

## **Unraveling the potential of underutilised edible tubers (*Dioscorea alata*) toward achieving sustainable food security: A case study of 10 farmers in east coast Malaysia**

[Merungkai potensi ubi tradisional (*Dioscorea alata*) ke arah kelestarian keterjaminan makanan: Kajian kes ke atas 10 petani di pantai timur Malaysia]

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Keywords: potential, underutilised, edible tubers, *Dioscorea alata*, FAMA, SWOT, agriculture

### **Abstract**

Nowadays, various of agriculture challenges occurred and tubers of *Dioscorea alata* are expected to play a vital role as crop diversification as an alternative to food security in Malaysia. Various of literatures had revealed its abundance of health benefit to be exploited as well as its resilience in harsh climate change and many others. Therefore, this study had been carried out to examine the potential of underutilised edible tubers, namely *D. alata*. This study employed qualitative technique through case study approach towards 10 selected farmers using snowball sampling in East Coast Malaysia and had been analysed using SWOT analysis. SWOT analysis had been chosen as an initial strategic planning for *D. alata* in East Coast Malaysia for identifying the strength, opportunities, for the high probability of the potential as well as weaknesses and threat for the rooms for improvement. It was found that, through SWOT analysis, *D. alata* recorded higher demand in East Coast Malaysia during monsoon season due to alternative to sweet potato. It recorded higher ex-farm price at range RM7 – RM10/kg and mostly sold along the roadside. For the agronomic practices, *D. alata* is compatible to all kind of fertilisers and well resistance to pesticides. However, the weed control practices need to improve. *D. alata* normally harvest almost in nine months and within this period, there are no local edible tubers *D. alata* sold. The source of *D. alata* depends on imported from Thailand. Thailand had managed to produce the *D. alata* during off-season and able to supply to Malaysia regularly. Some of the villagers had used this imported *D. alata* to produce by-products. There is an opportunity for the research institution in Malaysia to take this initiative in breeding program to produce new *D. alata* with the shorter period of harvesting. On the marketing part, through observation, it is clearly seen that most of the *D. alata* is imported during off-season. In FAMA outlets, all *D. alata* are imported from Thailand, creating a potential if there is a regular supply of *D. alata*. As a conclusion, *D. alata* can be exploited to its fullest potential as an alternative to food security through crop diversification for the benefit of the future agriculture, the but further action needs to be taken for this underutilised edible tuber to be commercially grown by the farmers.

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## Introduction

Over the recent decades, food security has become the main agenda for improving food access (Ingram 2011) and food sustainability as both strongly related (El Bilali 2019).

Most literature states that resource scarcity, ecosystem degradation, human population growth, and climate change are the challenges to achieving sustainable food security (El Bilali 2019). Food and Agriculture Organization (2010) stated that more than half of the global dietary energy need is met by only four crops: rice, potatoes, wheat, and maize, which mostly are staple food. According to Li & Siddique (2018), crops can be divided into staple, commercial crops, and underutilised, neglected and orphan. The staples purposes for the widely produced and consumed crops, commercial crops for monetary profit, and neglected are the categories of crops traditionally overlooked or underutilised in agricultural practices (Jairu et al. 2023).

World recorded 40 – 100,000 plant species have been frequently used over the years as food, fiber, shelter, and for commercial, cultural, and medicinal purposes, and the remaining plant diversity is considered underutilised (Magbagbeola et al. 2010). Underutilised are identified as minor, neglected, local, orphan, promising species that have been used for centuries for their food, fibre, fodder, oil, or medicinal purposes (Peduruhewa et al. 2021). The majority of the edible crops are referred to as neglected and underutilised species (NUS) or niche and orphan crops (Li & Siddique 2018). Modernisation of agricultural practices resulting them being ‘neglected’ or ‘lost’ crops (Peduruhewa et al. 2021) and their importance and usage have drastically reduced due to low supply, poor shelf life, unrecognized nutritional values, poor consumer awareness, and reputational problems (famine food or “poor people’s food”) (Peduruhewa et al. 2021).

