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A COMPLETE REVIEW OF MOMORDICA CHARANTIA: A BITTER PLANT TRADITIONALLY USED IN SENEGAL

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ABSTRACT
This study highlighted the ethnobotanical knowledge, biological properties and economic importance of *M. charantia* in Senegal. It is a climbing plant cultivated in tropical and subtropical regions, belonging to the Cucurbitaceae family. *M. charantia* has provided many remedies for various diseases from ancient times to the present. It has been used in various traditional Asian medicines for the treatment of cholera, bronchitis, anemia, blood diseases, ulcers, diarrhea, dysentery, gonorrhea, rheumatism, gout, worms, colic, diseases of the liver and spleen, cancer and diabetes, etc. The main constituents are triterpene, protein, steroid, alkaloid, inorganic, lipid and phenolic compounds, which are responsible for biological effects and pharmacological activities, including antidiabetic, anticancer and antitumor, antimicrobial, antiviral, antihelmintic, antimalarial, antiulcer and immunomodulatory . Combination of its Ayuervedic properties namely Gunna, Rasa and Virya (Dry, Pungent, Mild, Bitter and Pungent) makes it the true wonder of nature. In this article, general description, traditional uses and medicinal properties of *M. charantia* have been reviewed.

KEYWORDS: *Momordica charantia* Linn, general description, medicinal properties.

1. INTRODUCTION
Man has always relied on nature to provide his needs for food, medicine and shelter. In this sense, plants are used as medicines and food sources throughout the world. According to the World Health Organization (WHO), 80% of the population in developing countries rely on traditional medicine, relying mainly on plant extracts to meet their primary health care needs.[1] Indeed, populations benefit from a great variability of useful and essential plant resources in terms of medicine, food and timber.[2] The same is true for Momordica charantia, because of the therapeutic properties of the leaves and stems reported in Benin by Johnson et al, (2017).[3] It is a lianescent plant of the Cucurbitaceae family which has approximately 800 tropical and subtropical species.[3] It is subdivided into two subfamilies, Zanonidoids and Cucurbitoids, with squash coming from the latter.[2,4] Indeed, within the Cucurbitaceae family, the Momordica genus has been identified in tropical regions and includes more than 600 species, very useful for their nutritional and medicinal properties.[5] Thus, Momordica charantia, M. balsamina and Momordica cochinchinensis are among them, but the most widespread and cultivated is Momordica charantia.[6,7] The Cucurbitaceae are grouped into 119 genera, the main ones of which are: gurania (75 species), sicyos (50 species), Momordica (45 species), cayaponia (45 species) and cucumis (32 species).[4] Of all the species of the genus Momordica, M. charantia and M. balsamina are those found in all intertropical zones of the globe. The plant is called "bitter melon" or "bitter gourd" because all its parts have a more or less bitter taste.[6] Today, 47 species in Africa and 12 in Asia have been recorded.[8] All of these species have unisexual flowers with 24 African species dioecious, 23 monoecious, while all Asian species are dioecious.[5] They are creeping plants, but also capable of climbing on an established support.[9] They grow on soils with a pH between 6.5 and 6.8, hence their preference for rather less acidic soils than other species in the same family. The seeds do not germinate if the substrate temperature is not higher than 10°C; on the other hand at 25-30°C the seeds germinate after 5 to 8 days. For good maturity and good preservation of the fruits, it is necessary to ensure that the plant is well supplied, especially with phosphorus and potassium.[10] Today the consumption of bitter gourd has increased enormously in Asia, East Africa and South America, due to its nutritional value but also its therapeutic properties.[11] In Senegal, the

plant is widely used in traditional medicine and somewhat in human food. According to some authors, ethnobotanical knowledge of plant resources is of great importance for the proper preservation of these natural resources.[12] In this context, the general objective of this research work is to carry out a complete review on the ethnobotany, uses and biological properties of the different parts of *Momordica charantia* L.

