A review of *Momordica* species in Africa (Cucurbitaceae): current knowledge and perspectives for sustainable management

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Review

Abstract

Background: African Indigenous Vegetables (AIVs), particularly species of the genus *Momordica*, are crucial for West African communities, offering nutritious leaves, fruits, and seeds used both as food and traditional medicine. Earlier publications emphasized the significance of the genus *Momordica*, focusing on pharmacology, traditional uses, and biochemical components. However, current knowledge and research on sustainable management policies remain limited. This study presents a comprehensive systematic review of the past three decades, highlighting publication trends and key insights on the conservation ecology and domestication of *Momordica* species in Africa.

Methods: The search was conducted in four academic databases and covered peer-reviewed literature from 1993 to 2023. This systematic review initially identified 1,480 potentially relevant publications. Through a sequential screening process, beginning with evaluating titles, keywords, and abstracts, followed by a full-text assessment based on predefined inclusion criteria, 128 studies (8.6%) were ultimately selected for in-depth analysis.

Results: A systematic analysis of the literature reveals that research on *Momordica* species has been geographically uneven across Africa. The majority of studies have been concentrated in West Africa (n = 89). *Momordica charantia* L. (n = 59), *Momordica balsamina* L. (n = 20), and *Momordica. foetida* Schumach. (n = 18) emerged as the most frequently investigated species. Despite growing interest, the systematic review reveals significant research gaps, especially regarding ecosystem services, genetic diversity, and the conservation status of *Momordica* species across Africa.

Conclusion: Addressing these gaps could facilitate more informed decision-making and promote sustainable strategies for the ongoing domestication of these species in Africa.

Keywords: African Indigenous Vegetables, genus *Momordica*, Ethnobotany, Conservation biology, Domestication.

Background

For millennia, biological resources have supported human societies. In developing countries, African Indigenous Vegetables (AIVs) have emerged as a valuable natural asset, serving as sustainable dietary resources and fulfilling primary healthcare needs through the ages (Michaelle *et al*. 2020; Hounsou-Dindin *et al*. 2022). African Indigenous Vegetables (AIVs) include plant species that are either native to Africa or have been cultivated and adapted to African agroecological conditions over a long period. These plants are characterized using their leaves, fruits, or roots being utilized as vegetables, and are deeply embedded in the dietary habits, customs, and traditions of both rural and urban communities across the continent. (Maundu *et al*. 2009; Gido *et al.* 2017; Kansiime *et al.* 2018). Across various cultural groups worldwide, different AIVs are used, both as sources of nourishment and in the practice of traditional medicine (Andrabi *et al.* 2015). The increasing recognition of their economic, nutritional, and medicinal contributions to people's lives has been the primary driver behind this attention (Welcome & Van Wyk 2019; Akinola *et al*. 2020; Nxusani *et al*. 2023). They offer significant dietary diversity and often play a crucial role in enhancing the intake of essential micronutrients (Mabhaudhi *et al*. 2019; Imathiu, 2021). Typically, their cultivation requires little care (Thiaw *et al*. 2023). Africa hosts an exceptionally diverse flora, notably including the Cucurbitaceae family, which comprises approximately 965 species across 120 genera. Within this family, the genus *Momordica* consists of 59 species, mainly annual and perennial climbers, herbaceous plants, and, more rarely, small shrubs, distributed globally, with 47 species found in Africa and 12 in Australia and Asia (Heneidak & Khalik, 2015). These plants are characterized by their distinct bitter taste, attributed to the presence of phytochemicals such as alkaloids, and are recognized for their extensive medicinal properties. While the precise origin of the *Momordica* genus remains uncertain, most scientific consensus points to eastern Asia, particularly eastern India or southern China, as the center of domestication for *Momordica charantia* (Walters *et al.* 1988; Nagarani *et al.* 2014). In contrast, Ayurvedic texts from the Indo-Aryan culture suggest its emergence in India between 2000 and 200 BCE (Decker-Walters, 1999). The consumption of *Momordica* species as vegetables is primarily concentrated in Africa and Asia, where they hold significant dietary and cultural importance. In West Africa, the genus *Momordica* is represented by seven species (Hutchinson & Dalziel 1954), predominantly composed of climbing plants, often bearing tendrils (modified stems), and widely distributed in tropical and subtropical regions. All have unisexual flowers, and of the African species, 24 are dioecious and 23 monoecious (Schaefer & Renner 2010). The West African species of *Momordica* in the tribe *Momordiceae* are *Momordica balsamina* L., *Momordica multiflora* Hook.f*., Momordica charantia* L*., Momordica cissoides* Planch. ex Benth., *Momordica cabraei* (Cogn.) C. Jeffrey*, Momordica angustisepala* Harms, and *Momordica foetida* Schumach. (Kadiri & Olowokudejo 2016). The versatile nature of the genus *Momordica*, as a source of food and medicine, places these species among the most socio-economically and culturally important AIVs in many communities in Africa (Singh *et al.* 2020). Most of these species are common throughout tropical and subtropical regions, thriving naturally in their wild habitats. They are used to treat various ailments. These include conditions related to diabetes (Venugopal & Dhanasekaran, 2020), cancer (Sur & Ray, 2020), and inflammatory diseases (Dandawate *et al.* 2016). Notably, the leaves, seeds, and fruit exhibit pharmacological properties, including anti-obesity (Michaelle *et al.* 2020), antioxidant (Samadi *et al.* 2022), abortifacient, and antiovulatory effects (Muronga *et al.* 2021; Mbouh *et al*. 2022), as well as potential anti-HIV activity (Dans *et al.* 2007). Furthermore, they demonstrate antifungal (Santos *et al.* 2012), antiulcer (Alam *et al.* 2009), antihyperlipidemic (Chen & Li 2005), antimutagenic (Singh *et al.* 1998), and antiviral (Khanna, 2005) activities. These diverse uses can be attributed to the complex phytochemical composition of these plants (Hassen *et al*. 2022). Numerous studies have shown that these AIVs have elevated concentrations of essential minerals such as zinc, magnesium, potassium, calcium, and iron, which are needed for maintaining good health (Upadhyay, 2015). The consumption of these wild plants in local diets brings numerous benefits (Ogwu, 2023). This suggests that these species could play a pivotal role in devising solutions to combat the rising mortality rates attributed to diseases stemming from malnutrition. However, even though these plants boast a nutrient profile comparable to that of more expensive popular and exotic vegetables, they are faced with various human-induced threats in their natural environments. These challenges arise from factors such as habitat destruction, overexploitation, the expansion of commercial agriculture (particularly cotton and palm oil production), and the effects of climate change. Urbanization is widely acknowledged to be a major factor contributing to the increased incidence of local extinctions and the loss of native species (Angel *et al*. 2011). The loss of biodiversity has emerged as a pressing global issue, impacting the economy, human well-being, and ecological processes on a large scale (Shelef *et al*. 2017). Consequently, the sustainable management of AIVs' biodiversity has become a major concern, as there is still limited knowledge about their sustainable management and domestication in Africa. Scientists have

made significant efforts over time to tackle these challenges and improve our understanding of AIVs' plant biodiversity and their practical applications (Agbo *et al*. 2017). Despite this, there are few comprehensive reviews of existing studies, particularly in terms of the conservation biology and domestication of species or identifying knowledge gaps and proposing future research directions. Aside from the research conducted by Mukaila *et al*. (2023), which involved a bibliographic synthesis of the ethnopharmacological significance of *M. foetida*, there is only one other notable attempt to consolidate the published literature. Kadiri and Olowokudejo (2016) summarized available information on *Momordica*, specifically focusing on foliar epidermis and tendril morphology. However, suppose we are to gain a more thorough understanding. In that case, it is essential to include a characterization of the geographical context, specify the plant's uses, highlight key aspects of traditional knowledge, and assess both genetic and morphological diversity. In addition, it is crucial to identify areas with the potential to increase the abundance of these plant species. Therefore, there is a need for more comprehensive and analytical review studies on the genus to strengthen future research prospects in Africa. Additionally, systematic reviews are essential for identifying research gaps and shaping the direction of future research agendas (Chérif *et al*. 2023). Considering the wealth of published information on the species of *Momordica*, this review was undertaken to assess the current situation in terms of the conservation and domestication of the genus *Momordica* in Africa. Specifically, the review sought to: (i) document the ecological, conservation, and domestication dynamics of the genus *Momordica* based on existing literature, and (ii) identify the critical knowledge gaps and research perspectives for sustainable use and management of members of the genus *Momordica* in Africa.

