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A Comprehensive Review of *Vernonia amygdalina*: Phytochemistry, Nutritional Benefits and Biological Activities

Kabir D.[1]*, Mu'azu J.B.[2], Lawan I.[3], Hamza M.[4]

[1]*Department of Pure and Industrial Chemistry, Faculty of Physical Sciences, University of Nigeria Nsukka, Nigeria*
[2]*Department of Chemistry, Sa'adatu Rimi College of Education, Kano, Nigeria*
[3]*Department of Chemistry, Northwest University Kano, Nigeria*
[4]*Department of Chemistry/Biochemistry, Federal Polytechnic Idah, Kogi State, Nigeria*

**Corresponding author, Email address: kabirdanjuma@gmail.com*

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Abstract: *Vernonia amygdalina*, commonly known as bitter leaf, is an important medicinal and dietary plant widely used in African traditional medicine. This review summarizes current knowledge on its phytochemistry, nutritional value, and biological activities. The bibliometric analysis used is limited to 980 articles from 2000 to 2025 to the evolution of interest in this plant (3 articles in 2000) to oscillate around 100 last years. The Bibliometric analysis indicates that more than 96% of the published documents are articles (85.9%), reviews (7.0%), conference papers (3.4%), and it also shows that the concern of researchers is towards medicine (17.1%), pharmacology (17.0%) and agriculture (16.5%). The biochemistry and chemistry are 12.2% and 6.6%, respectively The phytochemical studies reveal the presence of bioactive compounds such as sesquiterpene lactones, flavonoids, alkaloids, saponins, tannins, and phenolic compounds. Nutritionally, the leaves contain essential vitamins, minerals, proteins, and dietary fiber, supporting their use as a functional food. Experimental studies have demonstrated diverse biological activities, including antimicrobial, antioxidant, antidiabetic, anti-inflammatory, anticancer, and hepatoprotective effects, largely attributed to its phytoconstituents. Despite promising findings, further studies on standardization, safety, and clinical efficacy are required. In conclusion, *Vernonia amygdalina* remains a valuable source of nutraceuticals and potential lead compounds for therapeutic development

1. Introduction

Although modern medicine is rapidly evolving, traditional medicine continues to be an important part of the global healthcare system in the 21st century (Evbuomwan *et al.*, 2023; Aremu *et al.*, 2024). Traditional medicine includes a broad spectrum of knowledge, systems, practices, and beliefs, which rely on plant, animal, and mineral remedies, spiritual therapies and manual practices to prevent, diagnose and treat illnesses (Kabir *et al.*, 2025; Ijaz *et al.*, 2024). The practices are very entrenched in the culture and have been passed down the generations. The world health organization (WHO) estimates that approximately 80 percent of the population in the developing world uses traditional medicine as a primary source of health care needs (Musa *et al.*, 2022; Kabir and Lawan, 2025; Kabir *et al.*, 2025). In some parts of the world, like Africa, Asia, and Latin America, traditional medicine is

generally the most available, cheapest, and culturally-acceptable form of medical care, especially in rural and underserving populations. Traditional Chinese Medicine (TCM), Ayurveda (India), Unani, African traditional medicine, and Amerindian and Australian Indigenous healing systems are some of the well-known systems (Musa *et al.*, 2022). The traditional medicine has become what is commonly known as complementary and alternative medicine (CAM) in the developed countries. The use of herbal medicine, acupuncture, chiropractic treatment, yoga and naturopathy is becoming increasingly adopted with the traditional healthcare. This has created an increasing level of popular interest due to the view that more natural, holistic and less side-effect-related remedies are traditional. The World Health Organization (WHO) reports that 11% of drugs used to treat illnesses in humans come from plants (Kabir *et al.*, 2025). According to a 2017 report by Behavior Change Communication, the use of herbal products has increased the global market to 59.45 billion US dollars. This market is expected to reach 104.78 billion US dollars in 2026 at an annual pace of 6.5%. Functional foods are being used to provide health benefits beyond their nutritional value (Kabir and Lawan, 2025; Kabir *et al.*, 2025). By providing humans with a variety of small bioactive compounds, nature offered a wide range of new prospects regarding the treatment of many ailments (Kabir *et al*., 2025). The best-selling commercial medications of the past century, including as morphine (Papaver somniferum), vincristine (Vinca rosea), and taxol (T. brevifolia), were created from natural materials. The acid test of this has been the current surge in interest in natural goods as an alternative source of pharmaceuticals in both the academic community and pharmaceutical businesses. According to Danjuma *et al.* (2025), almost 40% of newly produced medications are derived from natural ingredients.

Vernonia amygdalina, commonly known as bitter leaf, is a perennial shrub belonging to the family Asteraceae which has a characteristic feature of bitterness in taste (Figure 1). It is widely distributed across tropical Africa, particularly in West and Central Africa, where it grows naturally around homesteads and farms. The plant is well known for its characteristic bitter taste and its extensive use in traditional medicine, nutrition, and ethnoveterinary practices. In African traditional healthcare systems, *V. amygdalina* is one of the most frequently used medicinal plants. (Echem and Kabari, 2013). Despite being native to tropical Africa, it is widely farmed in Yemen, Brazil, South Uganda, Ethiopia, Kenya, Nigeria, and Tanzania (Nursuhaili *et al.*, 2019). The plant is naturally found in locations that get 750,2000 mm of annual rainfall and 2,800 m of elevation, such as the borders of forests, the areas around rivers and lakes, woodlands, and grasslands. It enjoys a humid atmosphere and needs direct sunlight. It may grow in any type of soil, however humus-rich soils are preferred (Ofori *et al.*, 2013). In the genus Vernonia, it is arguably the most commonly used medicinal herb. It is known as "bitter leaf" due to its bitter taste and is used as a vegetable and medicinally. Saponins, tannins, alkaloids, and glycosides are among the secondary metabolites of the species that have anti-dietary properties. These components are what give this medicinal plant its bitter flavor (Danladi *et al.*, 2018).