2. MORPHOLOGY AND VARIETIES OF *MOMORDICA CHARANTIA*

2.1 History and origin of *M. charantia*

Native to the Old World tropics, *Momordica charantia* is now a tropical plant. Asia, Africa, the Caribbean and South America are regions of the world where *M. balsamina* and M. charantia are frequently found.[13] The latter grows in tropical areas, including parts of the Amazon, East Africa, Asia and the Caribbean. It is widely cultivated in India, Southeast Asia, China and East Africa.[14] The plant is used throughout the world for food or traditional pharmacopoeia by populations.[15] It was first domesticated in Southeast Asia, particularly in India and southern China. It is an important commercial vegetable in East and South Asia, such as India, Vietnam, Thailand, Malaysia, the Philippines and South China.[16]

2.2 Botanical description

M. charantia is a monoecious annual herbaceous plant, whose height can reach 5m. The stems are thin herbaceous with simple grooved tendrils and greenish in color (**Figure 1a**). The leaves are membranous, alternate and simple with a shape comparable to that of vine leaves (Figure 1b).[17] They have a hairy, mucorinated surface with a toothed edge and a pubescent lobed base.[18] The blade has a broadly oval-reniform or orbicular outline which measures between 2.5 and 12.5 cm and has a deeply palmate-lobed cordate base.

The flowers are small, diclinous, with a diurnal anthesis of pale yellow or whitish color (**Figure 2**) carried by frail peduncles. The flowering time is around 55 to 60 days.[14] Male flowers have three stamens, while female flowers have a three-lobed stigma and an inferior ovary.[19] Fruit formation occurs by cross-pollination and sometimes with self-fertilization.[18]

Figure 1: The stem (a) and leaf (b) of *Momordica charantia.*

2.3 Varieties of fruits and seeds

The fruits are pendulous berries, largely ovoid and equipped with an attenuated ellipse beak (Figure 3a and 3b). When ripe, the fruits measure approximately 2 to 7 cm long and 1.5 to 2 cm wide. The mature fruit is usually orange in color with a reddish, slimy pulp surrounding the seeds.[20] They are decorated with approximately 8 longitudinal rows of subconical tubercles and numerous smaller tubercles in the intervals (Figure 3c). They will very often open into 3 valves, revealing the seeds surrounded by a viscous red pulp.[14] However, the fruits of some cultivars have a smooth or spiny surface and often have rounded protuberances with rows in the form of 8 to 10 longitudinal ribs. On the other hand, other cultivars have completely thorny fruits without longitudinal ribs.[21,22]

Figure 3: Wild fruits (a) mature, (b) immature and (c) cultivar of *Momordica charantia.*

Some varieties of Momordica charantia can be differentiated based on fruit morphology or characteristics. However, genetic data are scarce, making it difficult to correctly estimate genetic diversity.[4] Furthermore, groupings based on genetic distances and fruit characteristics have still been carried out, making it possible to classify certain plants within the same variety.[23] Thus we found varieties of fruits with an elliptical, oblong or ovoid shape (Figure 4a, b and c). It is also possible to find varieties with smooth or rough fruits. Productivity and fruit length are also factors in variety identification.[24]

Figure 4: Fruit Varieties of *M. charantia*: (a) wild fruits (b) and (c) cultivars.

The seeds are enveloped in a reddish pulp and edible by animals in general and birds in particular. They are oblong, approximately 10 mm, flattened in shape with a whitish or brownish color.[21] The integuments are sculpted with fluted edges. Some cultivars are completely spiny and ribless with a light brown or sometimes blackish coloring (figure 5a and b).[25] However, in India, the seeds of the cultivars have a narrower morphology with pointed ends and a surface covered with triangular "teeth" with dark brown coloration (Figure 5c).[26]

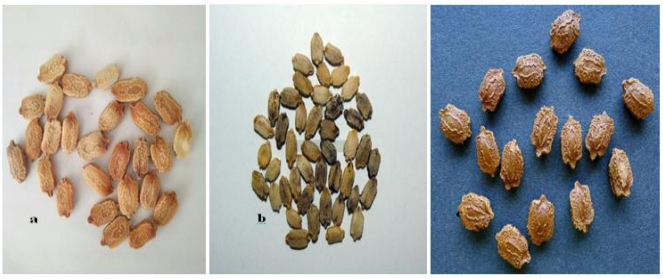

Figure 5: The different seed varieties of *M. charantia*: (a) and (b) spiny seeds and (c) serrated seeds.

