Wild edible fruits generate substantial income for local people of the Gunung Leuser National Park, Aceh Tamiang Region

Adi Bejo Suwardi, Zidni Ilman Navia, Tisna Harmawan, Syamsuardi, Erizal Mukhtar

Research

Abstract

Background: Gunung Leuser National Park offers a variety of wild edible fruit species (WEFs) with food, nutrition, medicine, and economic value to the local people. In recent times, these WEFs have been threatened by over-exploitation, land-use changes, and biodiversity loss. This study aims to investigate the diversity of WEFs and their contribution to household income for communities living around the National Park.

Methods: The study was conducted in three sub-districts adjacent to Gunung Leuser National Park. The plant materials were randomly collected from three sub-districts, while local knowledge was gathered through a structured survey and in-depth interviews. The informant sample comprised 450 people, 150 from each of the three sub-districts.

Results: A total of 54 wild edible fruit plants belonging to 41 genera and 27 families were recorded in the study area. Thirty-nine (72.22 %) species were found growing in forests, 12 (22.22 %) species in farmland, and 3 (5.56%) species occur in the bush. Several species have economic value including Baccaurea macrophylla (Müll.Arg.) Müll.Arg., Baccaurea polynoeura Hook.f., Diospyros kaki L.f., Flacourtia rukam Zoll.&Moritzi, Garcinia atroviridis Griff. ex T.Anderson, Garcinia xanthochymus Hook.f. ex T.Anderson, Lansium domesticum Corrêa, Mangifera foetida Lour., Mangifera odorata Griff., Mangifera laurina Blume, Nephelium cuspidatum Blume, Passiflora edulis Sims., Pometia pinnata J.R. Forst. & G. Forst., Syzygium aquum (Burm. f.) Alston, and Syzygium malaccense (L.) Merr. & L.M. Perry. These fruits formed a source of household income and were harvested by approximately 82% of respondents. The sale of WEFs contributed approximately 34.31% of the total annual household income. These findings confirm the assumption that WEFs are important for the generation of household income.

Conclusion: This study demonstrates the importance of WEFs to local communities in Aceh Tamiang, Indonesia, particularly rural communities living near Gunung Palung National Park. WEFs play an important role in rural livelihoods by ensuring food, medicine, and sustained income. Policies and legislation involving stakeholders are required to ensure the cultivation, management, sustainable use, and promotion of WEFs in order to encourage the economic growth of the rural community in the Aceh Tamiang region.

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ABSTRAK

Pendahuluan: Taman nasional Gunung Leuser memiliki berbagai jenis tumbuhan buah edible liar yang dimanfaatkan oleh masyarakat pedesaan, terutama sebagai sumber pangan, nutrisi, obat-obatan, dan dapat menjadi sumber pendapatan keluarga. Saat ini, tumbuhan buah liar terancam oleh eksploitasi berlebihan, perubahan penggunaan lahan, dan kehilangan keanekaragaman jenis. Penelitian ini bertujuan untuk menginvestigasi keanekaragaman jenis tumbuhan buah edible liar dan kontribusinya terhadap pendapatan keluarga bagi masyarakat yang tinggal di sekitar Taman Nasional Gunung Leuser.

Metode: Penelitian dilakukan pada tiga Kecamatan yang berbatasan langsung dengan Taman Nasional Gunung Leuser. Sampel tumbuhan dikumpulkan secara acak dari tiga kecamatan, sementara itu, pengetahuan masyarakat dinilai dengan survey dan wawancara. Data diambil dengan melibatkan 450 orang dengan masing-masing 150 orang di setiap kecamatan.

Hasil: Sebanyak 54 jenis tumbuhan buah edible liar yang terdiri dari 41 marga dan 27 keluarga telah ditemukan selama penelitian. Sebanyak 39 (72.22 %) jenis ditemukan di hutan, 12 (22.22 %) jenis di kebun, dan 3 (5,56 %) jenis ditemukan di semak belukar. Beberapa jenis ini memiliki nilai ekonomi diantaranya Baccaurea macrophylla (Müll.Arg.), Flacourtia rukam (L.) Merr., Mangifera foetida Lour., Mangifera odorata Griff., Mangifera laurina Blume, Nephelium cuspidatum Blume, Passiflora edulis Sims., Pometia pinnata J.R. Forst. & G. Forst., Syzygium aqueum (Burm. f.) Alston, and Syzygium malaccense (L.) Merr. & L.M. Perry. Tumbuhan tersebut menjadi sumber pendapatan keluarga dan dipanen oleh sekitar 82 % responden. Penjualan tumbuhan tersebut berkontribusi sebesar 34,31 % terhadap total pendapatan tahunan keluarga. Hasil penelitian ini mengasumsikan bahwa tumbuhan buah edible liar ini sangat penting dalam mendukung ekonomi keluarga.

