

VARIATION IN PLANT MORPHOLOGY OF *GARCINIA ATROVIRIDIS* (ASAM GELUGOR)

Azuan Bin Amron
Agrobiodiversity & Environment Research Centre
MARDI Headquarter, 43400, Serdang, Selangor, Malaysia
Email: azuan@mardi.gov.my

Salma Binti Idris
Agrobiodiversity & Environment Research Centre
MARDI Headquarter, 43400, Serdang, Selangor, Malaysia
Email: salma@mardi.gov.my

Mohd Saifuddin Bin Ismail
Agrobiodiversity & Environment Research Centre
MARDI Headquarter, 43400, Serdang, Selangor, Malaysia
Email: msi@mardi.gov.my

Rosliza Binti Jajuli
Agrobiodiversity & Environment Research Centre
MARDI Headquarter, 43400, Serdang, Selangor, Malaysia
Email: rosliza@mardi.gov.my

Muhammad Luqman Hakim Bin Muhammad Fuad
Agrobiodiversity & Environment Research Centre
MARDI Headquarter, 43400, Serdang, Selangor, Malaysia
Email: luqmanhakimfuad@gmail.com

ABSTRACT

Garcinia atroviridis Griff ex T. Anders commonly known as asam gelugor is an underutilized fruit of the family Guttiferae. *Garcinia atroviridis* is native to Peninsular Malaysia. It is distributed from Malaysia to Thailand, Myanmar and Assam (India), and is also found in the Philippines. In Malaysia, asam gelugor is found cultivated in the home gardens or small orchards. Some of the tree species can still be found in lowland forest. Asam gelugor are found mostly in the humid tropics as second storey trees and adapted to shade. A total of 2,846 trees were documented and *Garcinia atroviridis* were spread all over Malaysia covering 54 districts. Asam gelugor trees are usually planted from seeds and showing variations mainly in fruit characters. The tree is large with its trunk fluted at the base. The canopies were basically either pyramidal, conical, oblong, oval or irregular. The branches that arose from main trunk of *Garcinia atroviridis* usually dense. The bark colour of *Garcinia atroviridis* trunk are dark brown, greyish brown, brown, grey, greenish brown, light brown and black. The tree produces large orange-yellow colour fruits, nearly round, fluted with ribs and grooves. Fruit shape varies from ovoid to ovoid-oblong; and from spherical to flattened. From the study, mean values of individual fruit weight varied widely from 176.3g in Acc. no. 40 to 744.1g in Acc. no.69. The average fruit width slightly varied from 5.73cm (Acc. no. 18) to 16.13cm (Acc. no. 14). The thickness of rind of fruit showed a slightly variation among the accessions studied. The leaves mostly were oblong, few elliptic and some with obovate and oblong shapes. In Peninsular Malaysia, asam gelugor cultivation was considered as a moderately common, grown in home gardens and orchards; and had quite a popular ranking based on its popularity to households. The trees are able to provide food, nutrition as well as generate income to the farmers. In view of this, MARDI has carried out a survey on the distribution and genetic diversity of asam gelugor throughout the country.

Keywords: *Garcinia atroviridis*, gelugor, variation, morphology, rare fruits

INTRODUCTION

Garcinia is one of the main genera in Guttiferae (Clusiaceae) comprising an estimated 200 species (Richards, 1990) which is smaller than the earlier estimation of 400 species by Whitmore (1973). *Garcinia* also is the largest genus of Guttiferae in Peninsular Malaysia and important locally as a genus of fruit trees, especially mangosteen (*G. mangostana*); one of the well-known tropical fruits from South East Asia. Peninsular Malaysian *Garcinia* species are almost wholly small or medium trees not exceeding 30m in height or a 120cm width and can be found growing from seashores to mountain tops (Whitmore, 1973). About 49 species of *Garcinia* have been recorded in Peninsular Malaysia but the identification of several of them is incomplete especially the group of high mountain species.

Garcinia atroviridis Griff. ex T. Anders or locally known as 'asam gelugor', is a slow growing medium-sized tree which can growing up to 27m height and 70cm width with a deep monopodial crown of dense, slender and drooping branches (Whitmore, 1973). It is recognized as an endemic species in Peninsular Malaysia (Whitmore, 1973), and distributed from Peninsular Malaysia to Thailand, Myanmar and Assam (India), and it is also found in the Philippines (Verheji and Coronel, 1992). This species grows wild throughout Peninsular Malaysia in the plains of lowland forest and up to 600 m in the hills but is also widely cultivated especially in the home gardens. *Garcinia atroviridis* are usually planted from seeds and showing variations mainly in fruit

characters. The tree is large with its trunk fluted at the base. The tree produces large orange-yellow colour fruits, nearly round, fluted with ribs and rooves (Ridley, 1992). In Peninsular Malaysia, *Garcinia atroviridis* cultivation was considered as moderately common, grown in home gardens and orchards; and had quite a popular ranking based on its popularity to households (Raziah et al., 2007). *Garcinia atroviridis* was found many planted in Bukit Gantang and Yan in Peninsular Malaysia; each home garden at Bukit Gantang has an average of 10 trees of *Garcinia atroviridis* which is considered high in number (Salma et al., 2012). The trees are able to provide food, nutrition as well as generate income to the farmers.

