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The diversity and contribution of indigenous edible fruit plants to the rural community in the Gayo Highlands, Indonesia

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Abstract

The Gayo Highlands offer different indigenous edible fruit species (IEFs) used by the rural community, essentially to provide products such as fruits, oil, medicine, nuts, and fodder. In recent times, these IEFs are being threatened by over-exploitation and biodiversity loss. This study, therefore, aimed to explore the diversity of IEFs and evaluate its contribution to the enhancement of the rural community income in the Gayo Highlands region. The plant materials were randomly collected from nine villages in three districts, while local knowledge was valued through a survey and in-depth interviews. Data were collected by surveying 225 people, 25 from each of the nine villages. A total of 38 species of fruits belonging to 19 families were found with the most utilised including *Artocarpus integer*, *Artocarpus integer*, *Diospyros kaki*, *Durio zibethinus*, *Garcinia mangostana*, *Lansium parasiticum*, *Mangifera foetida*, *Mangifera odorata*, *Passiflora foetida*, *Syzygium aqueum*, *Syzygium attenuatum*, *Syzygium cumini*, and *Syzygium malaccense*. These fruits made up the main source of food and income and were harvested by approximately 86 % of the respondents. Moreover, the sale of IEFs contributed to approximately 43 % of the total yearly household income. These findings confirmed the prior assumption that IEFs are of significant importance to the rural economy as a food and through income generation.

Keywords: Botanical inventory, economic, ethnobotany, traditional knowledge, Sumatra

1 Introduction

The Gayo Highlands consists of a hilly area with dense tropical mountain forests on the stretch of the Bukit Barisan ridge in NW-Sumatra and also a part of the Gunung Leuser National Park region with diverse fauna and flora. There are over 4,500 plant species in this area making up 45 % of the total observed plant species of Western Indo-Malaya (Irfan & Priatna, 2004). The tropical forests support the livelihoods of many local populations through the provision of fruits, nuts, and tubers (Yobo & Ito, 2015; Batubara & Affandi, 2017; Suwardi *et al*., 2018). Therefore, the resources of these forests are considered important for the reduction of poverty, preservation of biodiversity, and facilitation of economic growth in the rural area (Maske *et al*., 2011).

Indigenous edible fruit species (IEFs) are non-timber forest products that play essential roles as sources of supplemental foods, as medicine, and also in providing income for households e.g. in Cameroon and Nigeria (Leakey *et al*., 2005; Schreckenberg *et al*., 2006), South Africa (Akinnifesi *et al*., 2006), India (Gangwar *et al*., 2010; Gusain & Khanduri, 2016), Malaysia (Ong *et al*., 2012), and Indonesia (Navia *et al*., 2015; Suwardi *et al*., 2019a; Suwardi *et al*., 2020a). Harvesting wild fruits have the ability to generate substantial rural income as well as jobs (Leakey *et al*., 2005). The local population in the Eastern Nuba Mountains of Sudan use IEFs as food, fodder, firewood, medicine, construction material or to produce furniture and agricultural tools; and the sales of wild fruits accounted for 50 – 100 % of the total annual family income (Salih-Kamal & Ali, 2014). Moreover, in Rwanda, they are also used as food, medicine,

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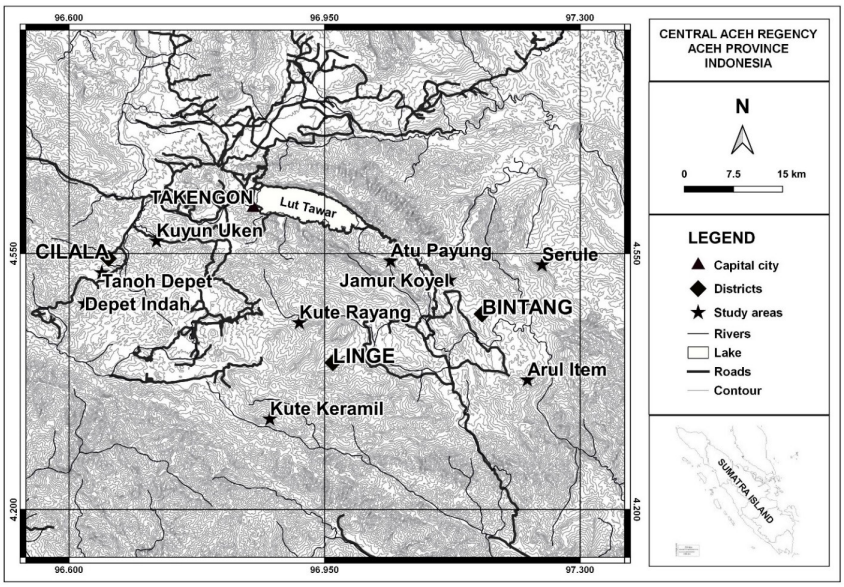

Fig. 1: *Map of Gayo Highlands on Sumatra island showing the three study areas, Bintang, Cilala, and Linge districts*

firewood, and timber as well as for income, charcoal, shade, erosion control, and fodder (Bigirimana *et al*., 2016).

IEFs are, however, threatened by over-exploitation and loss of biodiversity as observed in the high rates of deforestation recorded with the conversion of forests to coffee plantations (Hylander *et al*., 2013) even in Gayo Highlands. Each individual has a different perception of the importance of the forest because it is related to meeting their personal needs and not everyone do care about forest sustainability (Puspaningrum, 2015). Indigenous knowledge plays an important role in forest conservation by increasing the awareness and well-being of future generations and by avoiding over-exploitation of natural resources beyond their carrying capacity (Mawardi, 2011). However, this piloting role of indigenous knowledge is disappearing as a consequence of resource over-exploitation, land-use change, and behavioural changes (Joshi & Joshi, 2005). Therefore, there is an urgent need for the exploration of the traditional knowledge of IEFs and their contribution to household income in rural areas. This study was conducted to determine the diversity of IEFs and evaluate its contribution to the enhancement of rural community income in the Gayo Highlands region.

