plants with red or orange stems and leaves taste saltier than green ones, so people only harvest green plants.

Portulaca oleracea is a vegetable commonly found in rice fields and moorlands. This plant is usually found during the rainy season, especially after the rice harvest season. In addition, this plant grows a lot on newly prepared rice fields for tobacco planting at the beginning of the dry season and becomes a dominating weed. People harvest this plant to be processed into vegetable soup, stir-fried or boiled, and *lalab* is eaten with sambal. *P. oleracea* plants have the highest omega-3 fatty acid content compared to other cultivated vegetables such as spinach, mustard greens, and lettuce (Nemzer et al. 2020).

Source of fruits

A total of 68 plant species are utilized as a source of fruits, such as *T. indica, Ziziphus mauritiana, A. bunius, Lantana camara, Syzygium cumini, Ficus montana, Melastoma malabathricum, M. citrifolia, Schleichera oleosa, A. ghaesembilla, A. arachnoidea, Phyllanthus emblica, M. lalijiwa, A. occidentale, M. odorata, Passiflora foetida, Coccinia grandis, P. javanicum,* and *Physalis angulata*. In addition, people prefer fruits that have a sour or sweet taste. Therefore, these fruits are usually eaten fresh or processed into a salad, such as *A. bunius*. This fruit contains anthocyanin, phenol, and flavonoid compounds (Suravanichnirachorn et al. 2018).

Lengmalengan fruit (*A. arachnoidea*) has a unique way of consumption. The name lengmalengan originated from the word 'maling' or thief. Before consuming this fruit, people who pick the fruit must be chased while shouting thief. This activity is believed to eliminate the fruit's itching when eaten. According to Dalimunthe et al. (2016), plants of the *Ampelocissus* genus have the characteristics of flower buds covered by wooly hairs. When the fruit is ripe, the remaining hairs are still attached around the fruit and cause itching in the throat. Therefore, the chasing activity before eating the fruit can indirectly shed the remaining hairs on it and reduce the itching when it is consumed.

Source of beverage ingredients

A total of five plant species are utilized as beverage ingredients, namely *T. indica, Arenga pinnata, M. citrifolia, B. flabellifer*, and *R. stylosa*. *T. indica* fruit is processed by brewing and adding sugar. The leaves are processed into herbal drinks, *sinom* or *kunir asam*, mixed with *Curcuma domestica*, brown sugar, and water. This drink is believed to treat fever, menstrual pain, thrush, and dysentery. *A. pinnata* and *B. flabellifer* are utilized for their inflorescent sap as a beverage called *la'ang*. *La'ang* has a short shelf life if stored at room temperature due to the fermentation process. Madurese people preserve the *la'ang* by boiling it and adding slices of *M. citrifolia* and *Capsicum frutescens* to flavoring. *La'ang* from the *B. flabellifer* plant has health effects such as laxatives and diuretics (Krishnaveni et al. 2020). *R. stylosa* fruit is used as a beverage ingredient, a substitute for coffee. This drink is believed to have health benefits such as increasing body stamina, having aphrodisiac properties, and treating diabetes and high blood pressure. It is proven in several studies that extract from *R. stylosa* have health benefits such as anti-diabetes (Usman et al. 2019) and antibacterial (Burhanuddin et al. 2019).

Source of seeds

Nine plant species are a source of seeds, such as *Adenanthera pavoniana, Anacardium occidentale, Artocarpus heterophyllus, Artocarpus camansi, Terminalia catappa, Sterculia foetida, Ceiba pentandra, Psophocarpus tetragonolobus,* and *T. indica*. *T. indica* seed in Madurese is called maghi' and is processed by roasting, then soaking overnight to soften the

seeds before eating. Apart from maghi', *A. pavonina* seed is a source of seeds that is also in demand by the community. *A. pavonina* seeds that have been roasted are usually very popular with children because the seed coat is usually used as a toy. *A. pavonina* seeds have been studied to be processed into tempeh (Damayanti et al. 2022). The protein content of *A. pavonina* seeds is around 22-31% (Krishnan et al. 2022), while the protein content of *maghi'* is 18.4-26.9% (Anjali et al. 2020). Therefore, both seeds of *A. pavonina and T. indica* can be an alternative source of protein for the community.