Garcinia atroviridis have been traditionally used in food preparation and cooking, having a distinctive sour taste and are reported to make meals more filling. The unripe, but full-grown fruits are cut into slices and dried, and used in place of tamarind pulp for flavouring. Currently, *Garcinia atroviridis* fruit juice is used on the body weight reduction and lowering cholesterol activity. The leaves have been traditionally used for the treatment of earache. The plant also been attributed with anti-inflammatory properties and reported to have high antioxidant activity.

The distribution and diversity of the *Garcinia* species on farm is not much known and further, not much research and development has been carried out (Salma et al., 2012). There is lack of information on morphological diversity within the species of *Garcinia atroviridis* which are very important information that may be useful, especially in identifying elite accession for future genetic manipulation or tree improvement of the cultivated species. In view of this, an assessment on the distribution and diversity of the *Garcinia atroviridis* was carried in the home gardens in Peninsular Malaysia.

MATERIAL AND METHODS

A systematic survey on the distribution and diversity of *Garcinia atroviridis* was carried out at home gardens and orchards from 33 districts and six states in Peninsular Malaysia (Table 1). *Garcinia atroviridis* available in the home gardens or orchards, their frequency as well as their uses were recorded. Field observations and morphological characters were characterized and documented based on Descriptors for Mangosteen (*Garcinia mangostana*) by IPGRI, 2003.

The baseline dataset on the distribution of *Garcinia atroviridis* that been carried out in all states throughout the country was mapped

Table 1: Number of accessions in districts and states

States	Districts	Number of Accessions
Kedah	Alor Setar	1
	Baling	1
	Jitra	1
	Kuala Muda	2
	Padang Terap	4
	Pendang	1
	Sik	2
	Yan	5
	Kelantan	Kota Bharu
Kuala Krai		3
Machang		7
Pasir Mas		3
Pasir Putih		1
Tanah Merah		3
N. Sembilan	Tumpat	1
	Jelebu	2
Pahang	Kuala Pilah	1
	Jerantut	4
	Kuantan	1
	Lipis	1
	Pekan	1
Perak	Termeloh	1
	Gerik	2

	Hulu Perak	1
	Kerian	1
	Kuala Kangsar	7
	Larut Matang	9
	Perak Tengah	4
Terengganu	Besut	1
	Dungun	3
	Hulu Terengganu	6
	Marang	2
	Setiu	1

RESULTS AND DISCUSSION

Distribution of Garcinia atroviridis

Baseline dataset of *Garcinia atroviridis* from previous study was gathered for distribution study. The data obtained using Participatory Rural Appraisal (PRA) which was conducted on 624 home gardens from 11 states throughout the country (Salma, et al, 2003). A total of 2,846 trees were documented and *Garcinia atroviridis* were spread all over Malaysia covering 54 districts. High frequency of *Garcinia atroviridis* can be seen in the North of Peninsular Malaysia, followed by east coast area and very low frequency in the south of Peninsular Malaysia (Figure 1). Very high number of *Garcinia atroviridis* trees were recorded in Perak (724), followed by Terengganu (608), Kelantan (576), Pahang (277), Kedah (223), N. Sembilan (113) and Penang (65). Both Malacca and Selangor recorded 28 trees each, Johor recorded four, while no *Garcinia atroviridis* tree found in Sabah and Sarawak (Fig. 3). The reason why no *Garcinia atroviridis* was recorded in Sabah and Sarawak because people in that area mostly cultivated *Garcinia forbesii* and *Garcinia parvifolia* which have almost same function with *Garcinia atroviridis* in term of food flavouring.

