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REVIEW

A review: medicinal values, agronomic practices and postharvest handlings of *Vernonia amygdalina*

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Abstract

Recently, researchers are aiming to discover a new source of therapeutic substance produced organically with no harm or possible toxicity to humans, environment and even to animals. Herbal plant-based approach is one of the options available since organic herbal products are gaining popularity around the world as food supplements. Regarding on the commercialization of herbal plants, cultivation of raw materials with standardized farming practices is crucial to achieve the consistency of its quality to fulfill the market demand. *Vernonia amygdalina*, is one of the herbal plants, commonly known as '*Pokok Bismillah*' from Asteraceae family, having valuable medicinal properties due to the presence of phytochemical compounds for treating various diseases. There exists scarce information on appropriate agronomic practices for the cultivation of this plant either in small or commercial scale. Therefore, this review collates current knowledge in appropriate agronomic practices and postharvest handlings in order to achieve optimum growth and yield with high medicinal properties of *Vernonia amygdalina*.

1.Introduction

Vernonia amygdalina, known as '*Pokok Bismillah'*, is a perennial shrub from Asteraceae family and also commonly called 'Bitter Leaf' because of bitter taste of its leaves. Not only named Bitter Leaf, this plant also has a lot of other local names in different languages of the different regions of the world, such as Ewuro, Onugbu, Oriwo, Etidot and Ityuna in Nigeria, Mululuza and Omubirizi in Uganda, Ebichaa in Ethiopia and Awonwono in Ghana (Yineger and Yewhalaw, 2007; Moshi *et al.,* 2010; Farombi and Owoeye, 2011; Komlaga *et al.,* 2015; Kiguba *et al.,* 2016). Even in Malaysia, this plant is called South African leaf. As the largest genus among *Vernoniae* tribe, *Vernonia* has close to 1000 species in its family (Keeley and Jones, 1979). The genus *Vernonia* gets its name after an English botanist, William Vernon who identified the plant in Maryland, in the late 1600s before his death in 1711 (Quattrocchi, 1999).

This herb has been domesticated in many parts of West Africa, but grows freely in tropical Africa (Igile *et al.,* 1994). However, it is also well distributed in Asia (Oseni and Babatunde, 2016). Although it is well distributed in Asia, Nigerians are more aware about its benefit and have been utilizing this plant to its maximum usage as it has many health benefits compared to other regions. As a home-grown plant, *Vernonia* species can easily adapt to different environments according to its habitat. They are generally found in natural forests where easy water access is available. They also can easily be found in forest margins, woodlands and grasslands up to 2,800 m in altitude, with mean annual rainfall 750-2000 mm. Ndaeyo (2007) reported that even though *V. amygdalina* was more prone to humid environment, it could also tolerate drought and grow very well on all types of soil. However, it grows better on humus-rich soil. This explains why this plant has an amazing survival ability in such a wide range of ecological zones.

1.1 Morphological characteristics

V. amygdalina is a perennial soft wooded shrub (Yeap *et al.,* 2010) (Figure 1a) that can reach up to 10 m in height with 40 cm stem diameter. The bark is densely pubescent at the young stage, as the plant gets matured, the bark turns to grey then to brown in colour, smooth, and disclosed. The leaves are arranged alternately with each other, simple with 0.2 to 4 cm long petioles. The leaf blade is ovate-elliptical to lanceolate and measures 4 -15 cm x 1-4 cm, cuneate or rounded at base, shortly acuminated at the apex of the leaves and the margins are clearly toothed to coarsely serrate, finely pubescent but

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often glabrescent (Figure 1d). The inflorescence of this plant is in the form of head, arranged in terminal, compound, and umbel-like cymes. The head stalk measures about 1 cm long and pubescent. The flowers are bisexual, regular, strongly exerted from the involucres which are cylindrical to broadly ellipsoid (Figures 1b and 1c). As the flower developed into fruit, the fruit is a 10-ribbed achene measuring 1.5 – 3.5 mm long, pubescent and glandular and brown to black in colour, crowned by a much longer (Grubben, 2004).

