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Review

Current perspectives on the medicinal potentials of *Vernonia amygdalina* Del.

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***Vernonia amygdalina* Del., commonly called bitter leaf, is a perennial shrub that belongs to the family *Asteraceae* and grows throughout tropical Africa. It is probably the most used medicinal plant in the genus *Vernonia.* Traditional medicine practitioners use the plant as an anti-helminth, anti-malarial, laxative, digestive tonic, appetizer, febrifuge and for the topical treatment of wounds. Scientific research in the last few decades has scrutinized these claims and found that extracts from the plant have numerous phytotherapeutic properties. Extracts from *V. amygdalina* Del. have been shown to have antimicrobial (antibacterial, antifungal, antiplasmodial etc), anti-cancer/tumor, antioxidant, hypoglycemic/anti-diabetic, oxytocic, hepato- and nephro- protective, serum lipid modulation, and other properties. These properties are believed to be mediated by different phytochemicals found in the plant, acting singly or in concert. This paper critically reviews the present state of scientific knowledge on the medicinal and nutritional potentials of *V. amygdalina* Del. It concludes that future research must aim at characterizing the active principle(s) responsible for each effect, and determining if they act singly or synergistically with other principles present in the plant.**

Key words: *Vernonia amygdalina*, medicinal uses, nutrient composition.

INTRODUCTION

Africa has arguably one of the richest phytodiversities in the world. Africa's forests geographically span approximately 216,634,000 ha (Farombi, 2003). More than 50% of all modern clinical drugs are of plant origin (Suffness and Douros, 1982). Plant products therefore play an important role in drug development programs of the pharmaceutical industry (Baker et al., 1995; Cordell, 1995). Furthermore, the consumption of plant materials is believed to contribute immensely to the improvement of the health of man and his plants and animals. Yedjou et al. (2008) estimated that 80% of the population of Africa depends on medicinal plants to satisfy their health care requirements. Knowing the nutritional, medicinal and economic value of vegetables found in Africa could add value to their cultivation, consumption, conservation and commercialization. Proper exploitation of such knowledge could help in the fight against hunger and disease – two daunting challenges, in the region. One of the most studied plants that grow widely in Africa is *V. amygdalina* Del. (VA). This paper reviews the literature on the uses of VA and presents the current state of knowledge on the nutrient and phytochemical composition, and medicinal uses of VA.

METHODS OF DATA RETRIEVAL

A keyword search was done, in January, 2010, using electronic search engines (Google Scholar and Pubmed) with the words "*Vernonia amygdalina*".

The results of the search were carefully sorted by both authors and those considered to be directly related to the thrust of this review were selected. Differences in opinions (of the authors) were resolved by debate. Researchers working on the plant were also approached

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Figure 1. Diagram and picture of *V. amygdalina* Del.

and literature procured from them. These were put together with the literature previously in our collection and used for the review.

BOTANICAL OVERVIEW

V. amygdalina Del, commonly called bitter leaf, is a perennial shrub of 2-5m in height that grows throughout tropical Africa. It belongs to the family Asteraceae, has a rough bark with dense black straits, and elliptic leaves that are about 6 mm in length (Figure 1). The leaves are green and have a characteristic odor and bitter taste (Singha, 1966). In many parts of West Africa, the plant has been domesticated (Igile et al., 1994). It is known as 'Grawa' in Amharic, 'Ewuro' in Yoruba, 'Etidot' in Ibibio, 'Onugbu' in Igbo, 'Ityuna' in Tiv, 'Oriwo' in Edo and 'Chusar-doki' in Hausa (Egedigwe, 2010). VA is drought-tolerant (though it grows better in a humid environment). It thrives on a range of ecological zones and is used as a hedge plant in some communities (Bonsi et al., 1995).

NUTRIENT COMPOSITION/NUTRITIONAL USES

An estimated 815 million people in developing countries suffer from malnutrition, and infants and children are the worst hit (FAO, 2004). Unfortunately, efforts at improving food production and accessibility in these regions have been directed lope-sidedly to roots/tubers, cereals, and animal production. The largely ignored dark green leafy vegetables can however augment the nutrients derivable from other sources, thereby reducing malnutrition tremendously. Leaves are easy to prepare, and contain appreciable quantities of nutrients (Devadas and Saroja, 1980; Oshodi, 1992).