2 Materials and methods

2.1 Study site

The study was conducted in three districts of Gayo Highlands (city of Takengon – 04°37'N, 96°50'E, 1250 m a.s.l.), Central Aceh, Indonesia including Linge, Bintang, and Cilala as shown in Figure 1. These areas have a tropical humid climate with a dry season predominantly occurring from January to July while the rainy season lasts from August to December. The rainfall ranges between 1,082 and 2,409 mm per year with between 113 - 160 rainy days with an average humidity of 80.1 %. The average temperature is around 20.10C with April and May being the hottest months with 26.60C while September remains the coldest with 19.70C . The topography is generally mountainous and hilly and the zone is characterised by a cropping system where coffee and vegetables make up the primary crops (The Central Bureau of Statistics of Aceh Tengah Regency, 2019).

2.2 Data collection

The study was conducted between April and June 2018 to collect, identify, and document the IEFs from the three districts of Central Aceh, Indonesia. Plant materials were collected, along with the recording of their local names, the parts used, and field habits. The botanical identification was performed at the Herbarium ANDA of Andalas University, Padang, West Sumatra.

A total of 225 people comprising 25 individuals from each of the nine study sites in the three districts were randomly sampled. All respondents were either Gayo, Aceh, or Javanese. The interview was conducted face to face in Indonesian language and each interview lasted between 30 and 60 minutes. A semi-structured questionnaire was used to cover background of respondents, collection and harvesting methods, uses, and marketing of IEFs. Local market inventories were performed to identify the potential commercial

value of IEFs in the study area. The data collected were related to the uses, preparation, and economic values of IEFs.

Table 1: *Name of villages, districts, altitude, and number of inhabitants of the study area.*

Name of village	*District*	*Altitude (m a.s.l.)*	*Inhabitants (number, 2018)*
Arul Itam	Linge	975	641
Kute Keramil	Linge	958	363
Kute Rayang	Linge	950	225
Atu Payung	Bintang	983	158
Jamur Konyel	Bintang	1,008	268
Serule	Bintang	834	340
Tanoh Depet	Cilala	1,250	539
Kuyun Uken	Cilala	950	925
Depet Indah	Cilala	1,250	269

Source: The Central Bureau of Statistics of Aceh Tengah Regency (2019)

2.3 Data analysis

Two quantitative parameters, namely Fidelity Level (FL) and Informant Consensus Factor (ICF) were used to analyse the qualitative ethnobotanical information collected from informants, as shown below:

Fidelity Level (FL)
The importance of a certain plant species for a specific usage was quantified using the Fidelity Level (FL) which was calculated in percentage from the following relationship:

$$FL\ (\%) = Np/N \times 100$$

Where Np is the number of informants using a plant species for a specific use, and N is the number of informants using the plant for any given use category (Alexiades, 1996).

Informant Consensus Factor (ICF) Informant Consensus Factor (ICF) was employed to identify the agreements of the informants on the importance of each specific use category. It was calculated using the following equation:

$$ICF = (Nur - Nt) / Nur - 1$$

Where Nur is the number of use citations in each category and Nt the total number of species used (Heinrich *et al.*, 1998).

The contribution of the purchased fruits to household income was calculated as a percentage of the total annual income generated from IEF sales. Computations were performed in Microsoft Office Excel 2016.

3 Results

3.1 Diversity of IEFs

A total of 38 species of IEFs belonging to 19 families were discovered in the study area as shown in Table 2. Twenty-four (63.1 %) species were found growing in forests, 11 (28.9 %) in cultivated fields, and 3 (7.9 %) species occurred in both forest and cultivated fields. The Lauraceae and Rosaceae were the most represented families with five species each while *Artocarpus integer*, *Durio zibethinus*, *Garcinia mangostana*, *Lansium parasiticum*, *Mangifera odorata*, *Syzygium aqueum*, and *Syzygium malaccense* were the most common IEFs found in the Gayo Highlands region.

3.2 Utilisation of IEFs

The Gayo Highlands consist of a forest with rich floristic diversity and has been reported to be one of the megabiodiversity hotspots on Sumatra. The forest offers all necessities like food, fuelwood, medicine, timber, and building materials. The communities inhabiting the Gayo Highlands work mainly as farmers. They cultivate different crops such as rice, maize, and vegetables. IEFs like durian (*D. zibethinus*) and introduced plant species like avocado (*Persea americana*) are also planted in the fields, while other IEFs like kuwini (*M. odorata*) appear naturally and are protected.

The local population in the Gayo Highlands collect various IEFs from the forest to meet their daily needs. The use of IEFs by these communities has been going on for a long time. The indigenous knowledge is passed on from parents to children to ensure that it is not lost across generations. However, the study found older people to be more knowledgeable about fruit species than younger ones. The collected fruits are eaten fresh or sold on the local market in cities to supplement household income. Though, the maturation of most IEFs has been reported to coincide with the season of coffee harvesting, and this limit the amount of IEFs collected. Fidelity Level (FL) of various IEFs used as food in the study areas are shown in Table 3.

Approximately 62 % of all households eat IEFs as additional food, while 28 % substitute lunch with IEFs during their peak fruiting periods while the remaining 10 % eat them for breakfast and dinner. The study showed that most of the IEFs were consumed as fresh fruits without further processing. However, fruits of *M. odorata* and *M. foetida* were consumed as juices, while *L. wallichianu*s seeds were boiled or fried and consumed as a snack.

