

05 *Vernonia amygdalina* (Asteraceae)

Bitter Leaf—A Nutritional, Medicinal and
Poverty Alleviating Shrub

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ABSTRACT

Vernonia amygdalina is a homestead shrub widely used as green vegetable in most delicacies to boost human nutrition as well as an herb to treat most ailments like diabetes and malaria. Recent discoveries have unveiled several other medicinal, nutritional and economic value of this crop. However, in the recent past, there is little attention to the biodiversity and genetic improvement of this crop in the international research programme. This review provides an overview of the nutritional and medicinal importance of *V. amygdalina* as well as presents the economic advantages in the cultivation and management of *V. amygdalina* as a potential crop in poverty alleviation.

INTRODUCTION

Vernonia amygdalina is a soft woody shrub belonging to the family Asteraceae. It is a perennial plant characterized by its bitter sap from the leaf which has been widely explored for its medicinal use. This plant reaches a height of between 2 to 10 m tall with simple leaves (Yeap et al., 2010). It is known by different names by different people across the West and Central African regions (Table 5.1) where it is commonly grown either as vegetable or hedge. The genus *Vernonia* has about 1,000 species, more than 500 of which are distributed in Africa and Asia. There are approximately 300 in Mexico, Central and South America while 16 occur in USA. *V. amygdalina* can be commonly found along drainage lines and in natural forests or at home and commercial plantations (Alem and Woldemariam, 2009).

ECONOMIC IMPORTANCE

General use

V. amygdalina is a common homestead farming vegetable and fodder tree in Nigeria (Ndaeyo, 2007) and has been used as the vegetable in preparing a South Eastern Nigerian delicacy (Onugbo soup) or a Cameroonian dish (Ndole) after removal of its bitter taste through soaking in several changes of water or by boiling (Koshimizu et al., 1993; Abosi and Raseroka, 2003; Onabanjo and Oguntona, 2003). In the Ethiopian highland, *V. amygdalina* has been classified by the farmer as a multipurpose fodder tree with high biomass yield, easy propagation, high adaptability and high compatibility with other crops which do not compete with them for soil nutrients or moisture but instead help to improve the soil fertility and growth of perennial crops (Mekoya et al., 2008). Furthermore, in most West African communities, *V. amygdalina*, is grown to serve as hedges around homes. Wood from stems is used as fuel, and branches from young stems are used to make chewing stick for teeth and mouth care. The processed *V. amygdalina* has been exported to Europe and North America restaurants for preparation of African dishes (Fontem et al., 2003).

STATISTICS ON PRODUCTION AND AREA OF CULTIVATION

Vernonia leaves are sometimes collected from the wild but most preferably from the cultivated trees, which are often less bitter. The leaves are usually grown for home consumption and less often for sale at the market. However, there is an increasing tendency to sell the processed leaves rather than branches with leaves (Fomum, 2004). In Cameroon, the processed leaves attract up to five times the price of the raw commodity. Processed leaves are exported from West Africa in dried or deep frozen form and offered in major markets for African vegetables in Europe (Fomum, 2004). However, people have become aware of few adulterated processed bitterleaf mixed with other leafy vegetables by some unscrupulous traders to increase the volume. Meanwhile, there are no available statistics on production across West Central Africa.

NUTRITION CONTENT

The Nutritional composition of *V. amygdalina* leaves per 100 g edible portion is: water 82.6 g, energy 218 kJ, protein 5.2 g, fat 0.4 g, carbohydrate 10.0 g, fibre 1.5 g, Ca 145 mg, P 67 mg, Fe 5.0 mg and ascorbic acid 51 mg (Leung et al., 1968). This composition is in line with other dark green leafy vegetables (Fomum, 2004).