Kesimpulan: Penelitian ini menunjukkan tingkat kepentingan tumbuhan buah edible liar bagi masyarakat di Aceh Tamiang, Indonesia, terutama yang tinggal di sekitar Taman Nasional Gunung Leuser. Tumbuhan buah edible liar berperan penting dalam mendukung kehidupan masyarakat pedesaan sebagai sumber pangan, nutrisi, obat-obatan dan penghasilan keluarga. Kebijakan dan peraturan yang melibatkan semua pemangku kepentingan diperlukan untuk mendukung budidaya, manajemen, pemanfaatan berkelanjutan, dan promosi WEFs dalam rangka mendorong pertumbuhan ekonomi masyarakat pedesaan di wilayah Aceh Tamiang.

Background

Wild edible fruit plants (WEFs) refer to fruit plants growing in the natural habitat (Shava 2005). Wild plants form an important part of the human diet; almost 75,000 plant species are known to be edible (Diamond 2002; Leonti et al. 2006). These plants are generally grown in different habitats such as forests, cultivable fields, and even anthropogenically disturbed areas such as roadsides and wastelands (Beluhan & Ranogajec 2010). WEFs have played a significant role in the livelihoods of rural communities in developing countries (Oryema et al. 2013). Oryema et al. (2013) reported that several WEFs have been identified as one of the non-timber forest products offer potential to enhance the economic conditions of local communities (Deb et al. 2013). Orjema et al. (2013) reported that several WEFs have been identified as being consumed in large quantities, while also significantly contributing to the livelihoods of the local community in Gulu District, Uganda. For the local people in Riau Province, Indonesia, sales of WEFs accounted for 38% of the total annual family income.
(Pardede et al. 2018). Similarly, the communities in Central Aceh, Indonesia and the Eastern Nuba Mountains of Sudan obtained 43% and 0-100% of the total annual family income from sold WEFs (Salih-Kamal & Ali, 2014; Navia et al., 2020). WEFs are therefore considered vital to sustaining rural livelihoods, reduce rural poverty, and promote rural economic growth (Maske et al. 2011; Ahenkan & Boon 2011). Underutilization, high population growth, and land-use changes including the expansion of agricultural sector leading to deforestation have also led to loss of diversity of the WEFs (Ohiokpehai 2003; Bagra et al. 2006; Navia et al. 2020; Suwardi et al. 2020b), even in GLNP. WCS (2019) reported that about 4,685 ha of GLNP forests had been converted to agricultural land between 2000 and 2017, which also drove biodiversity loss. Loss of various species, in particular WEFs, will lead to increased food insecurity (Lulekal et al. 2011; Addis et al. 2013). Therefore, this study aims to investigate the diversity of WEFs and their contribution to household income for communities living around Gunung Leuser National Park, Aceh Tamiang Region.

Materials and methods

Study area
The study was conducted in three sub-districts of Aceh Tamiang districts (03°53’N, 97°43’E, 700 m a.s.l.), Aceh province, Indonesia including Tenggulun, Tamiang Hulu, and Bandar Pusaka as shown in Figure 1. These areas are typically forested and part of the buffer zone of the Gunung Leuser National Park. These areas have a tropical humid climate with a dry season mainly occurring from January to June, while the rainy season lasts from July to December. The rainfall ranges between 406 and 2,886 mm per year with 20 – 158 rainy days and the average temperature is around 260 - 300C. The topography is generally mountainous and the zone is characterized by a cropping system (The Central Bureau of Statistics of Aceh Tamiang Regency, 2019).

Data collection
The present investigation of WEFs was based on an extensive field survey carried out from April to September 2018. Information on WEFs was obtained through participatory observations. The study involved a total of 450 respondents (150 individuals from each sub-district), who were selected through simple random sampling, with different background characteristics such as sex, age group, religion, marital status, tribe, and local language (Table 1). A questionnaire was prepared with four sections, namely: background characteristics of the respondents, collections and harvestings, sales, and other values of WEFs (Appendix 1). The questionnaire also included the amount of fruit harvested per year and income secured from fruit sales. The interview was conducted face to face in the Indonesian language and each interview lasted between 30 and 60 minutes.