V. amygdalina Del. has been shown to contain significant quantities of lipids (Ejoh et al., 2007; Eleyinmi et al., 2008), proteins with high essential amino acid score (Igile et al., 1994; Udensi et al., 2002; Ejoh et al., 2007; Eleyinmi et al., 2008) that compare favorably with values reported for *Telfairia occidentalis* and *Talinum* triangulare (Ijeh et al., 1996), carbohydrates (Ejoh et al., 2007) and fiber (Udensi et *al.,* 2002; Ejoh et al., 2007; Eleyinmi et al., 2008). The plant has also been shown to contain appreciable quantities of ascorbic acid and caroteinoids (Udensi et al., 2002; Ejoh et al., 2007). Calcium, iron, potassium, phosphorous, manganese, copper and cobalt have also been found in significant quantities in VA (Bonsi et al., 1995; Ejoh et al., 2007; Eleyinmi et al., 2008). Table 1 shows a summary of the nutrients found in the leaves of VA.

Unfortunately, the dietary use of the leaves of VA has remained limited only to the cultures that use it as vegetable (after maceration to remove the bitter principles) in soup and porridge preparation, suggesting an under-utilization of the plant's leaves.

PHYTOCHEMICALS IMPORTANCE

A wide array of phytochemicals (including anti-nutritional factors) has been shown to be present in VA. A summary of the phytochemicals present in VA is presented in Table 2. The presence of oxalates, phytates and tannins has been reported (Harborne, 1973; Udensi et al., 2002; Ejoh et al., 2007; Eleyinmi et al., 2008). Stigmastane-type saponins such as vernoniosides A1, A2, A3 (Jisaka et al., 1992), A4, B2, B3 (Jisaka et al., 1993a), C, D and E (Kamperdick et al., 1992; Ohigashi, 1994) have been

Table 1. Proximate nutrient composition of *V. amygdalina* Del.

Nutrient (concentration)	Author(s)
Proteins (9.7%*, 18%†, 19.2%¶, #)	*Udensi et al. (2002), † Igile et al. (1994), ¶Ejoh et al. (2007), and #Eleyinmi et al., (2008)
Fibre (8.2-16.8%*, 8.5%†, 19.2%¶, #)	*Udensi et al. (2002), † Igile et al. (1994), ¶Ejoh et al. (2007) and #Eleyinmi et al. (2008)
Moisture (79.9%)	Ejoh et al., 2007
Carbohydrates (68.4%)	Ejoh et al. (2007)
Lipids (4.7%¶, #)	¶Ejoh et al. (2007) and #Eleyinmi et al. (2008)
Ascorbic acid (mg/100g) (80-104*, 166.5¶)	*Udensi et al. (2002) and ¶Ejoh et al. (2007)
Caroteinoid (mg/100g) (30)	Ejoh et al. (2007)
Calcium (g/100g) (0.97¶, #)	¶Ejoh et al. (2007), #Eleyinmi et al. (2008) and Bonsi et al. (1995)
Iron (mg/100g) (7.5¶, #)	¶Ejoh et al. (2007) and #Bonsi et al. (1995)
Phosphorous (#)	#Eleyinmi et al. (2008) and Bonsi et al. (1995)
Potassium, sulphur, sodium, manganese, copper, zinc (#)	#Bonsi et al. (1995)
Magnesium, selenium	Atangwho et al. (2009b)

#represents qualitative determination; *,† and ¶ identify the author(s) that reported the nutrient concentration bearing a corresponding sign.

Table 2. Phytochemical constituents of *V. amygdalina* Del.