Figure 1: Distribution of *Garcinia atroviridis* in Malaysia

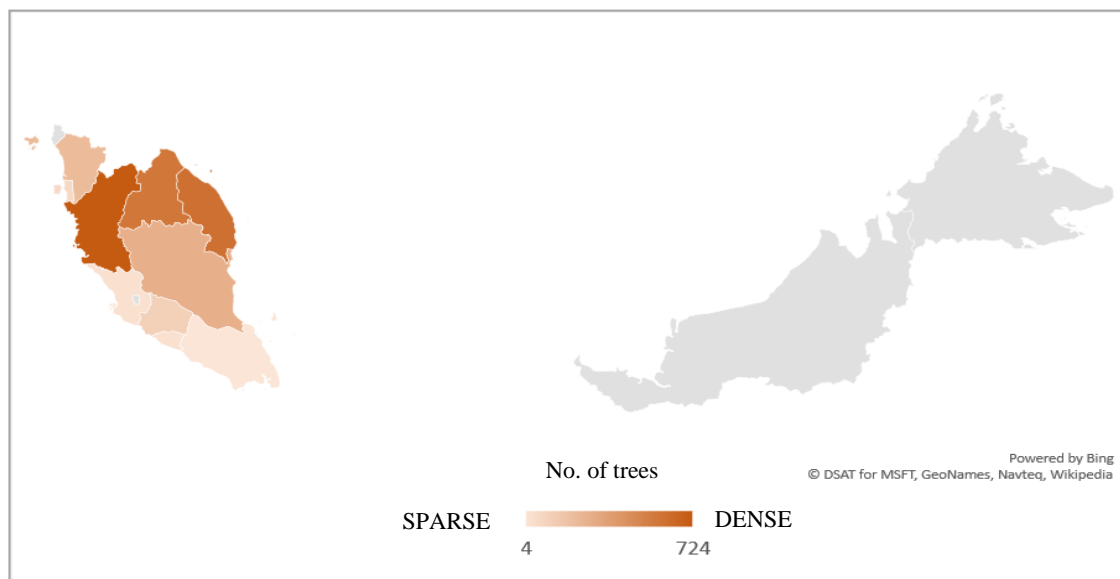
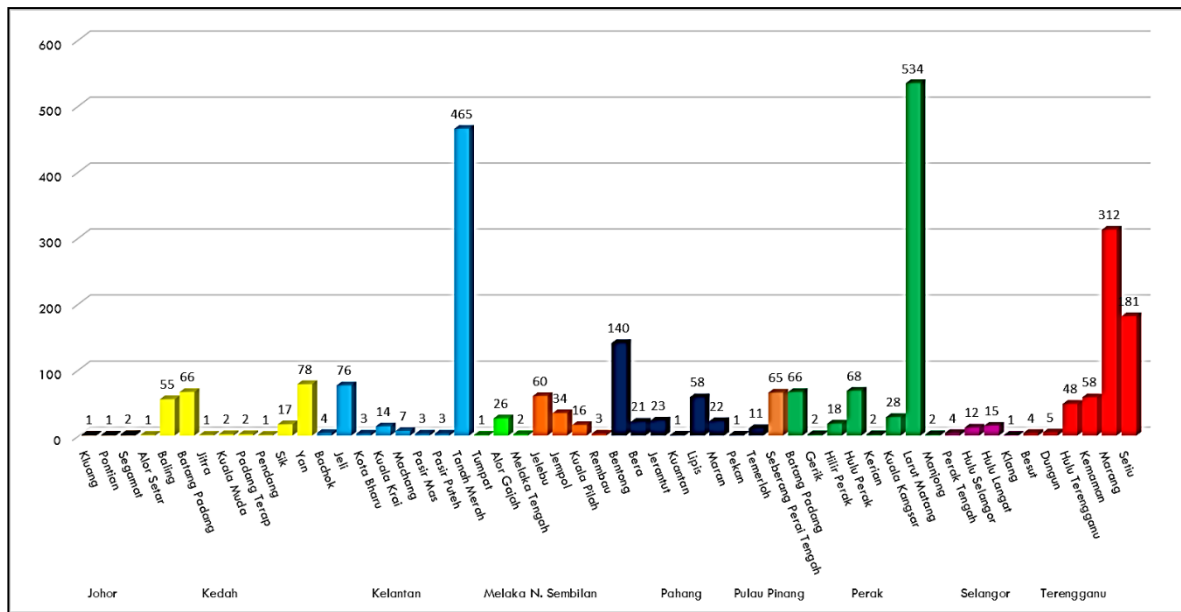