Seasoning source

Six species of WSEPs are used as a seasoning source: *Borassus flabellifer, M. lalijiwa, Bergera koenigii, O. tenuiflorum, Syzygium polyanthum,* and *T. indica. Bergera koenigii* leaves are used to boost the flavor of curry dishes. This plant usually grows around the yard or by the roadside around the village. The fruits of *T. indica* and *M. lalijiwa* are used as spices to add a sour taste to dishes, especially fish cooking. The leaves of *O. tenuiflorum* are used to season fish dishes and treat asthma. The Malay people in Upper Kampar Kiri Riau utilize *O. tenuiflorum* as a vegetable. In addition, this plant has been used as an antiseptic, antistress, analgesic, anti-inflammatory, immunomodulatory, and antimicrobial (Borah and Biswas 2018).

The important value of wild and semi-wild edible plants

Index cultural significance (ICS)

The plant that has the highest ICS value is *T. indica* (54-115), followed by *Borassus flabellifer* (99), *Ceiba pentandra* (32-90), *Adenanthera pavonina* (45-59), *Scleichera oleosa* (44-57), *Morinda citrifolia* (29-51) (Table 2). *T. indica* has the most utilization compared to other plant species, such as a source of fruits, spices, seeds, and beverages. In addition, it is also used as a medicinal ingredient, such as to treat fever, internal heat, and stomach pain. The leaves are used as animal feed, wood as building materials, charcoal, and firewood. Accem (*Tamarindus indica*) has a high exclusivity value as a source of spices or herbs, significantly as the main ingredient to add a sour taste to dishes. In addition, *T. indica* has a high intensity of utilization as a seasoning. This plant species is used as an antimicrobial, antiallergic, analgesic, and antiemetic (Menezes et al. 2016). Its also used as a menstrual pain reliever in North Banyumas (Utaminingrum et al. 2022).

Use value (UV)

Plant species that have high UV values are *T. indica* (2.91-3.91), followed by *Borassus flabellifer* (3.91), *Anacardium occidentale* (1.5-2), *Ceiba pentandra* (1.16-1.83), *Syzygium polianthum* (1.5-1.66), *Morinda citrifolia* (0.61-1) (Table 3). *T. indica* has more than one category of utilization in the food group, namely as a source of fruits, spices, beverage ingredients, and seeds. In addition, this plant is evenly utilized by the Madurese people, so it has a high UV value. This result also follows Bibi et al. (2022), who revealed that *T. indica* is an essential plant in the Tanawal area, Lesser Western Himalayas, Pakistan. *B. flabellifer* is also a species with a high use value because it is used as a source of fruit, beverage, and spice. The utilization of this plant is also extensive, especially as a condiment. The inflorescent sap is fermented into vinegar, utilized by the community, and sold outside the region.

Table 2. Plant species with the highest value of Index Cultural Significance (ICS) used by the Madurese in Sampang and Pamekasan Districts, Indonesia

Species	Sampang						Pamekasan					
	DC	AP	SM	TB	KPO	GR	BD	LB	PP	PK	WB	PG
A.pavonina	59	-	-	-	50	-	-	-	-	-	45	-
B. flabellifer	-	-	-	-	-	-	99	-	-	-	-	-
C. pentandra			48		55				37	32	90	
M. citrifolia	51	30	30	51	39	30	29	29	-	29	51	-
S. oleosa	45	57	-	-	-	-	-	44	57	-	-	54
T. indica	78	115	82	100	66	54	87	82	81	68	109	109

Notes: Sampang (DC: Dharma Camplong, AP: Apaan, SM: Samaran, TB: Tambak, KPO: Karang Penang Oloh, GR: Gunung Rancak); Pamekasan (BD: Bunder, LB: Lembung, PP: Proppo, PK: Pakong, WB: Waru Barat, PG: Pegantenan)

Table 3. Plant species with the highest Use Value (UV) used by Madurese in Sampang and Pamekasan Districts, Indonesia