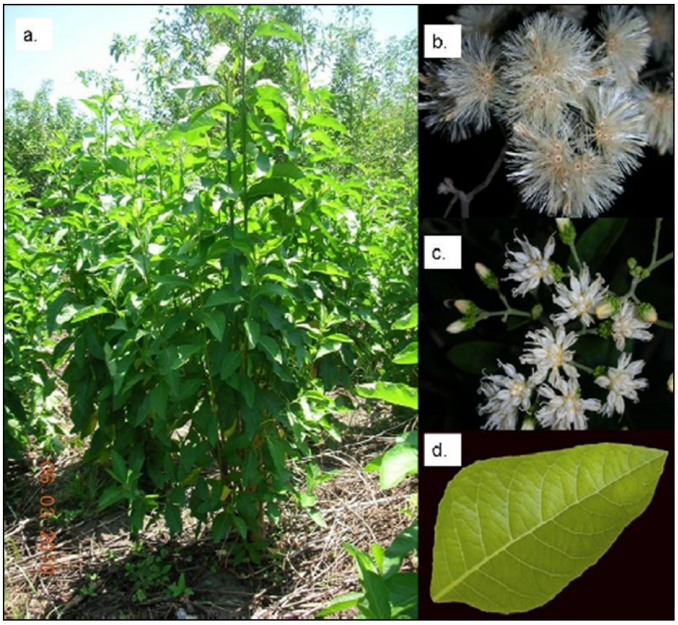

Figure 1. 1a: Photos of *V. amygdalina*. 1b and 1c: *V. amygdalina* flowers. 1d: A leaf of *V. amygdalina* (Yeap *et al.,* 2010).

1.2 Main uses

Bitter herb is described as good for the body as it assists the crucial organs of the body such as kidney and liver. Traditionally, old folks believe that the bitterness of a plant is related to its medicinal properties, with potential medicinal values. The same goes for *V. amygdalina*, there are many reports on its medicinal properties. However, due to the lack of modern medicine, indigenous people of many countries make use of this plant to cure diseases. They would make use of the plant parts, mostly leaves, either extracting it into juice, ingesting it or applying it externally. Presently, some methods are found to give positive response that eventually cure the disease.

Not only that, due to cultural and economic reasons, some people especially in Africa utilize this plant for health purpose. In Nigeria, the plant is made into tonic for medicinal purposes. To get rid of the bitter taste, the leaves of *V. amygdalina* are used as soup condiments after the leaves are washed and boiled (Hamzah *et al.,* 2013). This method is used specially to prepare bitter leaf soup, 'Onugbo' a popular Nigerian dish (Ho *et al.,* 2012).

V. amygdalina has many nutritive properties that can cure some diseases. Compared to other plant parts, leaves are the most used in disease treatment such as hypertension, measles, constipation, induction of uterine mobility, control of post-partum hemorrhage, fever, viral disease, hypercholesterolemia, voluntary skin depigmentation, emesis, nausea, loss of appetite-induced ambrosia, schistomiasis, amoebic dysentery and other gastrointestinal tract problems (Huffman *et al.,* 1996; Francis, 2015). It is also used to cure malaria, venereal diseases, wounds, hepatitis, jaundice, tuberculosis and diabetes (Riley, 1963; Chagnon, 1984; Vlietinck *et al.,* 1995; Akah and Ekekwe, 1995; Hamill *et al.,* 2000; Kambizi and Afolayan, 2001; Munaya, 2013).

Not restricted to humans, this plant can be applied to animals too for the treatment of many animal diseases. Exploitation of *V. amygdalina* as herb in animal use begin when a zoo pharmacologist found out that sick chimpanzees with empty stomach sucked out pith and juice from the unsavory *Vernonia* plant stalk. This incident caught many attentions as *Vernonia* was not a common diet for the chimpanzees because of its bitterness. The bitter taste of this plant is suspected as a guide for the chimpanzees to do self-deparasitization, enhance body fitness and appetite, and reduce constipation or diarrhea specifically during rainy season (Huffman and Seifu, 1989; Clayton and Wolfe, 1993; Jisaka, Ohigashi, Takegawa, Hirota *et al.,* 1993; Jisaka, Ohigashi, Takegawa, Huffman *et al.,* 1993; Koshimizu *et al.,* 1994; Huffman *et al.,* 1997). In another instance in Northern Nigeria, this plant was made into strengthening or fattening tonic called 'Chusan Dokin' (Hamzah *et al.,* 2013).

1.3 Other uses

Besides, because of its huge stem diameter, this plant also has been widely used as fuel wood, stakes, and fodder and construction poles. Furthermore, this plant can also be used as live fencing of agroforestry buffer zone as it can grow tall up to 10 m high. *V. amygdalina* is utilized as an ingredient for composting purpose. Due to its bitterness, it can be used as a bittering agent, a hop substitute and for the control of microbial contamination in beer brewing without affecting the quality of malt. In Ethiopia, it is used to make honey wine called 'Tei' (Kasalo and Temu, 2008).