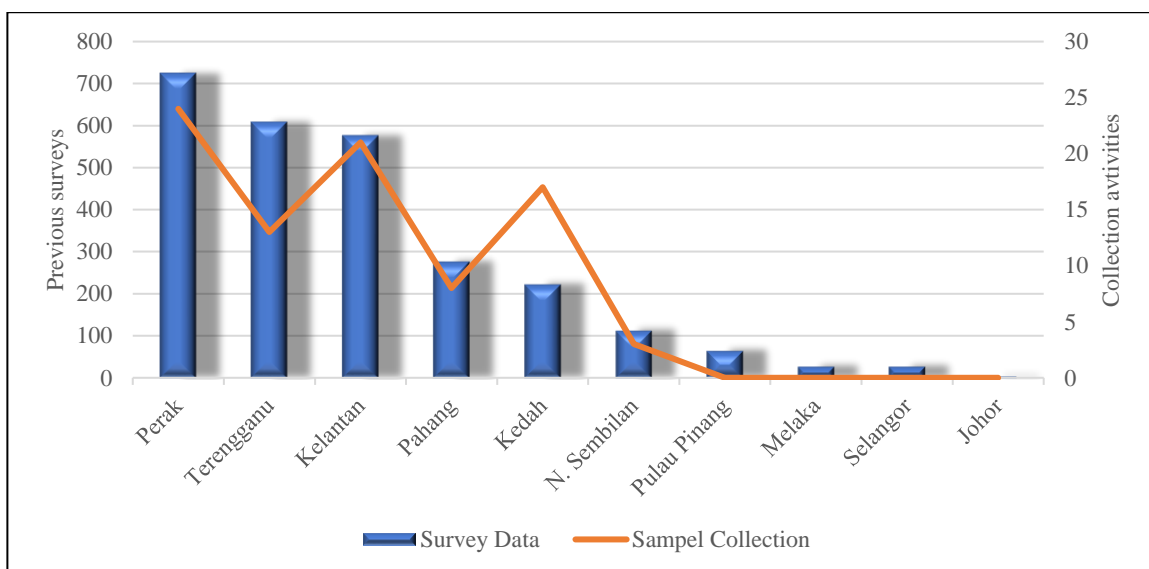
Figure 2: Number of *Garcinia atroviridis* trees in districts in Malaysia



Except for Sabah and Sarawak, *Garcinia atroviridis* trees are very common being cultivated in various districts in Peninsular Malaysia. As an underutilized species, *Garcinia atroviridis* was found with highest number growing in the home gardens and orchards in Larut Matang, Perak. The Larut Matang District in Perak alone recorded 534 trees. This is because the main product from *Garcinia atroviridis* which is the ‘asam keping’ fetches high market demand over there. This situation similar at Tanah Merah, Kelantan where *Garcinia atroviridis* can be found widely cultivated (465 trees). *Garcinia atroviridis* also can be found many growing in Marang (312) and Setiu (181) in Terengganu, as well as Bentong, Pahang (140). *Garcinia atroviridis* distributed in almost all districts for the states like Kedah, Kelantan, Perak and Terengganu.

Exploration for diversity study of *Garcinia atroviridis* was carried out in Peninsular Malaysia. The collection, characterization and conservation of *Garcinia atroviridis* was conducted at home gardens and orchards in Peninsular Malaysia. Extensive collection and characterization were conducted systematically in six districts namely, Perak, Pahang, Kedah, Negeri Sembilan, Kelantan and Terengganu. A total of 86 accessions *Garcinia atroviridis* were found cultivated and the passport data created for each accession found. The number of species found during collection activities is very low compared to the total number of recorded previously (Figure 3). There were no accessions found at all for states like Penang, Malacca, Selangor and Johor.

Figure 3: Comparison between tree numbers of survey data and collection activities data



Diversity in tree characters

Canopy shape of each accession studied was recorded. The canopies were basically either pyramidal, conical, oblong, oval or irregular. Out of 86 *Garcinia atroviridis* trees studied, 41 (48%) were conical, 27 (31%) were oblong, 10 (12%) were pyramidal, 5 (6%) were oval and 3 (3%) were irregular (Figure 4). Corner (1988) reported same kind of canopy shapes for *Garcinia atroviridis* trees which was conical crown. Like other *Garcinia* trees, branches that arose from main trunk of *Garcinia atroviridis* usually dense. This is can be seen from the branching density data (Figure 5) where 70% of trees were recorded as dense. Another 27% were medium density and only 3% of the trees have sparse branching. In addition, 33 (38%) of accessions found have been recorded to have horizontal branching pattern, another 27 (32%) were droopy, 18 (21%) were semi erect and only 8 (9%) have erect branching pattern (Figure 6). Even though Burkill (1966) and Coner (1988) stated that the bark colour of *Garcinia atroviridis* trunk is dull grey and black, from our own observations we found that the bark colour majority was dark brown (64%), followed by greyish brown (12%) and brown (10%). Other bark colour of *Garcinia atroviridis* trunks found to be grey (8%), greenish brown (4%) and 1% each for light brown and black colours (Figure 7).