In addition to bitter leaf, this medicinal plant is referred to by a number of common names in various languages and geographical areas, such as "ebicha" (oromifa) (Bekele and Reddy, 2015), "grawa" (Amharic), and "vernonia tree" (English) (Wubayehu *et al.*, 2018). The leaves, roots, and stems are employed in the management of various ailments such as malaria, diabetes mellitus, gastrointestinal disorders, fever, helminth infections, and microbial diseases. In addition to its medicinal importance, the leaves are commonly consumed as a vegetable in soups and sauces, contributing to food security and nutrition. Phytochemical studies have shown that *V. amygdalina* is rich in biologically active compounds including sesquiterpene lactones, flavonoids, alkaloids, saponins, tannins, phenolic compounds, and glycosides. These constituents are responsible for its diverse pharmacological

activities, such as antimicrobial, antimalarial, antidiabetic, antioxidant, anti-inflammatory, and anticancer effects, as reported in several scientific studies. Due to its wide availability, low cost, and proven bioactivity, *Vernonia amygdalina* has attracted significant attention in natural products chemistry, pharmacology, and drug discovery research. However, despite its extensive traditional use, further studies are required to standardize extracts, establish safe dosage levels, and validate its clinical efficacy. Vernonia amygdalina remains a plant of considerable medicinal, nutritional, and socioeconomic importance in Africa and beyond (Bekele and Reddy, 2015). This review discussed the potential phytochemistry, nutritional and biological applications of *Vernonia amygdalina*.

Figure 1: Vernonia amygdalina

2. Bibliometric analysis on *V. amygdalina*

A bibliometric analysis becomes a popular and rigorous method for exploring and analyzing large volumes of scientific data (Aria and Cuccurullo, 2017; N'diyae *et al.*, 2022; Elmsellem *et al.*, 2023; Hammouti *et al.*, 2025; Kadda *et al.*, 2025). *Vernonia Amygdalina* is largely studied with more than 1000 articles on Scopus between 1965 to the present. The bibliometric analysis is limited to 980 articles from 2000 to 2025 to the evolution of interest in this plant (3 articles in 2000) to oscillate around 100 last years (**Figure 2**). The analysis indicates that more than 96% of the published documents are articles (85.9%), reviews (7.0%), conference papers (3.4%), etc. (**Figure 3**). This result may be explained by the promotion condition in universities to accept only journal articles. **Figure 4** shows the concern of researchers towards medicine (17.1%), pharmacology (17.0%) and agriculture (16.5%). The biochemistry and chemistry are 12.2% and 6.6%, respectively, to provide more details on the phytochemical compounds.

Figure 5 provides the top 10 authors for the studied period. The Indonesian Satria D. has published 23 articles in this field and a total of 149 articles, reaching an H-index of 19 and more than 1250 citations, followed by his 2 compatriots, Hasibuan P.A.Z. (21 articles) and Harahap U (14 articles). The Malaysian Abdurahman N.H. (13 articles). The University of Ibadan, Nigeria is the most profiled institution during this period, which published more than 29000 articles covered by 8261 authors.