1.4 Benefits of V. amygdalina

1.4.1 Antibacterial properties

V. amygdalina leaves are the most used part for extraction which has been shown to exhibit an inhibitory effect on both Gram-positive *Staphylococcus aureus* and

Gram-negative *Escherichia coli* bacteria (Oboh and Enobhayisobo, 2009). This is also supported by Udochukwu *et al.* (2015) that both of these bacteria showed sensitivity towards *V. amygdalina* extract as they gave out 0.8 cm zone of exhibition.

Meanwhile, extract of *V. amygdalina* by water and ethanol exhibited antibacterial activity against pure culture of clinical bacterial isolates such as *Pseudomonas aeruginosa, Klebsiella* spp.*, Streptococcus* spp.*,* and *Candida albicans* (Ghamba *et al.,* 2014). In addition, acetone extract of this plant had indicated antibacterial activity against *Bacillus cereus, Bacillus pumilus, Bacillus subtilis, Micrococcus kristinae, Enterobacter cloacaem, E. coli* and *Staphylococcus aureus* (Kambizi and Afolayan, 2001).

Not only the leaf extract of *V. amygdalina* but its root water extract also possessed antibacterial activity against *Streptococcus gordonii, Porphyromonas gingivalis, Porphyromonas nigrescens, Prevotella intermedia, Fusobacterium nucleatum* and *P. aeruginosa* at minimum inhibitory concentration of 100 mg/mL (Taiwo *et al.,* 1999).

The peeled stem of *V. amygdalina* can be used as chewing stick for teeth cleaning purposes and it was reported to be very active as it contributed to anticaries, gum healing, antisickling, haemostasis; to stop the blood flow and antimicrobial activity and plaque inhibiting effect (Etkin, 2002; Adekunle, 2002).

1.4.2 Antifungal properties

Antifungal activity in *V. amygdalina* is concentrated more on its water extract. Leaf water extract of this plant was shown to inhibit growth of *Fusarium moniliforme* on maize seed and growth of conidia and mycelia of *Collectotrichum gleosporiodes* in rubber trees (Owolade *et al.,* 2000; Ogbebor *et al.,* 2007; Suleiman *et al.,* 2008). In pepper, cold water extract of stem and root barks was able to suppress growth of *Collectotrichum capcici* that can cause leaf blight disease (Nduagu *et al.,* 2008).

Infection of *Sclerocium rolfii*, a causal agent for Southern blight disease in cowpea can be controlled by using hot water extract of *V. amygdalina.* Not only it can suppress growth of mycelia, but the extract also can enhance physical growth of cowpea plant including number of pods per plant, weight and grain yield. Physiologically, phytotoxic effect of the extract will be induced where it reduces the recoverable of photosynthesis and transpiration rate of the treated plant. This can be used to preserve high water content in seedlings of cowpea via antitranspirants during the dry season for its survival (Alabi *et al.,* 2005).

Strong antifungal activity against *Pseudoperonospora cubensis* and moderate activity against *Rhizoctonia solani* were expressed by methanol extract of *V. amygdalina* (Ohigashi *et al.,* 1991). Furthermore Enikuomehin *et al.* (1998) reported that the ash from *V. amygdalina* also contained antifungal activity as it was found to suppress mycelial growth of *Sclerotium rolfsii* Sacc. The ash also protected the seed from post-emergence infection through inhibition of fungal growth within the roots and crown zone. High nitrogen level in the ash of *V. amygdalina* was the sole reason why it could inhibit growth of *S. rolfsii* Sacc (Enikuomehin *et al.,* 1998). However, leaf extract of *V. amygdalina* could be metabolized by *Mycospharella fijiensis,* causal agent for Black sigatoka disease in banana for growth and sporulation induction (Okigbo and Emoghene, 2003). The ash from *V. amygdalina* also possesses antifungal property which has reported to retard mycelial growth of *S. rolfsii* Sacc on wheat and seedlings (Enikuomehin *et al.,* 1998).