Figure 4: Diversity of Canopy Shape

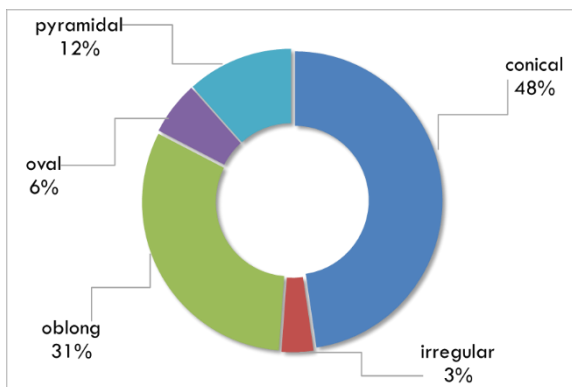


Figure 5: Branching Density

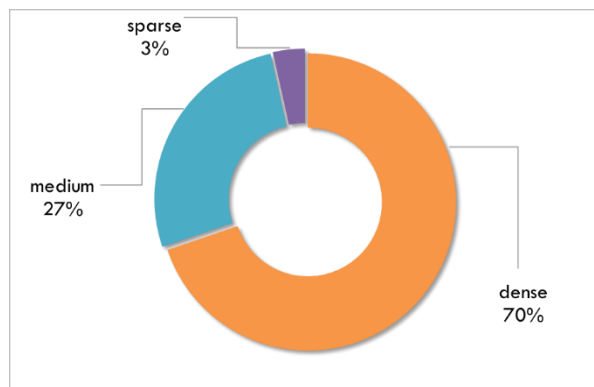


Figure 6: Branching Pattern

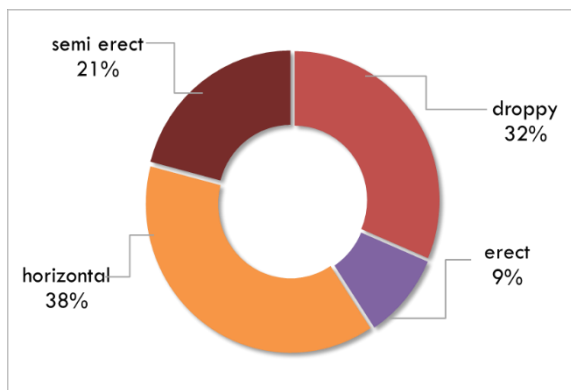
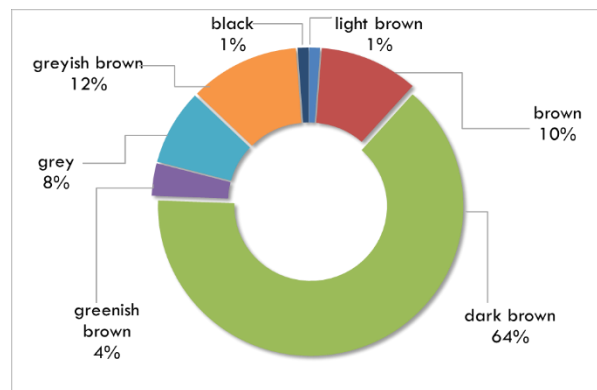