TABLE 5.1

Different local names of *Vernonia amygdalina* in various countries

Country	Local Name
English	Bitterleaf
Africa	Akpa gbo, Kossa fina, Mponasere, Ndumbughai
Cameroon	Ated nkol, Suwaaka
China	Ikaruga Chrysanthemum tonsil, Non-tree south
Democratic Republic of São Tomé and Príncipe	Libo Macambu, Libo Que
Democratic Republic of Congo	Mpasi Nyioso
Ethiopia	Buzut, Giraw, Grawa, Ibicha
Gabon	Ndoki
Ghana	Awonoo, Awonwene, Jankpantire
Kenya	Olulosia, South African Leaf
Malaysia	South African Leaf
Nigeria	Etidod, Ewuro, Ejije, Onugbo, Shiwaka, Olugbo
Rwanda	Umubiliz
Swaziland	LINyatselo
Tanzania	Mtugutu
Uganda	Ekibirizi, Labwori, Lubilili, Lubirizi, Omubirizi
Zimbabwe	Musikavakadzi

(Source: Yeap et al., 2010)

V. amygdalina with just a little amount of processing can be classified as healthy food. It contains not only the active drug molecules but also other substances that are necessary for maintaining health and physiological functions of the body without manifestation of toxicity (Iwu, 2002). As a result, *V. amygdalina* serves well as a low cost and readily available source of important nutrients to human (Ojiako and Nwanjo, 2006). *V. amygdalina* contains 21 to 23% of dry matter (Fafunso and Bassir, 1976; Ifon and Bassir, 1980). Out of the dry matter, it contained 6.5 to 29.2% of crude fibre content (Alabi et al., 2005a; Antia et al., 2006; Ifon and Bassir, 1979; 1980; Oboh, 2006; Okoli et al., 2003a) and 0.137% of chlorophyll content (with 75% of chlorophyll-a) (Faboya, 1985). Higher hemicellulose was found in the dry than the fresh leaves of *V. amygdalina* (Bonsi et al., 1995a; b; Okoli et al., 2003a). *V. amygdalina* contains crude protein (17 to 33 g/100 g Dry Weight) (Ifon and Bassir, 1980; Mekoya et al., 2008; Oboh, 2006; Okoli et al., 2003a) and fat (2 to 15 g/100g DW) with 24.54% saturated and 65.45% polyunsaturated. Oleic acid was the major monounsaturated fatty acid (Alabi et al., 2005a; Eleyinmi et al., 2008; Ifon and Bassir, 1980; Oboh, 2006). Due to its high content of crude protein, it was found to be a good source of protein. A high

amount of protein is essential for animal growth and increased milk production (Oke, 1965; Tangka, 2003). It was found that *V. amygdalina* leaves, when added to soybean meal, made the best infant weaning food which helps the baby to gain weight (Agbede et al., 2007).

High ash content (10 to 13 g/100g DW) (Alabi et al., 2005a; Faboya, 1983; Ifon and Bassir, 1979; Ifon and Bassir, 1980; Mekoya et al., 2008; Oboh, 2006; Okoli et al., 2003a) reflected the useful mineral contents (calcium, chlorine, chromium, copper, ferum, potassium, iron, magnesium, manganese, nickel, phosphorus, potassium, sodium, sulphur and zinc) that are present in this plant (Alabi et al., 2005a; Faboya, 1983; Gbaruko and Friday, 2007; Ifon and Bassir, 1979; 1980; Oboh, 2006). Ash of *V. amygdalina* contained high levels of nitrogen, phosphorus and other types of exchangeable bases (Calcium, Magnesium, Sodium and Potassium) (Enikuomehin et al., 1998). A high concentration of sulphur is important for detoxification of cyanide while low sodium content is suitable for obese patients (Ifon and Bassir, 1979). The nutritive values of young and mature leaves did not differ significantly (Akachuku, 2001). Abrasion of the leaf caused a significant decrease, in both the nutrient and antinutrient content of the leaf except in carbohydrate (Oboh, 2006).

On the other hand, high sugar (raffinose, lactose, sucrose, glucose, galactose, fructose, maltose and arabinose) (Alabi et al., 2005a; Ifon and Bassir, 1980), vitamin (thiamine, nicotinamide, thiamine, riboflavin, pyridoxine and ascorbic acid), casein hydrolysate, amino acids (non-essential amino acids: cysteine and glycine and essential amino acids: leucine, valine and phenylalanine), low acid values (10 mg/100g DW) and high iodine (35 mg/100g) values have promoted it as a popular vegetable in Africa and proposed as a potential treatment for goiter. Washing and cooking reduce 40 to 77% of vitamin C content (Ejoh et al., 2003; Fafunso and Bassir, 1976). These suggest that *V. amygdalina* should be consumed immediately after harvesting or must be kept in a refrigerator before processing (Yeap et al., 2010). Most of the active ingredients from this plant were thermostable (Alabi et al., 2005a; Ifon and Bassir, 1979). Other than the common metabolites and minerals, *V. amygdalina* also contains several active secondary metabolites which contribute to its bioactivity.