The analysis of use diversity showed the five major uses of IEFs in the region. Moreover, the ICF values presented in

Table 2: *The scientific name, vascular name, and family of the indigenous edible fruits (IEF) in the study area.*

Scientific name	*Local name*	*Family*	*Habit*	*Habitat*
Acronychia pedunculata (L.) Miq.		Rutaceae	Tree	Forest
Alseodaphne bancana Miq.		Lauraceae	Tree	Forest
Aralia dasyphylla Miq		Araliaceae	Tree	Forest
Artocarpus integer (Thunb.) Merr.	Cempedak	Moraceae	Tree	Forest, Cultivated fields
Baccaurea motleyana (Müll.Arg.) Müll.Arg.	Rambai	Phyllantaceae	Tree	Cultivated fields
Cayratia trifolia (L.) Domin	Anggur hutan	Vitaceae	Liana	Forest
Cryptocarya nigra Kosterm.		Lauraceae	Tree	Forest
Dalbergia pinnata (Lour.) Prain	Peking	Ebenaceae	Tree	Forest
Debregeasia longifolia (Burm.f.) Wedd.		Urticaceae	Tree	Forest
Diospyros kaki L.f.	Kesemek	Ebenaceae	Tree	Cultivated fields
Durio zibethinus L.	Durian	Malvaceae	Tree	Forest, Cultivated fields
Endiandra rubescens (Blume) Miq.	Pala hutan	Lauraceae	Tree	Forest
Eriobotrya japonica (Thunb.) Lindl	Biwa	Rosaceae	Tree	Cultivated fields
Flacourtia rukam Zoll.	Moritzi&Rukam	Fagaceae	Tree	Forest
Garcinia bancana Miq.	Manggis hutan	Clusiaceae	Tree	Forest
Garcinia celebica L.	Manggis hutan	Clusiaceae	Tree	Forest
Garcinia mangostana Linn.	Manggis	Clusiaceae	Tree	Forest, Cultivated fields
Homalanthus populneus (Geiseler) Pax		Euphorbiaceae	Tree	Forest
Lansium parasiticum (Osbeck) K.C.Sahni & Bennet	Lansat	Meliaceae	Tree	Cultivated fields
Lithocarpus wallichianus (Lindl. ex Hance) Rehder	Geseng tanduk	Fagaceae	Tree	Forest
Litsea cubeba (Lour.) Pers.	Medang	Lauraceae	Tree	Forest
Mangifera foetida Lour.	Mancang	Anacardiaceae	Tree	Cultivated fields
Mangifera odorata Griff.	Kuwini	Anacardiaceae	Tree	Cultivated fields
Melicope hookeri T.G.Hartley		Rutaceae	Tree	Forest
Mitrephora teysmannii Scheff.	Banitan	Annonaceae	Tree	Forest
Morus alba L.	Murbei gunung	Moraceae	Tree	Forest
Passiflora foetida L.	Markisa hutan	Passifloraceae	Climber	Cultivated fields
Phoebe grandis (Nees) Merr.	Medang nangka	Lauraceae	Tree	Forest
Prunus arborea (Blume) Kalkman		Rosaceae	Tree	Forest
Rubus buergeri Miq.&Beri hutan	Rosaceae	Shrub	Forest	
Rubus pyrifolius Hook.f.&Thomson ex.Hook.f.	Beri hutan	Rosaceae	Shrub	Forest
Rubus rosifolius Sm.	Beri hutan	Rosaceae	Shrub	Forest
Sloanea javanica (Miq.) Koord. & Valeton		Elaeocarpaceae	Tree	Forest
Spondias dulcis Parkinson	Kedondong hutan	Anacardiaceae	Tree	Forest
Syzygium aqueum (Burm.f.) Alston	Jambu air	Myrtaceae	Tree	Cultivated fields
Syzygium attenuatum (Miq.) Merr. &L.M.Perry	Jambu wer	Myrtaceae	Tree	Cultivated fields
Syzygium cumini (L.) Skeels	Jambu keling	Myrtaceae	Tree	Cultivated fields
Syzygium malaccense (L.) Merr. & L.M. Perry	Jambu bol merah	Myrtaceae	Tree	Cultivated fields

Table 4 provided general information on the ethnobotanical importance of each use category in each of the study sites.

The mean ICF for the district of Linge was the highest (43.7 %) followed by Cilala and Bintang at 42.3 % and 41.4 %, respectively. The highest ICF values were obtained for food and firewood (mean ICF = 0.84), followed by construction material (mean ICF = 0.83), medicinal plants (mean ICF = 0.81), and furniture (mean ICF = 0.79). The high ICF values indicate that IEFs play an important role in the livelihood of the local population. However, 70 % of the respondents reported that IEFs contribute less than 25 % of the annual food supply. The higher number of plants used by local people for firewood indicates their dependence on accessible plant resources for fuel.