However, NUS has become attention nowadays towards fulfilling food security and alternative carbohydrate sources after

staples food. The ever-increasing population pressure, food security, climate change, fast depletion of natural resources, increasing input cost of modern agricultural practices, and finally the nutraceutical value of the plant are the underpinning factors that influenced the gaining attention for the underutilised edible tubers (Shajeela et al. 2011). The NUS which are also recognised as an orphan crop and consists of mostly wild or semi-domesticated species that are well-adapted to local environments and have been used as traditional foods for centuries (Ravi et al. 2010). NUS is normally grown under harsh and extreme agro-climatic conditions and is more resistant and resilient to stresses, biotic as well as abiotic (Wani et al. 2021). Mukherjee et al. (2015) found that underutilised roots and tubers are rich in minerals, vitamins, antioxidants and dietary fibre plus play an important role in mitigating hidden hunger through diet diversification. El Bilali et al. (2024) stated that NUS has been claimed to contribute to sustainable development as they hold the potential to address numerous challenges facing humanity. Other authors stated that NUS promotion has been reported to contribute to food and nutrition security (Padulosi et al. 2013; Ulian et al. 2020), agro-biodiversity conservation (Padulosi et al. 2013), climate change adaptation and mitigation (Mabhaudhi et al. 2019), environmental integrity and health (Mabhaudhi et al. 2019), human health (Tadele 2018) and rural livelihoods sustainability and resilience (Kour et al. 2018; Padulosi et al. 2013).

According to Williams and Haq (2002), there are several constraints to NUS development which are limited availability of germplasm, lack of interest by actors in the food chain (e.g. farmers, researchers, extension agents), and lack of technical information and tailored national policies. Their mainstreaming and integration into the food system must be identified and thoroughly analysed to promote NUS (Baldermann et al. 2016). It is depicted

that research, innovation, and development are highly required to unlock the NUS potential (Mabhaudhi et al. 2017), especially in developing countries (Chivenge et al. 2015). Therefore, based on past literature, this study was carried out to explore the potential of underutilised edible tubers namely *Dioscorea alata* among selected farmers in East Coast Malaysia.

**Background of the study**

**Cash crop contribution to Malaysia agrifood**

Underutilised edible tubers in Malaysia are included in the cash crop commodity which contributed almost 215,600 mt in 2022 and ranked 5<sup>th</sup> after commodity paddy, fruits, vegetables and industrial crops. Meanwhile, the hectareage of cash crops is second highest after vegetables amounting to 18,329 ha comprised of 21.2%. This shows that cash crops are also an important contribution to Malaysian agrifood commodities in 2022 (Figure 1). In detail, Figure 1 shows the separation of the cash crops which sweet corn recorded the highest percentage of production quantity (29%), followed by sweet potato (21%) and tapioca (20%) (Figure 2).

**Underutilised edible tubers**

According to Figure 2, minor tubers such as ubi badak (UB) are recorded. Table 1 details the information on the types of underutilised edible tubers. UB was planted in Dungun and Hulu Terengganu with the same planted area (0.3 ha) and amounted to 2.35 mt and 1.85 mt respectively.

**Ubi badak (*Dioscorea alata*)**

*Dioscorea alata* is part of the yam family (*Dioscorea* spp.) and plays a significant niche due to its richness in in several phytochemicals (saponins, tannin, flavonoids, sterols, polyphenols and glycosides) in addition to its higher contents of basic essential nutrients such as protein, carbohydrates, vitamins, minerals, etc and can have advantage of grown under multiple harsh conditions (Jahan et al. 2019).

*Dioscorea* spp. contains four categories which are 1) water yam, 2) white yam, 3) air potato and 4) bitter yam and *Dioscorea alata* in the water yam category. Besides it is also known as the “winged yam” or “purple yam” and the height of this species could reach up to 10 m or more (Jahan et al. 2019). They are also known by various names such as *ubi badak*, *ubi gajah*, *ubi*