Species	Sampang						Pamekasan					
	DC	AP	SM	TB	KPO	GR	BD	LB	PP	PK	WB	PG
A. occidentale	-	-	-	-	2	2	-	-	1.5	-	2	-
B. flabellifer	-	-	-	-	-	-	3.91	-	-	-	-	-
C. pentandra			1.58		1.83				1.2	1.83	1.16	-
M. citrifolia	1	0.61	1	0.9	0.83	-	1.58	1	-	1	1	-
S. polyanthum		-	1.66	-	-	1.5	-	-	2	1.66	-	-
T. indica	3.58	3.38	2.91	3	3	3	3.91	3.58	3.3	3.3	3.41	3.3

Notes: Sampang (DC: Dharma Camplong, AP: Apaan, SM: Samaran, TB: Tambak, KPO: Karang Penang Oloh, GR: Gunung Rancak); Pamekasan (BD: Bunder, LB: Lembung, PP: Proppo, PK: Pakong, WB: Waru Barat, PG: Pegantenan)

Table 4. Plant species with the highest Local User's Value Index (LUVI) used by Madurese in Sampang and Pamekasan Districts, Indonesia

Species	Sampang						Pamekasan					
	DC	AP	SM	TB	KPO	GR	BD	LB	PP	PK	WB	PG
A. occidentale	-	-	-	-	3.81	3.88	-	-	-	-	3.93	-
S. polyanthum	-	-	3.27	-	-	-	-	-	2.31	3.57	-	-
B. flabellifer	-	-	-	-	-	-	4.10	-	-	-	-	-
R. stylosa	-	-	-	-	-	-	-	3.02	-	-	-	-
S. coetjape	-	-	-	-	-	-	-	-	-	3.18	-	-
T. imdica	3.46	3.51	4.67	3.59	4.12	2.96	4.10	3.72	3.59	3.50	3.05	3.76

Notes: Sampang (DC: Dharma Camplong, AP: Apaan, SM: Samaran, TB: Tambak, KPO: Karang Penang Oloh, GR: Gunung Rancak); Pamekasan (BD: Bunder, LB: Lembung, PP: Proppo, PK: Pakong, WB: Waru Barat, PG: Pegantenan)

Local user's value index (LUVI)

Plant species that have the highest LUVI are *T. indica* (2.96-4.67%), followed by *B. flabellifer* (4.10%), *A. occidentale* (3.81-3.93%), *S. polyanthum* (2.31-3.57%), *S. coetjape* (3.18%), and *R. stylosa* (3.02%) (Table 4). *T. indica* has the highest value due to its utilization as the primary spice to add sour flavor in cooking. Likewise, *S. polyanthum* as a spice is considered necessary by the community. *B. flabellifer* is considered important because this plant has many uses. In addition, vinegar and brown sugar from *B. flabellifer* sap are the sources of spices that are widely used in cooking, especially in making pickles or sambal (chili sauce), which is often consumed by the community. Finally, *A. occidentale* has a high value because this plant is one of the sources of side livelihoods for the community. After all, dried seeds have a relatively high selling price.

The economic value of wild and semi-wild edible plants

Madurese people harvest wild plants from nature to fulfill subsistence needs. However, when the amount harvested is abundant, the community will sell wild plants in the market or on the roadside. The generally traded species are fruits such as *A. occidentale, A. heterophyllus, B. flabellifer, T. indica, S. oleosa, P. acidus, P. javanicum, S. cumini,* and *Z. mauritiana.* Some wild vegetables are also sold, either fresh or processed, such as *S. maritima* and *L. leucocephala*. WSEPs have economic value that can provide financial income to the community. Therefore, the community usually sells WSEPs that have economic value to be sold in the market, either in the form of fresh raw products or those that have been processed into food (Karabak 2017; Moksia et al. 2019). Plant species that have the highest economic value in the community are *A. occidentale* (IDR 2.4-4.8 million/year), *A. heterophyllus* (IDR 0.4-1.2 million/year), *B. flabellifer* (IDR 3.4 million/year), and *T. indica* (IDR 0.48-2.8 million/year) (Table 5).