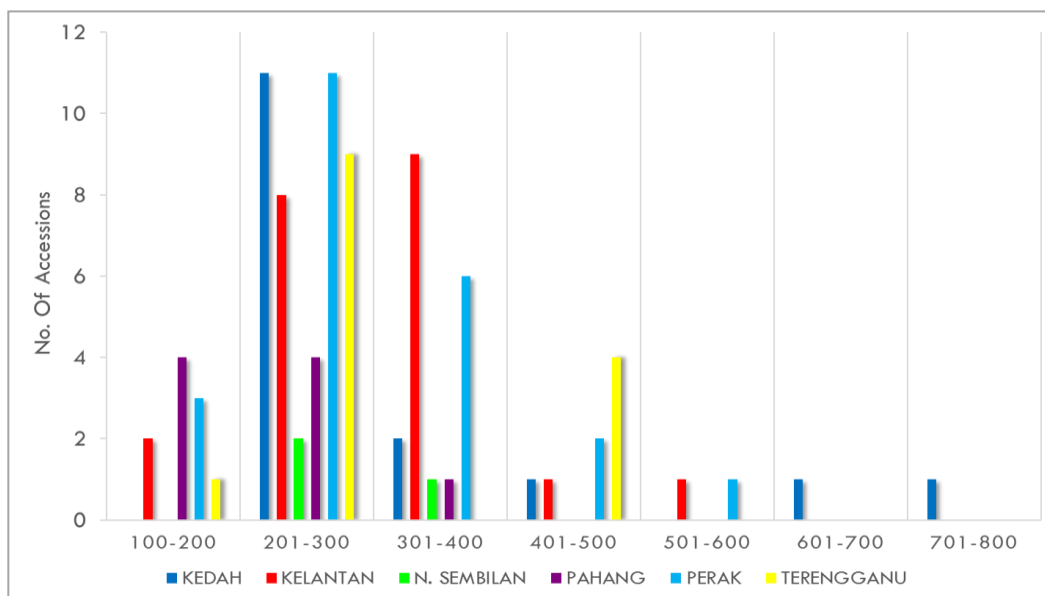
Figure 7: Diversity of Bark Colours



Diversity in fruits characters

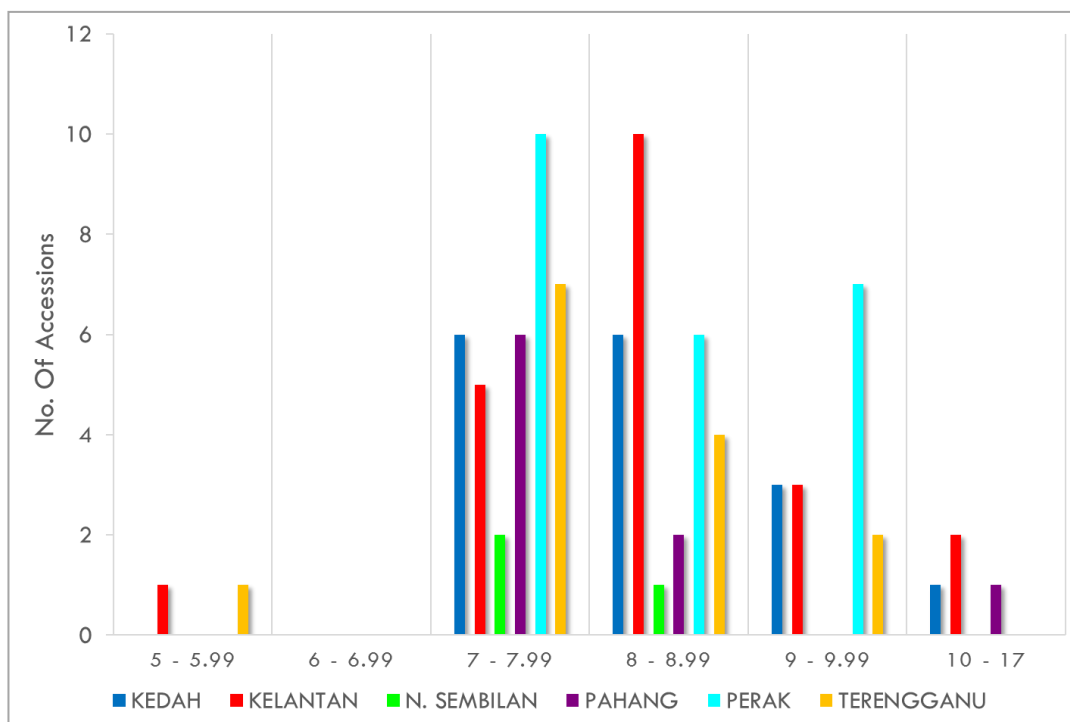
From the study, mean values of individual fruit weight varied widely from 176.3g in Acc. no. 40 to 744.1g in Acc. no.69. When the accessions were plotted on Clustered Column Chart (Figure 8), it was found that the fruits of higher fruit weight i.e., above 500g were in Kelantan (Acc. no.48), Perak (Acc. no.25) and Kedah (Acc.no.10 & Acc. no 69). Accessions of medium sized fruits of rate ranging from 200 to 400g were distributed in all districts. The accessions that bore fruits of weights ranging from 300 to 400g were scattered in all districts except for Terengganu. Slightly small fruits weighing 200g and below were noticed in Kelantan, Pahang, Perak and Terengganu. Kelantan, Pahang and Perak also show the most variations in terms of fruit weight.

Figure 8: Fruit Weight Variations (g)



The average fruit width slightly varied from 5.73cm (Acc. no. 18) to 16.13cm (Acc. no. 14). When fruit width data was plotted as clustered column chart (Figure 9), it was observed that the highest range of fruit width (10 to 17 cm) was found in Kedah, Kelantan and Pahang. Fruit width of range 9 to 10 cm spotted over Kedah, Kelantan, Perak and Terengganu. The accessions having medium width range of 7 to 9 cm were distributed in all districts. The accessions having lower range of fruit width (5 to 6 cm) were only seen in few trees found in Kelantan and Terengganu.

Figure 9: Fruit Width Variations (cm)



The thickness of rind of fruit showed a slightly variation among the accessions studied (Figure 10). It varied from a minimum of 6.50cm in Acc. no. 22, 66 and 80; to a maximum of 14.35cm in Acc. no.64. The rind thickness of 10cm and above (up to a maximum of 15cm) was noticed in only three accessions from Kedah (Acc. no.64 and 67) and from Kelantan (Acc. no. 76). The accessions having rind thickness range of 7 to 9 cm were distributed in all districts.