Materials and Methods

Bibliographic search approach

For this systematic review, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page *et al*. 2021). As illustrated in Figure 1, we have clearly outlined the detailed literature review processes used in this study. Throughout our investigation, we assembled publications spanning 30 years, from 1993 to 2023, to capture the most recent advancements related to the sustainable conservation of *Momordica* plant species in Africa. This choice also reflects the foundational influence of studies from 1993-2003 on the research from 2003-2023. This approach allowed us to focus on emerging trends and gaps in the literature by identifying relevant articles that met our search criteria based on the paper's title, keywords, or abstract, with studies satisfying the specific inclusion and exclusion criteria being included in the review. The inclusion criteria stipulated that only peer-reviewed journal articles (excluding theses, dissertations, and reports) published in English or French, available in full text, and released between 1993 and 2023 were considered, while exclusion criteria removed review studies, abstracts, commentaries, book chapters, conferences, protocols, posters, editorials, inaccessible articles, duplicates, and studies outside the native range of *Momordica*. To ensure relevance and quality, all publications underwent a four-step screening process (Figure 1): (i) evaluating title pertinence, (ii) assessing topic relevance via abstract, (iii) reviewing the full text if needed, and (iv) retaining only those meeting the selection criteria.

Selection and compilation of publications

To find relevant publications in the field, the following four (4) popular databases were searched: ScienceDirect, Google Scholar, PubMed, and African Journals Online. This ensured that we only focused on high-quality, reputable publications. After multiple trial-and-error iterations, the ultimate search query is as follows: ["*Momordica*"] AND ["Ecology OR Ecophysiology"] AND ["Conservation OR "Domestication"] AND ["Traditional Uses" OR "Ecosystem services"] AND ["Africa"]. These keywords underwent systematic application in online search engines, ensuring a judicious identification of pertinent publications. This approach embraced multifaceted dimensions, encapsulating traditional uses (i), distribution ecology (ii), management strategy (iii), threats and conservation status (iv), genetic diversity (v), ecophysiological aspects (vi), morphological diversity (vii), taxonomy and botanical description (viii), ecosystem services (ix), pharmacology (x) and biochemistry (xi). After completing the search process, we combined all retrieved entries from the search engines into a single Excel file; any duplicated entries were removed. In summary, a compilation of details from all identified publications encompassed: the title of the publication, objectives of the study, journal name, country where the study took place, year of publication, publications DOI address, and the specific aspect(s) addressed in the study, according to the categories listed above. Using ArcGIS version 10.2 (ESRI, Redlands, California, USA), we constructed spatial distribution maps of the number of studies conducted in sub-regions and countries, based on the locations where the research was carried out within the native range of *Momordica* species in Africa. In this study, we focus on the genus *Momordica* to ensure a precise, targeted, and scientifically robust analysis of the existing literature. Taxonomic revisions, including those by Jeffrey (2005) on the Cucurbitaceae family, have consolidated the genus under the name *Momordica* based on both morphological and molecular phylogenetic evidence. The use of the name *Momordica* reflects the prevailing consensus among taxonomists and aligns with its updated status in global databases (Schaefer & Renner, 2011). This study also emphasizes the ecological significance

of *Momordica*, which is critical for understanding its role in both ecosystems and human systems. By focusing exclusively on this genus, we avoid the potential confounding effects associated with related genera or historical synonyms, such as *Calpidosicyos* and *Dimorphochlamys*, which, while of historical interest, are beyond the scope of this investigation.

Characteristics of the selected publications

Initially, our search yielded a total of 1480 entries from the four online databases. After a thorough screening process, which involved removing irrelevant publications, duplicates, and those falling outside the scope of *Momordica* native range, approximately 1352 publications were excluded. Ultimately, 128 pertinent publications spanning the past three decades were included in this bibliographic overview (Figure 1). These selected articles are distributed across 49 distinct journals, with contributions from 14 journals sourced from AJOL, 10 from Science Direct, 8 from PubMed, and 17 from Google Scholar. A total of 40 journals remained after nine duplicate entries were eliminated from the records.

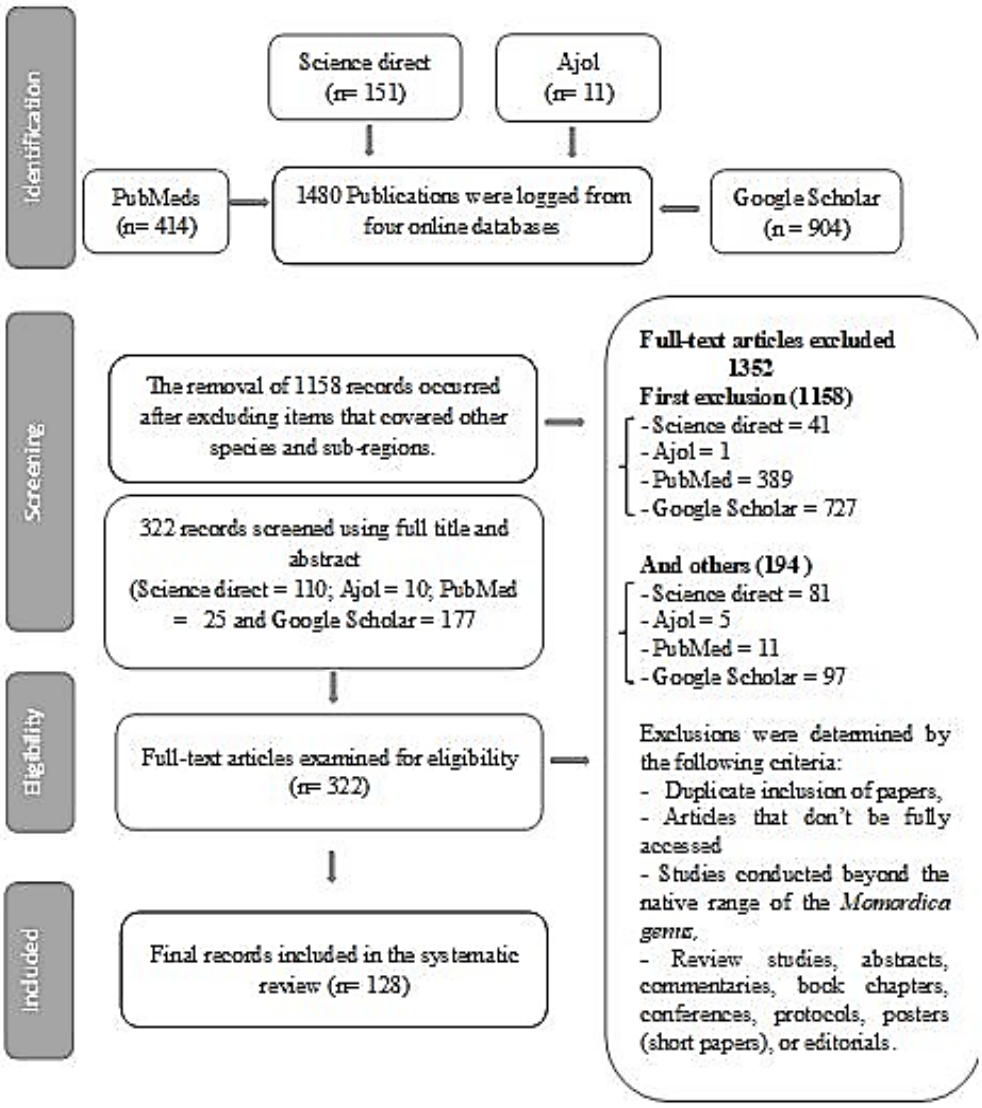

Figure 1. Flow diagram of the literature selection process.

Results

Spatio-temporal trends (1993-2023) in publications of *Momordica* species

The timeline of publications on *Momordica* species reveals a notable surge in recorded publications, marked by some fluctuations over the past three decades (Figure 2). Approximately 74% of the selected papers were published between 2013 and 2023. The period from 1993 to 2003 saw the lowest publication rate at 4%, while the peak, comprising a total of 15 articles, occurred in 2021 and 2022. It's worth noting that no documented publications were identified for the years 1993, 1995, 1996, 1998-2000, and 2002 (Figure 2).