1.4.3 Antioxidant properties

Any substance that slows down or inhibits oxidative damage to a target molecule can be called antioxidant (Yamagishi and Matsui, 2011). The primary characteristic that an antioxidant has is its ability to entrap free radicals such as peroxide, hydroperoxide or lipid peroxyl and inhibit the oxidative mechanism that then will lead to degenerative disease (Wu *et al.,* 2011). Most of the time, it is believed that herbal plants have good antioxidant activities and that could be the reason that all of the supplements and medicine are extracted from them.

From DPPH radical scavenging test, ethanol extract of *V. amygdalina* was shown to have antioxidant activity (Ayoola *et al.,* 2008). When compared to vernodalol and vernolide at 250 µg/mL, ethanol extract of *V. amygdalina* showed the highest reducing capacity and DPPH radical scavenging activity effect (Erasto *et al.,* 2007a). From the root of *V. amygdalina,* DPPH radical scavenging activity was compared among the different extracts at 1 µg/ml concentration, and ethanol extract was found to inhibit 77% of scavenging activity followed by hot and cold-water extracts with 63% and 49% of scavenging activity, respectively. It was found that all of the extracts were able to inhibit bleaching of β-carotene, oxidation of linoleic acid and lipid peroxidation induced by Fe^{2+}/ascorbate in a rat liver microsomal preparation (Owolabi *et al.,* 2008; Khalafalla *et al.,* 2009). However, methanol extract gave the highest antioxidant activity compared to acetone and water extracts (Erasto *et al.,* 2007b). This could probably be due to the methanol extract been capable of protecting the stability of the

membrane in the hemagglutination test (Iwalewa *et al.,* 2005).

Drying, boiling and blanching are common process carried out during extraction of *V. amygdalina*. However, these processes tended to reduce the ascorbic acid content in the plant (Oboh and Akindahunsi, 2004; Oboh, 2005; Odukoya *et al.,* 2007). Free radical scavenging activity and toxicity of *V. amygdalina* and reducing capacity were also reduced by blanching process (Oboh, 2005) but the total phenolic content, reducing power and free radical scavenging ability of the plant were increased. This indicates that in *V. amygdalina*, vitamin C does not act as an important antioxidant agent (Yeap *et al.,* 2010).

1.5 Chemical composition

1.5.1 Phytochemicals content

In relation to phytochemicals content, a study conducted by Usunobun and Ngozi (2016) found that saponins, tannins, alkaloids and flavonoids, triterpenoids, steroids and cardiac glycosides were high in *V. amygdalina* which served as a great source of pharmacologically active phytochemicals and effective as supplements in human and animal nutrition.

More than thirty compounds belonging to several classes of compounds with different bioactives have been isolated and characterized from *V. amygdalina*. Compounds such as vernolide, vernodalol, vernodalin and hydrxyvernolide can be used for antimicrobial, antioxidant, antitumoral and antischistosomal agents. There are also several compounds in this plant that are useful in fighting cancerous cells, such as vernodalinol, vernomygdin, and epivernodalol. 11, 13-Dihydrovernodalin can be used for anti-feed pesticide, to prevent pests from feeding. All these compounds come from sesquiterpene lactone class (Kupchan *et al.,* 1969; Owoeye *et al.,* 2010; Luo *et al.,* 2011) Luteolin, Luteolin -7-O-β-glucuronoside, Luteolin-7-O-β-glucoside that comes from flavonoid class can be used as antioxidant (Igile *et al.,* 1995).

On the other hand, steroid saponins compound class that have Vernoamyosides A, B, C and D are useful as anti-inflammatory agents (Quasie *et al.,* 2016). Extraction of this plant has to be standardized to ensure the quality of the product derived from this plant such as alternative medicine in disease treatment (Oyeyemi *et al.,* 2018). This is because, compared to the parent plant, phytochemical activities seem to be less in individual isolated compounds as several isolated compounds have shown one or more of the activities exhibited by the plant itself. This means that the activities by the plant happened because of synergic reactions of the individual components.

1.5.2 Nutritional content

Proximate composition of *V. amygdalina* reveals the presence of protein (62.2%), crude carbohydrate (22%), ash (9.95%), crude fibre (16%) and crude fat (3.45%) as reported by Nwaoguikpe (2010) (Figure 2). High ash content has been found by Yeap *et al.* (2010) and this reflected that *V. amygdalina* leaves contain useful mineral contents. This herb rich in mineral elements including chlorine, copper, ferum, potassium, manganese, nickel, sodium, sulphur (Yeap *et al.,* 2010) phosphorus, calcium, potassium, magnesium, zinc, iron and some vitamins such as Vitamin A, C and E (Nwaoguikpe, 2010).