MEDICINAL VALUES

In addition to its usefulness as a vegetable, hedge plant and fodder, Vernonia has a wide variety of medicinal values, which are being explored in order to al-

leviate human, livestock and plant health needs.

Antibacterial

Many experimental studies of *V. amygdalina*, have reported that this plant possesses antibacterial activity. Newbold et al. (1997) showed that this plant has mild antimicrobial effects on rumen bacteria and protozoa while Kambizi and Afolayan (2001) proved that acetone extract of *V. amygdalina* possesses antibacterial activity towards *Bacillus cereus*, *B. pumilus*, *B. subtilis*, *Micrococcus kristinae*, *Staphylococcus aureus*, *Enterobacter cloacae* and *Escherichia coli* growth with minimum inhibition concentration (MIC) of 5 mg/ml. Although, Cos et al. (2002) concluded that *V. amygdalina* was more sensitive towards the gram positive bacteria than gram negative bacteria; some researchers found that the activity of *V. amygdalina* against gram-negative bacteria was comparable to that of the gram positive species. Ethanolic extract from the plant also showed antibacterial effect against both gram-negative (*E. coli* and *Salmonella typhi*) and gram-positive (*Clostridium sporogenes*, *Staphylococcus pyogenes* and *S. aureus*) bacteria (Ogbulie et al., 2007; Kola, 2007). Ogbulie et al. (2007), however, concluded that ethanol and Soxhlet extractions are the best solvents and the best methods to give optimum antibacterial effect of this plant whereas, Pesewu et al. (2008) reported that this extract could not inhibit the methicillin-resistant (MRSA UELSHB 102, UELSHB) and methicillin-sensitive (MRSA NCTC 6571) strains of the bacteria while chloroform, water and blender extract of *V. amygdalina* leaves showed low inhibitory effects towards its growth. Only water and blender extract showed effect on *Streptococcus pyogenes*, *E. coli* and *P. vulgaris* with MIC and Minimum Bactericidal Concentration (MBC) higher than 50 mg/ml. On the other hand, *V. amygdalina* root water extract also showed antibacterial activity on *Streptococcus gordonii*, *Porphyromonas gingivalis*, *Porphyromonas nigrescens*, *Prevotella intermedia*,

Antifungal

The water extract of *V. amygdalina* leaves can inhibit the growth of *Fusarium moniliforme* on seeds of maize (*Zea mays*) as well as mycelial and conidial growths of *Colletotrichum gloeosporioides* in rubber trees (Ogbebor et al., 2007; Owolade et al., 2000; Suleiman et al., 2008). Cold water extract of stem and root bark (but not leaves) was able to inhibit *Colletotrichum capsici* (Synd) isolated from pepper (Nduagu et al., 2008). On the other hand, the juice of *V. amygdalina* had a stronger effect than its cold water extract where its juice could more effectively inhibit seed borne fungi (*F. moniliforme*, *Botryodiplodia theobromae*, *Aspergillus niger* and *A. flavus*) in vitro and in vivo (Nwachukwu

and Umechuruba, 2001). In the crop industry, *V. amygdalina*'s hot water extract was able to control the infection of *Sclerocium rolfii* and increased the plant height, shelf life, relative water content, chlorophyll content, leaf area index, number of branches, total dry matter, number of pods per plant, weight and also grain yield on cowpea. However, it induced phytotoxic effects where it reduced the recoverable amount of photosynthethates and the treated plant's transpiration rate.