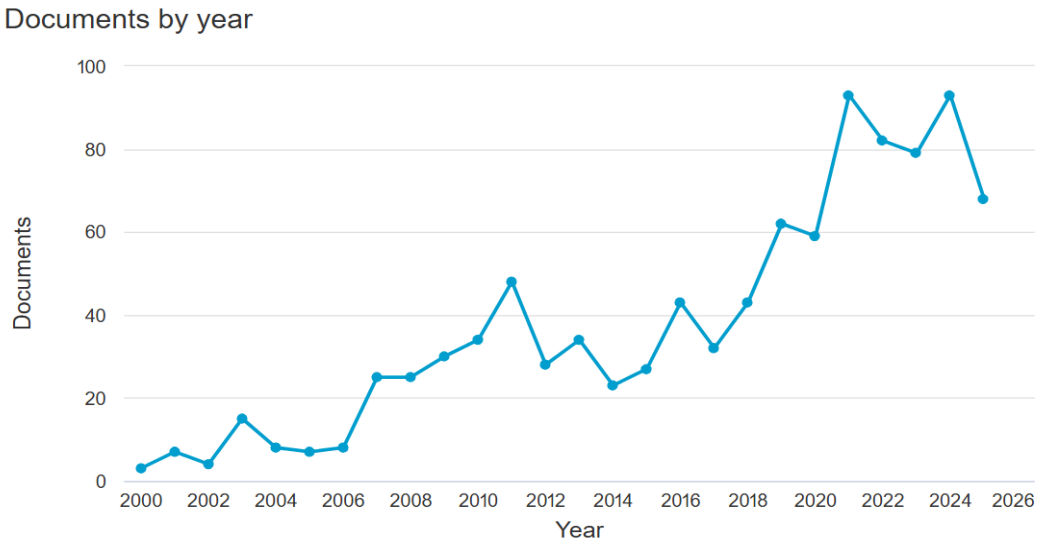

Figure 2. Evolution of article's number from 2000 to 2025

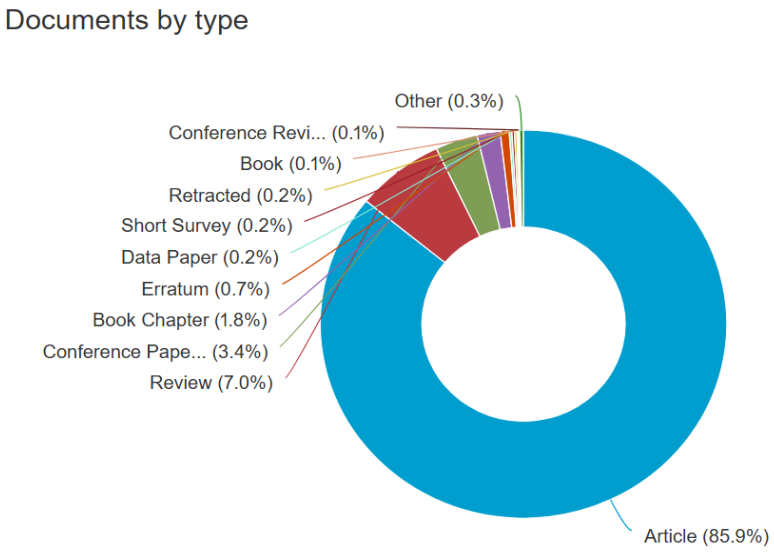

Figure 3. Percentage of article's type from 2000 to 2025

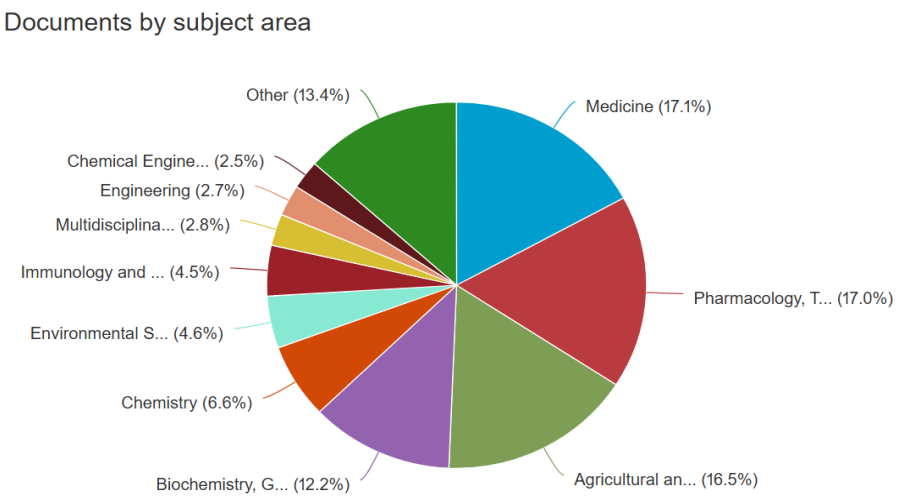

Figure 4. Articles by subject area from 2000 to 2025

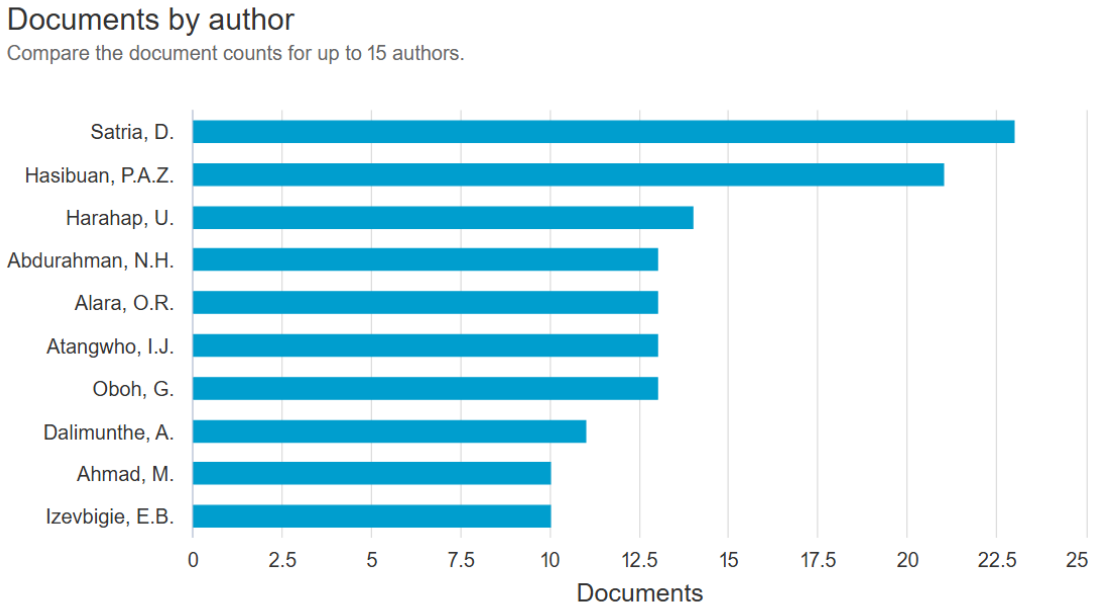

Figure 5. The top ten authors in the studied period

The second one is University of Nigeria (Nauka, Enugu) (**Figure 6**). This finding corroborates that Nigeria is the top country concerned by the studies on this plant (444 articles), followed by Ethiopia (95 articles) and Indonesia (90 articles) occupying the third position (**Figure 7**). The top ten selected journals shown in **Figure 8**, indicate that authors prefer the Journal of Ethnopharmacology: Q1 5.4 impact factor (55 articles), Tropical Journal of Natural Product Research: Q3, 1.6 impact factor (25 articles) and the third one is African Journal of Biotechnology Q3/Q4.