Table 1. Demographic characteristics of respondents

| Baseline Characteristics | Number (Total = 450) | Percentage |
|--------------------------|----------------------|------------|
| Gender                   |                      |            |
| Male                     | 214                  | 47.56      |
| Female                   | 236                  | 52.44      |
| Age                      |                      |            |
| 20-30                    | 96                   | 21.33      |
| 31-40                    | 148                  | 32.89      |
| 41-50                    | 122                  | 27.11      |
| 51-60                    | 64                   | 14.22      |
| >60                      | 20                   | 4.44       |
| Religion                 |                      |            |
| Islam                    | 450                  | 100        |
| Marital status           |                      |            |
| Single                   | 32                   | 6.22       |
| Married                  | 406                  | 91.11      |
| Widowed                  | 12                   | 2.67       |
| Tribe                    |                      |            |
| Acehnese                 | 96                   | 21.33      |
| Tamiang                  | 235                  | 52.22      |
| Javanese                 | 119                  | 26.44      |
| Local language           |                      |            |
| Acehnese                 | 96                   | 21.33      |
| Malay                    | 235                  | 52.22      |
| Javanese                 | 119                  | 26.44      |

Data analysis
The contribution of WEFs to household income was estimated as a percentage of the total annual household income generated by WEFs sales. Computations were made in Microsoft Office Excel 2016.
Results

A total of 54 wild edible fruit plants, consisting of 41 genera and 27 families, were identified in the study area. Sapindaceae was the largest family contributing six species, followed by Meliaceae (5 species), Clusiaceae (4 species), and Myrtaceae (4 species). Anacardiaceae, Fagaceae, Malvaceae, and Phyllantaceae contributed three species each (Table 2).

Thirty-nine (72.22 %) species were found growing in forests, 12 (22.22 %) species in farmland, and 3 (5.56%) species occurred in the bush. The mean number of WEFs identified by each age group of respondents ranged from 15.8±2.05 (20-30 years) to 50.3±2.2 (41-50 years). Several WEFs have been recognized for all ages including Langsat (Lansium domesticum Corrêa), Kuwini (Mangifera odorata Griff.), Macang (Mangifera foetida Lour.), Asam pauh (Mangifera laurina Blume), Tampoi (Baccaurea macrophylla Müll.Arg.) Müll.Arg.), Jentik (Baccaurea polyneura Hook.f.), Ceri (Prunus beccarii (Ridley) Kalkman), Jambu air (Syzygium garciniiifolium (King) Merr. & L.M.Perry), Jambu bol (Syzygium malaccense (L.) Merr. & L.M. Perry), Asam kandis (Garcinia xanthochymus Hook.f., ex T.Anderson) and Asam gelugur (Garcinia atroviridis Griff. ex T.Anderson). While Durian enggang (Durio griffithii (Mast.) Bakh.), Jengkol hutan (Archidendron borneense I.C. Nielsen), Rambutan hutan (Nephelium juglandifolium Blume), and Peralih (Garcinia nigrolineata Planch. ex T.Anderson) are several examples for such less known species.

The respondents explained that the harvesting of WEFs is carried out mostly by men compared to women. Several of the WEFs such as Baccaurea macrophylla, B. polyneura, Diospyros kaki, Flacourtia rukam, Garcinia atroviridis, G. xanthochymus, Lansium domesticum, Mangifera foetida, M. odorata, M. laurina, Nephelium cuspidatum, Passiflora edulis, Pometia pinnata, Syzygium malaccense, and S. aqueum were harvested by 82% of the respondents. The majority of respondents collected between 10 to 200 kg of WEFs for sale or consumption by themselves. L. domesticum and M. foetida were found to be harvested in large quantities (more than 100 kg). Approximately 40 % of respondents reported that they only harvested small quantities of WEFs such as Castanopsis costata (Blume) A.DC, Eleiodoxa conferta (Griff.) Burret., and Garcinia nigrolineata Planch, ex T. Anders.

Value addition

According to the local people, a total of 15 species have additional values and are utilized as medicines, additive, juice, pickles, chutney, and in dried forms (Table 3).
Most fruits were consumed raw and fresh, but several were consumed as pickles (M. foetida, M. odorata, M. laurina, S. aqueum, S. garciniifolia, and S. malaccense), chutney (M. foetida, M. odorata, and M. laurina), or as an additive (G. atroviridis, G. xanthochymus, and Szygium polyanthum (Wight) Walp). Few species were processed into juice (M. foetida, M. odorata, and M. laurina). In addition, B. macrophylla is used as traditional medicine for the treatment of ringworm, while Santiria laevigata Blume, and Momordica balsamina L. are used in the treatment of diarrhea.