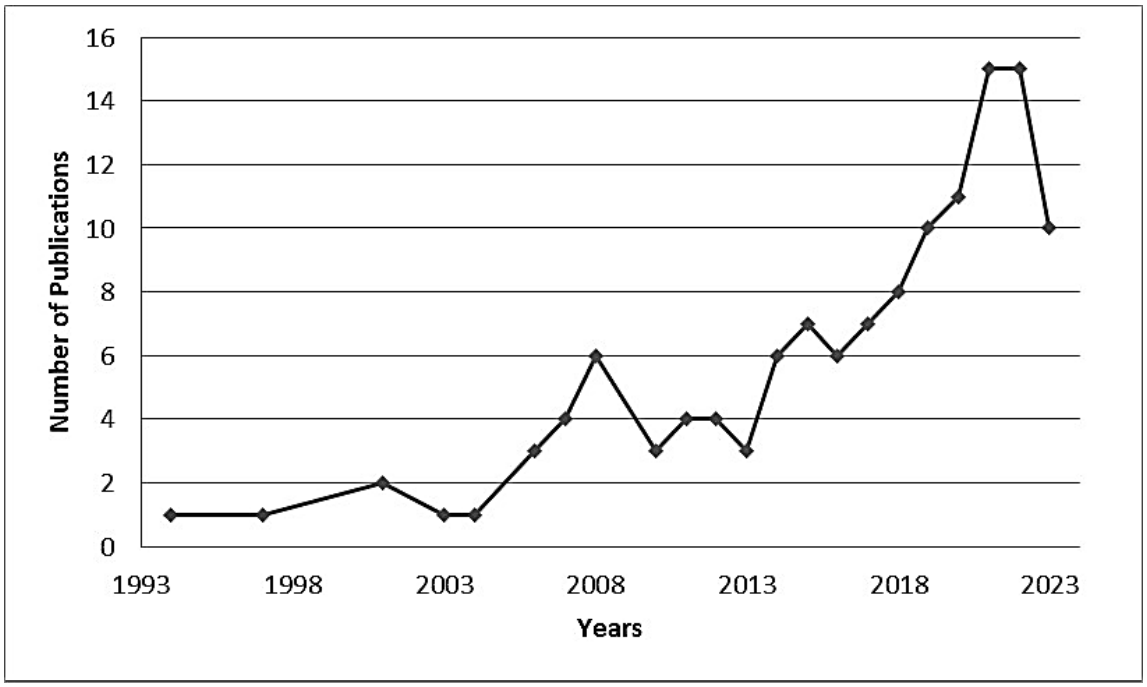

Figure 2. Temporal dynamics of publication trends on selected *Momordica* species in Africa over the past three decades

Of the 128 papers examined, all originated from the five African sub-regions encompassing the native distribution range of the species in Africa. However, most of these publications were derived from West Africa (n = 89), with lesser contributions from other sub-regions such as Central Africa (n = 17), Southern Africa (n = 14), East Africa (n = 6) and North Africa (n = 2) (Figure 3A). At the country level, our analyses revealed that publications on *Momordica* spanned 19 African countries, predominantly including Nigeria (n = 60), Cameroon (n = 14), Benin (n = 14), and South Africa (n = 13) (Figure 3B).

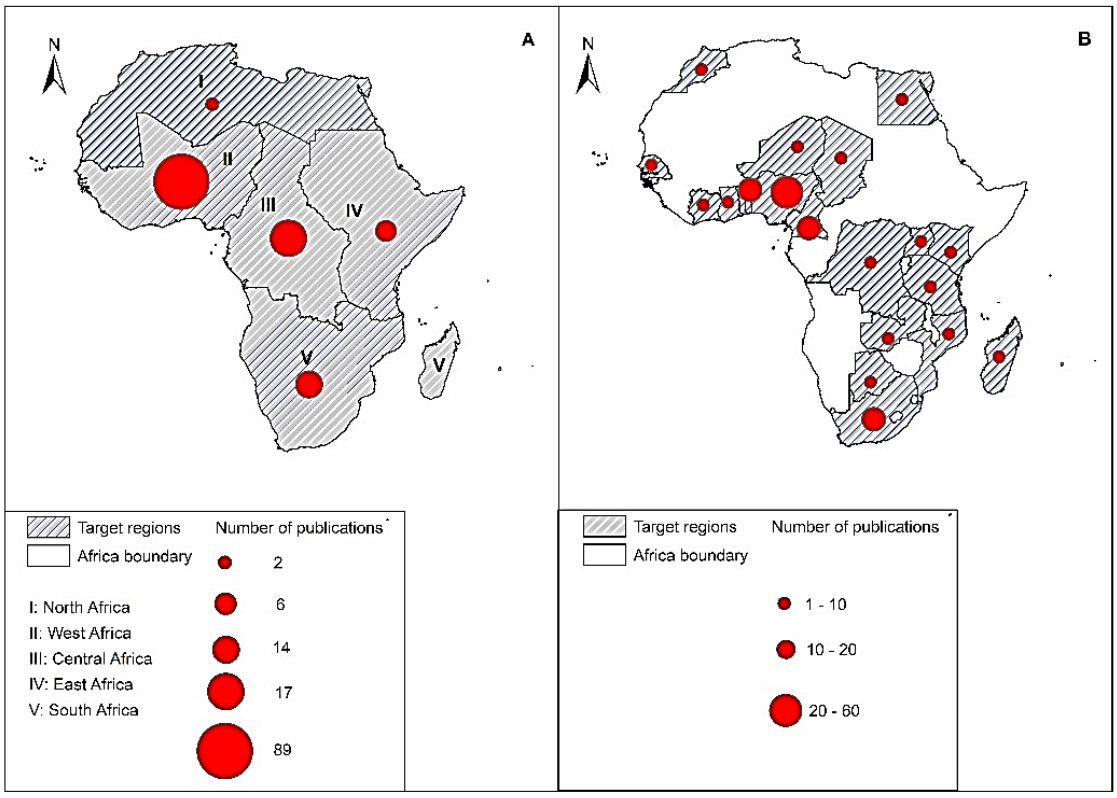

Figure 3. Spatial distribution of the number of publications recorded across countries forming the native distribution range of West African *Mormordica* species in Africa.

Most identified publications covered a spectrum of aspects beyond those related to conservation and domestication (Figure 4), with a focus on pharmacology, traditional uses, and biochemistry. Only a limited number of studies focused on distributional ecology, botanical description, morphological descriptions, ecosystemic services, genetic diversity, ecophysiological aspects, management strategies, and conservation of *Momordica* species (Figure 4).

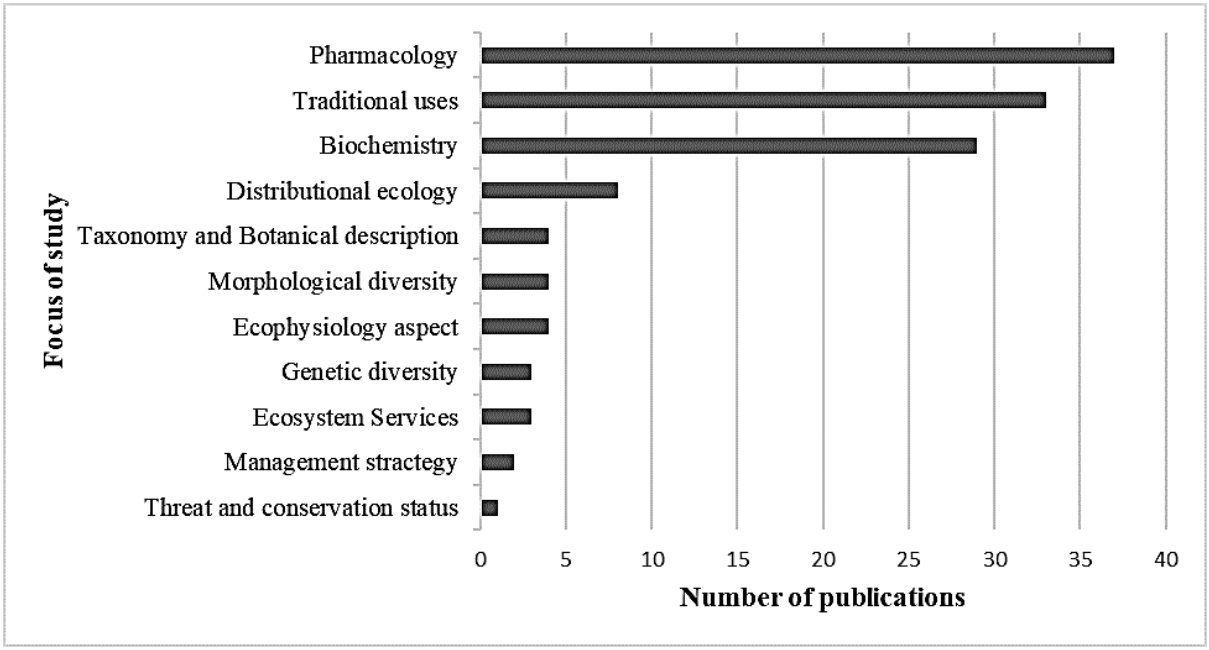

Figure 4. Distribution of the number of publications on *Momordica* species according to different research aspects in Africa.