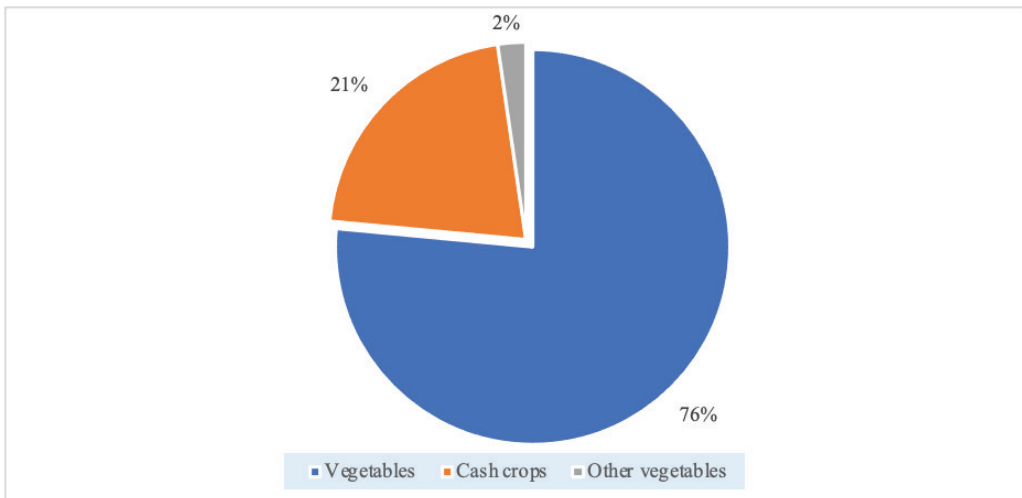


Figure 1. Hectarage of crops by category (2022)

Source: Department of Agriculture (2022)

*nasi* and many more. Meanwhile, *ubi badak* (*UB*) is better known as purple yam, winged yam, or water yam in English (Muimba-Kankolongo 2018). It is a species of tuber that grows underground and these tubers are usually purple but some are white or yellowish white. According to Muimba-Kankolongo (2018), *UB* was first cultivated in Southeast Asia and is one of the most widely available yams in markets around the world where most of them are grown throughout Africa. According to Mignouna et al. (2003) also, this tuber is grown in Asia, the Pacific Islands, Africa, and the West Indies. These tubers are generally cylindrical

but can also be found in different shapes (Reddy 2015).

In Malaysia, the planting of *UB* has been recorded by the Malaysian Department of Agriculture starting in 2017 as shown in *Figure 3*. Overall, the hectarage shows an increasing trend throughout 2017 until 2023, however, the production shows a declining trend started at 2018.

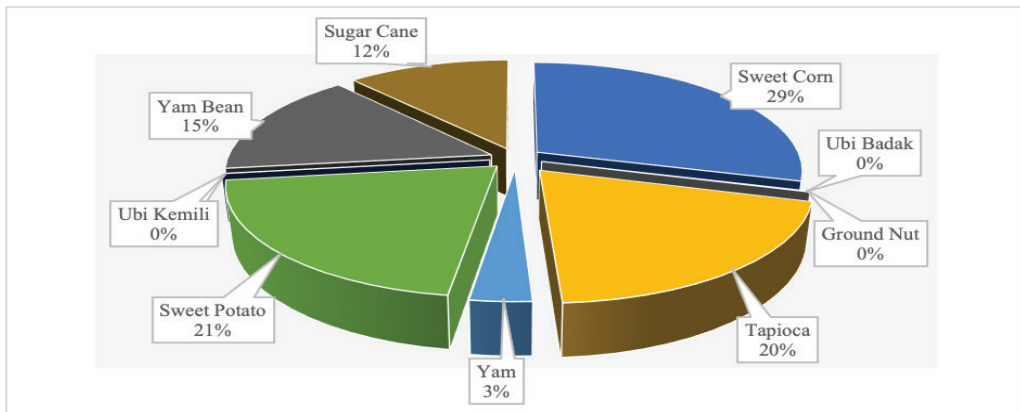


Figure 2. List of cash crop production in Malaysia (2023)

Source: Booklet Crop Statistics (Food crop sub-sector) 2023

Table 1. Details information on types of underutilised edible tubers

Type of underutilised edible tuber	State	Planted area (ha)	Harvested area (ha)	Production (mt)	Average production (mt/ha)
Ubi badak ( <i>UB</i> )	Dungun	0.3	0.3	2.35	7.0
	Hulu Terengganu	0.3	0.3	1.85	
	Total	0.6	0.6	4.2	