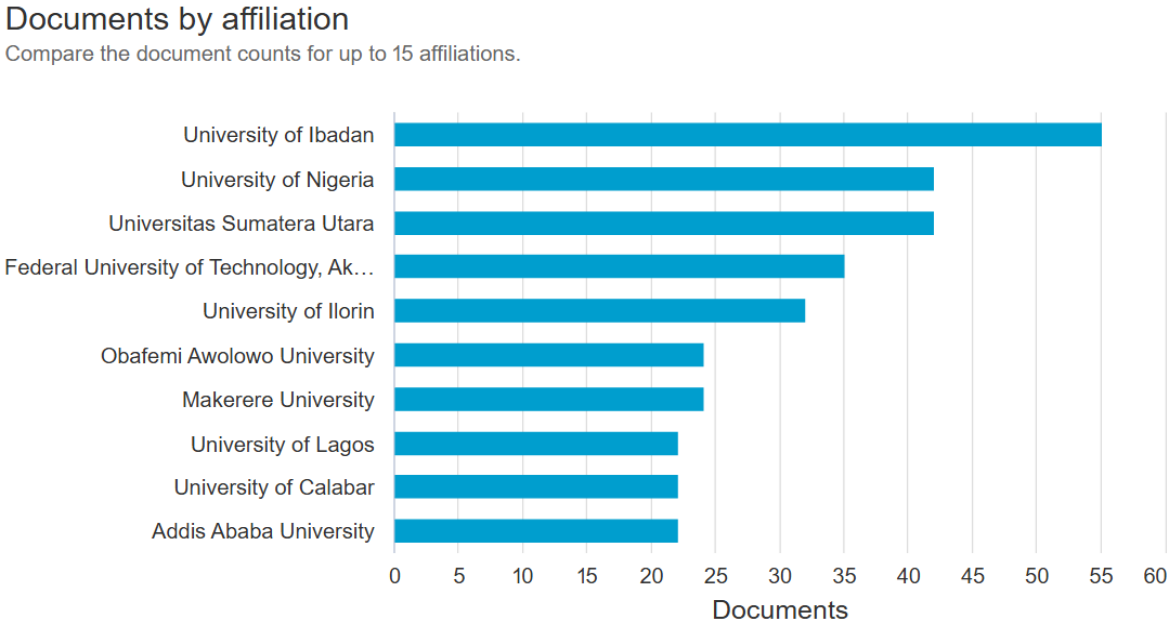

Figure 6. The top ten Institutions in the studied period

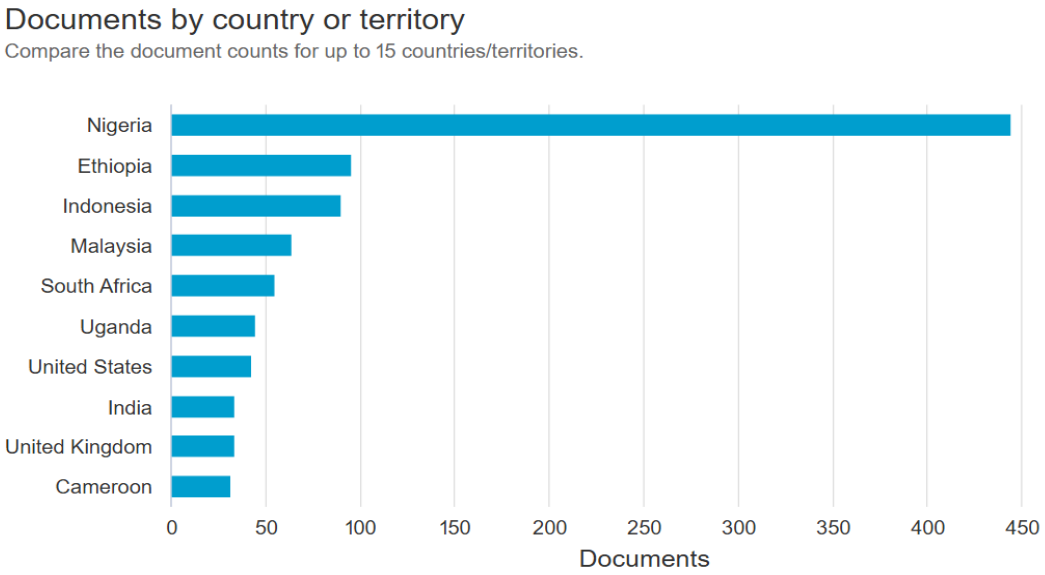

Figure 7. The top ten Countries in the studied period

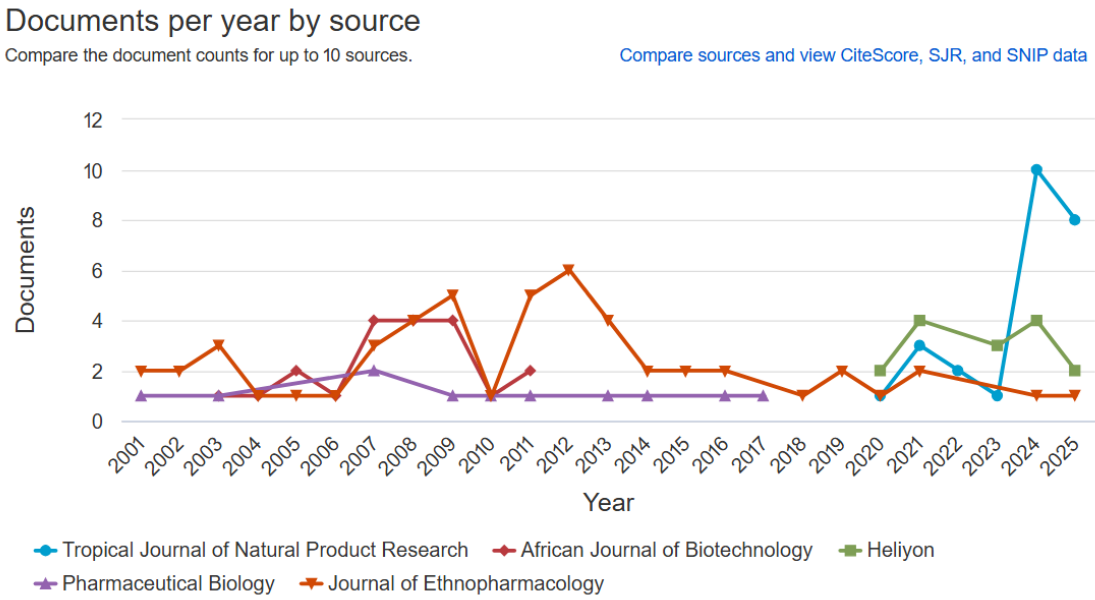

Figure 8. The best selected journals by authors in the studied period

Since its creation by two researchers working in scientometrics (Eck and Waltman, 2010), VOSviewer has received more attention from researchers. VOSviewer is based on data from Web of Science, Scopus, and PubMed, and its outputs are maps that represent networks of keywords, scientific publications and journals, researchers and research organizations, and their countries of origin. VOSviewer considers nodes (circles or frames) within a two-dimensional space, where one scholarly publication constitutes a node that is joined by many edges to a finite number of other nodes through a pattern of citations (Mouloudi *et al.*, 2023; Ullah *et al.*, 2023; Laita *et al.*, 2024; Salghi *et al.*, 2025). **Figure 9** shows the 46 authors with at least five papers. Satria is shown by a green frame and Hasibuan by orange frame, and Harahap is not visualized. Abdurahman indicated by pistachio frame. This result can be linked to time using the overlay visualization. Dark blue frames indicated that articles are published around 2005 and those of yellow for publications recently (**Figure 10**).