3. VERNACULAR NAMES

The generic name apparently derives from the Latin mordeo (bite), perhaps a reference to the jagged edges of the seeds while charantia is from ancient Greek meaning beautiful flower.[27] The different names depending on the languages are summarized in Table II below.

Table II: Some vernacular names of *M. charantia.*

Langues	Noms	References
English	Balsam pear; bitt gourd; African cucumber; bitter cucumber; bitter melon; bitter apple.	[27,28]
French	Concombre africain ; margose à piquants ; melon amer ; poire de balsam ; concombre sauvage.	[29]
German	Gurkenahnlicher ; Balsamapel	[30]
Chinese	karela ; Ku gua ; k'uhua ; chin li chih ; balsam pear	
Spanish	melão de São Caetano ; melão de São Vicente	
Wolof	mbermbef	[31]
sérère	birbop	
Peulh ou toucouleur	Mburbof ; mburbop	
Diola	édélindèl, fu gélèda, tébétébèd, éposopobod	
Mandingues	Orobodo ; zara	
Coniaguis	va huré, va guri vé no ngol	

4. NUTRITIONAL, CHEMICAL AND PHYTOCHEMICAL COMPOSITION

The fruit of *M charantia* is said to contain the highest nutritional value among all species of the Cucurbitaceae family.[30,91,31,92] Indeed, the vitamin C content of Chinese bitter gourd varies considerably (440-780 mg/kg edible portion).[14] Considerable variation in nutrients including protein, carbohydrates, iron, zinc, calcium,

magnesium, phosphorus and ascorbic acid were noted in some cultivars of M. charantia. According to Tauqeer et al.,[33,59] cultivation under organic and inorganic fertilizer makes it possible to obtain high fruit values of around 14.67% in proteins, 7.90% in lipids and 15.24%. fiber, unlike wild fruits containing 2.9%, 1.7% and 1.4% respectively.[14]

Momordica charantia is very rich in bioactive chemical constituents such as cucurbitan-type triterpenoids, triterpene glycosides, phenolic acids, flavonoids, essential oils, saponins, fatty acids but also in many proteins of different natures and functions[34,94], However, these phytochemical compounds are not distributed on all parts of the plant in the same way and are with variable concentrations.[35,68] Among these bioactive compounds, we include charantin, momordicin, momordine, momordicosides G, I, K, momorcharins extracted from all parts of the plant (Figure 7).[36,82] On the other hand, momordenol, momordicilin, cucurbitin, cucurbitacin, cucurbitan are extracted from the leaves.[20,36]

Several bioactive compounds from the fruit of M. charantia grown in Asia have been recorded in the literature such as carbohydrates, proteins and lipids.[16,37,98] In addition, the leaves and fruits of M. charantia also contain triterpenoids and saponins[38,58], polypeptides[39,N64], flavonoids[40,99], alkaloids[37,42,100] and sterols.[43,101] Immature fruits contain cucurbitan-type triterpenoids[44,102], flavonoids[45,73], saponins[36,94], phenolic compound.[46,103] These triterpenoid compound and their glycosides contribute to fruit bitterness.[104]

5. BIOLOGICAL PROPERTIES

The different organs of *M. charantia* exhibit several ethnopharmacological effects such as immunomodulatory[47,53], anti-dengue[48,54] and antioxidant activities,[49,55] against the development of hepatic fibrosis in humans.[50,56] In agriculture, M. charantia is used to promote allopathic activity.[51,57]