Source: Department of Agriculture (2022)

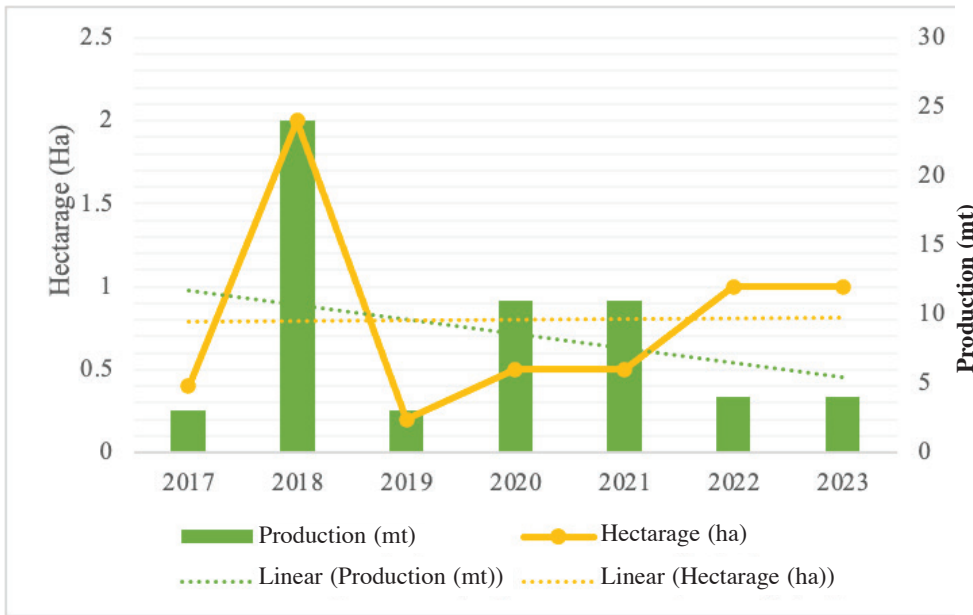


Figure 3. Hectareage (ha) and production (mt) of *Dioscorea alata* in Malaysia (2017 – 2023)

Source: Booklet Crop Statistics (Food crop sub-sector) 2023

## Methodology

### Data collection

This study uses secondary data and primary data. Secondary data was obtained from the Malaysian Department of Agriculture which includes information related to the area planted (ha) and the production of underutilised edible tubers in Malaysia. Primary data was obtained through face-to-face interviews with farmers (n = 10) through snowball sampling using the semi-structured questionnaire. There are no proper documented on list of farmers cultivated the underutilised edible tubers. Therefore, the snowball sampling is adopted to identify the selected underutilised edible tubers and the data collection session was assisted by the Terengganu State Department of Agriculture and the *Besut* District Agriculture Office while for farmers in Kelantan, data collection was assisted by the Kemubu Agricultural Development Board (KADA), Tumpat district (*Balai Baru*).

### Analysis

The data was analysed using SWOT

(strengths, weaknesses, opportunities and threats) analysis to identify the strengths, weaknesses, opportunities and threats. SWOT analysis had been chosen as an initial strategic planning for *Dioscorea alata* in East Coast Malaysia for identifying the strength, opportunities, for the high probability of the potential as well as weaknesses and threat for the rooms for improvement. SWOT analysis had been widely applied extensively in many different fields including agriculture (Benzaghta et al. 2021), and becoming a useful tool in organisations, disciplines, agencies and industries in achieving set desired goals and objectives (Onyema et al. 2013). The result of SWOT analysis is presented in the form of a matrix (Ansoff 1980).