Geographical distribution of the number of publications recorded on Momordica species

When examining the publication landscape concerning *Momordica* species (Figure 5), there is a significant variation across the five sub-regions. This variation has undergone fluctuations over the past three decades (Figure 6)

The distribution of reported scientific aspects concerning *Momordica* species across geographical regions indicates a predominant focus on Pharmacology (n = 37), traditional uses (n = 33), and biochemistry (n = 29) (Figure 6). Particularly, publications in Central Africa, East Africa, and West Africa predominantly explored aspects unrelated to management and conservation. Furthermore, West Africa (n = 21) stood out for its emphasis on studies related to traditional uses (Figure 6). However, only four instances of publications on this aspect were based on studies in East Africa, South Africa, and Central Africa.

Most investigations regarding the distributional ecology (n = 7), morphological diversity (n = 4), taxonomy and botanical description (n = 4), and ecosystem services (n = 4) of *Momordica* species were concentrated in West Africa. A few studies in West Africa addressed genetic diversity (n = 3), ecophysiological aspects (n = 3), threats and conservation status (n = 2), and management strategy (n = 1).

Temporal variation in the number of publications recorded on Momordica according to the study focus in Africa

Over the past three decades, the number of publications related to *Momordica* species has increased (Figure 7). Most recorded publications (n = 128) are related to pharmacology (n = 37), with a peak (n = 7) observed in 2022. This is followed by traditional uses (n = 33) and biochemistry (n = 29). However, distributional ecology (n = 7) has garnered substantial publications from 1993 to 2023. Especially, the lowest number of publications for *Momordica* species was recorded in the categories of taxonomy and botanical description (n = 4), morphological deversity, ecophysiological aspects (n = 4), genetic diversity (n = 3), ecosystem services (n = 3), management strategy (n = 2), and threat and conservation status (n = 1).

Overall, *M. charantia* (n = 59), *M. balsamina* (n = 20), and *M. foetida* (n = 18) stand out as the most extensively researched species. Minimal research has been conducted on *M. angustisepala* (n = 6) and *M. cissoides* (n = 4) (Figure 8). Notably, no relevant publications were recorded on *M. cabraei* and *M. multiflora* during this period in Africa. Furthermore, studies related to these species do not focus on a single species, but rather they often cover two or more species (Figure 8).

Figure 5. *Momordica* plant species

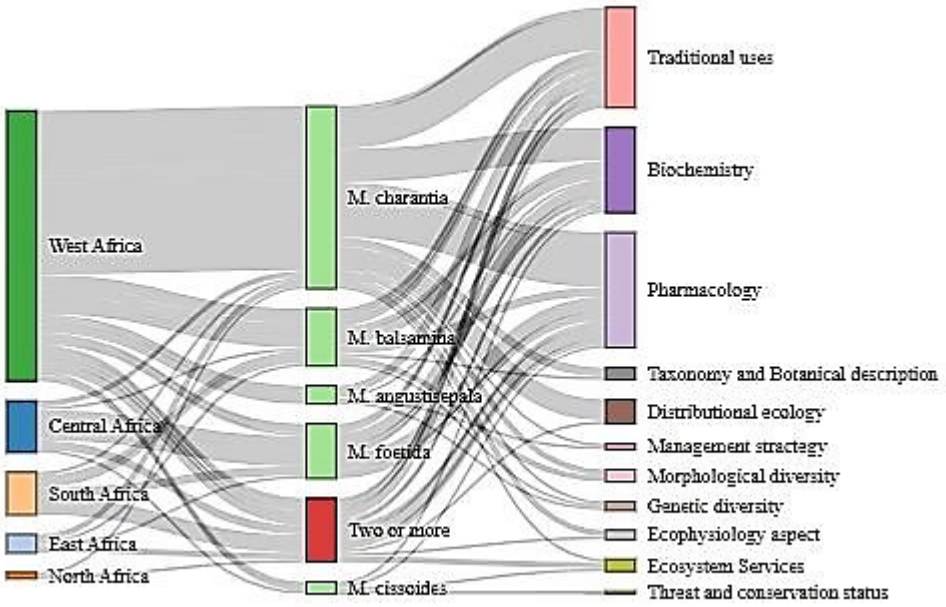

Figure 6. Sankey diagram illustrating the geographical distribution and utilization categories of *Momordica* Species.

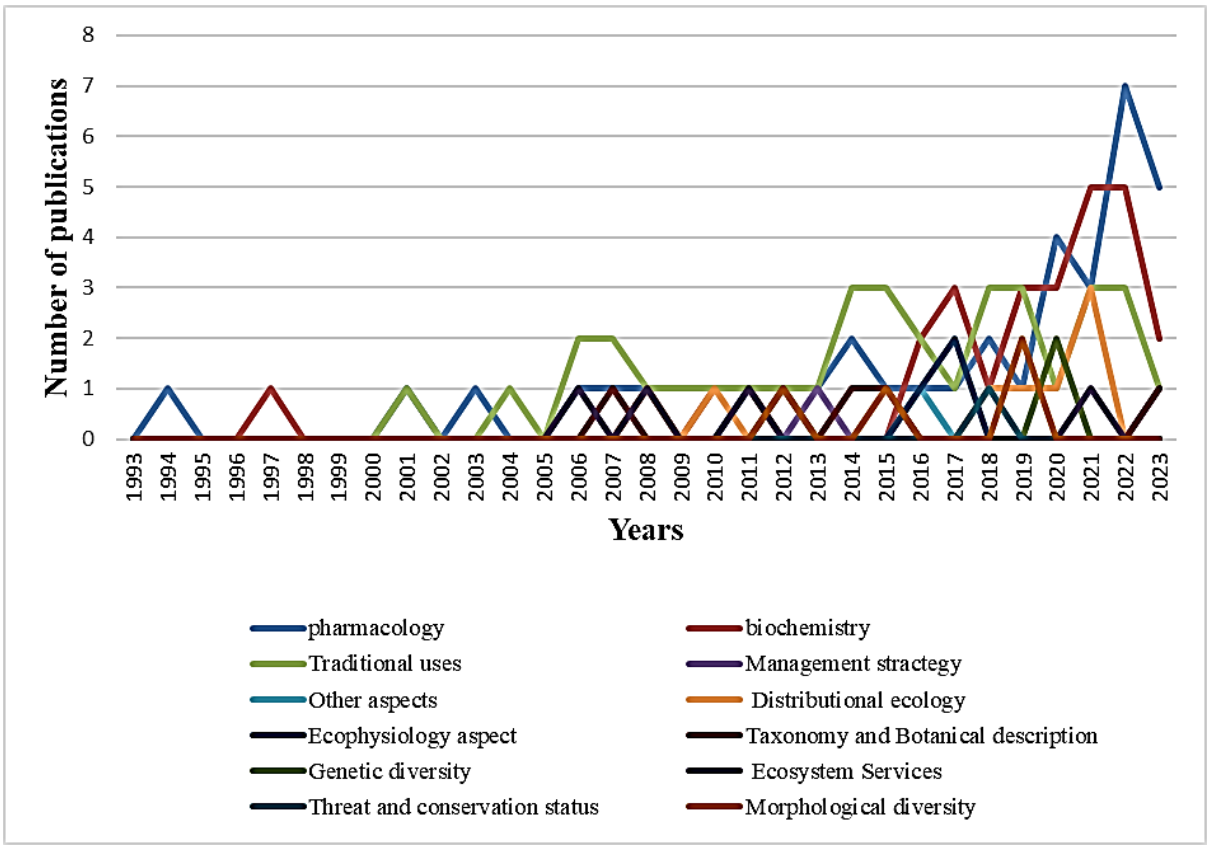

Figure 7. Temporal variation in the publications on *Momordica* species according to the different research aspects addressed in this review.