5.1 Antidiabetic activity

M. charantia extracts can be used as a remedy for the treatment of all types of diabetes.[52,58,59,53 60] Researchers have demonstrated that M. charantia has potent antidiabetic activities on animal and human cells cultured in the laboratory.[54,61,55,62] Thus, the aqueous extract of M. charantia fruits, administered orally, could very significantly lower the blood sugar levels of diabetic rats induced by streptozotocin, while stimulating insulin secretion from β cells in islets of langerhans isolated from hyperglycemic obese mice.[56,63] These same extracts play a role in cell renewal in diabetic rats, in healing and recovery of destroyed cells.[49,57,64] Other authors also reported that the P-polypeptide isolated from bitter gourd fruits exhibited hypoglycemic activity in the same way as insulin.[58,65,59,66] The antidiabetic mechanism of M. charantia extracts may be due to increased insulin secretion by improving peripheral glucose utilization and increased serum protein levels.[59,66]

5.2 Antioxidant activity

Antioxidant activities of *M. chanrantia* fruit have been reported by Vietnamese and Indian researchers under in vitro and in vivo experimental conditions on animal cells.[61,96,60] The phytochemical compound responsible for these antioxidant activities are polysaccharides, saponins[62,69] and flavonoids measured in the pulp and seeds.[63,70] During these tests, the change in hepatic markers also suggests that the extract helps maintain the cellular integrity of liver tissue in rats with ammonium chloride-induced hyperammonemia[60,68], having a median effective concentration (CEM50) of 2.22 mg/ml. The latter (CEM50) is a measure of the concentration of a drug, antibody or toxicant that induces a response halfway (median) between the baseline and the maximum effect after a certain time of exposure to it.[64,71]

5.3 Anti-tumor activity

Whole fruit extracts of M. charantia elevated hepatic secretion rates and tumor burden in papillomavirus (causing extremely widespread skin or mucosal tumors in the form of warts, condylomas, and papillomas).[65,72] Extracts from the leaves and stem inhibit the growth and proliferation of cancer cells by inducing their apoptosis and cell cycle arrest.[66,73,67,74]

5.4 Antimicrobial activity

The pulp extract of M. charantia has broad-spectrum antimicrobial activity[68,75], like the hydrophilic leaf extracts against E. coli, Staphylococcus, Pseudomonas, Salmonella and Streptobacillus.[69,76,70,77] Additionally, methanolic leaf extracts mixed with immature fruits of M. charantia showed strong antibacterial activity, significantly inhibiting E. coli and S. aureus.[71,78]

5.5 Antiviral activity

Ethanol extracts of the leaves and stems of M. charantia very strongly inhibit the multiplication of certain viruses such as HSV-1 and SINV. Several compound isolated from the plant have antiviral activity and many of them are proteins and steroids.[72,79] Similarly, research has also revealed that proteins from M. charantia can inhibit HIV activity, by depressing the expression of the core protein (p24) of the virus while reversing the activity of the enzyme viral transcriptase-associated virus (HIV-RT), and having less effect on cellular synthesis of DNA or proteins of other cell types.[73,80] Momordicin showed a direct protective effect against Coxsackie virus (CVB3).[74,81]

5.6 Anti-inflammatory activity

According to some authors, Momordica charantia has anti-inflammatory and immunomodulatory activities.[72] Thus, oral administration of 2% and 5% M. charantia dry powder significantly depressed the infiltrated macrophages in the epididymal adipose tissues and

brown adipose tissues (BAT) of rats fed a high-fat diet. This administration leads to the negative regulation of the expression of pro-inflammatory cytokine monocytes better known under the names TNF-1 and IL-6.[75,82] Further experiments showed that extracts from the vegetative parts and immature fruit of M. charantia normalized the content of neuroinflammatory markers (TNF-, IL-16, IL-22, IL-17R) while significantly reducing the oxidative stress of the brain induced by a diet very high in fat.[60,68]