Phytochemical	Author(s)
Stigmastane-type saponins	
Vernoniosides A1, A2, A3, A4, B1, B2, B3, C, D, E	Ohigashi et al. (1991), Jisaka et al. (1992), Kamperdick et al. (1992), Jisaka et al. (1993a), Ohigashi (1994) and Aregheore et al. (1997)
Steroidal saponins	Rwangabo et al. (1986), Ohigashi et al. (1991), Jisaka et al. (1992), Jisaka et al. (1993a), Igile et al. (1994) and Igile et al. (1995)
Sesquiterpene lactones	
Vernolide, vernodalol, vernolepin, vernodalin, vernomygdin, hydroxyvernolide	Kupchan et al. (1969), Jisaka et al. (1992) Jisaka et al. (1993b), Koshmizu et al. (1994) and Erasto et al., 2006
Flavonoids	
Luteolin, luteolin 7-*O*-β-glucoroniside, luteolin 7-*O*-β-glucoside	Igile et al. (1994), Udensi et al. (2002) and Tona et al. (2004)
Terpenes, coumarins, phenolic acids, lignans, xanthones, anthraquinones	Wall et al. (1998) and Tona et al.(2004)
Edoties (peptides)	Izevbigie (2003)

shown to be present in the leaves. The A-series saponins have been shown to be responsible for the bitter taste of VA. Other steroidal saponins have been identified in the plant (Rwangabo et al., 1986; Igile et al., 1994; Igile et al., 1995).

Sesquiterpene lactones are another class of

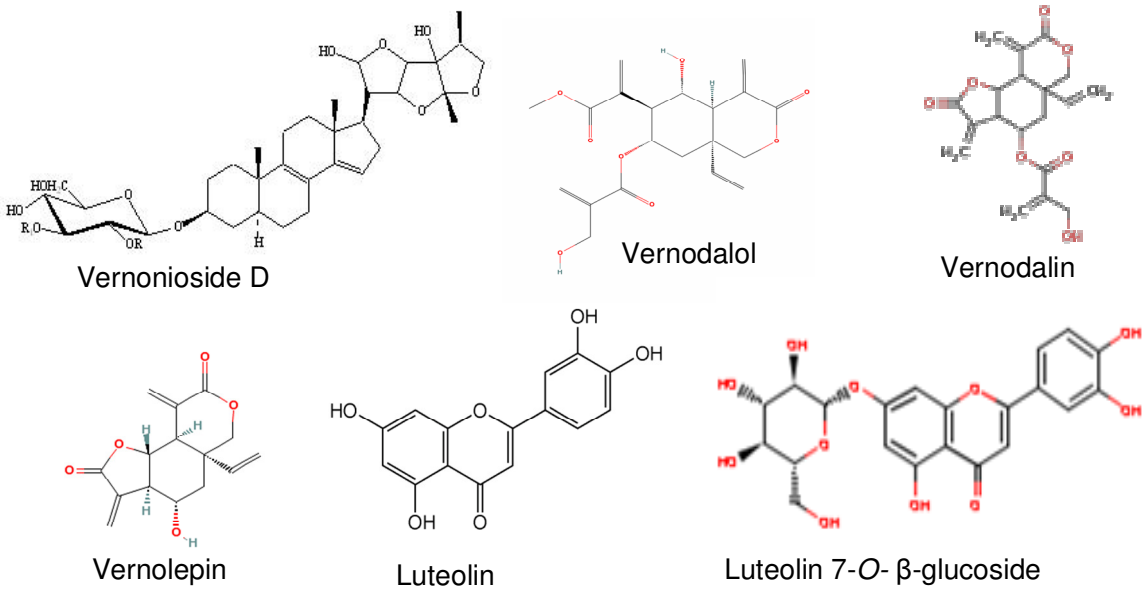

Figure 2. Structures of some phytochemicals found in the leaves of *V. amygdalina* Del.

phytochemicals found abundantly in the leaves of VA (Figure 2). Some of the identified Sesquiterpene lactones are vernolide, vernodalol (Erasto et al., 2006), vernolepin, vernodalin and hydroxyvernolide (Jisaka et al., 1993b; Koshnimizu et al., 1994). Igile et al. (1994) reported the presence of the flavonoids luteolin, luteolin 7-*O*-β-glucoroniside and luteolin 7-*O*-β-glucoside, in the leaves of VA. Other researchers have confirmed the presence of flavonoids in the plant (Udensi et al., 2002; Tona et al., 2004).

Other phytochemicals present in the leaves of VA are terpenes,coumarins, phenolic acids, lignans, xanthones and anthraquinones (Wall et al., 1998; Tona et al., 2004). Izevbigie (2003) has reported the presence of bio-active peptides called edotides in the leaves of VA.

These phytochemicals (and possibly some more yet to be identified) are believed to be responsible for the plethora of bio-activities possessed by the plant.