Antimalarial

The ethanol, petroleum ether, dichloromethane, ethyl acetate, acetone-water and isoamyl alcohol extracts of *V. amygdalina* showed antimalarial activity against *Plasmodium falciparum* (Dd2) in vitro (Madureira et al., 2002; Masaba, 2000; Tona et al., 2004). The root extract of *V. amygdalina* displayed mild activity against chloroquine-sensitive *P. falciparum* with IC₅₀ of 19 µg/ml but no activity against the chloroquine-resistant strain (Froelich et al., 2006). *P. falciparum* parasite can lead to the most pathogenic form of human malaria which is one of the most dangerous infectious diseases endangering human lives (Anderson et al., 2000). The active compounds of *V. amygdalina* contribute to its antimalarial effect, or more specifically sesquiterpene lactones such as vernolepin, vernolin, vernolide, vernodalin and hydroxyvernodalin, which exhibited antiplasmodial activity of IC₅₀ value lower than 4 µg/ml (Tona et al., 2004). Masaba (2000) discovered that acetone-water extract from *V. amygdalina* leaves showed a lower IC₅₀ value (25.5 µg/ml against *P. falciparum* than water extract, 76.7 µg/ml) after 48 h. The relatively lower bioactivity of water extract as compared to solvent extraction explains why a larger quantity (100 to 200 ml) of *V. amygdalina* decoction is used in traditional practices for defeating the disease. Besides *P. falciparum*, *V. amygdalina* is also effective against another species of Plasmodium (*Plasmodium protozoan*), which serves as the causative agent of malaria (Yeap et al., 2010). Ethanolic leaves and root extract of *V. amygdalina* exerted in vivo suppressing effect against *P. berghei* at early stage of infection with ED₅₀ 125 mg/kg body weight for leaves and 250 mg/kg for root extract after 3 days treatment. However, the extracts failed to remove the infection completely (Abosi and Raseroka, 2003). Furthermore, Iwalokun (2008) showed that aqueous leaves extract (62.5, 125 mg/kg) was able to work synergistically with chloroquine (5 and 30 mg/kg) against both chloroquine-sensitive and resistant *P. berghei* to shorten the parasite clearance time, prolong the recrudescence times and improve curing rate. The study has also suggested that administration of *V. amygdalina* ethanol extract one hour prior to chloroquine

intake can help avoid the reduction in chloroquine bioavailability (Igboasoiiya et al., 2008).

Antiviral activity

Ethanol extract of the fruit (which is rarely found on most of the *V. amygdalina* shrub) possessed antiviral effect against the polio virus (Vlietinck et al., 1995).

Anticancer and cytotoxic effect

Cold water extract of *V. amygdalina* leaf extract exhibited cytostatic action on MCF-7 cell growth and DNA synthesis (Izevbigie, 2003; Izevbigie et al., 2003; Izevbigie et al., 2004) through down regulation of extracellular signal-regulated protein kinase (ERK) signaling (Izevbigie et al., 2003; Izevbigie et al., 2004), induction of cytochrome P450 3A4 (CYP3A4) and microsomal epoxide hydrolase expression (Howard et al., 2003) and alteration of cell membrane permeability and efflux (Opata and Izevbigie, 2006). The aqueous extract when combined with tamoxifen was able to reduce the concentration of tamoxifen by 10-fold in order to inhibit 50% of cell growth (Izevbigie et al., 2005). In addition, exposure of aqueous extract of *V. amygdalina* at 100 to 300 µg/ml was also able to reverse the ethanol-induced stimulatory response in paclitaxel-sensitive and resistant human breast cancer cell MCF-7 (Howard et al., 2006). These results suggest that *V. amygdalina* may prevent or delay the onset of breast cancer (Yeap et al., 2010). However, other researches also reported that cold water extract of the plant possessed moderate cytotoxicity effect with IC₅₀ of 218 µg/ml (Opata and Izevbigie, 2006) or even without IC₅₀ at 1 ~ 2 mg/ml (Yedjou et al., 2008) against MCF-7 cell. This was believed to be attributed to batch variation of the extracts (Opata and Izevbigie, 2006). Aqueous extracts of *V. amygdalina* also showed increasing effects against the growth of estrogen receptor negative ductal carcinoma (BT-549) cell lines in a concentration dependent fashion with IC₅₀ at 1000 µg/ml through inhibition of DNA synthesis. Although the inhibition concentration was high, *V. amygdalina* has been consumed in large quantities without reported cases of toxicity and thus may be suitable for incorporation into the diet of cancer patients to improve their prognosis or quality of life (Gresham et al., 2008; Robinson et al., 2009). Cold water, hot water and ethanol extract were found to induce apoptosis against acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) from the patients with IC₅₀ ranging between 5 and 10 µg/ml. Ethanol extract was found to be most effective against both ALL and AML when compared to cold and hot water extract (Khalafalla et al., 2009). Petroleum ether/ethyl acetate leaf extract also possessed cytotoxic