5.7 Immunomodulatory activity

Previous work revealed that methanolic extracts of M. charantia leaves could very significantly promote phagocytic activity in in vivo studies.[76,83] Polysaccharides have been proven to play an immune-modulatory role by inhibiting lymphocyte activity or modifying the kinetics of immune response parameters.[72,79] These compounds significantly inhibit the mitogenic responses of mouse spleen cells due to concanavalin A (glycoprotein of the lectin family) and lipopolysaccharides (also called lipoglycans or endotoxins, leading to the secretion of pro-inflammatory cytokines by lymphocytes T4). Furthermore, momordicin activates and promotes the proliferation of B lymphocytes by inducing the activity of immunoglobulins.[77,106] Furthermore, after 96 hours of co-culture, these polysaccharide compounds stimulate spleen cells to secrete large quantities of IgM immunoglobulin.[78,84]

5.8 Toxicity and side effects

The ethanolic extract of M. charantia seeds causes histological changes in the testicular cells and reproductive organs of albino mice causing infertility[79,87], while the aqueous extracts of the leaves are likely to reduce plasma levels of progesterone and estrogen.[80,88] Thus, alpha momorcharin (α-MMC) contained in the leaves could cause early abortion in pregnant rats. Furthermore, beta momorcharin (β-MMC) demonstrated opposite effects, influencing adhesion but also implantation of the embryo. Thus other components of M. charantia have an inhibitory effect on gastrointestinal nematodes responsible for chronic infections.[81,89] Momordin extracted from the leaves and fruits appears to have hypotensive effects on rats previously suffering from severe hypertension.[82,90]

6. SOCIO-ECONOMIC VALUE OF *MOMORDICA CHARANTIA*

This work highlights the socio-economic value of the different parts of Momordica charantia in Senegal. The marketing of non-timber forest products (NTFP) brings surplus income to indigenous populations. However, revenues may vary depending on the parts and types of products exploited and the type of market.[83,110] Furthermore, for the same products, the profits generated on harvested products are greater outside the harvest season.[84,111] Several studies have revealed the importance of trade in non-timber forest products (NTFP) for socio-cultural groups, particularly because of the income generated by marketing.[85,112,86,113] Regarding M. charantia, the leaves and stem are the main organ parts traded. These parts are more used in traditional medicine for the treatment of certain pathologies such as diabetes, dermatoses and general fatigue. The marketing of the leaves and the stem is most often carried out by men (herbalists) and sometimes by women aged over 40. The wholesale traders, coming from the towns, get their supplies from retailers in the localities or directly from the harvesters. After harvesting, the leaves and the stem are piled up in piles to be sold at 200 Francs each. The average contribution of the sale of leaves and stems of M. charantia to overall income during the harvest season is estimated at 20% in Senegal. Consequently, the marketing of these different products plays an essential role in the socio-economic balance of actors in the sector and traditional practitioners.[88,114] However, the fruit and seeds are not sold in Senegalese markets because they are neither in food nor in traditional medicine.

Figure 8: Pile of leaves and stem of *M. charantia* at the market.

7. CONCLUSION

This study highlighted the ethnobotanical knowledge, biological properties and economic importance of M. charantia in Senegal. The main players in the M. charantia sector are harvesters, traders and traditional farmers. Although the harvesting and trading of leaves and stems is a seasonal activity, the income generated is not negligible for the populations. The socio-economic usefulness of M. charantia is all the greater to the extent that its exploitation is more assured to cure chronic diseases such as diabetes and dermatoses. In order to ensure better management and valorization of M. charantia, it is imperative to evaluate the demographic structure and the state of conservation of training on the use of the plant and its benefits for populations. It is also necessary to take the species into account in programs for the cultivation and protection of medicinal plants in Senegal.

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