These bio-active principles may act singly, or synergistically to produce the results for which the medicinal values of VA have been vigorously studied.

MEDICINAL USES

V. amygdalina Del. is probably the most used medicinal plant in the genus *Vernonia* (Erasto et al., 2006). The observation that an apparently sick wild chimpanzee chewed *V. amygdalina* Del. and seemed to return to normal activity after a while, by Huffman and Seifu (1989) and Ohigashi et al. (1991) elicited the attention of the phytomedicine community such that dozens of studies have been done since then to test the efficacy of different extracts of the plant in managing a wide array of medical ailments. Igile et al. (1994) reported that in traditional medicine, practitioners use the plant as an anti-helminth, anti-malarial, and as a laxative. Others use it as a digestive tonic, appetizer, febrifuge and for the topical treatment of wounds (Iwu, 1986). Dalziel (1937) was about the first to report that the root and twig of the plant are used for the treatment of stomach and gastro-intestinal problems by the Hausas of Northern Nigeria, while the decoction from the leaves is used in treating malaria fever in Guinea and cough in Ghana. In some parts of Nigeria, the stems are used as chew sticks for oral hygiene, and for the management of some dental problems. In Malawi and Uganda, VA is used by traditional birth attendants to aid the expulsion of the placenta, after birth, aid post-partum uterine contraction, induce lactation and control post-partum hemorrhage (Bullough and Leary, 1982; Kamatenesi-Mugisha, 2004). Many of these traditional uses of the plant have been scrutinized scientifically. The results of the numerous investigations conducted to date on VA are revealing (Table 3).

Antibiotic/antimicrobial/antimalarial properties of *V. amygdalina* Del.

The sap of the leaves of VA was found to show inhibitory capacities against *Staphylococcus epidermidis*, *Staphylococcus aureus, Escherichia coli,* and *Pseudomonas aeroginosa* (Ijeh et al., 1996). A 60% methanolic extract of the leaves gave antimicrobial activity against *Bacillus subtilis, Klebsiella pneumonia, P. aeruginosa, Proteus vulgaris, Shigella dysenteriae* and *S. aureus* (Akinpelu, 1999). Both vernolide and vernodalol

Table 3. Properties/uses of *V. amygdalina* Del.

Property	Type of extract	Author(s)
Antibacterial	60% methanol	Akinpelu (1999)
	Crude sap	Ijeh et al. (1996)
	Ethanolic	Erasto et al. (2006)
	-	Jisaka et al. (1993b)
Antiplasmodial/antimalarial	Aqueous	Njan et al. (2008)
	Aqueous	Iwalokun. (2008)
	Ethanolic	Abosi and Raseroka (2003)
	-	Phillipson et al. (1993)
	-	Masaba (2000)
Amoebicidal	-	Moundipa et al. (2005)
	-	Huffman et al. (1996)
Antifungal	Aqueous	Alabi et al. (2005)
	Ethanolic	Erasto et al. (2006)
	-	Wedge et al. (2000)
Antileishmanial	Chloroformic and methanolic	Tadesse et al. (1993)
	-	Huffman et al. (1996)
Antischistosomial	-	Ogboli et al. (2000)
Wound management	Crude sap	Giday et al. (2003)
Venereal disease management	-	Kambizi and Afolayin (2001)
Anti-Cancer/Tumor	Chloroformic	Kupchan et al. (1969)
	Aqueous	Yedjou et al. (2008)
	Aqueous	Gresham et al. (2008)
	Aqueous	Izevbigie (2003)
	Aqueous	Oyugi et al. (2009)
	Aqueous	Howard et al. (2006)
	Aqueous	Izevbigie et al., (2004)
	-	Jisaka et al., (1993b)
	Aqueous and ethanolic of root cultures	Khalafalla et al., (2009)
Antioxidant	Aqueous and ethanolic	Owolabi et al., (2008)
	30% methanolic	Igile et al., (1994)
	Aqueous	Nwanjo, (2005)
	Methanolic	Adaramoye et al. (2008)
	-	Iwalokun et al., (2006)
Hypoglycemic/Antidiabetic	Ethanolic	Ekpo et al. (2007)
	Aqueous	Osinubi (1996)
	Aqueous	Nwanjo and Nwokoro, (2004)
	Aqueous	Akah and Okafor (1992)
	Aqueous	Uhuegbu and Ogbechi, (2004)
	Ethanolic	Atangwho et al. (2007)
	Crude sap	Okolie et al. (2008)
Oxytocic	Aqueous	Kamatenesi-Mugisha (2004)
	Aqueous	Kamatenesi-Mugisha et al. (2005)

Table 3. Continued.