**Contribution of WEFs to household income**

Local communities in the study area collect WEFs for sale in the traditional market, roadsides, or neighborhood. Species, traded part, average quantity, and the market price of WEFs that were sold by local communities in the study area are shown in Table 4. Approximately 85.5% of respondents sold WEFs. Trading of WEFs were dominated by women compared to men. The highest quantity of fruits sold were M. foetida (200 ± 12.24 kg), and L. parasiticum (200 ± 10.54 kg), followed by M. odorata (160 ± 2.82 kg), S. aqueum (100 ± 12.37 kg), S. garciniifolia (100 ± 13.65 kg), and D. kaki (60 ± 4.21 kg). Several WEFs such as L. domesticum, N. cuspitatum, and M. foetida are sold in traditional markets or promoted on the roadside by local people. Among fruit species, M. foetida and M. odorata have high market price of around IDR 15,000-20,000 per kg, followed by L. domesticum (IDR 12,000-15,000), D. kaki, G. atroviridis (IDR 10,000-12,000 kg-1), and P. edulis (IDR 10,000 kg-1). The mean income earned through the selling of WEFs by the households is IDR 13,220,000 per year, with the mean income of each respondent being IDR 1,101,667 per month. Of all households selling WEFs, 68% earned less than 25,000,000 Indonesian Rupiah (IDR) annually, while 32% earned more than 25,000,000 IDR. The mean total annual contribution to the household income from selling of WEFs was around 34.41%.