Figure 9. Network visualization view of authors

Figure 10. Overlay visualization view of authors

Many medicinal herbs have been shown to have antibacterial (Degu *et al.*, 2021a; Gonfa *et al.*, 2022; Legesse *et al.*, 2022; Asfaw *et al.*, 2023b; Dagne *et al.*, 2023), antifungal (Degu *et al.*, 2020b), antiviral (Tesera et al., 2022), anti-parasitic (Muluye *et al.*, 2021), anti-hypertensive (Fekadu *et al.*, 2017), anti-asthmatic (Sisay *et al.*, 2020), insect repellent properties. According to Olowoyeye *et al.* (2022), they are used as a food source in addition to their medicinal qualities. In Africa, bitter leaf has long been used for both culinary and medicinal purposes. The herb has been used to cure and control a variety of illnesses in African traditional medicine. In African traditional medicine, the plant has several applications and has been used to cure and manage a variety of illnesses. The traditional medicinal

value (Asfaw *et al.*, 2023a), nutritional content (Okolie *et al.*, 2021), isolation of several classes of phytochemicals and compounds, and assessment of their pharmacological actions (Habtamu and Melaku, 2018) have all been the subject of earlier research. This review highlights the current knowledge about the phytochemistry, nutritional applications and biological activities of *Vernonia amygdalina*

3. Proximate Analysis, Vitamins, and Phytochemical Constituents of *V. amygdalina*

Muhammad Ali, *et al.* (2024) examined the proximate analysis and phytochemical screening of *Vernonia Amygdalina* and found that the proximate analysis of the leaf extract showed that, it contains carbohydrates (37%), proteins (28.2%), fats (5.5%), crude fiber (11.6%), moisture content (8.4%) and ash content (9.3%) (**Table 1**). The preliminary phytochemical screening of V. amygdalina leaf extract revealed the presence of alkaloids, terpenoids, flavonoids, steroids, phenols, saponins, and tannins (**Table 2).** Quantitative phytochemical analysis of the extract showed that the flavonoids are the most abundant constituent which is about 12.2%, followed by steroids, alkaloids, and phenols constituting 4.8%, 4.6%, and 3.6% respectively (**Table 2**). **4**

Table 1: Proximate analysis of *Vernonia Amygdalina*

SN	Nutrients	Composition (mg/100g)
1	Carbohydrates	37.00 ± 1.50
2	Proteins	28.20 ± 1.20
3	Fats	5.50 ± 0.23
4	Crude fibre	11.60 ± 0.30
5	Moisture content	8.40 ± 0.04
6	Ash content	9.30 ± 0.23

Table 2: Phytochemical Constituents in Vernonia amygdalina

SN	Phytochemicals	Qualitative	Quantitative (% 100 g)
1	Alkaloids	+	4.60±0.23
2	Flavonoids	+	12.20±1.30
3	Saponins	+	2.70±0.50
4	Steroids	+	4.80±0.25
5	Terpenoids	+	1.70±0.04
6	Phenol	+	3.60±0.20
7	Tannins	+	1.20±0.03

The mineral analysis of the extract indicates the presence of calcium (61 mg/100g), potassium (61 mg/100g), magnesium (85.8 mg/100g), phosphorous (60.5 mg/100g), zinc (9 mg/100g), iron (15.2 mg/100g) and copper (5 mg/100g) (Table 3). From the findings of this study, it is concluded that *V.*

amygdalina leaf has therapeutic potential and can be used in dietary supplements. Some bioactive compounds isolated from *Vernonia amygdalina* are presented in Table 4.

Table 3: Minerals Composition of Vernonia amygdalina

SN	Minerals	Composition (mg/100g)
1	Potassium	61.00
2	Calcium	65.50
3	Magnesium	85.80
4	Phosphorus	60.50
5	Zinc	9.00
6	Iron	15.20
7	Copper	5.30

Table 4: Some Compounds isolated from *Vernonia amygdalina*

SN	Compound	Part of the plant	Reference
1	vernoamyoside A	Leaves	Quasie *et al.* (2016)
2	vernodalol	Roots	Quasie et al. (2016)
3	vernodalinol	Leaves	Habtamu and Melaku (2018)
4	Tricosane	Flour	Habtamu and Melaku (2018)
5	Vernolid	Flour	Habtamu and Melaku (2018)
6	Isorhamnetin	Flour	Djeujo *et al.* (2023)
7	Luteolin	Flour	Djeujo *et al.* (2023)
8	beta-Pinene	Leaves	Djeujo *et al.* (2023)
9	Myrtenal	Leaves	Djeujo *et al.* (2023)
10	Vernoamyoside B	Leaves	Quasie *et al.* (2016)
11	Vernoamyoside C	Leaves	Quasie *et al.* (2016)
12	Vernoamyoside D	Leaves	Quasie *et al.* (2016)
13	Squalene	Leaves	Oladunmoye *et al.* (2019)
14	Phytol	Leaves	Oladunmoye *et al.* (2019)
15	luteolin hexoside	Leaves	Oladunmoye *et al.* (2019)

The green component of *Vernonia amygdalina* also facilitates a significant amount to the nutritional demand of human health and the food security because it possesses sufficient concentrations of

proximate composition (Usunomena and Ngozi, 2016). The presence of the high concentration value of protein, dry matter, crude fiber, ash, minerals (sodium, potassium, calcium, magnesium, zinc, and iron) and ash in the leaves of the plant made them the excellent sources of food (Usunementa and Ngozi, 2016; Olusola and Olaifa, 2018; Olumide *et al.*, 2019). Moreover, other studies have also demonstrated various levels of protein (and essential amino acids), moisture, carbohydrates, ash, and fat in the leaves (Etta *et al.*, 2017; Olumide *et al.*, 2019).

As an appetizer and a digestive tonic, the bitter leaf soup (Onugbo, a well-known Nigerian dish) is made of leaves (Nursuhaili *et al.*, 2019) as an appetizer. Leaves and shoots are considered to be good as goat fodder (Okeke *et al.*, 2015). The growth rate of the birds was also improved numerically with the bitter leaf meal, administered with the drinking water (Nwogwugwu *et al.*, 2015). Honey wine is made out of it in Ethiopia as a honey wine known as Tej (Nursuhaili *et al.*, 2019) and as hops in the production of the tella beer (Shewo and Girma, 2017).