Besides fruits and seeds, the most widely used plant parts of the IEFs are leaves and stems (table 5). Stems are being used as building material, furniture and firewood, and leaves are used as traditional medicine. The leaves of *A.*

Table 3: *The Fidelity Level of various indigenous edible fruit species used as a source of food in the nine villages of the study area.*

Scientific name	*Part used*	*Arul Itam*	*Kute Keramil*	*Kute Rayang*	*Atu Payung*	*Jamur Konyel*	*Serule*	*Tanoh Depet*	*Kuyun Uken*	*Depet Indah*
Acronychia pedunculata	Fruit	2	2	0	0	2	0	0	0	8
Alseodaphne bancana	Fruit	6	0	0	2	2	0	2	0	4
Aralia dasyphylla	Fruit	0	0	0	4	10	0	0	14	2
Artocarpus integer	Fruit	100	100	100	100	100	100	100	100	100
Baccaurea motleyana	Fruit	100	100	100	100	100	100	100	100	100
Cayratia trifolia	Fruit	6	2	0	2	0	0	2	2	0
Cryptocarya nigra	Fruit	2	0	10	0	0	2	4	0	2
Dalbergia pinnata	Fruit	12	0	0	0	0	0	0	0	4
Debregeasia longifolia	Fruit	2	0	8	0	0	4	2	4	2
Diospyros kaki	Fruit	100	100	100	100	100	100	100	100	100
Durio zibethinus	Fruit	100	100	100	100	100	100	100	100	100
Endiandra rubescens	Fruit	2	4	4	0	4	10	4	6	6
Eriobotrya japonica	Fruit	62	40	58	56	60	24	64	46	64
Flacourtia rukam	Fruit	56	62	44	54	64	52	66	58	82
Garcinia bancana	Fruit	36	56	14	12	4	16	24	24	16
Garcinia celebica	Fruit	52	42	48	65	46	64	48	37	58
Garcinia mangostana	Fruit	100	100	100	100	100	100	100	100	100
Homalanthus populneus	Fruit	0	0	2	2	2	2	0	2	0
Lansium parasiticum	Fruit	100	100	100	100	100	100	100	100	100
Lithocarpus wallichianus	Seed	46	42	12	28	40	32	4	10	66
Litsea cubeba	Fruit	2	2	0	2	4	8	2	4	4
Mangifera foetida	Fruit	100	100	100	100	100	100	100	100	100
Mangifera odorata	Fruit	100	100	100	100	100	100	100	100	100
Melicope hookeri	Fruit	22	10	2	0	0	10	6	6	8
Mitrephora teysmannii	Fruit	2	0	0	0	8	8	4	0	0
Morus alba	Fruit	24	12	14	4	0	4	0	24	28
Passiflora foetida	Fruit	100	100	100	100	100	100	100	100	100
Phoebe grandis	Fruit	14	18	14	4	4	4	8	0	8
Prunus arborea	Fruit	28	0	0	6	6	4	0	0	8
Rubus buergeri	Fruit	72	14	62	44	34	52	18	26	32
Rubus pyrifolius	Fruit	66	24	42	24	26	44	10	24	36
Rubus rosifolius	Fruit	24	22	24	10	36	56	24	46	30
Sloanea javanica	Fruit	6	0	0	2	3	0	3	0	0
Spondias dulcis	Fruit	38	5	4	8	18	4	12	24	24
Syzygium aqueum	Fruit	100	100	100	100	100	100	100	100	100
Syzygium attenuatum	Fruit	100	100	100	100	100	100	100	100	100
Syzygium cumini	Fruit	100	100	100	100	100	100	100	100	100
Syzygium malaccense	Fruit	100	100	100	100	100	100	100	100	100
mean		50.8	45.1	45.2	44.3	45.5	46.2	43.8	45.1	48.5

pedunculata are used in Arul Itam as a traditional medicine against sores. Leaves from *C. trifolia* are used to treat ulcers in Arul Itam, while it is used as a fever treatment in Tanoh Depet and Kute Keramil. *L. cubeba* is utilised as swelling and pain treatment, while the leaves of *P. foetida* are said to treat sleeping disorders. Further, the leaves of *R. rosifolius* can be applied to itches and an infusion of the leaves of *S. cumini* is used as a diarrhea treatment.

Maximum numbers of species were harvested for their fruit, followed by leaves, stems, and seeds. One part of a plant can be used for several purposes. For example, the stem of *D. zibethinus* is used as construction material for floors or walls, while the fruit is eaten fresh.

Table 4: *The Informant Consensus Factors (ICF) for the different use categories in the nine villages of the study area.*

Use category	*Arul Itam*	*Kute Keramil*	*Kute Rayang*	*Atu Payung*	*Jamur Konyel*	*Serule*	*Tanoh Depet*	*Kuyun Uken*	*Depet Indah*
Food	0.85	0.84	0.80	0.82	0.88	0.81	0.80	0.87	0.88
Fuel wood	0.86	0.84	0.83	0.86	0.82	0.80	0.85	0.83	0.85
Medicinal use	0.84	0.82	0.82	0.80	0.80	0.76	0.79	0.80	0.82
Construction material	0.87	0.86	0.82	0.80	0.82	0.76	0.88	0.80	0.82
Furniture	0.84	0.79	0.74	0.78	0.80	0.78	0.79	0.80	0.82

Table 5: *The Informant Consensus Factors (ICF) for the different use categories in the nine villages of the study area.*