Table 2. Wild edible fruits in the study area

| Scientific Name | Family | Local Name | Lifeforms | Habitat | Co. No |
|-----------------|--------|------------|-----------|---------|--------|
| Actinodaphne cuneata (Blume) Boerl. Adenia macrophylla (Blume) Koord. Aglaia tomentosa Tejsm. & Binn. Aporosa benthamiana Hook.f. Archidendron borneense I.C. Nielsen Baccaurea macrophylla (Müll.Arg.) Müll.Arg. Baccaurea polynera Hook.f. Blumeodendron tokbrai (Blume) Kurz Canarium littorale Blume Castanopsis costata (Blume) A.DC Cheilosia montana Blume Chisocheton patens Blume Diospyros kaki L.f. Durio griffithii (Mast.) Bakh. Dysoxylum allicaeum (Blume) Blume Dysoxylum cystrobotryum Miq. Eleidoxa conferta (Griff.) Burret. Ficus lepicarpa Blume Flacourtia rukam Zoll. & Moritzi Garcinia atroviridis Griff. ex T.Anderson Garcinia nervosa (Miq.) Miq. | Lauraceae Passifloraceae Meliaceae Phyllantaceae Leguminosae Phyllantaceae Euphorbiaceae Burseraceae Fagaceae Euphorbiaceae Meliaceae Ebenaceae Malvaceae | Medang Climber Tree Tree Tree Tree Tree Tree Tree Tree Tree | Tree Tree Tree Tree Tree Tree Tree Tree Tree Tree | F F F F F F F F F F | ATAM-22 ATAM-20 ATAM-19 ATAM-35 ATAM-21 ATAM-17 ATAM-46 ATAM-41 ATAM-45 ATAM-25 ATAM-43 ATAM-24 ATAM-07 ATAM-32 ATAM-40 ATAM-29 ATAM-16 ATAM-18 ATAM-04 ATAM-09 ATAM-34 |
| Scientific Name                  | Family          | Common Name       | Type    | Co. No | Habitat |
|---------------------------------|-----------------|-------------------|---------|-------|---------|
| *Garcinia nigrolineata* Planch. ex T. Anderson | Clusiaceae | Peralih | Tree | F | ATAM-28 |
| *Garcinia xanthochymus* Hook.f. ex T. Anderson | Clusiaceae | Asam kandis | Tree | F | ATAM-54 |
| *Glycosmis parviflora* (Sims) Little | Rutaceae | Urot Merah | Shrub | F | ATAM-23 |
| *Grewia laevigata* Vahl | Malvaceae | | Tree | F | ATAM-49 |
| *Helicia robusta* (Roxb.) R.Br. ex Blume | Proteaceae | | Tree | F | ATAM-31 |
| *Horsfieldia superba* (Hook.f. & Thomson) Warb. | Myristicaceae | | Tree | F | ATAM-36 |
| *Knema laurina* (Blume) Warb. | Myristicaceae | Dedarah | Tree | F | ATAM-38 |
| *Lansium domesticum* Corrêa Leenh. | Meliaceae | Langsat | Tree | FL | ATAM-06 |
| *Lepisanthes fruticosa* (Roxb.) Leenh. | Sapindaceae | Rambutan biak | Tree | F | ATAM-37 |
| *Lepisanthes amoena* (Haask.) Leenh. | Sapindaceae | | Tree | F | ATAM-26 |
| *Lithocarpus echinulatus* Soepadmo | Fagaceae | | Tree | F | ATAM-27 |
| *Lithocarpus indutus* (Blume) Rehder | Fagaceae | | Tree | F | ATAM-33 |
| *Mangifera foetida* Lour. | Anacardiaceae | Macang | Tree | FL | ATAM-01 |
| *Mangifera odorata* Griff. | Anacardiaceae | Kuweni | Tree | FL | ATAM-02 |
| *Mangifera laurina* Blume | Anacardiaceae | Asam pauh | Tree | FL | ATAM-03 |
| *Microcos latistipulata* (Ridl.) Burret | Malvaceae | | Tree | F | ATAM-47 |
| *Momordica balsamina* L. | Cucurbitaceae | Pare hutan | Climber | B | ATAM-13 |
| *Nephelium cuspidatum* Blume | Sapindaceae | Kapulasan | Tree | FL | ATAM-05 |
| *Nephelium juglandifolium* Blume | Sapindaceae | Rambutan hutan | Tree | F | ATAM-30 |
| *Passiflora edulis* Sims. | Passifloraceae | Markisa kuning | Climber | B | ATAM-15 |
| *Physalis angulata* L. | Solanaceae | Ciplukan | Herb | B | ATAM-14 |
| *Polyspora oblongifolia* (Michq.) Orel, Peter G.Wilson, Curry & Luu | Theaceae | | Tree | F | ATAM-44 |
| *Pometia pinnata* J.R. Forst. & G. Forst. | Sapindaceae | Matoa hutan | Tree | F | ATAM-48 |
| *Pouteria viridis* (Pitirr) Cronquist | Sapotaceae | | Tree | F | ATAM-42 |
| *Prunus beccarii* (Ridley) Kalkman | Rosaceae | Buah Ceri | Tree | FL | ATAM-08 |
| *Santiria laevigata* Blume | Burseraceae | Kedondong tunjuk | Tree | F | ATAM-53 |
| *Solanum betaceum* Cav. | Solanaceae | | Shrub | F | ATAM-39 |
| *Syzygium garcinifolium* (King) Merr. & L.M. Perry | Myrtaceae | Jambu | Tree | FL | ATAM-11 |
| *Syzygium polyanthum* (Wight) Walp | Myrtaceae | Salam | Tree | F | ATAM-10 |
| *Syzygium aqueum* (Burm. f.) Alston | Myrtaceae | Jambu Air | Tree | FL | ATAM-12 |
| *Syzygium malaccense* (L.) Merr. & L.M. Perry | Myrtaceae | Jambu Bol | Tree | FL | ATAM-52 |
| *Voacanga foetida* (Blume) Rolfe | Apocynaceae | Telur kambing | Tree | F | ATAM-51 |
| *Xerospermum noronhianum* (Blume) Blume | Sapindaceae | | Tree | F | ATAM-50 |

Note:
Co. No = collection number
Habitat: B = Bush; F = Forest; FL = Farm land
Table 3. Species with their value addition

| Scientific name       | Plant part | Medicine | Additive | Juice | Pickle | Chutney | Dried |
|-----------------------|------------|----------|----------|-------|--------|---------|-------|
| Mangifera foetida     | Fruit      |          |          | ✔     | ✔      | ✔       | ✔     |
| Mangifera odorata     | Fruit      |          |          | ✔     | ✔      |          | ✔     |
| Mangifera laurina     | Fruit      |          |          | ✔     | ✔      |          | ✔     |
| Microcos latistipulata| Leaves     |          | ✔        | ✔     |        |         | ✔     |
| Momordica balsamina  | Fruit      |          | ✔        | ✔     | ✔      |         | ✔     |
| Garcinia atroviridis  | Fruit      | ✔        |          | ✔     | ✔      |         | ✔     |
| Garcinia xanthochymus | Fruit      | ✔        |          |       |        |         | ✔     |
| Syzygium aqueum       | Fruit      | ✔        |          | ✔     | ✔      |         | ✔     |
| Syzygium garciniiolium| Fruit      | ✔        |          | ✔     | ✔      |         | ✔     |
| Syzygium malaccense   | Fruit      | ✔        |          | ✔     | ✔      |         | ✔     |
| Santiria laevigata    | Leave      | ✔        |          |       |        |         | ✔     |
| Baccaurea macrophylla | Leave      | ✔        |          |       |        |         | ✔     |
| Physalis angulata     | Leave      | ✔        |          |       |        |         | ✔     |
| Syzygium polyanthum   | Leave      | ✔        |          |       |        |         | ✔     |
| Voacanga foetida      | Leave      | ✔        |          |       |        |         | ✔     |