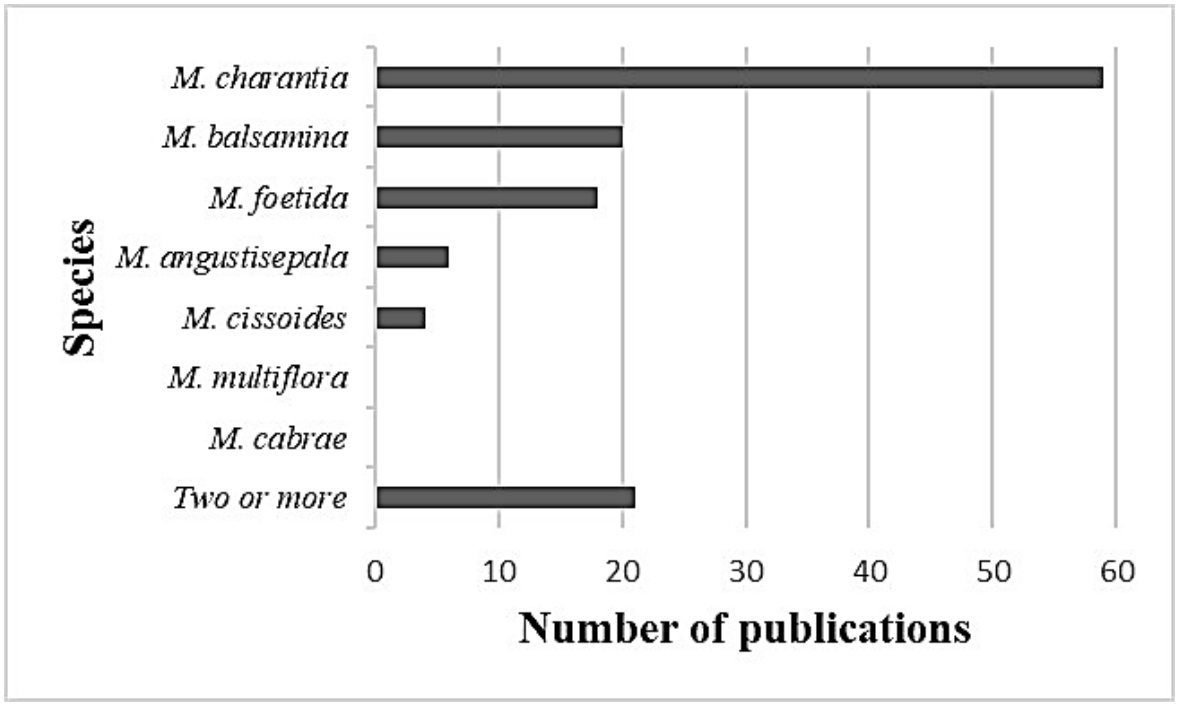

Figure 8 Comparison of the number of studies addressing each of the species

Knowledge of pharmacology, biochemistry, and traditional uses of African Momordica plant species

Table 1 presents the diversity of bioactive compounds and associated pharmacological activities identified across various *Momordica* species. Compounds such as saponins, alkaloids, and flavonoids highlight the genus's therapeutic potential.

These findings underscore the growing interest in *Momordica* species as promising candidates for pharmaceutical research and drug development.

Table 1. Bioactive compounds and pharmacological activities of *Momordica* species.

Species	Main Bioactive Compounds	Pharmacological Activities	References
Momordica charantia L.	Triterpenoids (momordicine, charantin), carotenoids (antheraxanthin, lutein, violaxanthin, α-carotene, β-carotene), phenylpropanoids (caffeic acid, chlorogenic acid, epicatechin, gallic acid, p-coumaric acid, rutin, trans-cinnamic acid)	Anticancer, anti-inflammatory, hypoglycemic	Venugopal and Dhanasekaran, (2020) ; Cuong *et al.* (2021) ; Muronga *et al.* (2021), Samadi *et al.* (2022).
Momordica balsamina L.	Polyphenols, flavonoids, alkaloids, glycosides, steroids, terpenoids, saponins, tannins, lectins	Antioxidant, antibacterial, antidiabetic, antimicrobial, antispasmodic, anti-inflammatory, analgesic, anti-HIV, hypoglycemic, antidiarrheal, hepatoprotective, antimalarial, anticancer, wound healing	Benoit-Vical et al. (2006) ; Bot *et al*. (2007) ; Flyman and Afolayan (2007) ; Muronga *et al*. (2021b) ; Choudhary *et al*. (2022)
Momordica foetida Schumach	Alkaloids, glycosides, steroids, saponins, phenolics, terpenes, flavonoids	Antidiabetic, antilipogenic, antiplasmodial, antimalarial, antioxidant	Acquaviva *et al.* (2013) Heneidak and Khalik, (2015) Aris *et al*. (2018) ; Souda *et al*. (2018), Muronga *et al*. (2021b) ; Kada *et al.* (2022) ; Mukaila *et al.* (2023)
Momordica cissoides Planch. ex Benth	Antioxidant compound, Alkaloids, anticonvulsant	Antioxidant, neuroprotective,	Ojong *et al.* (2016) ; Duraiswamy *et al*. (2023) ; Mukaila *et al.* (2023)
Momordica angustisepala Harms	Tannins, glycosides, flavonoids, saponins, phenolics, terpenoids, steroids, anthraquinones	Abortifacient properties, medicinal uses	Shehu *et al.* (2019)

Table 2 presents a comprehensive overview of the traditional uses, species concerns, and preparation methods for various plants within the genus *Momordica*. It highlights these plants' broad spectrum of roles in African societies, spanning medicinal, nutritional, and ritualistic uses. An essential element involves using *Momordica* species to treat common health conditions like diabetes, hypertension, malaria, and wounds. For instance, *Momordica charantia*, commonly known as bitter melon, is used in many countries to manage diabetes using different preparations, including decoctions, infusions, and consumption of various plant parts (Table 2). Similarly, *Momordica balsamina* is used to address ailments such as hypertension, malaria, and hemorrhoids through decoctions and infusions of different plant parts.

Table 2. Overview of traditional uses of *Momordica* plant species in Africa**.**

Traditional Uses	Species name	Plant part used and method of preparation	Country	Local Name	References
Diabetes	*Momordica charantia* L	The entire plant is infused in traditional alcoholic preparations and taken three times per day.	Benin	Yinsinkin (Fon) Baroman (Waama), Gnisinkin (Mahi), Kpalaari (Anii), Kpalayi (Tchabè), Tchaati (Ifè), Tchatchala (Boko)	(Achigan-Dako *et al*. (2010); Dansi *et al*. (2012); Dossou-Yovo *et al*. (2021); Tchetan *et al*. (2021)
		The entire plant is infused in water and consumed	Niger	-	Adam *et al*. (1972)
		The decoction of the leaf is taken orally	Nigeria	-	Sonibare *et al*., (2009); Ajibesin *et al*. (2012), Mukaila *et al*. (2023)
		Boil 2 g of stem, leaf, flower, and fruit powder per kg of body weight in 2 liters of water. Drink a teaspoon of the herbal tea. Consume 300 ml of the filtrate 3 times daily. High doses are toxic. Pregnant women should avoid this preparation.	Cameroon	Bhghwei (Nso), NjiNgoue (Bamena-Ndé), Nyangala (Douala), Nzoo-zonang (Bakossi), Layel dimel (Fufuldé)	Tsabang *et al*. (2016)
	Momordica foetida Schumach.	The decoction of the plant is taken orally	Cameroon	-	Tsabang *et al*. (2016)
		The decoction of the leaves or whole plant is taken orally.	Ghana	Nyanya or Nyenye in local language *Fante*	Mshana *et al*. (2001); Basch *et al.* (2003); Reyes *et al*. (2006); Thomford *et al*. 20
Hypertension	*Momordica balsamina* L.	Decoction or maceration, of the plant is taken orally.	Benin	Yinsinkin assou (Fon)	Lagnika *et al*. (2016)
		The decoction of the leaves or whole plant is taken orally	Ghana	Nyanya or Nyenye in local language *Fante*	Asase and Oppong-Mensah. (2009)
Malaria	*Momordica balsamina* L.	The decoction of the leaves is taken	Guinea Bissau	-	Denis Zofou *et al*. (2013)
	Momordica charantia L	The stem and the leaf are plunged in water and the decoction is taken orally	Togo	guingbe (plant of the Guin).	Beloin *et al*. (2000)
		Leaf decoction is taken orally	Ivory- Coast	-	N'Guessan *et al*. (2009) Malan *et al*. (2015)
Wounds	*Momordica charantia* L	Fruits: Wound healing. Applied to treat boils and wounds.	Mali	-	Diallo *et al*. (2002)