In a study, the proximate analysis of the leaf extract of *Vernonia amygdalina* revealed that the extract contains carbohydrates (37 percent), proteins (28.2 percent), fats (5.5 percent), crude fiber (11.6 percent), moisture content (8.4 percent), and ash content (9.3 percent) (Ali *et al.*, 2020). In another study of fresh green leaves the moisture content (dry matter: 17.02) of the leaf was 83.0 percent, protein content was 1.30 percent and ash content was 0.50 percent. The mineral content was 61.55 mg/g, 8.2 x 10 mg/g, 4.71mg/g, and 1.13mg/g of phosphorus, selenium, iron and zinc respectively based on the fresh weight of the leaves. This observation was in line with the findings of the Okolie *et al*. (2021) study that reported the quantified levels of sodium, magnesium, phosphorus, potassium, iron and zinc to be 180.36 mg/100g, 162.54mg/100g, 27.8 mg/100g, 949.35 mg/100mg, 1.13 mg/100g, and 0.48 mg/100 Again, the B1, B2, B3, and E vitamins analysis provided the values of 0.16 mg/100g, 0.22mg/100g, 0.15mg/100mg, and 0.32mg/100g, respectively (Okolie *et al*., 2021).

Table 5: Vitamins found in Vernonia amygdalina

SN	Vitamins	Composition	Reference
1	Vitamin A	0.11-0.29	Okolie *et al.*, 2021
2	VitaminB1 (thiamin)	0.15-0.16	Okolie *et al.*, 2021
3	Vitamin B2 (riboflavin)	0.19-0.22	Okolie *et al.*, 2021
4	Vitamin B3 (niacin)	0.14-0.15	Okolie *et al.*, 2021
5	Vitamin C (ascorbic acid)	6.43-8.54	Ifesan *et al.*, 2014
6	Vitamin E (tocopherol)	0.12-0.32	Okolie *et al.*, 2021
7	Carotenoids	30.00	Ojimelukwe and Amaechi (2019)
9	Pyridoxine	2.60	Ojimelukwe and Amaechi (2019)

Research on micronutrients, macronutrients and minerals had acquisition of a concentration gap where magnesium, copper and lead in the fresh leaf were observed to be high, and calcium, ash, fiber lipid content and iron in the dried leaf were found to be high (Garba and Oviosa, 2019). The leaf contains also oil (Biru *et al*., 2022), starch (Okeke *et al*., 2015), and iodine (Ojimelukwe and Amaechi, 2019).

Besides, vitamins found in the leaf include vitamin A, vitamin C (ascorbic acid) min E, vitamin B1, vitamin B2, and niacin (Dafam *et al.*, 2020).

4. Pharmacological Activities of *Vernonia amygdalina*

4.1.Antidiarrhoeal activity of *Vernonia amygdalina*

Degu et al. (2020) examined V. amygdalina extracts as antidiarrhoeal agents in the diarrhoea induced by castor oil in mice. *V. amygdalina* extracts were separated by cold maceration using 80% methanol. It was at the highest tested dose (400 mg/kg.bw) *V. amygdalina* that a reduction in the onset of diarrhoea, and reduction in the frequency of stool and faeces weight was also observed. V. (amygdalina) inhibitory effect in this study underlines the antidiarrhoeal effects of amygdalina. Shittu *et al*. (2016) compared antidiarrheal effects of extracts of *V. amygdalina* with Vibrio cholerae induced diarrhoea mice. *V. cholera* was inoculated in experimental rats in a single dose of 100 L. V. amygdalina 250 mg/kg gave anti-inflammatory and anti-secretory effects in tissues in experimental mice. This study highlights the anti-diarrhoeal effects of *V. amygdalina* because of its inhibitory effects.

4.2.Antioxidant activity of *Vernonia amygdalina*

As a 7-day injection, acetaminophen (300 mg/kg) was administered. Oxidative stress was mitigated by the pre-treatment of the *V. amygdalina* extract of 50-100 mg/kg. Using 2, 2-diphenyl-1-picrylhydrazyl, nitric oxide, and hydrogen peroxide radical scavenging of the mice using isolate compounds of methanolic stem-bark extract of *V. amygdalina*, they showed weak anti-oxidative activity (IfedibaluChukwu *et al.*, 2020). V. amygdalina was introduced into the brain tissues, which showed a reduction in the metabolic 2-keto-glutaramic acid and cysteinyl-tyrosine under oxidative stress conditions (Erukainure *et al*., 2018). By up-regulating of the antioxidant enzymes, Adesanoye *et al.* (2015) tested the chemoprotective effect of *V. amygdalina* in 2 - acetylaminofluorene-induced hepatotoxicity rats by using methanolic extracts (250 and 500 mg/kg) of the plant. It was reported that the anti-oxidative effect of *V. amygdalina* flavonoid fractions were on rats subjected to arsenic induced oxidative stress. It was also found that the methanol extract of Vernonia amygdalina had the highest antioxidative activity as opposed to acetone and water extract. Antioxidation Methanol extracts can scavenge 75.9, 93.9, 97.1 and 99.3 percent of the DPPH radical of 0.01, 0.02, 0.05, and 0.1mg/ml of extracts respectively. Scavenging radicals have been extracted between 63.3 and 91.7 by acetone extracts. Findings in this research explained the antioxidative property of *V. amygdalina*. Lolodi and Eriyamremu (2013) also undertook the study of the antioxidative activity of V. *amygdalina* methanolic extract. The antioxidative of the extract was established by subjecting 200 mg/kg of V. amygdalina to rats who had been induced with normal diet 5% of Cycas revoluta (cycads). The findings indicated that the extract administration caused an increment in the levels of MDA and a decrease in SOD levels relative to the control group (Ubaja *et al*., 2021). Omojokun *et al*. (2019) also found that the extract (0-30.51 g/mL) suppressed arginase and the alkaloid of the extract suppressed the Fe2+-induced lipid peroxidation.