Table 4. Wild edible fruit plants commercialized in the study area

| Scientific name       | Trade part | Mean quantity per respondent (kg) | Market Price (IDR/kg) |
|-----------------------|------------|----------------------------------|-----------------------|
| Baccaurea macrophylla | Fruit      | 50 ± 1.05                        | 8,000 ± 408.24        |
| Baccaurea polyneara   | Fruit      | 25 ± 2.75                        | 6,000 ± 712.19        |
| Diospyros kaki        | Fruit      | 60 ± 4.21                        | 12,000 ± 1,290.99     |
| Flacourtia rukam      | Fruit      | 10 ± 1.94                        | 5,000 ± 308.11        |
| Garcinia atroviridis  | Fruit      | 50 ± 1.53                        | 12,000 ± 1,312.33     |
| Garcinia xanthochymus | Fruit      | 50 ± 1.93                        | 5,000 ± 406.25        |
| Lansium domesticum    | Fruit      | 200 ± 10.54                      | 15,000 ± 471.41       |
| Mangifera foetida     | Fruit      | 200 ± 12.24                      | 20,000 ± 2,818.59     |
| Mangifera odorata     | Fruit      | 160 ± 2.82                       | 20,000 ± 2,581.57     |
| Mangifera laurina     | Fruit      | 50 ± 1.08                        | 7,000 ± 1,490.71      |
| Nephelium cuspidatum  | Fruit      | 40 ± 2.10                        | 7,000 ± 1,220.19      |
| Passiflora edulis     | Fruit      | 50 ± 1.23                        | 10,000 ± 1,228.29     |
| Pometia pinnata       | Fruit      | 40 ± 2.16                        | 8,000 ± 302.18        |
| Syzygium malaccense   | Fruit      | 100 ± 12.37                      | 8,000 ± 430.21        |
| Syzygium aqueum       | Fruit      | 100 ± 13.65                      | 8,000 ± 204.56        |

* Mean ± Standard deviation
Note: 1 USD = 14,500 IDR in August 12, 2018 from id.exchange-rates.org
Discussion
A total of 54 wild edible fruit species belonging to 41 genera and 27 families were identified in the study areas. Most WEFs were found to grow wild in the forest, while several WEFs such as *Kuwini (M. odorata)* and *Mancang (M. foetida)* have been found to have a natural occurrence in the farmlands. The harvesting of WEFs is carried out by men compared to women. Men make more frequent visits to the forest to gather fuelwood and hunt animals, which explains this. This study differs from the report by Mahapatra & Panda (2012) from the state of Orissa, India, which gathers most of the wild fruits of women compared to men. Differences between genders in the collection of WEFs are influenced by different objectives, perceptions, interests, and access to resources between communities. In this study area, men collect WEFs while also collecting fuelwood or hunting animals. A similar method of the collection was reported in localities of Peru (Phillips & Gentry 1993), and in Botswana (Legwaila et al. 2011). The intensity of use of WEFs has been reported on the characteristics of the plants used and the livelihood of the people (Shrestha & Dhillion 2006; Suresh et al. 2014). WEFs have been associated with the traditions and culture of local peoples (Bussmann et al. 2006; Medley & Kalibo 2007; Addis et al. 2013).

The high diversity of WEFs in the study area shows that local people possess traditional knowledge about local plant species that provide food. Local people tend to take advantage of a variety of plants that are more accessible or abundant locally (Srivastava 1988). The number of species recorded in this study is comparable to the 56 wild edible fruit species (26 families) reported from the Orissa state of India (Mahapatra & Panda 2012), and 56 species (24 families) in South Aceh, Indonesia (Suwardi et al. 2020b). However, it is also higher than the 44 species reported from the West Aceh, Indonesia (Suwardi et al. 2019b), 38 species from the Gayo Highlands of Indonesia (Navia et al. 2020), 33 species from Rupandehi district, Nepal (Acharya & Acharya 2010), 27 species from Shorobe, Northern Botswana (Neudeck et al. 2012), 12 species from Uttara Kannada district of Karnataka (Hebbal et al. 2010), and 11 species reported from Dera Ismail Khan district of northwestern Pakistan (Marwat et al. 2011). This variance in the diversity of WEFs has been attributed to disparities in culture and location (Arora & Anjula 1996).