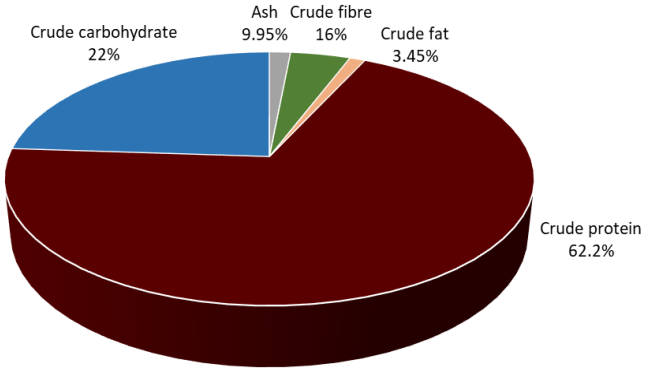

Figure 2. Proximate composition of nutritional value of *V. amygdalina.* Adapted from Nwaoguikpe (2010); Yeap *et al.* (2010)

The mineral contents of potassium, zinc, calcium, manganese and chromium are believed to possess beneficial effect in the treatment of diabetes mellitus (Marles and Farnsworth, 1995). Potassium and calcium play important roles to control the glucose level as they help to maintain the normal glucose-tolerance in the human body (Kadiri and Olawoye, 2016) (Table 1). Besides, high sulphur concentration in this herb is essential for detoxification of cyanide while low sodium content is suitable for obese patients (Ifon and Bassir, 1979). While the vitamins act as antioxidant and able to protect the tissues or cells of the diabetic patients against degenerative changes associated with the sydrome (Fasuyi *et al.,* 2006).

Table 1. Mineral composition of *V. amygdalina* (mg/100 g dry matter)

Calcium	Phosphorus	Iron	Zinc	Manganese
145.0	6.7	5.0	85.0	710.0

Adapted from Kadiri and Olawoye (2016)

On the other hand, high sugar (raffinose, lactose, sucrose, glucose, galactose, fructose, maltose and arabinose), vitamin (thiamine, nicotinamide, thiamine, riboflavin, pyridoxine and ascorbic acid), casein

hydrolysate, amino acids (non-essential amino acid: cysteine, glycine and essential amino acid: leucine, valine and phenylalanine), less acid value (10 mg/100 g dry matter) and high iodine (35 mg/100 g) value have promoted *V. amygdalina* as a popular vegetable in Africa and has been proposed as potential agent in treating goiter (Yeap *et al.,* 2010).

2. Production and cultivation

V. amygdalina is an important vegetable in Cameroon, where out of 93,600 tons of leafy vegetables harvested in 1998, 23% (21,549 tons) was bitter leaf. For instance, Nigeria is a main producer of the health products based on *V. amygdalina* and its derivative products have been commercialized as EdoBotanics, EdoTide Plus and Diabetes 5 (Yeap *et al.,* 2010).

2.1 Preparation of cuttings

Propagation of this herb is usually through stem cuttings of mature plants (>1 year old mother plants) by the farmers, however it does not produce seeds in normal circumstances (Yeap *et al.,* 2010). The stem cuttings of *V. amygdalina* of 15 cm long (4-5 nodes) taken from the middle parts of a mother plant could be the most suitable planting material (Figure 3). It should be propagated in humus-rich soil (ratio 3:2:1 cocopeat: sand) to trigger high root formation. It grows well under shaded environment to reduce excessive sunlight exposure (Ucheck Fomum, 2004). However, some studies found that the white, fragrant and bee-infested flowers growing under drastic growth environment and the seeds from dried flower heads could thrive well in slightly acidic soil with low organic matter and high-water holding capacity (Kayode, 2004).

Figure 3. Propagation of *V. amygdalina* by stem cuttings after one day propagation. Picture taken from Field 15, Universiti Putra Malaysia, Serdang, Selangor.

2.2 Field preparation

The growing media in the polybags were prepared by following the ratio of 3:2:1 (soil: organic matter: sand). The organic matter of empty fruit bunch (EFB) could be applied as a soil amandement. The growing media with the combination of soil: EFB: sand was mixed and transferred into polybags (41 x 41 cm).