4.3.Antimicrobial activity of *Vernonia amygdalina*

According to Dumas *et al*., 2020), *V. amygdalina* extracts had an inhibitory effect against all the tested bacteria such as Staphylococcus aureus, Salmonella enterica and Klebsiella pneumoniae. It was found to have an inhibitory effect on the Toxoplasma gondii, a protozoan parasite causing toxoplasmosis (Degbe *et al.*, 2018). *V. amygdalina* chloroform extract exhibited a high degree of activity against S.

aureus with an inhibition radius of 21 mm. Extracts of isorhamnetin and acetone exhibited an activity level against all the pathogenic bacteria used (Habtamu and Melaku, 2018). Yusoff *et al.* (2020) compared the antifungal effect of the leaf extracts on Botrytis cinereal. B. cinereal was inhibited by water extract of the plant at the concentration of 100-500 mg/mL, crude extracts of hexane, dichloromethane and methanol. Nevertheless, the V. amygdalina extract exhibited the highest efficacies in the case of fungus. Mid severity of infection was observed in extracts of dichloromethane at 400 and 500 mg/mL. Chukwuemeka *et al.* (2018) demonstrated that the extract suppressed the activities of S. aureus and Bacillus subtilis, Salmonella typhi and Pseudomonas aeruginosa in mice. Abay *et al.* (2015) analyzed the acetone extract of *V. amygdalina* to ascertain its antiparasitic activity on the eggs and larvae of Haemonchus contortus. The extract prevented hatching and development of eggs and H. contortus killing them. Omoregie and Pal (2016) assessed the antiplasmodial effect of *V. amygdalina* on Plasmodium berghei caused in male Swiss rats. Findings in vivo revealed that the P. berghei activity was suppressed by the ethanolic extract of the plan. The P. berghei was inhibited by 23.7 percent and 82.3 percent oral administration of the plant at 100 and 1000 mg/kg respectively at day 4.

4.4. Anti-inflammatory activity of *Vernonia amygdalina*

The antiinflammatory properties of *V. amygdalina* have been studied (Nguyen *et al.*, 2020; Liu *et al.*, 2020), the antiinflammatory properties of cynaroside and novel vernonioside V were investigated, which are isolated by using ethanolic extracts of V. amygdalina leaves. The results of their study revealed that tumour necrosis (TNF), interleukin-6 (IL-6), and interleukin-8 (IL-8) inflammatory cytokine secretion was highly inhibited by vernonioside V, in 30 mg/mL. Such findings revealed the anti-inflammatory effects of V. amygdalina isolates. A study by Liu *et al.* (2020) investigated the synthesized zinc oxide nanoparticles of V. amygdalina as anti-inflammatory in mice (Liu *et al.*, 2020). *V. amygdalina* decreased the level of inflammatory response and pro-inflammatory cytokines in the mice. Asante *et al.* (2019) evaluated the extracts of young and old leaves of the extract to determine their capacity to inhibit inflammation, pain, and fever in a carrageenan-induced inflammation model of the rats. The *V. amygdalina* extracts of ethanol were used at the dosage of 50-200 mg/kg, combined with diclofenac (10 mg/kg). The study findings indicated that there was a dose-dependent improvement of the anti-inflammatory properties in both the young and old leaves extract ethanol extracts, and the standard drugs, diclofenac. Onasanjo *et al.* (2017) found out that V. amygdalina have anti-inflammatory properties due to its characteristic in the reduction of inflammatory leukocyte migration. These reports demonstrate the justification of using V. amygdalina extracts in the treatment of inflammation.

4.5.Anticancer activity of *Vernonia amygdalina*

Hasibuan *et al.* (2020) examined the anticancer action of V. amygdalina extracts of leaves on 4T1 breast cancer cells. *V. amygdalina* leaves caused apoptosis, cell accumulation in the G2/M of the cell cycle and suppressed cell intracellular signals of PI3K and mTOR in 4T1 breast cancer cells. Yedjou *et al.* (2018) examined the effects of the V. amygdalina extract as an antiproliferative agent against human cancer cells (A-549) and human prostate cancer (PC-3) cells. Based on their results, both A-549 and PC-3 cells are inhibited as the dose of the extract increases. Yedjou *et al.* (2018) evaluated the anticancer property of the plant using MCF-7 cells. The trypan blue exclusion test was applied in the research to identify the presence and absence of life in the cells, and propidium iodine (PI) assay with the cellometer vision was performed to analyze the presence of the stain in the cells. Flow cytometry

was used to determine cell apoptosis. The findings of this study indicated the decrease in cell viability in a concentration- and time-dependent manner. In the PI test, the number of necrotic cells was gradually increasing. The study by Howard *et al.* (2016) assessed the chemotherapeutic effect of V. amygdalina in the TNBC cells and tumors generated in the stem cell. This experiment showed that there was a significant decrease in the volume of tumor of MDA-MB-468 cells relative to HRAS cells. *V. amygdalina* also augmented cell apoptosis that suppresses tumour growth, and this explains its chemoprotective quality (Howard *et al.*, 2016).

Other articles which also reported the anticancer effects are Hasibuan *et al.* (2020) that examined the anticancer effects of the extracts on 4T1 breast cancer cells. Its effect on WiDr colon cancer cell line was studied on cancer by Bestari *et al.* (2018). The researchers demonstrated that the extract of V. amygdalina that has the lowest IC50 value is ethyl acetate extract with a high cytotoxic potential (Bestari *et al.*, 2017). Chukwuemeka *et al.* (2018) studied the anticancer properties of stem and leaves of the plant in mice, whereas Yedjou *et al.* (2018) studied the extracts in anti-cancer properties in human breast cancer in vitro. Wang *et al.* (2018) explored the cytotoxic effect of isolated steroidal saponins of V. amygdalina, which are vernoniamyosides A-D (1-4), vernoamyoside D (5) and vernonioside B 2 (6). Vernoniamyoside A, B and B2 were demonstrated as cytotoxic to BT-549 cell lines. Vernoniamyoside C, vernoniamyoside D and vernoamyoside D had different levels of cytotoxicity. The results of the experiment can be viewed as a significant foundation of V. amygdalina use as an anti-tumour tool as well as the explanation of its anti-cancer capabilities (Wang *et al.*, 2018). Fachrunisa *et al.* (2019) examined the cytotoxic properties, cell cycle inhibition, and apoptosis induction properties of the *V. amygdalina* ethyl acetate extract on the MCF-7 cancer cells. Ethyl acetate extract 1/2 IC50 and 1/5 IC50 treatment led to cell cycle of 62.58% and 44.72% respectively as opposed to cell control of 72.08%. Such results aid the chemopreventive and anticancer effects of *V. amygdalina* leaves.