Scientific name	*Arul Itam*	*Kute Keramil*	*Kute Rayang*	*Atu Payung*	*Jamur Konyel*	*Serule*	*Tanoh Depet*	*Kuyun Uken*	*Depet Indah*
Acronychia pedunculata	F, M	F	-	-	F	-	-	-	F
Alseodaphne bancana	F	-	-	F	F	F	F	F	F
Aralia dasyphylla	-	-	-	F	F	-	-	F	F
Artocarpus integer	F,W	F	F	F,W	F	F	F	F,W	F,W
Baccaurea motleyana	F,W	F,W	F	F	F,W	F	F	F	F
Cayratia trifolia	F,M	F,M	-	F	-	-	F,M	F	-
Cryptocarya nigra	F,W	-	F	F	-	F	F	-	F
Dalbergia pinnata	F	-	F	-	F	F	F,M	F	F
Debregeasia longifolia	F	-	F	-	-	F	F	F	F
Diospyros kaki	F	F	F	F	F	F	F	F	F
Durio zibethinus	F, W,C	F,W,C	F,W,C	F,C	F,C	F,W,C	F,C	F,W,C	F,C
Endiandra rubescens	F	F	F	-	F	F	F	F	F
*Eriobotrya japonic*a	F	F	F	F	F	F	F	F	F
Flacourtia rukam	F,M	F	F,M	F	F,M	F	F,M	F,M	F
Garcinia bancana	F	F	F	F	F	F	F	F	F
Garcinia celebica	F,W	F	F,W	F	F	F	F,W,M	F	F,W
Garcinia mangostana	F,M	F	F,W	F	F,M	F	F	F	F
Homalanthus populneus	-	-	F,M	F	F	F	-	F	-
Lansium parasiticum	F,W	F,W	F	F,W	F	F	F	F	F
Lithocarpus wallichianus	F,W,FN	F,W	F,W	F,W,FN	F,W	F,W,FN	F,W	F,W	F,W
Litsea cubeba	F,C,M	F,C	W	F	F,M	F	F	F,M	F
Mangifera foetida	F,W	F	F	F	F,W	F	F	F	F
Mangifera odorata	F, W	F	F,W	F	F,W	F	F	F,W	F
Melicope hookeri	F,W	F	F	-	-	F,W	F	F,W	F,W
Mitrephora teysmannii	F	-	-	-	F,W	F	F	-	-
Morus alba	F	F	F	F	-	F	-	F	F
Passiflora foetida	F	F,M	F	F	F,M	F	F	F	F
Phoebe grandis	F	F	F	F	F	F	F	-	F
Prunus arborea	F	-	-	F	F	F	-	-	-
Rubus buergeri	F	F	F	F	F	F	F	F	F
Rubus pyrifolius	F	F	F	F	F	F	F	F	F
Rubus rosifolius	F,M	F	F,M	F,M	F	F	F	F	F,M
Sloanea javanica	F,C,W	-	-	F,C	-	F,C,W	-	-	-
Spondias dulcis	F,W	-	F,W	F,W	F,W	F	F,W	F	F,W
*Syzygium aqueu*m	F,W	F	F	F,W	F,W	F	F,W	F	F
Syzygium attenuatum	F	F,W	F	F	F	F,W	F	F	F,W
Syzygium cumini	F,M	F,M	F,M	F	F,M	F,M	F	F,M	F
Syzygium malaccense	F,W	F	F,W	F	F	F,W	F	F	F

F= food, W= firewood, C=construction material, FN= furniture, M= medicine

Table 6: *The indigenous edible fruits (IEF) commercialised in the Gayo Highlands region.*

		Marketing (n=225)		
Scientific name	*Trade part*	*Number of respondents*	*Mean quantity marketed per respondent (kg)*	*Market price (IDR/kg)*
Artocarpus integer	Fruit	223	250 (12.8)	8,000 (250)
Baccaurea motleyana	Fruit	220	50 (6.1)	8,000 (288)
Diospyros kaki	Fruit	195	50 (7.9)	12,000 (500)
Durio zibethinus	Fruit	225	1,500 (105.5)	20,000 (894)
Eriobotrya japonica	Fruit	189	40 (5.2)	6,000 (447)
Garcinia mangostana	Fruit	225	50 (6.6)	12,000 (500)
Garcinia bancana	Fruit	112	10 (2.2)	5,000 (447)
Garcinia celebica	Fruit	86	10 (2.4)	5,000 (447)
Lansium parasiticum	Fruit	225	100 (17.5)	15,000 (447)
Mangifera foetida	Fruit	225	150 (18.6)	10,000 (447)
Mangifera odorata	Fruit	225	150 (11.1)	10,000 (447)
Syzygium aqueum	Fruit	220	50 (6.6)	8,000 (447)
Syzygium attenuatum	Fruit	215	40 (5.8)	8,000 (447)
Syzygium cumini	Fruit	218	25 (2.9)	8,000 (447)
Syzygium malaccense	Fruit	128	50 (6.3)	10,000 (707)

Means plus standard deviation in brackets and Indonesian Rupiah-IDR
Note: 1 USD = 14,077 IDR in 22 June 2018 from id.exchange-rates.org

3.3 Socioeconomic significance of IEFs

The market survey showed that many IEFs are sold in the local market and have the potential to improve the livelihoods and socioeconomic status of the local population. Fifteen (39.5 %) of the harvested IEFs had market value (Table 6).

The results showed 86 % of the respondents have sold IEFs to increase household income and the high-priced local fruit species included *D. zibethinus, D. kaki, L. parasiticum, G. mangostana, M. foetida*, and *M. odorata*. *D. zibethinus* and *A. integer* were sold in relatively high quantities during the growing seasons. The mean total annual contribution to the income of the household of the IEFs was regardless of type and quantity around 43 %. From all households selling fruits, 54 % were found to be earning annually less than 20,000,000 Indonesian Rupiah (IDR), 31 % earned between IDR 20,000,000 and IDR 30,000,000 while the remaining households earned more than IDR 30,000,000 but less than IDR 50,000,000.