Conservation strategy of wild and semi-wild edible plants

Madurese people need to become more familiar with the culture of planting trees because Madura's dry soil conditions make people who plant trees have to take care of them, especially during the dry season. However, Madurese people know the important value of trees, especially for shade or animal feed during the dry season when no grass or other herbaceous plants are around them. The community also has a local wisdom not to cut down trees in the spring area because it will cause drought. This local wisdom is similar to the people of North Aceh not to cut trees around springs within a 200 m radius (Suwardi et al. 2020).

The availability of WSEPs is essential for the Madurese community because these plants grow wild or uncultivated, so they require attention to maintain their availability. The correlation between the importance of cultural significance value (ICS) and plant importance value index (IVI) can help determine the conservation strategy of WSEPs utilized by the Madurese community. Plant species that need conservation efforts to maintain species availability are *T. indica* (IVI 34,1; ICS 81,67) and *A. occidentale* (IVI 32,68; ICS 33) (Table 7). These two species have high ICS and IVI values, so it is recommended to maintain their population so that the needs of these plant species remain available.

Table 5. Plant species with the highest economic value used by Madurese in Sampang and Pamekasan Districts, Indonesia

Species	Economic value/HH/Year (IDR million)											
	Sampang						Pamekasan					
	DC	AP	SM	TB	KPO	GR	BD	LB	PP	PK	WB	PG
T. indica	0.48	0.48	1.04	0.54	0.78	-	-	2.8	2.2	1.75	2.4	2.4
A. occidentale	-	-	-	-	2.8	4.8	-	-	-	-	4.8	-
A.heterophyllus	0.4	-	-	1.2	-	-	-	-	-	-	-	-
B. flabellifer	-	-	-	-	-	-	3.4	-	-	-	-	-

Notes: Sampang (DC: Dharma Camplong, AP: Apaan, SM: Samaran, TB: Tambak, KPO: Karang Penang Oloh, GR: Gunung Rancak); Pamekasan (BD: Bunder, LB: Lembung, PP: Proppo, PK: Pakong, WB: Waru Barat, PG: Pegantenan), HH: head of houshold

Table 6. Wild and semi-wild edible plants used by the Madurese in Sampang and Pamekasan Districts, Indonesia