4.6. Anti-diabetic activity of *Vernonia amygdalina*

It has also been noted that *V. amygdalina* has anti-diabetic activities (IfedibaluChukwu *et al.*, 2020). Asante *et al.* (2019) compared the anti-diabetic activities of young and old ethanolic leaf extract of the resource plant against streptozotocin (STZ) induced diabetes in mice. Isolated compounds of the methanolic stem-bark extracts of V. amygdalina such as 6,10,14-trimethylheptadecan-15 -olyl-15-O--Dglucopyranosyl-1,5 -olide demonstrated a significant decrease in the blood glucose in STZ induced diabetic rats (IfedibaluChukwu *et al*, 2020). A different research study that was reported by Tekou et *al.* (2018) revealed that 4 weeks of oral administration of V. amygdalina reduced the type 2 diabetes in rats that had been induced with STZ. Erukainure *et al.* (2019) found that the leaves of V. amygdalina infused with hot water possessed an inhibitory effect on -glucosidase, a low intestinal glucose absorption, and an increased muscle glucose uptake. Okon and Umoren (2017) tested the antidiabetic effect of *V. amygdalina* on STZ (65 mg/kg) in type 1 diabetic rats. V. amygdalina and Ocimum gratissimum of 52 and 208mg/kg respectively were orally administered over a period of 28 days. Findings showed that *V. amygdalina* extracts had a hypoglycemic activity. The article by Wu *et al.*, 2018 compared the effects of *V. amygdalina*, as an antidiabetic, with diabetes induced by STZ in mice. Following the 6 weeks of treatment which involved 50, 100, 150mg/kg of *V. amygdalina* extracts showed a decrease of fasting blood glucose and also increased glucose and insulin resistance. Extract also caused an adenosine- 5'monophosphate kinase enzyme up-regulation and phosphoenolpyruvate carboxykinase and glucose-6-phosphatase inhibition. Based on the findings made it can be inferred that V. amygdalina extracts are antidiabetic. inhibition.

4.7.Antimalarial Activity of *Vernonia amygdalina*

Bihonegn *et al.* (2019) compared the potency of an 80% methanol extract and solvent fractions of V. amygdalina leaves in mice infected with P. berghei. The extract inhibited parasitaemia after 4-day test in the following sequence 200mg/kg; 32.47% (+-2.65), 400mg/kg; 35.40% (+-3.14) as well as 600mg/kg; 37.67% (+-2.50). Okpe *et al.* (2016) found an increase in red blood cells and recovery of the packed cell volume in *V. amygdalina* treated categories in Plasmodium infected mice. Plant extracts were administered to hepatic cells that were previously damaged by Plasmodium, and after the treatment, they returned to their normal state. Yeshanew *et al.* (2021) investigated the antimalarial effect of *V. amygdalina* at the infection of 1 x 106 P. berghei parasitemia in mice. Extract administration was commenced 3 hours following 400, 600 and 800 mg/kg inoculation with extract administered orally as a continuous 4days course. There was low parasitemia level in the highest treatment group of 17.94+-0.31 as compared to the negative control group of 46.53+-1.23.

5. Ethno medicinal Applications of *Vernonia amygdalina*

VA is extensively used in classic medical practice across the world. Traditional and herbal medicine practices the use of the plant to treat various disorders, such as intestinal worms, headaches, bloating, malaria, urinary problems, herpes, athletes foot, blood clotting, dyspepsia, menstrual pain, gout, wounds, tonsillitis, evil eye, skin infections, and other human and animal ailments (Jima and Megersa 2018; Girma *et al*., 2022; Mekonnen *et al*., 20). Reviewed ethnobotanical studies indicate that the leaf part is most commonly alleged to various diseases, next is the root, followed by the shoot, stem and seed. These are medicinal plants that are used either singly or as a combination to treat numerous diseases. It has been established that those synergistic interactions of this medicinal part of plants with other parts of plants, local preparations, and animal by products in herbal medicine preparation enhance the efficacy of the remedies. Examples include the leaf, which is mixed with butter and coffee seeds (Beyi, 2018; Kindie, 2023), the leaf of Ruta chalepensis (Melkamu, 2021), the leaf of Eucalyptus globules (Molla, 2019), the leaf of Teclea nobilis, Croton macrostachyus, Justicia schimperiana, and Achyranthes aspera in a combination with leaves and water left ear and left noisetril. Moreover, the root that has been infused with "tella" is used as potency medicine (Chekole *et al.*, 2015).

Conclusion

Vernonia amygdalina is a nutritionally valuable and biologically active plant that plays a significant role in both traditional medicine and dietary practices. A bibliometric analysis is conducted based on Scopus and VOSviewer to show the best researchers and countries concerned by *V. amygdalina*. Its leaves provide essential nutrients, including vitamins, minerals, proteins, dietary fiber, and beneficial phytochemicals, supporting their use as a functional food. Beyond its nutritional importance, extensive scientific evidence demonstrates a wide range of biological activities, such as antimicrobial, antioxidant, antidiabetic, anti-inflammatory, hepatoprotective, and anticancer effects. These activities are largely attributed to the presence of bioactive compounds, particularly sesquiterpene lactones, flavonoids, and phenolic compounds, which act through multiple biochemical pathways. Although existing experimental studies strongly support its therapeutic potential, limitations remain regarding standardization, safety evaluation, and clinical validation. Future research should focus on dose optimization, toxicity assessment, and well-designed clinical studies to fully harness the nutritional and biological benefits of *Vernonia amygdalina* for nutraceutical and pharmaceutical applications.

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Conflict of Interest, this research has been done in the absence of conflicting interests

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