	Aqueous	Ijeh et al. (2010)
Hepatoprotection	Aqueous	Arhoghro et al. (2009)
	Diet incorporation	Ijeh and Obidoa (2004)
	-	Babalola et al. (2001)
	-	Iwalokun et al. (2006)
Nephroprotection	Ethanolic	Atangwho et al. (2007)
	80% ethanolic	Atangwho et al. (2009a)
Serum lipid modulation	Diet incorporation	Egedigwe (2010)
	Diet incorporation	Ugwu et al. (2010)
	Methanolic	Adaramoye et al. (2008)
	Ethanolic	Ekpo et al. (2007)
	Aqueous	Nwanjo (2005)
	-	Ezekwe and Obidoa (2001)
Gastric secretion	Aqueous	Owu et al. (2008)
Analgesic	Aqueous	Njan et al. (2008)
Anti-fertility	Root extract	Steen-Kamp (2003)
	-	Desta (1994)
Insecticidal	Dust	Kabeh and jalingo (2007)
	Oil	Asawalam and Hassanali (2006)
Phytotoxic	Aqueous	Alabi et al. (2005)

isolated from VA showed activity against the Gram positive *Bacillus cereus, S. epidermidis, S. aureus, Micrococcus kristinae* and *Streptococcus pyrogens* and the Gram negative *Salmonella pooni*, but neither of the two had any activity against the Gram negative *E. coli, Serratia marcescens, P. aeruginosa* and *K. pneumonae* (Erasto et al., 2006). This implies that the activity reported for the extracts of VA against *E. coli* and *P. aeruginosa* by Ijeh et al. (1996) and *P. aeruginosa* and *K. pneumonae* by Akinpelu (1999) may be mediated by other phytochemicals other than the Sesquiterpene lactones vernolide and vernodalol. Reports from Huffman et al. (1996) and Moundipa et al. (2005) show that the plant extracts possess potent amoebicidal activity. This implies that it may be useful in the management of amoebic dysentery – a fairly common ailment in poor settings where environmental sanitation and personal hygiene are often neglected. These results justify the use of VA in the treatment of wounds and some gastro-intestinal problems in traditional medicine.

Fungal infestations constitute a big proportion of the challenges facing developing countries. Fungi cause disease in man, and in his plants and animals (Schwin, 1982). Kurucheve et al. (1997) suggest that botanicals may be very useful in the management/control of fungal diseases, especially since they are effective, cheap, and environmentally non-hazardous. Extracts from the leaves of VA have therefore been tested for antifungal activity. Wedge et al. (2000) report that the leaf extracts of the plant had antifungal activity. The aqueous extracts of the leaves of VA have been shown to be potent against plant fungal pathogens, while not affecting the growth of the plant negatively (Alabi et al., 2005). On the other hand, Akinpelu (1999) report that a 60% methanolic extract of the leaves of VA had no effect against *Candida albicans* – a popular opportunistic pathogen of humans. Vernolide and vernodalol have however been shown to have activity against the fungi *Aspergillus flavus*, *Mucor hiemalis, Fusarium oxysporum, Penicillium notatum* and *Aspergillus niger* in a manner that is comparable (at 0.1 mg/ml and above) to the standard drug Nystatin (Erasto et al., 2006).