Hemorrhoids	*Momordica balsamina* L.	Prepare a decoction by boiling 5 g of the plant powder in 500 ml of water. Drink one cup of this decoction twice a day, preferably after meals. Use for two weeks, then take a one-week break before resuming if necessary.	Senegal	Wolof: mbeurbeuf sérère : birbop	Souda *et al*. (2018) Balde *et al*. (2019)
		The whole plant decoctions are taken orally	Nigeria	-	Wickens and Burkill (1986)
Stomach troubles	*Momordica foetida* Schumach.	The decoction of the leaf is taken orally for treatment of stomach troubles	Nigeria	-	(Dans *et al*. 2007; Ede *et al*. 2018; Mohammed *et al*. 2023)
Aphrodisiac	*Momordica balsamina* L.	Infuse 3 grams of root in 300 ml of hot water for 10 minutes. Drink one cup of this infusion daily, preferably in the evening.	Nigeria	-	Wickens & Burkill (1986)
Venomous stings	*Momordica foetida* Schumach.	Crush the leaves and apply the resulting paste after making an incision at the site.	Nigeria	-	Ede *et al*. (2018)
Vermifuge	*Momordica balsamina* L.	Drink one cup of the infusion of the plant daily	Senegal	Wolof: mbeurbeuf sérère: birbop	Food Plant Solution 2018
Insecticides	*Momordica foetida* Schumach.	The root and leaves of the plant are powdered and sprinkled on burning charcoal	Nigeria	-	Dans *et al*. (2007); Ede *et al*. (2018); Mohammed *et al*. (2023).
Eye complaints	*Momordica cissoides* Planch. ex Benth.	Leaf filtrates are used	Benin	Gbofu (Anii), Voyi (Cotafon, Adja)	Achigan-Dako *et al*.(2010)
Traditional ritual	*Momordica charantia* L	The plant remains revered as a potent charm and is commonly worn as a necklace, wristband, or anklet.	Togo	guingbe (plant of the Guin).	Beloin *et al*. (2005)
		The plant, in combination with others, is utilized for purification and spiritual purposes in Vodun ceremonies.	Benin	Yinsinkin in Fon or Tchaati in ife	Dossou-Yovo *et al*. (2021)
To enhance the compressive and tensile strengths of concrete	*Momordica angustisepala* Harms		Nigeria	-	(Burkill & Dalziel 1985; Ajibesin *et al*. 2012)
	Momordica balsamina L.	Dried leaves are mashed and added to food	Ghana	Nyanya or Nyenye in local language *Fante*	Thomford *et al*. (2021)

		Young fruits are boiled or eaten raw as a vegetable. They are also used in stew and pickled. The seeds are steeped in salt water and cooked before eating	Senegal	Wolof: mbeurbeuf sérère: birbop	(Souda *et al*. 2018; Balde *et al*. 2021)
Consumption	*Momordica charantia* L	The seed aril is consumed as a sweet by young children.	Benin	Yinsinkin in Fon	Achigan-Dako *et al*. (2010).
	Momordica cissoides Planch. ex Benth.	Consumption of immature fruit and even leaves	Benin	Gbofu (Anii), Voyi (Cotafon, Adja)	Achigan-Dako *et al*. (2010).

Discussion

Temporal trends of studies on Momordica species

Our systematic investigation revealed that between 1993 and 2023, publications on *Momordica* species were relatively few compared to other genera within the Cucurbitaceae family, such as *Cucumis* and *Citrullus*, indicating a significant gap in research attention to this genus (Lebeda *et al.* 2024). Nevertheless, over the past decade, there have been more articles that address the conservation and domestication of *Momordica* plant species. This may be because of their role in traditional African medicine, particularly in a region with rapid population growth and increasing needs for better living conditions. For instance, among the 128 identified publications spanning three decades, a striking 74% (90) were published between 2013 and 2023, with 15 publications recorded in each of 2021 and 2022, indicating a growing research interest in the genus *Momordica*. This heightened enthusiasm arises from scientific explorations of the medicinal potential of *Momordica* plants, elucidating their bioactive compounds and therapeutic effects, especially in areas such as diabetes management, cancer treatment, and inflammation reduction. This trend is consistent with recent discoveries discussed by Aguoru and Okoli (2012), which identify *Momordica* species as potential sources of both food and medicinal compounds, boasting a rich phytochemical profile and representing an abundant reservoir of natural products. Similarly, Dandawate *et al*. (2016) showed that active constituents present in *Momordica* species confer beneficial effects, including anti-rheumatic, anti-diabetic, and carminative properties.

The lower number of publications on the genus *Momordica* in the first two decades (1993-2013) may be due to a lack of awareness among academics regarding their applications. Indeed, past awareness and acknowledgment of the pharmacological properties and potential medicinal uses of *Momordica* species were limited, resulting in fewer researchers focusing on these plants. Additionally, cultural and ethnobotanical factors played a role, with traditional knowledge about the medicinal properties of *Momordica* species being confined to specific local communities, thus rendering research on these species a lower priority. These findings carry significant implications, potentially paving the way for new avenues of research that prioritize the cultivation, preservation, and sustainable utilization of these species.

Spatial trends in publications on Momordica in Africa

Our findings reveal a significant geographic bias in research efforts, with 69% of studies concentrated in West Africa, indicating a strong regional focus. At the country level, Nigeria dominates the literature, contributing the highest number of publications (n = 60). This disparity may be driven by the region's high biodiversity, distinct ecological conditions, and the socio-cultural significance of these species, as evidenced by their widespread use in rural communities (Aguoru & Okoli, 2012). However, critical knowledge gaps persist in other research domains, including taxonomy, distributional ecology, morphological and genetic diversity, ecosystem services, physiological adaptations, management strategies, and conservation status. Furthermore, research output remains disproportionately low in other African sub-regions: Central Africa (n = 17), Southern Africa (n = 14), East Africa (n = 6), and North Africa (n = 2). This uneven distribution likely reflects the restricted range of these species, which are predominantly endemic to West Africa (Kadiri & Olowokudejo, 2016).

Taxonomy and botanical description

Momordica is classified under the Joliffia tribe within the Cucurbitaceae family, specifically within the Cucurbitoidea subfamily (Jeffrey, 1980). In the field, *Momordica* species found in West Africa can be identified by distinct characteristics such as robust tendrils typically found outside the leaf axils, producing vines with separate male and female flowers, often in shades of yellow or white, and yielding lower, tough-skinned berries (Aguoru & Okoli, 2008). As indicated by Kadiri and Olowokudejo (2016), all species except for *M. balsamina* L. exhibit hypostomatic leaves, while the latter is characterized by amphistomatic leaves. The species *M. multiflora* Hook.f. is distinguished by its smooth leaves, whereas the leaves of other species are typically pubescent. Flowers in the genus are usually solitary, of varying sizes and distinctions of petals, with colors ranging from yellow to white. Regarding the fruit, upon reaching maturity, they show a diverse range of colors and exhibit characteristics typical of the Cucurbitaceae family, often adopting an oblong or elongated shape (Flores-León *et al*. 2022).

Ecology and geographical distribution

Species of this genus are natively distributed across tropical and subtropical regions worldwide, including West Africa, East and Southern Africa, Asia, India, South America, and Australia. These plants are widely utilized as dietary vegetables and play a significant role in traditional medicinal systems within these regions (Khazir *et al.* 2014; Schaefer & Renner, 2011). The adaptability of African *Momordica* species to specific climatic conditions highlights the genus's remarkable ecological diversity and resilience (Pelling *et al*. 2018). For instance, research by Schaefer and Renner (2010) indicates that *Momordica*

species flourish in diverse ecosystems, including rainforests, deciduous forests, bushlands, savannas, and grasslands. They show versatile ecological traits, with climbing or trailing growth habits and tendrils that assist in vertical ascent. Like most plant species in semi-arid environments, they thrive in areas characterized by well-drained soils and ample sunlight (Smith *et al*. 2005). Members of the genus *Momordica* engage in vital ecological interactions, serving as potential food sources for local fauna and participating in symbiotic relationships with pollinators for reproduction (Muronga *et al*. 2021). Their presence in warmer regions with well-drained soils and ample sunlight aligns with their physiological needs and growth requirements. However, in North Africa, the lower prevalence of *Momordica* species may be attributed to historical and cultural factors influencing plant introduction and experimentation. Unlike East and Southern Africa, where diverse ecosystems and climatic conditions have facilitated the natural proliferation of *Momordica* species (Pelling *et al.* 2018), North Africa's predominantly arid and semi-arid climate presents more challenges for the naturalization of these plants, although localized, more moist areas may support their presence. The climatic conditions in North Africa, characterized by extreme temperatures and limited water availability, are less conducive to the growth of *Momordica* species, which typically thrive in well-drained soils with ample sunlight and moderate moisture (Smith *et al*. 2005; Olarewaju *et al.* 2023). Furthermore, the historical pathways of plant introduction and cultural practices in North Africa may have limited the experimentation and incorporation of *Momordica* species into local medicinal systems. According to the versatility hypothesis, regions where introduced plants have been widely accepted and integrated into traditional medicine often have a history of experimentation with these plants. In North Africa, the primary focus of traditional medicine has been on indigenous flora that is well-adapted to the local environment. This focus has potentially restricted the scope for incorporating non-native species like *Momordica*, which are more prevalent in regions with different ecological conditions. In contrast, regions such as Central Africa, West Africa, and Southern Africa have experienced greater botanical diversity and plant exchange due to trade routes and cultural exchanges.