Species	Family	Vernacular name	Growth Form	Part of use	Mode of use
Acalypha indica L.	Euphorbiaceae	Tengantegan	Herb	Leaf	Vegetable
Adenanthera pavonina L.	Fabaceae	Sageh	Tree	Seed	Seed source
Aegle marmelos (L.) Corrêa	Rutaceae	Billa	Tree	Fruit	Fruit Source
Amaranthus hybridus E.H.L.Krause	Amaranthaceae	Tarnyak binik	Herb	Leaf	Vegetable
Amaranthus spinosus L.	Amaranthaceae	Tarnyak durih	Herb	Leaf	Vegetable
Amaranthus viridis L.	Amaranthaceae	Tarnyak lakek	Herb	Leaf	Vegetable
Amorphophallus paeoniifolius (Dennst.) Nicolson	Araceae	Sobeg	Herb	Tuber	Carbohydrate
Amorphophallus variabilis Blume	Arecaceae	Lorkong	Herb	Tuber	Carbohydrate
Ampelocissus arachnoidea (Hassk.) Planch.	Vitaceae	Lengmalengan	Vine	Fruit	Fruit source
Anacardium occidentale L.	Anacardiaceae	Pattek	Tree	Fruit, seed	Fruit source, seed source
Ananas comosus (L.) Merr.	Bromeliaceae	Nanas	Herb	Fruit	Fruit source
Annona reticulata L.	Annonaceae	Binoah	Tree	Fruit	Fruit source
Annona squamosa L.	Annonaceae	Sarkajeh	Shrub	Fruit	Fruit source
Uvaria dulcis Dunal	Annonaceae	Kalak	Shrub	Fruit	Fruit source
Antidesma bunius (L.) Spreng.	Phyllanthaceae	Burnih	Tree	Fruit	Fruit source
Antidesma ghaesembilla Gaertn.	Phyllanthaceae	Lang mantek	Tree	Fruit	Fruit source
Ardisia humilis Vahl	Primulaceae	Campenih	Shrub	Fruit	Vegetable, fruit source
Arenga pinnata (Wurmb) Merr.	Arecaceae	Aren	Tree	Fruit, sap	Beverage
Artocarpus camansi Blanco	Moraceae	Kolor	Tree	Fruit, seed	Vegetable, seed source
Artocarpus heterophyllus Lam.	Moraceae	Nangkah	Tree	Fruit, seed	Vegetable, fruit source, seed source
Avicennia alba Blume	Acanthaceae	Peapeh	Tree	Leaf	Vegetable
Bambusa spinosa Roxb.	Poaceae	Perreng durih	Tree	Shoot	Vegetable
Benincasa hispida (Thunb.) Cogn.	Cucurbitaceae	Kondur	Vine	Fruit	Vegetable
Bidens pilosa L.	Asteraceae	Ketol	Herb	Leaf	Vegetable
Borassus flabellifer L.	Arecaceae	Tarebung	Tree	Fruit, sap	Fruit source, beverage
Capparis micrantha A.Rich.	Capparidaceae	Sannik	Shrub	Fruit	Fruit source
Ceiba pentandra (L.) Gaertn.	Malvaceae	Kapoh	Tree	Leaf, fruit, seed	Vegetable, fruit source, seed source
Cleome rutidosperma DC.	Cleomaceae	Bhubuan	Herb	Leaf	Vegetable
Coccinia grandis (L.) Voigt	Cucurbitaceae	Temon tekos	Vine	Leaf, fruit	Vegetable, fruit source
Colocasia esculenta (L.) Schott	Araceae	Carpot	Herb	Leaf	Vegetable, carbohydrate
Commelina benghalensis L.	Commelinaceae	Tongcentongan	Herb	Leaf	Vegetable
Cyperus rotundus L.	Cyperaceae	Muttah	Herb	Tuber	Carbohydrate
Dioscorea alata L.	Dioscoreaceae	Obih	Vine	Tuber	Carbohydrate
Dioscorea esculenta (Lour.) Burkill	Dioscoreaceae	Kaburen	Vine	Tuber	Carbohydrate
Dioscorea hispida Dennst.	Dioscoreaceae	Ghedung	Vine	Tuber	Carbohydrate
Erythrina variegata L.	Fabaceae	Dhedhep	Tree	Leaf	Vegetable
Ficus montana Burm.f.	Moraceae	jekbujeen	Shrub	Fruit	Fruit source
Flacourtia indica (Burm.f.) Merr.	Flacourtiaceae	Rokem kenik	Shrub	Fruit	Fruit source
Flacourtia rukam Zoll. & Moritzi	Flacourtiaceae	Rokem	Tree	Fruit	Fruit source
Garcinia dulcis (Roxb.) Kurz	Clusiaceae	Monduh	Tree	Fruit	Fruit source
Gigantochloa apus (Schult.f.) Kurz	Poaceae	Pereng keles	Tree	Shoot	Vegetable
Hellenia speciosa (J.Koenig) S.R.Dutta	Costaceae	Paceng	Herb	Tuber	Carbohydrate
Ipomoea aquatica Forssk.	Convolvulaceae	Kangkong sabe	Herb	Leaf	Vegetable
Lablab purpureus (L.) Sweet	Fabaceae	Rakarah	Vine	Fruit	Vegetable
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	Kajuh jeren	Tree	Leaf	Vegetable
Lantana camara L.	Verbenaceae	Campelot	Shrub	Fruit	Fruit source
Leucaena leucocephala (Lam.) de Wit	Fabaceae	Malandengan	Tree	Leaf, fruit, seed	Vegetable
Macroptilium lathyroides (L.) Urb.	Fabaceae	To'otoan	Herb	Fruit	Vegetable
Mangifera indica L.	Anacardiaceae	Pao Carang	Tree	Fruit	Fruit source
Mangifera lalijiwa Kosterm.	Anacardiaceae	Pao taber	Tree	Leaf, fruit	Vegetable, fruit source
Mangifera odorata Griff.	Anacardiaceae	Pokaenih	Tree	Fruit	Fruit source
Marsdenia brunoniana Wight & Arn.	Apocynaceae	Bletah	Herb	Leaf	Vegetable
Melastoma sanguineum Sims	Melastomaceae	Kemanden	Shrub	Fruit	Fruit source
Momordica charantia L.	Cucurbitaceae	Reparean	Vines	Leaf, fruit	Vegetable
Morinda citrifolia L.	Rubiaceae	Kodhuk	Tree	Leaf, fruit	Vegetable, fruit source, beverage
Moringa oleifera Lam.	Moringaceae	Maronggih	Tree	Leaf, fruit	Vegetable
Muntingia calabura L.	Muntingiaceae	Kersen	Tree	Fruit	Fruit source
Bergera koenigii L.	Rutaceae	Engguh	Tree	Leaf	Spice