Malaria is said to be responsible for approximately one million infant deaths every year in sub-Saharan Africa (Abosi and Raseroka, 2003). What is worrisome is that the parasite is becoming resistant to a number of the

current drugs for malaria treatment available in the market. Abosi and Raseroka (2003) reported that the ethanolic extract of the leaves and root-bark of VAsuppressed parasitemia (induced by inoculation with *Plasmodium berghei*) in mice by 67 and 54%, respectively in four days. The aqueous extract of the leaves of the plant has also been shown to reduce the load of *P. berghei* in mice by 73% when given intra-peritoneally for 4 days (Njan et al., 2008). Iwalokun (2008) has also corroborated the effectiveness of the aqueous extract of VA in managing malaria. These data, and the reports by Phillipson et al., (1993), Masaba (2000), Tekobo et al. (2002) and Njan et al. (2008) that the extracts of VA may have central and peripheral analgesic properties lend credence to the use of the plant in the folk-loric management of malaria fever. It is thought that the flavonoids, saponins and alkaloids (Sayed et al., 1987) and sesquiterpene and steroidal constituents (Phillipson et al., 1993) are responsible for the anti-plasmodial properties of VA.

The potency of extracts of VA in combating some human parasites has also been studied. *In vitro* studies using *Leishmania aethiopica* show that amastigotes were more sensitive to the extracts than promastigotes, and that the chloroform extract had a stronger parasiticidal activity compared to the methanolic extracts (Tadesse et al., 1993). Furthermore, reports from Huffman et al. (1996) and Ogboli et al. (2000) show that VA has potent anti-schistosomial activity. These clearly imply that the plant could be useful in fighting these parasites in man.

Anti-cancer/tumor properties of *V. amygdalina* Del.

The burden of cancer has become a serious global problem. Prostate cancer and breast cancer are the most diagnosed non-skin cancers in men and women respectively. Breast cancer represents 15% of new cases of all cancers (ACS, 2010) while prostate cancer represents 15.3% of all cancers in men in the developed countries (Parkin et al., 2001). There is therefore an urgent need to develop botanicals/phytotherapeutics that are effective against different cancers. *V. amygdalina* Del. is increasingly becoming a strong candidate for cancer management. It is thought that coumarins, flavonoids, sesquiterpene lactones and edotides may be the principles in VA that are responsible for its anti-cancer activity (Kupchan et al., 1969; Jisaka et al., 1992; Wall et al., 1998; Izevbigie, 2003).

Kupchan et al. (1969) had shown that the chloroform extract of VA has potent anticancer activities. This anticancer potential of the plant was corroborated by Jisaka et al. (1993a). Bioactive peptides from the aqueous extract of the plant leaves (edotides) have been shown to be potent in managing cancer by its activity on mitogen activated protein kinases and signal transduction pathways (Izevbigie, 2003; Izevbigie et al., 2004). The studies of Howard et al. (2006) corroborate the finding of anti-cancer principles in the aqueous extract of the plant by showing that it inhibits the growth of MCF-7Rag cells in culture, and reverse the ethanol-induced stimulatory response in paclitaxel-sensitive human cancer cell growth.

Furthermore, it had been shown that aqueous extracts of VA significantly reduced the viability of MCF-7 cells in a dose-dependent manner and also induced DNA damage in the said cells (Yedjou et al., 2008). These data are corroborated by the report of Gresham et al. (2008) that show that the water soluble fractions of the plant inhibited DNA synthesis and growth of BT-549 cells in a dose-dependent fashion.

Recently, Oyugi et al. (2009) showed that fractions of hexane, chloroform, butanol and ethylacetate extracts of VA inhibited the growth of human breast cancer cells even at concentrations of 0.1 mg/ml at a concentration of 1 mg/ml, the inhibition was as high as 98% for some fractions of the extract.

With the establishment of the usefulness of *V. amygdalina* Del. in managing breast cancer, there is a need to study its effectiveness with other cancers.

Antioxidant properties of *V. amygdalina* Del.

Many chronic diseases and causes of food spoilage are linked to pro-oxidants. Antioxidant principles are therefore useful in food preservation and drug formulations (Loliger, 1991). Synthetic antioxidants like butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are suspected to be tumorigenic (Ito et al., 1985). Therefore there is a need to search for potential antioxidant principles, especially from herbs, that can replace their synthetic counterparts.