Pharmacology and biochemistry

The genus *Momordica* holds particular interest in ethnopharmacology due to the diversity and richness of its bioactive compounds. Species such as *M. charantia* and *M. balsamina* exhibit remarkable versatility in terms of pharmacological activities, attributed to the complexity and diversity of their secondary metabolites. These plants, used in traditional medicinal practices across cultures, prove to be a valuable source of potential new drugs. The growing interest in *Momordica* in medical research is partly due to their natural compounds that may offer alternatives or complements to synthetic treatments. For example, triterpenoids from *M. charantia* have demonstrated significant anticancer potential in various studies (Chen *et al*. 2016; Liu *et al*. 2022), while polyphenols from *M. balsamina* exhibit a wide range of therapeutic benefits, including antioxidant and antimicrobial properties (Afolayan & Sunmonu, 2010). *Momordica* plant species represent a treasure trove of bioactive compounds with multiple pharmacological applications. Continued research in this field could lead to significant advances in the treatment of chronic and infectious diseases, thereby reinforcing the importance of plant biodiversity in drug discovery.

Traditional uses

Traditional medicine plays a prominent role in primary healthcare globally. The genus *Momordica* is frequently cited among the plant families surveyed for traditional medicinal use across diverse regions worldwide, including Africa, India, China, and Australia (Schaefer & Renner, 2011; Chomicki *et al*. 2020). The traditional uses of *Momordica* species have long served as a foundation for understanding their pharmacological and biochemical properties, suggesting a potential link between traditional knowledge and modern scientific findings. This connection can be viewed through the lens of ethnopharmacology, which explores the relationship between traditional medicinal practices and their underlying biological mechanisms. Ethnopharmacological studies propose that the therapeutic efficacy of medicinal plants, such as those within the genus *Momordica*, is attributed to their rich phytochemical composition, consisting of various bioactive compounds. Traditional uses of medicinal plants are often rooted in empirical observations of their effects on human health (Thomford *et al.* 2021, Kada *et al.* 2022). In the case of *M. charantia*, for example, traditional healers have long used the plant for its purported antidiabetic properties. This traditional knowledge is supported by modern scientific research, which has identified bioactive compounds such as triterpenoids and carotenoids that exhibit hypoglycemic effects through mechanisms such as insulin-like activity and inhibition of carbohydrate metabolism enzymes (Mukaila *et al*. 2023). Thus, the traditional use of *M. charantia* in managing diabetes may be supported by its pharmacological actions on glucose metabolism. Recent studies have identified several bioactive compounds in *Momordica* species that contribute to their reproductive effects. These include triterpenoids and saponins that disrupt steroidogenesis and interfere with progesterone and estrogen production, which are essential for maintaining pregnancy. For example, a study by Mohammadmoradi *et al.* (2020) showed that *Momordica charantia* extract significantly reduced progesterone levels in rats, supporting its traditional use as an antiovulatory agent, while Kumar *et al*. (2020) highlighted the role of *Momordica* saponins in inducing uterine contractions, further validating its

abortifacient properties. Likewise, the historical application of *M. balsamina* for treating infections and enhancing wound recovery may stem from its antimicrobial and wound-healing attributes. Specifically, bioactive elements within *M. balsamina*, such as polyphenols and alkaloids, exhibit antibacterial effects and foster tissue regeneration. These findings lend credence to its longstanding role in folk medicine. Furthermore, the traditional use of *M. foetida* for malaria and diabetes management may be underpinned by its pharmacological effects on malarial parasites and glucose metabolism respectively. Phytochemical analyses have identified alkaloids and flavonoids in *M. foetida*; these compounds show antimalarial and antidiabetic activities, respectively (Reyes-Sierra & Coello 2006). These findings provide a plausible explanation for the plant's traditional efficacy in treating these ailments. Moreover, the antioxidant properties traditionally ascribed to *M. cissoides* may be supported by its phytochemical composition, which includes phenolics and flavonoids with known antioxidant activity. In Benin, traditional medicine is deeply rooted in cultural practices, with knowledge being transmitted through gender roles. Male elders typically manage the spiritual and ancestral aspects of healing, while female elders focus on herbal medicine, particularly related to women's health and fertility, ensuring a holistic approach that combines biological and spiritual elements. Certain families, especially those with a long tradition of herbalism, have specialized knowledge of medicinal plants such as *Momordica*, which is passed down orally through generations, creating a rich repository of ethnobotanical wisdom. However, urbanization and cultural erosion threaten the preservation of valuable traditional knowledge on *Momordica* species, particularly their medicinal uses in reproductive health. Ethnobotanical studies in Benin (Dossou-Yovo *et al.* 2021) highlight their cultural significance, reinforcing the need for scientific validation and conservation of this ethnomedical heritage. Such cultural specificity in plant use aligns with broader ethnobotanical patterns (Gaoue *et al*. 2017), where certain species gain prominence due to localized ecological and sociocultural factors.

Morphological and genetic diversity

Until now, few studies have addressed the morphology and genetic diversity of the genus *Momordica* in Africa. A genetic sequencing study conducted by Waako *et al*. (2005) and Smith *et al*. (2005) analyzed genetic variations among several *Momordica* species, including *M. charantia*, *M. foetida, and M. balsamina*. The results revealed high levels of genetic diversity, with distinct DNA sequences showing adaptive variations specific to each species. Additionally, *M. charantia* germplasm showed a very large morphological variation concerning fruit shape, size, and color (Singh *et al*. 1998). Thus, Achigan-Dako (2008) points out that ecological conditions affect the leaf size of *M. charantia,* as well as the size of male and female bracts and peduncle lengths of that species. Using molecular markers such as AFLPs has been a common approach to assessing genetic diversity. Cui *et al*. (2018) research applied these markers to study *Momordica* populations, demonstrating specific patterns of genetic polymorphism among different regions, emphasizing the genetic complexity of these species. Furthermore, a more specific study conducted by Akinsiku *et al*. (2019) examined genetic diversity at infraspecific levels within certain *Momordica* subspecies. The genus *Momordica* displays a fascinating range of reproductive systems, including dioecy and monoecy, that have evolved in response to different ecological and evolutionary pressures. Schaefer and Renner (2010) provide an insightful perspective on the transitions from dioecy to monoecy in *Momordica*, linking these shifts to ecological factors such as pollinator availability, habitat fragmentation, and the selective pressures associated with domestication. The widespread dioecy observed in wild species such as *Momordica charantia* and *Momordica balsamina* in West Africa ensures outcrossing, which promotes genetic diversity and the long-term viability of populations. However, as Schaefer and Renner (2010) point out, such a reproductive system may be disadvantageous in environments where pollinators are scarce or populations are fragmented, limiting reproductive success. This is consistent with the findings of other researchers, such as Pijl (1982), who explored the role of pollinators in shaping plant reproductive strategies. In contrast, the shift toward monoecy and hermaphroditism in cultivated *Momordica charantia* is a notable example of how domestication influences reproductive systems. The monoecious traits, including self-pollination, not only improve reproductive security but also reduce dependence on external pollinators, ensuring stable fruit and seed production in agricultural settings. As discussed by Duvick (2005) about crop domestication, such traits have been selected for their advantages in controlled environments, where ensuring high and reliable yields is critical. This evolution from dioecy to monoecy also parallels broader trends observed in plant domestication, where traits favoring high reproductive efficiency, ease of cultivation, and better yield become the focus. Similarly, authors such as Harlan (1975) have noted that domestication tends to favor traits that reduce dependence on external environmental factors, thereby increasing the stability and predictability of crop production. The results of this research highlighted significant genetic differences, even at finer taxonomic scales. These scientific references collectively lead to the conclusion that the genus *Momordica* exhibits substantial genetic diversity, underscoring the significance of this research for the conservation and sustainable use of these species. These genetic insights provide crucial perspectives for guiding the selection and preservation of *Momordica* species in the context of plant biodiversity. Nevertheless, genetic and morphological aspects are understudied, and we believe future studies will address these gaps in Africa. Unequal traditional knowledge, disparate valuation, and ethnic differentiation are

significant contributors to genetic diversity, shaping variations in morphology, chemical composition, taste, anatomy, and other characteristics of *Momordica* species (Popoola & Obembe 2013; Chomicki *et al.* 2020; Smith & Jones 2021).