During the discussions, the respondents stated that *M. foetida* and *M. odorata* are the most preferred fruit species because of their sweet taste and fragrant smell. This is similar to that report of Navia et al. (2020) that *M. foetida* and *M. odorata* were the most popular and preferred fruits by the community in Central Aceh, Indonesia. The taste was an important criterion for the preference for fruit (Sujarwo et al. 2015; Navia et al. 2020). Most WEFs have sweet or a slightly sour taste and are preferred by local people in the study area which is comparable to cultivated fruits. WEFs offer various essential nutrients to maintain human health. For example, *M. foetida* fruit is reported to have a high nutritional (Tee et al. 1997) and antioxidant content (Tyug et al. 2010), and is essential to supplement nutrients in the community. In addition, *G. atroviridis* fruits contain potassium hydroxycitrate that helps to reduce cholesterol (Jena et al. 2002), and may be used in the treatment of obesity (Mattes & Bornmann 2000; Tisdale et al. 2003; Preuss et al. 2004; Hamidon et al. 2017).

Most WEFs are eaten fresh by the local community in the study area, but several species have additional value. *M. odorata* and *M. laurina* are used for juice, pickles, and chutneys, while *M. foetida*, *S. aqueum*, *S. garciniifolium*, and *S. malaccense* are used for pickle. This study is in line with the report of Tyug et al. (2010) from Malaysia, where *M. foetida* is used as pickles. *G. atroviridis* has traditionally been used in food preparation and cooking, mainly to make food more filling. Clouatre & Rosenbaum (1994) reported that *G. atroviridis* contains HCA (Hydroxy citric acid) and is traditionally used to make meals more filling. In addition, *G. atroviridis* fruit is cut into thin slabs, dehydrated by sun-drying, and stored for a certain period before being used as an ingredient or sold on the market. Its preparation method is similar to that reported by Rittirut & Siripatana (2006) from Thailand, where the community often dried *G. atroviridis* thin slabs by sun-drying in the air and kept them before entering the juice production process.

The respondents state that the value addition of WEFs may increase the price of the product by three to four times. For example, *M. foetida* in raw fruit form is sold in traditional markets at IDR 20,000 kg⁻¹, whereas, it may increase to IDR 40,000 kg⁻¹ if processed into mango juice. Diversification of products is expected to increase profits, which are a good source of income for the community. The diversification of products of several wild fruits has already been adopted in other areas and reported as highly remunerative (Maikhuri et al. 1998). The fruit of *M. balsamina* was used as traditional medicine for the treatment of diarrhea by people in the Bandar Pusaka sub-district. Aqueous extract from *M. balsamina* showed an antidiarrheal effect (Otmenyin et al. 2008) and is being used in Nigeria for the management of diarrhea (Thakur et al. 2009). The leaves of *B. macrophylla* are used in the treatment of ringworm, while leaves of *S. laevigata* were used in the treatment of diarrhea. In addition, *G. atroviridis* is
traditionally used to treat cough and stomach pains. This fruit has been reported to have bioactive compounds such as saponins, phenolic, flavonoids, and anthraquinone glycosides (Roslan et al. 2019). It is traditionally used by the communities in Riau, Indonesia for pain in the ears, dandruff, cough, and stomach (Grosvenor et al. 1995; Alsarhan et al. 2014).

In the Aceh Tamiang region, all commerce and trade activities primarily are conducted in the local market. The frequency of the market days and the demand for goods depends on the socio-economic conditions of the people in the area. These markets serve as collection points for local products as well as for the distribution of goods. A variety of items are sold in this market. Some of the common products are fruits, vegetables, grains, agricultural produce, animals, and their by-products. In the study area, women and children usually sell WEFs in limited quantities door to door or on the roadside around villages. Similar methods have been reported from Gweta village, Bostwana (Badimo et al. 2015), in East Kalimantan, Indonesia (Koizumi 2005), and in Nepal (Shrestha & Dhillion 2006). However, when the quantity of WEFs is harvested in large quantities, they are sold in traditional local markets. The sale of WEFs provides income used to meet several family needs such as buying food or paying school fees. Sale of WEFs can provide 34.41% of the total annual family income in the study area. This contribution of WEFs is lower than reported by Pardede et al. (2018) from Riau Province, Indonesia where they accounted for 38% of the total annual family income, and in Central Aceh, Indonesia (43%) (Navia et al. 2020).