2.3 Planting

The rooted cuttings are transplanted to the field after a month (Figures 4 and 5). The cuttings can be planted erect or slanting at 45^{o} angle to obtain more side-shoots (Ucheck Fomum, 2004). Normally, the cuttings are planted directly on the field or into polybags to a depth of 3 cm. While, seeds take 2-3 weeks to germinate before transplant to the field after 4-6 weeks after emergence (Ucheck Fomum, 2004).

Figure 4. Seedlings of *V. amygdalina* during propagation under shade house after a month. Picture taken from Field 15, Universiti Putra Malaysia, Serdang, Selangor.

Figure 5. Rooted cuttings of *V. amygdalina* transplanted into polybags. Picture taken from Field 15, Universiti Putra Malaysia, Serdang, Selangor.

2.4 Fertilization

The application of N based fertilizer at the rate of 30 mg N/kg soil: 30 mg P_2O_5/kg soil: 22 mg K_2O/kg soil or without N based fertilizer with similar rates can be applied on *V. amygdalina* (Musa *et al.,* 2011). Organic fertilizer such as chicken manure can also be applied at the rate of 2 tons per hectare, once a month.

2.5 Field management

Weeding and mulching in the nursery stage contribute to healthy and rapid growth of seedlings and

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cuttings of *V. amygdalina*. A regular supply of moisture is important, and irrigation is necessary during dry season. Normally, the plants need to be watered twice daily (morning and evening) to trigger plant growth and development (Musa *et al.,* 2011). Water is the key factor for the growth of *V. amygdalina* leaves. Therefore, high yield can be produced during rainy season (Yeap *et al.,* 2010). The pruning of old branches should be done in order to stimulate abundant foliage. This is best done before the rainy season, whereby it only takes 3 weeks for fresh shoots to develop after pruning (Ucheck Fomum, 2004).

2.6 Harvest time

V. amygdalina is a short cycle crop which it can be harvested twice per month for up to seven years (Yeap *et al.,* 2010) by pruning the leafy shoots to allow new side shoots to develop, which they can be harvested a few weeks later (Ucheck Fomum, 2004). However, harvesting of *V. amygdalina* at 3 weeks intervals resulted that 9 and 18 weeks after sowing could be the best time in order to obtain the desirable yield as well as high phytochemicals content.

2.7 Pests

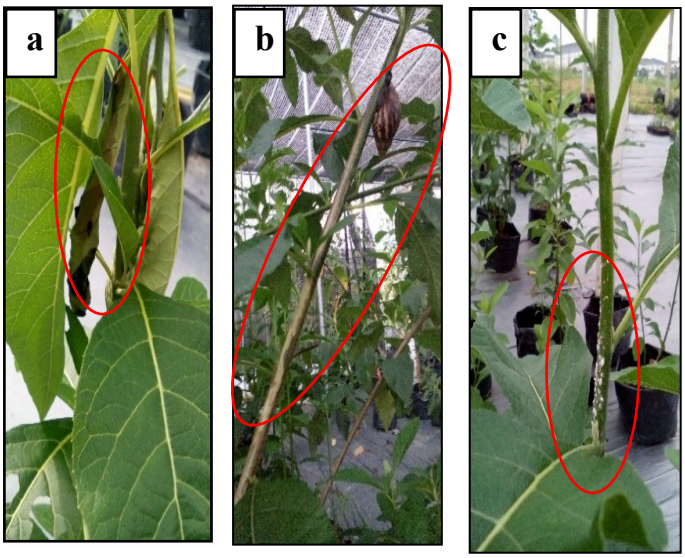

Figure 6. The main pests attacked on *V. amygdalina*: a) Caterpillars. b) Snail and c) Mealy bugs. Pictures taken from Field 15, Universiti Putra Malaysia, Serdang, Selangor.

The presence of bitter taste in *V. amygdalina* protects it from the vagaries of animals, insects and microbes, whereby the total area of leaf that is susceptible to insect attack ranges from 0.2-12% (Akachuku, 2001). Most of the pests that usually attack this herb are *Coleoptera curculionidae*, weevil *Lixus camerunus* and *Zonocerus variegates* which utilize it as a source of protein (Eluwa, 1979). In addition, other pest species such as thrips, aphids, ants, white flies, *Empoasa* spp., *Sphearocoris annulus*, *Fabricius* spp., *Ptyelus grossus*, *Polyclaeis* spp. and *Xanthochelus vulneratus* have been reported to attack *V. amygdalina* (Ucheck Fomum, 2004) besides caterpillars, snails ad mealy bugs (Figure 6). Spraying the plants with insecticide such as Sherpa plus at 100 mL per 100 L applied at four weeks after planting has been reported to control insect infestation (Musa *et al.,* 2011). A homemade organic pesticide using the ingredients including garlic, chillies, water, cooking oil and detergent could be also applied on the plants to control pests at the rate of 100 mL per 1.5 L. While, other pest such as snails could be controlled by applying the Siputox around the field plot.