Ocimum tenuiflorum L.	Lamiaceae	Korokoh	Shrub	Leaf	Spice
Opuntia littoralis (Engelm.) Cockerell	cactaceae	Ghubik	Herb	Fruit	Fruit source
Oxalis barrelieri L.	Oxalidaceae	Blimbingan	Herb	Leaf, fruit	Vegetable
Oxalis corniculata L.	Oxalidaceae	Cembicenan	Herb	Leaf	Vegetable
Pachyrhizus erosus (L.) Urb.	Fabaceae	Bitok	Herb	Tuber	Carbohydrate
Paederia foetida L.	Rubiaceae	Kasembuen	Vine	Leaf	Vegetable
Passiflora foetida L.	Passifloraceae	Rambusa	Vine	Fruit	Fruit source
Peperomia pellucida (L.) Kunth	Piperaceae	Sere cenah	Herb	Leaf	Vegetable
Phyllanthus acidus (L.) Skeels	Phyllanthaceae	Cermih	Tree	Fruit	Fruit source
Phyllanthus emblica L.	Phyllanthaceae	Malakah	Tree	Fruit	Fruit source
Phyllanthus reticulatus Poir.	Phyllanthaceae	Mangsenan	Shrub	Fruit	Fruit source
Physalis angulata L.	Solanaceae	Yornyioran	Herb	Fruit	Fruit source
Pithecellobium dulce (Roxb.) Benth.	Fabaceae	Accem belendeh	Tree	Fruit	Fruit source
Pluchea indica (L.) Less.	Asteraceae	Beluntas	Shrub	Leaf	Vegetable
Portulaca oleracea L.	Portulacaceae	Reserean	Herb	Leaf	Vegetable
Protium javanicum Burm.f.	Burseraceae	Trenggulun	Tree	Fruit	Fruit source
Psophocarpus tetragonolobus (L.) DC.	Anacardiaceae	Kaceper	Vine	Fruit, seed	Vegetable, seed source
Psidium guajava L.	Myrtaceae	Jembuh deduh	Tree	Fruit	Fruit source
Rhizophora stylosa Griff.	Rhizophoraceae	Tenjeng	Tree	Fruit, seed	Carbohydrate, beverage
Sandoricum koetjape (Burm.f.) Merr.	Meliaceae	Sentol	Tree	Fruit	Fruit source
Breynia androgyna (L.) Chakrab. & NP. Balakr.	Phyllanthaceae	Cangkok manis	Shrub	Leaf	Leaf
Schleichera oleosa (Lour.) Oken	Sapindaceae	Kosambih	Tree	Fruit, leaf	Fruit source, vegetable
Sesbania javanica Miq.	Fabaceae	Toroi koning	Shrub	Leaf, fruit	Vegetable
Sesuvium portulacastrum (L.) L.	Aiozoaceae	Pesepeh	Herb	Leaf	Vegetable
Solanum americanum Mill.	Solanaceae	Ranteh	Herb	Leaf, fruit	Vegetable, fruit source
Solanum torvum Sw.	Solanaceae	Terong Perat	Shrub	Fruit	Vegetable
Spondias dulcis Parkinson	Anacardiaceae	Kadungdung	Tree	Fruit	Fruit source
Sterculia foetida L.	Malvaceae	Kelompang	Tree	Seed	Seed source
Streblus asper Lour.	Moraceae	Pelle	Tree	Fruit	Fruit source
Suaeda maritima (L.) Dumort.	Amaranthaceae	Alor	Herb	Leaf	Vegetable
Syzygium cumini (L.) Skeels	Myrtaceae	Dhuwek Betoh	Tree	Fruit	Fruit source
Syzygium grande (Wight) Walp.	Myrtaceae	Mataba	Tree	Fruit	Fruit source
Syzygium littorale (Blume) Amshoff	Myrtaceae	Klampok lakek	Tree	Fruit	Fruit source
Syzygium polyanthum (Wight) Walp.	Myrtaceae	Dhuwek Salam	Tree	Fruit	Fruit source
Tamarindus indica L.	Fabaceae	Accem	Tree	Leaf, fruit, seed	Fruit source, beverage, seed source, spice
Terminalia catappa L.	Combretaceae	Ketapang	Tree	Seed	Seed source
Trianthema portulacastrum L.	Aiozoaceae	Telpok	Herb	Leaf	Vegetable
Trichosanthes costata Blume	Cucurbitaceae	Pakanah dengdeng	Vine	Fruit	Vegetable
Wrightia pubescens R.Br.	Apocynaceae	Bintaos	Tree	Leaf	Vegetable
Ziziphus mauritiana Lam.	Rhamnaceae	Bukkol	Tree	Fruit	Fruit source
Ziziphus oenopolia (L.) Mill.	Rhamnaceae	Sribuk	Tree	Fruit	Fruit source