## Results and discussion

### Farmers profile

Table 2 shows the profile of farmers involved in this study. This study focuses on the East Coast Malaysia which are Terengganu and Kelantan because this type of underutilised edible tuber is widely found

in these two states. Overall, for the UB, a total of 10 farmers are involved, namely seven farmers in Kelantan and three farmers in Terengganu. In Terengganu, the farmers planted UB due to its heritage crop from previous generations. The same scenario in Kelantan, where four farmers aged between 61 and 70 cultivated UB. The type of UB planted is the white yam better known by the local community as *ubi nasi*, and the

purple/red tubers with the local name *ubi sabut* (Terengganu) or *ubi merah* (Kelantan) as shown in *Image 1*.

**Price information and market channels underutilised edible tubers**

*Table 3* shows price information and market channels for UB. In Terengganu, most farmers sell their produce directly to vendors at roadside stalls with a farm price

Table 2. Farmers profile (n = 10) traditional tubers

Items	Terengganu	Kelantan
Number of farmers cultivated	3	7
Type of traditional tubers	<i>Ubi badak merah</i>	<i>Ubi badak putih and merah</i>
Age	51 – 60 years (n = 1) 61 – 70 years (n = 2)	40 – 50 years (n = 1) 51 – 60 years (n = 2) 61 – 70 years (n = 4)

Source: Survey (2022)



*Image 1. UB right (white UB) for boiled (eaten with salt & grated coconut), UB left (purple) for traditional cakes*

Source: Survey (2022)

of RM7/kg and the selling price reaches up to RM10/kg. In Terengganu, traditional local tubers are widely sold at stalls in *Besut*. Other market channels such as the wholesale market are not obtained due to very limited sources of supply. Meanwhile in Kelantan, the market channels are through harvesters/wholesalers or retailers and usually the farm price is lower compared to traditional tubers in the Terengganu market. RTC FAMA *Tunjung*, Kelantan says there is no record of sales of traditional tubers until now. The main source of traditional tubers is imported from Thailand for promotional purposes. Surveys from agencies such as the Department of Agriculture and KADA also said that traditional tubers sales around Tanah Merah are imported tubers.

Table 3. Price and market information

State	UB
Terengganu	Farmers → Seller (Roadside stall) Ex-farm price: RM7/kg Selling price : RM10/kg
Kelantan	Farmers → Wholesalers/retailer * → Customer Ex-farm price: RM2.50 – RM4/kg Selling price : RM10/kg *Market near <i>Tunjong, Tanah Merah and Rantau Panjang</i>

Source: Survey (2022)

### SWOT analysis

#### Strength

According to the farmers, UB recorded the demand more than the supply, especially during the monsoon season when this underutilised edible tuber replaces the sweet potato. UB is also tastier than imported from Thailand. In addition, UB requires minimal care which is minimal pest control and compatible with all types of fertilisation, making it easier in terms of planting care. This is in line with the study from Baah (2009) stated that UB has good agronomic characteristics and has an advantage for sustainable cultivation. El Bilali et al. (2023) findings of SWOT analysis revealed that the

literature reports many strengths on NUS and the similarity with this study area: 1) NUS seem adapted to cultivation in low-input systems as they have low requirements in terms of fertilisers and agrochemicals as well as tolerance to pests and diseases (biotic) and abiotic/environmental stresses (drought). Besides the authors also found that NUS are adaptability to grow in harsh conditions include marginal, poor and nutrient-depleted soils/lands. In the market, UB is sold at a minimum of RM7 – RM10/kg depending on the distribution channel.

#### Weakness

The main weakness of UB is the insufficient supply to meet the demand of the local market. During monsoon season, UB is available and normally has been bought for traditional food consumption or boiled and eaten together with salt and grated coconut. It substitutes the sweet potato and is sold at a range of RM7 – RM10/kg. The insufficient supply occurred due limited farmers cultivated UB, and most farmers are aging farmers. Furthermore, the survey found that it was a little bit difficult arose during the early stages of cultivation because they require a specific technique, as UB needs to be dipped with ash husks to ensure high yields. This technique is said to have been practiced from previous generations. Interestingly, this technique was also reported by Adeniji (1975) who stated that this technique can reduce nematode attacks on UB plants. The farmers revealed that this practice was inherited from their parents. The farmers also stated that they are worried that UB will disappear as young generations are not interested in this UB cultivation. According to the Department of Agriculture (2022), the average production of UB is 7 mt/ha. There is a need to increase the average production as UB recorded higher market demand. The lower production will lead to a lower yield, and a lower yield will lead to a lower economic scale and therefore push the price higher due to the insufficient supply as stated in the supply-demand

theory. Other than that, the farmers also reported that, they are unable to control the weed due to aging factors (*Image 2*). The weed is very important to manage for more yield produced. Besides, the farmers also stated it also higher cost for them to build 'pancang/junjung' as it cost RM0.30/tree.