Flavonoids are known to be good antioxidants, and luteolin (a flavonoid found in VA) has been reported to be a strong antioxidant (Torel et al., 1986). Igile et al. (1994) confirmed that luteolin is more potent an antioxidant than BHT, and reported that its glucosides – luteolin 7-*O*-β-glucuroniside and luteolin 7-*O*-β-glucoside also have antioxidant activities. A study of oxidative stress in diabetic rats showed that the aqueous extracts of VA decreased the levels of serum malondialdehyde, indicative of antioxidant property (Nwanjo, 2005). The findings of Iwalokun et al. (2006) and Adaramoye et al. (2008) corroborate the antioxidant properties of the plant. A study by Owolabi et al. (2008) further showed that both the ethanolic and aqueous extracts of VA have potent antioxidant abilities. The extracts were found to inhibit bleaching by β-carotene, oxidation of linoleic acid and lipid peroxidation induced by Fe^{2+}/ascorbate in rat liver microsomal preparations. The antioxidant activity of the ethanolic extracts was found to be higher than that of the aqueous extracts, and compared well with BHT and BHA (Owolabi et al., 2008). The said authors concluded that

the flavonoid content of the extracts may be responsible for their total antioxidant activity.

Hypoglycemic/anti-diabetic property of *V. amygdalina* Del.

Diabetes mellitus, a metabolic disorder that has arguably achieved epidemic proportions, is said to affect more than 200 million persons globally, and is projected to affect 366 million people by the year 2030 (Wild et al., 2004). Phytotherapy for some decades has played an important role in the management of the disease especially in resource-poor countries. Clearly, the identification of plant materials that can manage diabetes and its complications would save millions of people, especially in developing countries, from untimely death.

The blood sugar lowering effect of the aqueous extract of the leaves of VA was reported by Akah and Okafor (1992). This was strengthened by the observation that the aqueous extract produced significant reductions in the blood glucose concentrations of normal and diabetic rats, comparable to the effect of the standard drug – chlorpropamide (Osinubi, 1996). Reports from Nwanjo and Nwokoro (2004) and Uhuegbu and Ogbechi (2004) on the effects of the aqueous extracts of the plant corroborate these claims. The ethanolic extracts of the plant have also been shown to have blood sugar lowering effect in rats (Atangwho et al., 2007; Ekpo et al., 2007), suggesting that the active blood sugar lowering principles may be extracted by both polar and non-polar solvents. Okolie et al. (2008) administered the leaves of VA by 'squeeze-wash-drink' and 'chew-raw' options to normoglycemic humans, and found that VA (irrespective of mode of administration) had significant blood sugar reduction effects post-priandially at 30 min intervals for 2 h. Whether the same effect could be reproduced in diabetics is yet to be studied.

Oxytocic property of *V. amygdalina* Del.

The report by Bullough and Leary (1982) that traditional birth-attendants in Malawi use the leaves of VA to induce uterine motility and control post-partum hemorrhage elicited a couple of studies to examine the oxytocic potentials of the plant. Kamatenesi-Mugisha (2004) and Kamatenesi-Mugisha et al. (2005) reported that the aqueous extracts of the plant increased rat uterine motility, caused rabbit jejunum contraction and may therefore be a potent oxytocic. A recent study by Ijeh et al. (2010) using guinea pig dams showed that the aqueous extracts of the plant increased milk production, and at a dose of 100 mg/ml induced uterine contraction amplitudes that were similar to those of ergometrine, but mammary smooth muscle contraction amplitudes that were lower than those of ergometrine. The data support the oxytocic property of the aqueous extracts of VA and justify its use by traditional birth-attendants.

Hepato- and nephro- protective properties of *V. amygdalina* Del.

Liver diseases are serious medical problems, especially because of the central role of the liver in metabolic homeostasis and xenobiotic transformations. The search for alternative drugs for the treatment of liver diseases has produced some 'botanicals chief' among which is *V. amygdalina* Del.

Compounds of the sesquiterpene family have been shown to have antihepatotoxic activity in tetrachloromethane-induced hepatic damage in rats (Babalola et al., 2001). A study by Ijeh and Obidoa (2004) found that a diet incorporated with VA protected weanling albino rats against aflatoxin B_1-induced hepatotoxicity. Data published by Iwalokun et al. (2006) support the hepatoprotective effect of VA in rats. A report by Arhoghro et al. (2009) showed that the leaves of VA not only protect against tetrachloromethane-induced hepatotoxicity, but also reversed hepatic damages so-caused in the rats.