4 Discussion

The local population of Gayo Highlands have a close relationship with the forest. The different uses of the IEFs (table 4) – gathered in the forest or of the ones protected or cultivated in the fields - underline the local knowledge on IEFs. This result is consistent with a previous study by Suwardi *et al*. (2020b) in South Aceh, Indonesia. The forest provides products for food, shelter, medicine, fibres, and energy for many rural populations in the world (Vantomme, 2003; Saha & Sundriyal, 2012). In this study, several species have been identified which are used for various purposes. For example, the fruits of *L. cubeba* are used for fresh consumption, while the leaves are used as a medicine and the stems as a building material and firewood. However, the use categories of a species can be different throughout the study area (Table 5). This distinction can be provoked through the fact that individuals may have different interests, perceptions, knowledge, and access to IEFs. The intensity of the use of a plant species has been reported to depend on people's way of life in terms of their social, cultural, and economic background (Shrestha & Dhillion, 2006; Pardo-de Santayana *et al*., 2005; Suresh *et al*., 2014).

Fruit was the most commonly used IEF product. During discussions, respondents reported that taste was an important criterion for fruit preference, which is in agreement with other surveys as e.g. Sujarwo *et al*. (2015) in Bali, Indonesia. Several undomesticated species, such as *M. foetida* and *M. odorata*, are considered economically valuable and preferred by Gayo Highlands communities due to their sweet and fragrant taste. This is in line with the report of Suwardi *et al*. (2019b) that the community's preference for wild fruits in

the Aceh Tamiang district is similar to cultivated fruits. The gathered fruits play an important role in providing various essential nutrients, such as vitamins and minerals, to balance the diets and maintain human health. For example, Jambu Keling (S. cumini), has a sweet or slightly sour taste and is preferred by the local communities; this species is reported to have a high antioxidant activity (Afify *et al*., 2011) and to play a role in the treatment of diabetes mellitus (Swami *et al*., 2012; Silalahi, 2018).

The local population of Gayo Highlands works mainly as a farmer and is highly dependent on agricultural products, in particular rice and coffee. Settlements adjacent to the forest (1-5 km) make it easier for communities to access forest resources. The maturation of most IEFs was reported to be coinciding with the season of coffee cultivation and harvest and this limits the quantities of IEFs collected. Consequently, only a few IEFs of economic value are harvested and sold on the local market. As a result, the economic contribution of IEF to total household income was found to be around 43 %, which was lower than that reported for the eastern Nuba Mountains of Sudan with around 50-100 % (Salih-Kamal & Ali, 2014). The mean marketed quantity of IEFs of 1026.5 kg year-1 per household (Table 6), was lower than that recorded for South Aceh, Indonesia with around 6,115 kg year-1 per household (Suwardi *et al*., 2020b). Accessibility and availability of species are important factors for local communities to exploit these resources (Tchatat & Ndoye, 2006; Betti *et al*., 2016; Djihounouck *et al*., 2018). The amount of IEFs harvested has fluctuated in recent years. In the mid-1990s, new farmland was installed on the hillsides for coffee plantations as well as for the introduction of avocado (*Persea americana*). This expansion of (community) plantations has led to a reduction of the forest and in this way to a reduced number of wild fruit plants. This has led also to an increased competition between local population and monkeys and birds for the use of these IEFs. In addition, the fruiting season, in particular of wild fruit plants, is concurrent with coffee harvest. These factors influenced IEFs accessibility and availability considerably.

Farmers in the Gayo Highlands have been practicing traditional agroforestry systems for hundreds of years by combining different IEFs such as durian, with crops such as rice, maize, and vegetables. Agroforestry systems are considered to have a positive effect on soil physical and chemical properties by protecting the soils from erosion, by improving the microclimate and by meeting the needs of farmers for fuelwood, charcoal and fencing materials (Fadl & Gebauer, 2004). Such systems also can meet the social, economic, and ecological (conservation) interests of the farmers (Prasmatiwi *et al*., 2010). At present, the agroforestry system in the Gayo Highlands is dominated by exotic plants, particularly coffee and avocado. Farmers plant coffee mixed with avocado but do not plant any further crops (rice, maize or vegetables). However, a few farmers do plant durian (*D. zibethinus*) between their coffee or protect naturally grown Kuwini (M. odorata).The transfer of local knowledge from one generation to another is still being practiced in the Gayo Highlands. Van der Hoeven *et al*. (2013) reported elders to be the custodians of knowledge and transfer it to ensure it is not lost through generations. However, this study found a tendency to a decreased traditional knowledge in the use of IEFs among younger generations. Most young people in the study area were unfamiliar with IEFs, particularly with wild edible fruits. They only consume IEFs fresh and restrict to fruit species commonly found in home gardens or fields such as durian, mango or Jambu. Modernisation has led them even to prefer imported fruits like apple and grape. However, also formal education can play a role to transfer local knowledge, including the benefits of IEFs in terms of health, economics, and conservation. Teachers can integrate the concept of bio-conservation to enhance students' understanding of the potential of local resources. This is in accordance with the findings of Ramadoss & Moli (2011) that the biodiversity education programs in India can improve students' knowledge, interest, and skills to protect and conserve local natural resources and biodiversity. Moreover, through extension services for agricultural promotion, younger generations are involved in the implementation of agroforestry systems using local IEFs as well as in forest restoration programs. These activities were introduced by the Indonesian government through the Central Aceh District Agriculture Office to emphasize the importance of IEFs in providing economic values and the need to preserve and increase these for future use.

5 Conclusion and recommendations

A total of 38 IEF species belonging to 19 families were found in the study area. Twenty-four (63.1 %) species were found growing in forests, 11 (28.9 %) in cultivated fields, and 3 (7.9 %) species occur in both forest and cultivated fields. The most utilised species included *Artocarpus integer*, *Artocarpus integer*, *Diospyros kaki*, *Durio zibethinus*, *Garcinia mangostana*, *Lansium parasiticum*, *Mangifera foetida*, *Mangifera odorata*, *Passiflora foetida*, *Syzygium aqueum*, *Syzygium attenuatum*, *Syzygium cumini*, and *Syzygium malaccense*. The marketing of the products of these species do contribute about 43 % to the total household income and are relevant to household food security/dietary balance.