Variation in fruit shape was observed among the accessions. Fruit shape varies from ovoid to ovoid-oblong; and from spherical to flattened. Out of 86 *Garcinia atroviridis* fruit accessions, 54 (63%) were ovoid, 17 (20%) were flattened, 10 (11%) were ovoid-oblong and 5 (6%) were spherical. Besides, Pahang, Kelantan and Kedah show the most diverse *Garcinia atroviridis* fruit accessions in term of variation of fruit shape (Figure 11). Although most of accessions collected was from Perak, but not much variation shows in term of fruits shape. Similarly, Terengganu have more ovoid fruit shape accessions compare to other kind of shapes

Figure10: Rind Thickness Variations (cm)

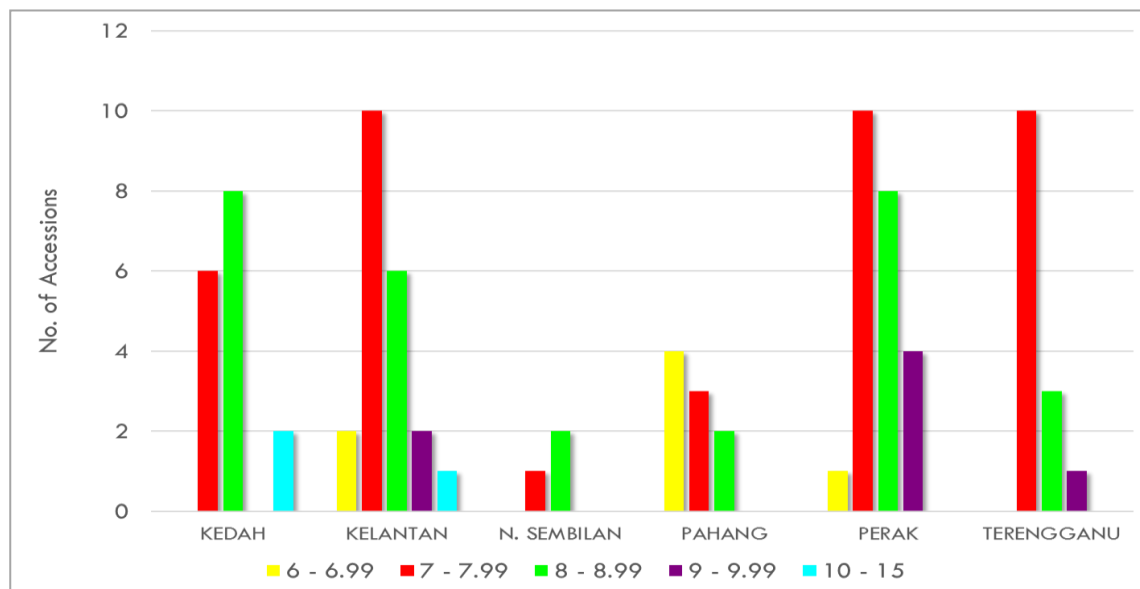
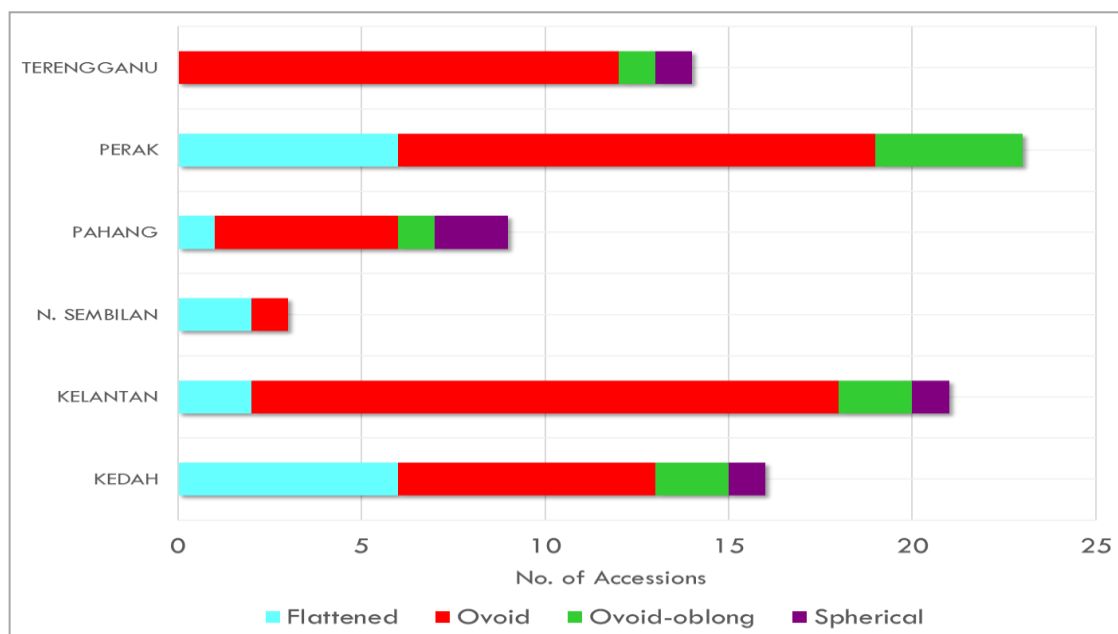