Dietary incorporation of the leaves of VA resulted in no significant difference in the mean weight of the liver and kidneys of weanling rats, implying an absence of acute toxicity (Ijeh and Obidoa, 2001). A study on the impact of an ethanolic extract of VA on some indices of kidney function in rats concluded that the extract can protect against kidney impairment, but may induce dilutional hyponatremia (Atangwho et al., 2007). The same team, subsequently published findings that the combined administration of VA extract and another plant extract was nephroprotective, and also reversed dilutional hyponatremia, but this time, amplified diabetes-induced hypophosphatemia (Atangwho et al., 2009a).

The apparent encumbrances with respect to the use of VA extracts as hepatoprotective agents reported that high doses of the plant material may indeed be toxic (Ijeh and Akomas, 2006; Ijeh and Adedokun, 2006; Ojiako and Nwanjo, 2006).

Serum lipid modulation properties of *V. amygdalina* Del.

Dyslipidemia is a known risk factor for cardiovascular diseases – a common cause of morbidity and mortality even in developing countries (WHO, 2003). Drugs that are used to modulate lipid levels in serum often have deleterious side effects (Millner, 2001). This has warranted the search for less toxic phytochemicals that can perform the same tasks.

Dietary incorporation of VA lowered serum triacylglycerol and LDL-cholesterol levels, and increased HDL-cholesterol levels (Egedigwe, 2010; Ugwu et al.,

2010). Nwanjo (2005) reported that the aqueous extract of the plant reduced triacylglycerol levels and normalized cholesterol concentrations in the serum of diabetic rats. The ethanolic extracts of the plant have also been reported to keep the lipid profile of rats within the normal range (taken as that of the control rats) when doses of 100-1000 mg/kg body weight were administered (Ekpo et al., 2007). The methanolic extracts of VA have also been shown to have lipid-lowering effects in rats fed on a high cholesterol diet for nine weeks (Adaramoye et al., 2008). These reports coupled with reports of the antidiabetic and antioxidant properties of VA suggest that the plant may play very important roles in the future management of chronic diseases.

Other medicinal properties of *V. amygdalina* Del.

Aqueous extracts of VA have been reported to induce gastric secretion and dose-dependent contraction of the ileum in guinea pigs (Owu et al., 2008). Desta (1994) and Steen-Kamp (2003) reported the anti-fertility potential of the root extract of the plant. This is interesting especially as the root extract of the plant is known (traditionally) to be toxic when consumed.

Pesticidal properties of *V. amygdalina* Del.

The aqueous extract of the leaves of VA has been reported to have phytotoxic properties (Alabi et al., 2005). Dust from the dried leaves of VA were also found to have insecticidal potency against the larvae of *Callosobruchus maculatus* and *Sitophilus zeamais* – insects that cause heavy losses of stored cow pea and maize, respectively (Kabeh and Jalingo, 2007). Asawalam and Hassanali (2006) also reported that the essential oil of VA was effective in the control of *Sitophilus zeamais.*

CONCLUSIONS/PERSPECTIVES FOR FUTURE RESEARCH

V. amygdalina Del. apparently is a plant with diverse potentials (resumed in Table 3). Its chemical constitution makes it ideal for nutritional and medicinal uses. Its content of virtually all the major food classes, albeit in modest ratios, make it an ideal supplement that can be used to augment the nutrient requirements of Africa and the developing world. The wide spectrum of phytochemicals 'bottled up' in its leaves and other parts could help in salvaging mankind from the present burden of diseases – communicable and otherwise – and help in the preservation of agricultural produce.

However, more has to be done, to transform the large volume of research already done on the plant into practical, ready made nutraceuticals or phytotherapeutics so that mankind may begin to effectively utilize the plant for maximal benefit. It is worrisome that most of the work done so far have not been followed up in such a way as to clear all scientific doubts and determine specific active principles and mechanisms of action – the typical and classical 'follow your nose' method of scientific investigation. A good number of the researches done so far on VA have been at best peripheral and haphazard. These are exemplified in the number of patents on the plant weighed against the number of publications on it. The usually peddled alibi however, is that a good proportion of the research on VA have been done in sub-Saharan Africa, where state-of-the-art laboratory equipments and facilities are often difficult to come by.

Future research must aim at characterizing the active principle (s) responsible for each effect, and determining if they act singly or synergistically with other principles present in the plant. Only such research would place *V. amygdalina* Del. in its proper place in nutritional and medical sciences.

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