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Conflict of interest

Authors state they have no conflict of interest.

References

Afify, A. E. M. M. R., Fayed, S. A., Shalaby, E. A. & El-Shemy, H. A. (2011). *Syzygium cumini* (Pomposia) active principles exhibit potent anticancer and antioxidant activities. *Afr. J. Pharm. Pharmaco.*, 5 (7), 948–956. DOI: 10.5897/AJPP10.420.

Akinnifesi, F. K., Kwesiga, F., Mhango, J., Chilanga, T., Mkonda, A., Kadu, C.A.C., Kadzere, I., Mithofer, D., Saka, J.D.K., Sileshi, G., Ramadhani, T. & Dhliwayo, P. (2006). Towards the development of miombo fruit trees as commercial tree crops in southern Africa. *Forests, Trees and Livelihoods*, 16, 103–121.

Alexiades, M. N. (1996). Collecting ethnobotanical data: An introduction to basic concepts and techniques. In: Alexiades, M.N. (Ed.). Selected guidelines for ethnobotanical research: Aa field manual. The New York Botanical Garden, Bronx, New York. pp. 53–94.

Batubara, R. & Affandi, O. (2017). Economic Value of Non-Timber Forest Products and Their Contributions to Household Income (Case Study in Two Villages Around Sibolangit Tourism Park). *Wahana Forestra*, 12 (2), 149–162. DOI: 0.24259/fs.v1i1.1096.

Betti, J. L., Ngankoué, C. M., Dibong, S. D. & Singa, A. E. (2016). Etude ethnobotanique des plantes alimentaires spontanées vendues dans les marchés de Yaoundé, Cameroun. *Int. J. Biol. Chem. Sci.*, 10 (4), 1678–1693. DOI: 10.4314/ijbcs.v10i4.19.

Bigirimana, C., Omujal, F., Isubikalu, P., Bizuru, E., Obaa, B., Malinga, M., Agea, J.G., & Okullo, J. B. L. (2016). Utilisation of Indigenous Fruit Trees Pecies Within the Lake Victoria Basin, Rwanda. *Agricultural Science: An International Journal*, 1 (1), 1–13.

Djihounouck, Y., Diop, D., Dieng, S.D., Sane, S., Bassène, C., Mbaye, S.M. & Noba, K. (2018). Diversité et importance socioeconomique des espèces fruitières sauvages comestibles en zone Kasa (Sud-Ouest du Sénégal). *European Scientific Journal*, 14 (36), 352–376. DOI: 10.19044/esj.2018.v14n36p352.

Fadl, K. E. M. & Gebauer, J. (2004). Crop performance and yield of Groundnut, Sesame and Roselle in agroforestry cropping system with Acacia senegal in North Kordofan (Sudan). *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 105 (2), 149–154.

Gangwar, K. K., Deepali, & Gangwar, R. S. (2010). Ethnobotanical plant diversity in Kumaun Himalaya of Uttarakhan. *India. Nat. Sci.*, 8 (5), 66–78.

Gusain, Y. S. & Khanduri, V. P. (2016). Myrica esculenta, wild edible fruit of Indian Himalaya: need a sustainable approach for indigenous utilization. *Eco. Env. Cons.*, 22, 267–270.

Heinrich, M., Ankli, A., Weimann, C., Frei, B. & Sticher, O. (1998). Medicinal Plants in Mexico: Healers' Consensus and Cultural Importance. *Soc. Sci. Med.*, 47 (11), 1859–1871. DOI: 10.1016/S0277-9536(98)00181-6.

Hylander, K., Nemomissa, S., Delrue, J. & Enkosa, W. (2013). Effects of coffee management on deforestation rates and forest integrity. *Conserv Biol.*, 27 (5), 1031–40. DOI: 10.1111/cobi.12079.

Irfan & Priatna, D. P. (2004). *Biodiversity of the Leuser Ecosystem*. Leuser Management Unit. Medan, Indonesia.

Joshi, A. R. & Joshi, K. (2005). *Ethnobotany and Conservation of Plant Diversity in Nepal*. Rubrick, Kathmandu, Nepal.

Leakey, R. R. B., Tchoundjeu, Z., Schreckenberg, K., Shackleton, S. E. & Shackleton, C. M. (2005). Agroforestry Tree Products (AFTPs): Targeting poverty reduction and enhanced livelihoods. *International Journal for Agricultural Sustainability*, 3, 1–23.DOI: 10.1080/14735903.2005.968.

Maske, M., Mungole, A., Kamble, R., Chaturvedi, A. & Chaturvedi, A. (2011). Impact of non-timber forest produces (NTFP's) on rural tribes economy in Gondia district of Maharashtra, India. *Archives of Applied Science Research*, 3 (3), 109–114.

Mawardi, I. (2011). Wisdom local empowerment in sustainable development perspective. *Jurnal Rekayasa Lingkungan*, 8 (1), 1—10.

Navia, Z.I. & Chikmawati T. (2015). *Durio tanjungpurensis* (Malvaceae), a new species and its one new variety from West Kalimantan, Indonesia. *Bangladesh J. Bot.*, 44 (3), 429–436. DOI: https://doi.org/10.3329/bjb.v44i3.38550.

Ong, H. C., Norliah, A. & Sorayya, M. (2012). Traditional knowledge and usage of edible plants among the Temuan villagers in Kampung Tering, Kuala Pilah, Negeri Sembilan, Malaysia. *Indian Journal of Traditional Knowledge*, 11 (1), 161–165.