Ecophysiology

The ecophysiology of *Momordica* plant species in Africa displays a captivating diversity, encompassing a spectrum of adaptive strategies. Kadiri & Olowokudejo, (2016) have noted that *Momordica* species demonstrate varied physiological responses to climatic and environmental variations in the region. Another study by Mwangi *et al.* (2018) highlighted that *Momordica* species, such as *M. charantia*, *M. foetida*, and *M. balsamina*, exhibit remarkable adaptations to the African ecosystem, including efficient water use, specialized photosynthetic pathways, and nutrient uptake mechanisms that enable them to thrive in diverse environmental conditions with minimal rainfall and varying soil pH levels.

While some species may exhibit drought tolerance, others employ efficient resource utilization strategies. It has further been reported that there are both wild and cultivated forms of the genus across tropical regions globally (Kadiri & Olowokudejo 2016). They are primarily cultivated in specific geographical pockets within various agrogeographical regions, mainly by tribal and economically disadvantaged farming communities (Behera *et al*. 2011). These locations are a potential source of wild or "escaped" variants that may be valuable resources for breeding bitter gourd varieties with desirable edible and qualitative traits, as well as varieties with greater tolerance of abiotic stresses and resistance to different insect pests (Flores-León *et al*. 2022). A better understanding of the ecophysiological diversity of *Momordica* plants in Africa is vital for well-informed conservation and developing sustainable management practices. Thus, ongoing and future research efforts in this field are imperative for the sustainable management and utilization of these plant species.

Proposed conservation strategy

Momordica species play a crucial role in providing diverse ecosystem services, particularly in the fields of traditional medicine, nutrition, and biodiversity support (Fajinmi *et al*. 2022). However, ensuring the sustainable use of these services requires meticulous management to prevent overexploitation and habitat degradation. The diminishing diversity of traditional vegetables in Africa is becoming a growing concern, influenced by various factors. Widespread threats, such as increasing land-use change and habitat destruction due to population growth, agricultural expansion (including the cultivation of oil palm, cotton, and other export-oriented crops), plantation silviculture, urbanization, and infrastructure development, are prevalent across many African countries. These activities, particularly the extensive cultivation of cash crops such as oil palm and cotton for export, pose significant threats to natural ecosystems and biodiversity, including species within the *Momordica* genus. The observed devastation of native forests in southern Benin, where only fragmented remnants persist along riverbeds, underscores a profound ecological transition driven by the expansion of agricultural activities focused on cash crops, including oil palm (*Elaeis guineensis* Jacq.), soybean (*Glycine max* L.), and cotton (*Gossypium hirsutum* L.). This aligns with the findings of Natta *et al*. (2002), who documented the severe impacts of agricultural encroachment on Benin's ecosystems. They highlighted the fragmentation of riparian forests due to cotton and food crop production, leading to biodiversity loss and disrupted ecosystem services such as water regulation and soil fertility. Similarly, Adéoti *et al.* (2009) revealed that the conversion of native forests to oil palm monocultures has significantly reduced species diversity and altered soil composition. Furthermore, specific threats emerge from the intensive exploitation of certain plant species used as vegetables, including well-known taxa like the bitter melon *M. charantia* (Santos *et al*. 2012). Given the significant medicinal and nutritional value of *M. charantia*, there is an urgent need for sustainable conservation strategies, as emphasized by Dossou-Yovo *et al*. (2021). For instance, the rare status of *M. balsamina* in the wild, attributed to its restricted distribution, indiscriminate overexploitation, low seed set, viability, habitat specificity, and poor seed germination rates, underscores the necessity for improved cultivation practices (Thakur *et al*. 2009). To address these challenges and strike a balance between human use and the preservation of these valuable plant species and their natural habitats, conservation efforts, and community involvement are crucial. In Benin, Gbedomon *et al*. (2017) and Idohou *et al*. (2014) highlighted the contribution of the management of home gardens to biodiversity conservation.

Ecosystem services

Members of the genus *Momordica* offer a remarkable diversity of ecosystem services. Their fruits, such as those of *M. charantia*, *M. balsamina,* and *M. cissoides* contribute to the food supply, providing nutritious compounds (Achigan-Dako *et al*. 2010; Fajinmi *et al*. 2022). Some species exhibit antimicrobial properties, thereby supporting biological regulation. As components of biodiversity, these plants provide habitats and promote species diversity. The traditional cultural and medicinal uses reported in several countries add a cultural dimension to ecosystem services. Overall, understanding this diversity of ecosystem services provided by the genus *Momordica* is crucial for promoting their sustainable management, offering benefits ranging from food security to conservation of biodiversity and support of human health.

Conclusion

The genus *Momordica* has played diverse roles in the lives of African people, providing accessible medicinal species and serving as a source of food and nutrition. However, the species is now threatened in its native habitats due to increasing anthropogenic pressures. Conservation efforts for the genus *Momordica* are still in their early stages. However, conserving the species will be challenging in the absence of adequate research and other information. The current systematic review has underscored critical knowledge gaps in terms of the taxonomy, botanical description, diversity, ecology and distribution, morphological diversity, genetic diversity, ecosystem services, eco-physiological aspects, management strategy, threats, and conservation status in Africa. The distribution of publications on the *Momordica* genus varies significantly across Africa. Notably, in West Africa, there is comprehensive documentation of *Momordica*, encompassing various research aspects.

Nevertheless, concerning the sustainable management of the genus *Momordica*, numerous additional studies should be undertaken to elucidate conservation and domestication measures for these species.

More specifically:

- An investigation of the ecophysiological performance of *Momordica* is essential for understanding the ability of these species to survive and thrive in extreme and changing climatic and environmental conditions in Africa. It is important to examine their physiological responses to both biotic and abiotic factors to identify the most suitable cultivars for domestication. Emphasizing this research will aid in identifying resilient cultivars that are well-adapted for sustainable agricultural practices in challenging environments.
- There is relatively little research focused on enhancing genetic resources through the selection of wild morphotypes within the genus *Momordica*. We must establish initiatives designed to select and improve these genetic resources. Additionally, support should be directed toward breeding programs that focus on characterizing and using germplasm that is known to have desirable traits for domestication efforts, fostering collaboration between researchers and local farmers in the process.
- Previous studies have shown there is relatively little published research on the morphological variability of the species of this genus in Africa. We must characterize the range of ecophenotypic of the genus *Momordica* within its geographical range, as this should offer crucial insight into the relationship between such variation and environmental factors.
- At present there is only limited published research on the distributional ecology of species within the genus *Momordica* and the responses of these species to various disturbances. This knowledge gap hampers our understanding of the life history of these species, which is critical for developing effective conservation strategies. Therefore, to better inform conservation planning, we must prioritize studies that investigate these ecological dynamics.
- There is little data published on the economic impact of the genus *Momordica* on rural household incomes in Africa. It is essential to conduct surveys to assess the contribution of *Momordica* species to household food security and income, especially compared to other local sources. This will provide valuable insights into the economic significance of these species and inform policy decisions aimed at enhancing rural livelihoods.
- We propose that future research efforts should be focused on predicting suitable habitats for the cultivation and conservation of *Momordica* species, considering the increasing anthropogenic pressures and potential effects of climate change in Africa. This research will be vital to the development of strategies that ensure sustainable management and preservation of these important plant species in the face of environmental challenges.

Declarations

List of abbreviations: M.: *Momordica*; AIVs: African Indigenous Vegetables, n: number of publications; BCE: Before Common Era.

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Conceptualization. JSHH: Writing - Original Draft, Methodology. HGW: Methodology, Conceptualization. GH: Writing - review & editing, Conceptualization. AEA: Validation, Methodology, Supervision.

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