*Image 2. The weed problem (left side) and higher cost in building 'pancang/junjung' (right side)*

Source: Survey (2022)

Other findings, Giuliani et al. (2009) also revealed that NUS main problems related to low yield and productivity especially when compared to modern and commercial varieties and the authors also stated that it might be the low input used (fertilisers) in NUS. Difficulty access to quality seeds and propagation materials also constraints in NUS at the production level as well as lack of economic of scale which push prices up and affect product affordability.

### ***Opportunity***

UB had a wide vast of opportunities to have a high chance of penetrating marketing access at FAMA outlets if the supply is consistent. Currently, the UB available in FAMA outlets is imported from Thailand. Thailand can import as they can produce non-seasoning UB, which means more shorter period of harvesting compared to local UB which is eight months. Therefore, it is an opportunity for agencies and research institutions in Malaysia for new varieties with the more shorter harvesting periods to supply more to the local market. The more shorter the harvesting period will gain more quicker cash crop received.

### ***Threat***

Insufficient supply of UB will lead to the continuously depends on the UB importation from the Thailand. The study had found that Thailand had successfully breed the UB varieties which produce non-season, meaning shorten their period of harvesting. Besides, the study also found that some of the nearby villagers rely on imported UB to produce snack products for their small-scale business.



Figure 3. SWOT analysis

Strength	Weakness
Demand > supply: demand is very encouraging, especially during the monsoon season → (the main substitute source of sweet potato) Malaysian UB are tastier than imported ones (Thailand) Suitable for all types of fertilising (mixed fertiliser) Minimal pest control High selling price (RM 10/kg)	Insufficient supply (supply < demand: very limited source of supply) A higher price (RM10/kg) due to the low yield → lack of economic scale → push price up → product availability/affordability Plants: plants that are complicated to grow (require a special technique) (need to dip the tubers with ash husks) Aged farmers (60 – 70 years old): the younger generation is not interested in traditional tuber crops because they want immediate returns; This tuber has a long return period (9 months) Weed management: weed control is required for more and quality yields
Opportunities	Threat
Research and development in new varieties of UB with a shorter crop period Opportunities for marketing access at FAMA outlets if supplies are consistently met.	Sources of imported supplies from Thailand are easy to obtain because Thailand successfully grows UB non-season. Some Malaysian villagers have worked on products based on UB tubers using imported tubers.

Source: Survey (2022)

### Conclusion

UB as an underutilised edible tuber should be given attention to prevent the extinction of this species in the future. According to previous studies, underutilised edible tubers are believed to have existed since before Malaysia gained independence and according to sources, it is also said that these underutilised edible tubers were part of the food source during the war. This is because based on surveys that have been carried out, most traditional tubers are carried out by farmers who are in their 60s to 70s. Most respondents said that this UB will disappear because is complicated and requires a certain technique, otherwise the traditional tubers will not produce good yield. Concerning that, the results of this study decided that there is a high need for further research to be conducted especially on the high yield variety to increase the productivity, weed management, and more shorter harvesting period.

UB produce an average yield of up to 2 kg/plant and are sold at a relatively reasonable retail/wholesale price of RM10/

kg The findings of the study also found that all respondents need to obtain supplies of UB from other nearby places to meet the growing consumer demand especially during off-seasons. In addition, among the advantages of these UB is that it is suitable for environments that require natural irrigation sources (rain).

In terms of market channels, the East Coast state has no problem to market the products, and even FAMA's initiative in promoting UB is seen as a very good initiative or strategy in further encouraging underutilised edible crops this. UB promotion strategies in addition to research proposals need to be drawn up and implemented proactively internally to ensure the sustainability of this highly potential underutilise edible Malaysian tubers species.