Table 7. Conservation strategies for wild and semi-wild edible plants in Madura, Indonesia

Conservation strategy/species	$\bar{X}$ IVI	$\bar{X}$ ICS	IVI category	ICS category
Maintaining the availability of species				
Accem (*Tamarindus indica*)	34.41	81.67	High	High
Pattek (*Anacardium occidentale*)	32.68	33	High	High
Assessing and developing other potentials				
Alor (*Suaeda maritima*)	80.61	12	High	Low
Peseppeh (*Sesuvium portulacastrum*)	56.39	12	High	Low
Cultivating species				
Dhuwek salam (*Syzygium polyanthum*)	13.74	45	Moderate	High
Pao taber (*Mangifera lalijiwa*)	6.88	36	Low	High
Cultivating, studying, and developing another potential				
Ghedung (*Dioscorea hispida*)	13.58	12	Moderate	Low
Sobeg (*Amorphophallus paeoniifolius*)	6	8	Low	Low

Notes: IVI (< 10 = low, 10-20 = moderate, > 20 = high), ICS (< 20 = low, > 20 =high), IVI: importance value index, ICS: index of cultural significance, $\bar{X}$: average

Despite having high IVI values, the community has no cultivation activities, especially for *T. indica*, whose stems are also used as charcoal-making material. Instead, people harvest acacia wood by cutting down old trees. If this continues without cultivation, it will threaten its availability in nature.

Conservation activities through cultivation need to be done for plants with low or medium IVI but high ICS values, such as *Mangifera lalijiwa* (IVI 6,88; ICS 36). The low availability of these species in nature indicates that the number of individuals in their habitat is also low. *M. lalijiwa* is rarely found in nature due to the high level of logging of this plant to utilize its wood as construction material without being followed by cultivation or replanting activities. According to data from the IUCN red list (2022), the conservation status of this plant has yet to be evaluated, but the number of old plant individual populations continues to decline. This plant is native to Indonesia, especially Java and Bali, so it needs to be preserved as a wealth of genetic resources.

In conclusion, this study shows that Madurese people still maintain local knowledge of WSEPs utilization, which can be seen from the many WSEPs species utilized by the Madurese community. The WSEPs species have a high value for Madurese people based on cultural, utilization, and individual importance values. WSEPs species also have an essential role for Madurese as a source of carbohydrates, vegetables, fruits, seeds, spices, and beverages. Furthermore, the WSEPs species have the economic value to support the family income. However, the threat of the decreasing number of WSEPs species in Madura Island causes the importance of managing each WSEPs species, especially those with high utilization value and economic value, such as cultivating the species to maintain their availability to fulfilled their need.

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