effects against human hepatoblastoma (HepG2) and urinary bladder carcinoma (ECV-304) cell lines (Froelich et al., 2006).

Analgesic

Aqueous leaf extracts and ethanol root extract of *V. amygdalina* exhibited antipyretic effects, central and peripheral analgesic effects against acetic acid induced writhing, as well as protective effect on formalin and pentylenetetrazole-induced lethality (Iroanya et al., 2010; Njan et al., 2008; Onah and Okokon, 2004; Tekobo et al., 2002).

Liver Protective

Oral administration of the aqueous extract from *V. amygdalina* leaves could accelerate the reversion of liver damage through reduction of liver marker enzymes, including aspartate aminotransferase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP), glutamate-oxaloacetate transaminase, glutamatepyruvate transaminase, lactate dehydrogenase and bilirubin indices in liver biochemical tests (Arhoghro et al., 2009; Iwalokun et al., 2006). Histopathological examination showed that as low as 15% of extract could even completely revert liver change to normal in the treated animals (Arhoghro et al., 2009).

Antidiabetic Effect

Diabetes mellitus is a chronic disease which affects millions of people worldwide. The prevalence of this disease was projected to reach 300 million before year 2025 (Erasto et al., 2009). *V. amygdalina* was the most popular antidiabetic traditional herbal remedy in Nigeria (Gbolade, 2009). Water and n-hexane/isopropanol extract of the plant have been reported to enhance the glucose utilization of muscle and liver cell cultures but not on adipose cells (Erasto et al., 2009). Scientific studies have confirmed the antidiabetic potential of *V. amygdalina* where oral intake of hot water and *V. amygdalina* leaves extract (500 mg/kg), reduced blood glucose concentration of both normoglycaemic and hyperglycaemic rats induced by alloxan (Osinubi, 2007). Consumption of *V. amygdalina* through means of squeeze-wash-drink and raw chewing by normal human subjects were found to control postprandial blood glucose without inducing severe hypoglycemic effect (Okolie et al., 2008). Osinubi (2007) proposed that sesquiterpene lactones and the bitter principle of the plant may be responsible for insulin production, stimulation and release of pancreatic islets from the beta-cells. On the other hand, tannin, flavoniods glycosides and phytosterols of the plant may also act as alpha glucosidase inhibitor which contributed to the hypoglycemic effect of the plant. However, the significant

reduction of serum sodium and potassium in diabetic rats, fed with its ethanol extract indicated a possible induction of dilutional hyponatremia as a side effect (Atangwho et al., 2007a and b).

BOTANY, ECOLOGY AND GEOGRAPHICAL DISTRIBUTION

The genus *Vernonia* of the flowering plant family, Asteraceae, has close to 1,000 species. Globally, *Vernonia* occurs mainly in South America and Africa (Fomum, 2004). Some of the species which also exhibit bitter characteristics found in Africa include *V. colorata* more frequently found in the savannah belts of Ghana; *V. hymenolepis* from mountainous areas in Cameroon, Uganda, Kenya, Kenya, Tanzania and Ethiopia and *V. cinerea* which is semi-cultivated in Kenya and Tanzania, *V. poskeana*, from Zimbabwe; *V. appendiculata* from Madagascar and *V. perrottetti* from Sierra Leone (Schippers, 1999). *V. colorata* is closely related to *V. amygdalina*. It however differs in its, more or less, entire leaves and glabrous fruits. Leaves of *V. colorata* are mostly collected from the wild for medicinal purposes. *Vernonia* has simple leaves, which alternate. The inflorescence is usually a head, arranged in terminal, compound, umbel-like cymes; stalk of head up to 1 cm long. Flowers are bisexual, regular, 5-merous, strongly exerted from the involucre; pappus consisting of outer linear, caduceus scale up to 1.5 mm long and inner creamy or brownish bristles 4-7 mm long (Fomum, 2004). Corolla has 5-8 petals; tubular; stamen with anthers united into a tube; ovary inferior, 1-celled, pubescent and glandular; style: hairy and 2-branched and fruit a 10-ribbed achene.