3. Postharvest handlings

3.1 Drying and storage

The information of postharvest handlings on *V. amygdalina* is still lacking. However, drying is a good method of preservation for *V. amygdalina* leaves. The drying temperature at 60°C within 24 hrs is suitable to maintain the physical and chemical properties of *V. amygdalina* leaves (Akani *et al.,* 2017). The removal of moisture during drying process minimizes enzyme-mediated deteriorative reactions, thus increasing shelf life of herb (Doymaz, 2005). Besides, drying process could kill the bacteria resulting in a decrease in heat-stable enzymes at high temperatures hence reducing the bacterial contamination (Joanne *et al.,* 2014). The microbial contamination could be reduced and prevented if *V. amygdalina* leaves are processed, packaged and stored aseptically. Maintenance of strict hygiene practices during processing and drying is important to produce dehydrated herbs with good microbial quality and extend shelf life (Akani *et al.,* 2017). With regards to the storage of fresh leaves, the temperature of 5°C and storage period 1-6 months could stabilize the content of phytochemicals such as soft resin, alpha and iso-alpha acids in *V. amygdalina* as compared to 27°C (Ejoh *et al.,* 2014). While, the losses in beta carotene, vitamins, oxalate and mineral content were found when *V. amygdalina* leaves were stored at -4°C for 4 weeks (Ejike and Ndukwu, 2017). For dried leaves, packing them in low-density polyethylene (LDPE) packaging material until 12 weeks at room temperature could be recommended as it enables to stabilize the phytochemicals mainly total phenolic and flavonoid content in this herb.

4. New direction of *V. amygdalina* cultivation in Malaysia

Consumption and cultivation of *V. amygdalina* should be encouraged based on its nutritional value as well as its medicinal properties. *V. amygdalina* has only recently been cultivated from its natural habit of growing wild in Malaysia. It is used traditionally for the treatment

of diabetes mellitus and hypertension, however no commercial product has successfully been developed (Atangwho *et al.,* 2013). It has been classified by farmers as a multipurpose fodder tree with high biomass yield, easy propagation, high adaptability and compatibility with other crops as it does not compete for soil nutrients or moisture but instead helps to improve soil fertility and growth of perennial crops (Mekoya *et al.,* 2008). Indeed, there is increased global awareness on the importance of *V. amygdalina* as a medicinal plant and many researchers and food processors are capitalizing on the potentials of its extract and phytochemicals in order to optimize their exploitation for disease treatment (Ejike and Ndukwu, 2017).

Besides using this herb for human consumption, *V. amygdalina* can also be used in animal feeds. Due to its high content of crude protein, it also was found to be a good source of protein for animals for normal growth and high milk production (Nwaoguikpe, 2010). While, addition of molasses to *V. amygdalina* (ratio 5:12) could reduce the bitterness of the plant and improve the palatability and acceptance by the rumen microbes (Yeap *et al.,* 2010).

V. amygdalina is also safe to be consumed as food or herbal medicine at lower concentration without plausible toxicity to body organs and tissues of humans as it also supplies useful nutrients to animals (Imaga and Bamigbetan, 2013; Oyeyemi *et al.,* 2018).

5. Conclusion

In conclusion, *V. amygdalina* is a multipurpose plant which possesses many uses, benefits and bioactivities. Along with its health promoting effect, it would be a good advantage if this plant can be turned into beneficial health products as it has little side effects. With its high survival ability to survive in any environmental condition, it would be less of a problem to cultivate this plant in large scale planting while applying proper and suitable agronomic practices for high yield of phytochemicals. Not only restricted to health products, this plant can also use to manufacture organic pesticides, organic fertilizers and even can be incorporated into feeds for the animals. Further studies and research on agronomic practices of *V. amygdalina* would add more information and develop new technologies to further promote this herb as a potential source of new products in enhancing the health and wellbeing of humans as well as for the livestock industry.

Conflict of Interest

The authors report no declaration conflict of interest.

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