### Limitations and way forward

The study for UB cultivation is only concentrated in the East Coast state, but to get a broader and more accurate picture, the scope of the study needs to be expanded to other states. Based on the SWOT analysis

done, there is a vast market potential market for UB as underutilised edible tubers. However, this article captured on the first step of strategic planning which was assist farmers and industries identifying their strengths and opportunities as well as weaknesses and threats and further indicated important strategies for UB cultivation. Therefore, the study in the future can included semi-systematic review for more extensive understanding of the industries.

Various of agriculture studied applied SWOT analysis for the first step of strategic planning especially in the developing countries (Benzaghta et al. 2021). This article applied SWOT analysis to assist farmers and industries identifying their strengths and opportunities as well as weaknesses and threats and further indicated important strategies for UB cultivation. In the future, SWOT analysis can be extend with any model such as PESTEL model, AHP and others for more comprehensive understanding (Benzaghta et al. 2021).

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## Abstrak

Pada masa kini, pelbagai cabaran yang dihadapi oleh sektor pertanian dan ubian tradisional *Dioscorea alata* dijangka memainkan peranan yang penting sebagai tanaman alternatif di Malaysia kepada keselamatan makanan di Malaysia. Pelbagai kajian lepas telah merungkai manfaat kesihatan yang diperolehi di samping ketahanan ubi tradisional ini ke atas perubahan cuaca yang ekstrim dan pelbagai lagi. Oleh itu, kajian ini dijalankan untuk mengkaji potensi ubian tradisional iaitu *D. alata*. Kajian ini menggunakan teknik kualitatif menerusi pendekatan kajian kes ke atas 10 petani terpilih menggunakan teknik persampelan bebola salji di Pantai Timur dengan menggunakan analisis SWOT. Analisis SWOT telah dipilih sebagai strategi perancangan di peringkat awal di Pantai Timur Malaysia untuk mengenal pasti kekuatan dan peluang untuk diketengahkan di samping kelemahan dan ancaman untuk ruang penambah baikkan. Kajian mendapati menerusi SWOT analisis, *D. alata* mencatatkan permintaan yang tinggi di Pantai Timur terutamanya semasa musim tengkujuh kerana merupakan tanaman alternatif kepada ubi keledek. Ubian tradisional ini mencatatkan harga ladang yang tinggi iaitu di antara RM7 – RM10/kg dan kebanyakannya dijual di tepi jalan. Ubian tradisional ini sesuai dengan semua jenis pembajaan dan tahan terhadap perosak. Walau bagaimanapun, aspek kawalan rumpai perlu ditambah baik. *D. alata* lazimnya ditanam selama 9 bulan dan sepanjang tempoh penanaman ini, tiada ubian tradisional tempatan dijual di pasaran melainkan yang diimport daripada Thailand. Ubian tradisional ini bergantung sepenuhnya terhadap ubi yang diimport daripada Thailand. Thailand telah berjaya menghasilkan ubian tradisional di luar musim dan mampu membekalkan secara konsisten ke Malaysia. Kajian kami juga mendapati, sebahagian daripada penduduk kampung telah menggunakan ubian tradisional import ini untuk menghasilkan produk-produk seperti kuih-muih dan kerepek. Oleh itu, terdapat peluang ke atas institusi penyelidikan di Malaysia untuk mengambil inisiatif membangunkan varieti ubi tradisional yang baharu yang lebih singkat tempoh kematangan. Dari aspek pemasaran pula, menerusi pemerhatian, *D. alata* diimport semasa luar musim. Di FAMA outlet, semua *D. alata* diimport daripada Thailand. Oleh itu terdapat potensi *D. alata* tempatan untuk menembusi FAMA outlet sekiranya terdapat bekalan yang konsisten. Sebagai kesimpulan, *D. alata* boleh dieksploitasi sepenuhnya sebagai alternatif kepada tanaman keselamatan makanan untuk manfaat sektor pertanian dalam jangka masa panjang, tetapi perlu akan tindakan yang lebih komprehensif untuk ubian tradisional ini ditanam oleh petani secara komersil.