Pardo-de Santayana, M., Tardio, J. & Morales, R. (2005). The gathering and consumption of wild edible plants in the Campoo (Cantabria, Spain). *International Journal of Food Sciences and Nutrition*, 56, 529–542. DOI: 10.1080/09637480500490731.

Prasmatiwi, F. E., Irham, Suryantini, A. & Jamhari. (2010). Determinants of the Adoption of Shade Systems and Their Effects on Coffee Farming Productivity and Income in West Lampung Regency. *Agriekstensia*, 9 (2),160–172.

Puspaningrum, D. (2015). Local wisdom on forest and ecosystem management in the community in the buffer zone village of Meru Betiri National Park. *J. of Social and Agricultural Economics*, 8 (1), 11—24.

Ramadoss, A. & Payyomoli, G. (2011). Biodiversity Conservation through Environmental Education for Sustainable Development: A Case Study from Puducherry, India. *Intern. Electr. J. of Environm. Educ.*, 1 (2), 97–111.

Saha, D. & Sundriyal, R. C. (2012). Utilization of non-timber forest products in humid tropics: Implications for management and livelihood. *For. Policy Econ.*, 14, 28–40.

Salih-Kamal, E. M. & Ali, A. H. (2014). Wild food trees in Eastern Nuba Mountains, Sudan: Use, diversity, and threatening factors. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 115 (1), 1–7.

Schreckenberg, K., Awono, A., Degrande, A., Mbosso, C., Ndoye, O. & Tchoundjeu, Z. (2006). Domesticating indigenous fruit trees as a contribution to poverty reduction. *Forests, Trees and Livelihoods*, 16, 35–52. DOI: 10.1016/j.forpol.2011.07.008.

Shrestha, P. M. & Dhillion, S. S. (2006). Diversity and traditional knowledge concerning indigenous food species in a locally managed forest in Nepal. *Agroforestry Systems*, 66, 55–63. DOI: 10.1007/s10457-005-6642-4.

Silalahi, M. (2018). Jamblang (*Syzygium cumini* (L.) and its bioactivities. *J. Terpadu Ilmu Kesehatan*, 7 (2), 124–132.

Sujarwo, W., Arinasa, I. B. K. Caneva, G. & Guarrera, P. M. (2015). Traditional knowledge of wild and semi-wild edible plants used in Bali (Indonesia) to maintain biological and cultural diversity. *Plant Biosystems*, 1–6. DOI: 10.1080/11263504.2014.994577.

Suresh, C. P., Bhutia, K. D., Shukla, G., Pradhan, K. & Chakravarty, S. (2014). Wild edible tree fruits of Sikkim Himalayas. *Journal of Tree Sciences*, 33, 43–48.

Suwardi, A. B., Indriaty & Navia, Z. I. (2018). Nutritional evaluation of some wild edible tuberous plants as an alternative Foods. *Innovare Journal of Food Sci.*, 6 (2), 9–12.

Suwardi, A. B., Navia, Z. I., Harmawan, T., Syamsuardi, & Mukhtar, E. (2019a). The diversity of wild edible fruit plants and traditional knowledge in West Aceh region, Indonesia. *J. of Medicinal Plants Studies*, 7 (4), 285–290.

Suwardi, A. B., Navia, Z. I., Harmawan, T., Syamsuardi, & Mukhtar, E. (2019b). Sensory Evaluation of Mangoes Grown in Aceh Tamiang District, Aceh, Indonesia. *Advances in Ecological and Environmental Research*, 4 (3), 79–85.

Suwardi, A. B., Navia, Z. I., Harmawan, T., Nuraini, Syamsuardi & Mukhtar, E. (2020a). Ethnobotany, nutritional composition and sensory evaluation of *Garcinia* from Aceh, Indonesia. *Materials Science and Engineering*, 725 (1), 012064.

Suwardi, A. B., Navia, Z. I., Harmawan, T., Syamsuardi & Mukhtar, E. (2020b). Ethnobotany and conservation of indigenous edible fruit plants in South Aceh, Indonesia. *BIODIVERSITAS*, 21 (5), 1850–1860. DOI: 10.1088/1757-899X/725/1/012064.

Swami, S. B., Thakor, N. S., Patil, M. M. & Haldankar, P. M. (2012). Jamun (*Syzygium cumini* (L.)): A Review of Its Food and Medicinal Uses. *Food and Nutrition Sciences*, 3, 1100–1117. DOI: 10.4236/fns.2012.38146.

Tchatat, M. & Ndoye, O. (2006). Étude des produits forestiers non ligneux d'Afrique centrale: réalités et perspectives. *Bois et forêts des tropiques*, 288, 27–39.

The Central Bureau of Statistics of Aceh Tengah Regency. (2019). *Aceh Tengah Regency in figure 2019*. The Central Bureau of Statistics of Aceh Tengah Regency, Aceh Tengah Regency, Indonesia.

Van der Hoeven, M., Osei, J., Greeff, M., Kruger, A., Faber, M. & Smuts, C.M. (2013). Indigenous and traditional plants: South African parents' knowledge, perceptions and uses and their children's sensory acceptance. *Journal of Ethnobiology and Ethnomedicine*, 9, 1–12. DOI: 10.1186/1746-4269-9-78.

Vantomme, P. (2003). *Forest products division*. Forestry Department, Food and Agriculture Organization, Rome, Italy.

Yobo, C. M. & Ito, K. (2015). Trade of the most popular Indigenous fruits and nuts, threats and opportunities for their sustainable management around the Ivindo National Park (INP), Gabon. *International Journal of Biodiversity and Conservation*, 7(2), 85–102. DOI: 10.5897/IJBC2014.0747.