WEFs in Aceh Tamiang region offers diverse benefits to the communities. These plants grow abundantly in the wild and have economic potential as a source of household income. However, efforts should be made to domesticate or cultivate them in the communities’ farmlands outside the GLNP area. Training and technology transfer must be provided to local communities to support the cultivation of WEFs. These activities must be supported by the Indonesian government through the Aceh Tamiang District Agriculture Office to emphasize the domesticating of WEFs in providing economic values. Intensive cultivation of WEFs may also reduce the dependence of communities on the GLNP. As a result, in addition to providing economic benefits, the domestication of WEFs is also a conservation strategy for WEFs in the GLNP. The marketing of WEFs continues to be a challenge, especially for local people who are engaged in this business. The promotion and marketing efforts of WEFs must be carried out intensively. Fortunately, the Aceh Tamiang region is an attractive tourist destination for both natural and cultural tourism, visited by millions of tourists every year. The Indonesian government through the Aceh Tamiang District Tourism, Youth, and Sports Office must be involved in promoting WEFs. Intensively promoting and marketing WEFs will have more positive impact on the economic growth of the people in the Aceh Tamiang region.

Conclusions and recommendations

A total of 54 WEFs belonging to 27 families and 41 genera were found in the study area. Thirty-nine (72.22 %) species were found growing in forests, 12 (22.22 %) species in farmland, and 3 (5.56%) species occur in the bush. Several species have economic value including Baccarea macropylla, Baccarea polyneura, Diospyros kaki, Flacourtia rukam, Garcinia atroviridis, Garcinia xanthochymus, Lansium domesticum, Mangifera foetida, Mangifera odorata, Mangifera laurina, Nephelium cuspidatum, Passiflora edulis, Pomelia pinnata, Syzygium malaccense, and Syzygium aquem. The sale of WEFs contributed approximately 34.31% to the total annual household income, and are thus relevant to household food security. Policies and legislations developed by involving all stakeholders are required to ensure the cultivation, management, sustainable use, and promotion of WEFs in order to encourage the economic growth of the rural community in the Aceh Tamiang region.

Declarations

List of abbreviations: WEFs = Wild edible fruit species; GLNP = Gunung Leuser National Park; a.s.l = above sea level.

Availability of data and materials: Data will be available from the corresponding author on special request.

Ethical approval and consent to participate:

Permission was taken from the subdistrict heads of Tenggulun, Tamiang Hulu, and Bandar Pusaka prior to data collection. Oral informed consent was obtained from all informants.

Consent for publication: Not applicable.

Conflict of interests: The authors declare no competing interests.

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Authors’ contributions: ABS and TH carried out fieldwork, data analysis, and drafted the manuscript. ZIN configured the research project. The work was supervised by S and EM. All authors read, reviewed, and approved the final version of the manuscript.
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Appendix 1. Survey Questionnaire for Identification of indigenous edible fruit plants to promote diversification and food security in Aceh Province, Indonesia

No. of Respondent: ________________________ Date: ______________

PART 1 — BACKGROUND INFORMATION
Name of Respondent:
Sex:
Age:
Marital status:
Tribe:
Address:

PART 2 — COLLECTION AND HARVESTING OF WILD EDIBLE FRUIT PLANTS
1. Are you familiar with the wild edible fruit plants?
2. Where do usually go to find wild edible fruit plants?
3. Have you ever harvested any wild edible fruit plants?
4. How often do you usually harvest wild edible fruit plants in a year?
5. Fill in the species and quantity of wild edible fruit plants that you are harvesting this year!

| No. | Common name | Quantity (Kg) |
|-----|-------------|--------------|
|     |             |              |

6. How do you consume these wild edible fruit plants? (to be eaten raw, processed, etc.)?
7. How do you use wild edible fruit plants? (for sale, self-consumption, etc.)

PART 3 — TRADE OF WILD EDIBLE FRUIT PLANTS
1. Have you ever sold any wild edible fruit plants?
2. Where do you usually sell wild edible fruit plants?
3. Fill in the species, traded part, quantity and market price of wild edible fruit plants that you're selling this year!

| No. | Common name | Traded part | Quantity (Kg) | Market Price (Rp) |
|-----|-------------|-------------|--------------|-------------------|
|     |             |             |              |                   |