V. amygdalina occurs naturally along rivers and lakes, in forest margins, woodland and grassland, up to 2,000 m altitude. It normally occurs in disturbed localities such as abandoned farmlands and can be found growing spontaneously in secondary forests. Its cultivation requires full sunlight and short day periods. It is fairly drought tolerant but requires a humid environment. It can thrive on all soil types but performs optimally in humus-rich soils (Plate 05.1, Photo 1).

CULTIVATION AND MANAGEMENT PRACTICES

Vernonia amygdalina is preferably cultivated by stem cuttings (Plate 5.1, Photo 2), however plants can also be generated by seed and in vitro using explant cultures in the presence of auxin. IBA (with concentration ranging between 0.25 to 2 mg/l) was found to be the best growth regulator for its adventitious

root induction (Fomum, 2004; Khalafalla et al., 2009). Cuttings for propagation are selected on the basis of attributes such as degree of bitterness, leaf size and growth characteristics. Cuttings may be planted erect or slanted at an angle of 45° in order to obtain more side shoots (Plate 5.1, Photo 4). Cuttings grow faster than seedlings. Cultivation by seeds requires the collection of seeds from dried flower heads and broadcasting on nursery beds prepared from humus-rich soils. Viable seeds will begin germination 2 to 3 weeks after planting. Wetting of the nursery beds is necessary during the dry season. Seedlings can be transplanted 4-6 weeks after emergence. At the nursery, weeding and application of organic manure is necessary. A regular supply of water is important especially during the dry season. Old branches can be pruned back to a low level to stimulate the production of larger, succulent and abundant foliage. The effect is optimized if pruning is done before the arrival of the rains. Young plants are more productive than the older ones; hence farmers prefer to plant new crop at the beginning of every new season but still maintain their old crops. Harvesting is carried out when the vegetative yield has reached an appreciable size. This is done by cutting the leafy shoots, allowing new side shoots to develop, which can be harvested a few weeks later. Stems of various lengths are cut in the afternoons, and are sorted and tied into bundles of equal length. Stems brought to the market are usually 30-50 cm in length depending on the season. Bundles of 15-20 stems, weighing 1-2 kg are often made, but smaller bundles are equally made during the scarce season (Plate 5.1, Photo 3). Harvest yields are obtained during the rainy season, the peak being in May to August. However, production statistics are not available.

Pest and Diseases

Vernonia amygdalina, so far, has been found to be resistant to a majority of crop diseases except the leaf curl virus (Fomum, 2004). Similarly, pests do not cause major damage. In Northern Nigeria the following pests have been reported: thrips, aphids, ants, white fly' *Empoasa spp.*, *Spherochoris annulus*, *Fabricus spp.* among others. Traditionally, these pests are controlled by applying wood ash on leaves. The bitterleaf weevil is also another important pest reported in cultivated areas.



Photo 1. A shoot of Vernonia amygdalina



Photo 2. Stem cutting of Vernonia amygdalina (Slanting)



Photo 3. Harvested branches of Vernonia amygdalina for market sale as vegetable



Photo 4. Stem cutting of Vernonia amygdalina (Slightly erect)

Plate 5.1. Vernonia amygdalina

INTERVENTIONS AND CASE STUDIES

Cameroon (processed for food export and leaf extract)

Vernonia 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 (Smith and Eyzaguirre, 2007). Currently, AfriProducts is selling a kilogram of fresh/frozen *V. amygdalina* leaves at USD \$4.55 and its powder at USD \$7.5 (AfriProduct, 2010) while RGL enterprise sells a kilogram of powder at USD \$10 (RGL enterprises, 2010). The processing of leaves prior to sale for consumer's convenience, especially for those living in the cities, depicts the great degree of market potential of the plant. Many health products formulated with *V. amygdalina* have been commercialized. For instance, EdoBotanics under the Jackson State University is selling processed *V. amygdalina* under the name of EdoTide Plus (which contains 600 mg of leaf extract with the suggestion of 600 to 1200 mg oral intake per day) (60 capsules at USD \$42) (EdoBotanics, 2010).