Figure11: Fruit Shape Diversity among States



Diversity in leaf characters

The *Garcinia atroviridis* leaves mostly were oblong, few elliptic and some with obovate and oblong shapes. Most of the leaves were oblong with acute tip and have a smooth and wavy leaves margin. The leaf length showed a variation ranging from a minimum of 14.19cm in Acc. no. 63 (Kedah) to a maximum of 34.7cm in Acc. no. 25 (Perak). Accessions of medium sized leaf length rate ranging from 15 – 25cm were distributed in all districts. Terengganu shows the most diverse in terms of leaf length. Observations on width of all accessions studied varied from 2.14cm in Acc. no.23 to 8.59cm in Acc. no. 25; both accessions are from Perak. As for petiole length, it was varied from 1.23cm to 2.86cm. We can say that the petiole length had no correlation with the leaf length. This is because, both the longest and shortest leaves recorded the same size of petiole length (2.21cm).

CONCLUSION AND RECOMMENDATION

Systematic survey of *Garcinia* species in Malaysia using vegetative morphological characters by Azuan et. al (2020) separates the 30 accessions of *Garcinia* species into five groups. There is very clear separation of the accessions according to their species. According to the findings, *Garcinia atroviridis* located in the largest group of accessions which have similarities. The other species which are together with *Garcinia atroviridis* are *G. cowa*, *G. parvifolia* and *G. prainiana*. This group possesses almost same size leaf and acute leaf tip shape.

From the results, it shows variation in *Garcinia atroviridis* characters was based on the morphological variation observed among the accessions. This is supported by study that shows variations in terms of *Garcinia atroviridis* segmentation surrounding its stigma lobes. The segmentation covers the stigma lobe 30-50%. The segmentations narrow at the tip of the fruit, while segmentation surrounds the stigma lobe entirely and in others the stigma lobe protrudes from the segmentation (Azuan, 2010). Other than that,

Baseline dataset have shown that there are vast numbers of *Garcinia atroviridis* trees cultivated in Peninsular Malaysia. The survey also revealed that the tree species is occurring in all states in Peninsular Malaysia. Market demand for *Garcinia atroviridis* may be one of the factors why vast numbers of fruit trees maintained in home gardens or orchards. Out of 86 accessions studied, morphological characters showed a variation in tree, fruit and leaf characters. The data documented for all the traits under this study will be very useful for the further research. An intensive sampling approach for *Garcinia atroviridis* should be improved for ex situ conservation to meet urgent needs since it has an enormous potential to be exploited as fruit trees and provide a high income to the farmers.

REFERENCES

- Azuan, A., Maya Izar, K., Zulhairil, A., Rosliza, J and Mohd Saifuddin, I (2020). Systematic Study of Selected Genus *Garcinia* L. Based on Vegetative Morphology. International Journal of Agriculture, Forestry and Plantation, Vol. 10 (Sept): 117-124. ISSN 2462-1757
- Azuan, A., Salma, I. and Mohd Saifuddin, I (2010). Asam Gelugor: Diversity and Use. The Second National Conference on Agrobiodiversity and Sustainable Utilization (NAC-2), Tawau, Sabah, Malaysia
- Corner, E. J. H. (1988) Wayside Trees of Malaya. Vol. 1. Ed. 3., Malayan Nature Society, Kuala Lumpur
- IPGRI (2003). Descriptors for Mangosteen (*Garcinia mangostana*). International Plant Genetic Resources Institute, Rome, Italy.
- M.L. Raziah, I. Salma, M. Abd. Rahman, A. Khadijah, T. Arrifin (2007). On-Farm Diversity of Malaysia Fruit Species and Their Determining Factors. Economic and Technology Management Review Vol.2 (2007): 22-44
- Richards A J. (1990). Studies in *Garcinia*, dioecious tropical forest trees: The phenology, pollination biology and fertilization of *Garcinia hombroniana* Pierre. Botanical Journal of the Linnean Society 103(3): 251–266.
- Ridley, N. H. (1922) The Flora of the Malay Peninsula: Vol. 1. Polypetalae. London: 918pp
- Salma, I., Mohd. Shauqi, N, Shariah, U. Pearlycia, B., Wong, W.W.W., and Abd. Rahim, B. (2012). On Farm Distribution and Diversity of *Garcinia* Species. 1st Regional Agrobiodiversity Conference (RAC-1). Langkawi, Kedah. Malaysia
- Salma, I., Raziah, M.L. and Abd. Rahman, M. (2003). Diversity of Fruit Species in Malaysia. Report submitted to TFNet.
- Verheij, E.W.M. (1992). *Garcinia mangostana* L. In: E.W.M.Verheij & R.E. Coronel (Eds.), Eatable Fruits and Nuts. Plant Resources of South East Asia 2, pp. 177–181. Pudoc, Wageningen.
- Whitmore T C. (1973). Tree Flora of Malaya. Kuala Lumpur: Longman.