Nigeria (Processed for medicinal purpose against Diabetes)

In Nigeria, "Diabetes 5" (containing up to 50% mixture of *V. amygdalina* leaves and *Anisopus manii* leaves) has been sold as an unofficial herb to treat diabetes mellitus. Studies have found that methanol (100 mg/kg) and chloroform (200 mg/kg) extracts of "Diabetes 5" possessed similar hypoglycemic activity as Glibenclamide (3 mg/kg) after 24 h of oral administration. However, both extracts and Glibenclamide exerted adverse effects on spleen and kidney of tested animals (Agunu et al., 2008).

Suitable as Alternate Feed Ingredient

More suitable processing is necessary and concentrations should be inspected and optimized in the formulation of better health products from *V. amygdalina*, to eliminate or minimize adverse effects to the consumers. It is actively consumed by locally reared goats (personal observation). *V. amygdalina* was used to prepare feed for rumen traditionally. However, the palatability of this herb was comparatively lower than other plants due to its bitterness which is contributed by alkaloids and saponins. Although the suggestion of adding molasses to *V. amygdalina* (ratio 5:12) may improve the acceptance of the rumen, this would further increase the dependency on molasses and the cost of commercial supplement. Thus, *V. amygdalina* may not be viable as a single dietary supplement in modern medicine (Bonsi et al., 1995a, b; Hindrichsen et al., 2004).

Testimony

Livestock feed

It is consumed regularly by free range locally reared goats (Plate 5.2, Photo 5) which necessitates the protection of the young growing bitterleaf plant (Plate 5.2, Photo 6a and 6b) serving both as food and medicinal purposes to the animals.

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Photo 5. Locally reared goats which consume Bitterleaf



Photo 6a. Protected Bitterleaf to prevent feeding by goats Photo 6b. Protected Bitterleaf to prevent feeding by goats

Plate 5.2

Vegetable

Vernonia amygdalina is a common home grown vegetable and fodder tree in Nigeria (Plate 5.3, Photo 7) and has been used as a vegetable (Plate 5.1, Photo 3) in preparing a South Eastern Nigerian delicacy (Onugbo soup) or a Cameroonian (Ndole) dish. It is sold in the market usually by South Eastern women of Nigeria either as a wet, processed, leafy vegetable (from which the bitter taste has been reduced by washing/squeezing in water repeatedly or by boiling) (Plate 5.3, Photo 8), either dried (Plate 5.2, Photo 9a & 9b) or fresh bitterleaf (Fig. 4). Market supply is maintained by small scale

farming of *Vernonia amygdalina* or home cultivation. However, moderately large farms are practiced in swamp soils of Ikorodu and Festac-Ojo, Lagos Nigeria for supply into large markets in Lagos and for export to Africans in diaspora and African restaurants in Europe and USA.



Photo 7. Home grown Vernonia amygdalina



Photo 8. Processed Vernonia amygdalina for market sale



Photo 9a. Dried Vernonia amygdalina for market sale



Photo 9b. Dried Vernonia amygdalina for market sale

Plate 5.3

CONCLUSION AND RECOMMENDATIONS

V. amygdalina possesses various bioactivities with low or absence of side effects. With its great health-promoting effects, there is vast potential for the crop. Its medicinal potential has been vastly explored and has proven very effective. The results are gradual, directing people to the natural source of obtaining healing from plants. However, other potential uses for this crop abound. An example is the use of the plant as fodder. This will, however, require a thorough genetic evaluation. There is need for a wide collection of germplasm which will serve as a reservoir of genotypes for selection in the development of commercial cultivars.

There are also huge potential in the processed bitterleaf, even on the international market. Therefore, there is the need to develop technology and protocols on the processing of bitterleaf so as to eliminate the challenges of reduced quality and thereby maximize its marketability nationally and on the global scale.

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