Minireview Article

ETHNOBOTANICAL, PHYTOCHEMICAL AND PHARMACOLOGICAL STUDIES OF *CAPSICUM ANNUUM* L. (Solanaceae*)* IN THE HEALING OF TRAUMATIC WOUNDS (CASE OF EYE WOUNDS). A MINI REVIEW

ABSTRACT

Several studies have shown that the extracts of *Capsicum annuum* L. have been used in the treatment of various ailments (fever, colds, chest pain, cancer, cough, sore throat, toothache, cardiovascular disease, diabetes, wound healing Rheumatic wounds and inflammations, etc. It also inhibits bacterial growth and clumping of blood platelets.

According to various bibliographical sources, *Capsicum annuum* L. is an excellent source of phytochemicals such as carotenoids, ascorbic acid, flavonoids, tocopherols and capsaïcinoïds which are very important in the prevention of chronic diseases mentioned above. This richness of the pigment in the possession of a diversity of bioactive molecules would constitute an excellent remedy in the healing of traumatic wounds of the eye and we predict that these compounds would prevent the development of cataracts of the eye. A situation contrary to the healing of eye wounds based on tetracycline and chloramphenicol, the healing of which leads to the formation of cataracts, the main cause of extensive eye operations aimed at "the destruction of this organ" d 'capital importance.

Research methods

In this Bibliographic survey, our approach revolved around the literature on the *Capsicum annuum L* plant. Several results were retrieved from the Articles, Memoirs and Theses having addressed the study of *Capsicum annuum* L. And these results were retrieved using Google which was considered our search engine. In summary, it is the documentary technique that was at work.

Keywords: Phytotherapy, Eye, Capsaicin, Capsaicinoids, Carotenoids

1. INTRODUCTION

Since antiquity, ethnobotany and herbal medicine have been used as major elements throughout the world and constitute an important resource for the research and progress of natural medicines (Bongo, 2017). Indeed, natural herbal products play a crucial therapeutic role in the treatment and prophylaxis of diseases (Arun and Vinay, 2016; Mukeba, 2022) .

According to the World Health Organization (WHO), 80% of the population living in the third world survive from herbal medicine for their primary health care needs (Bongo, 2017; Ngbolua *et al*., 2019 ; Mukeba *et al.*, 2020 ; Mpongo *et al.*, 2022).

In Africa, medicinal plants represent the main product for the urban and urban-rural population for their self-medication because the price of modern drugs is expensive and unaffordable. Medicinal plants have been shown to be rich in therapeutic virtues to combat major health problems (Ngbolua *et al*., 2017 ; Nkasa *et al*., 2020; Divengi *et al*., 2022) .

Toxicity studies are fundamental to assess the safety of extracts to drugs used in clinical medicine. The short or long term of administration of a chemical compound can lead to changes in the function, metabolic transformation, structure and concentration of biomolecules, enzymes and metabolic pathways. These alterations can be rapid or slow and can lead to biochemical mechanisms of the drug producing similar pathologies (Mpongo *et al.*, 2022) .

The current pharmacological treatment of various diseases (conditions) is based on oral and injectable agents which have so many side effects, coupled with their exorbitant costs which are not affordable in poor countries or communities. Therefore, in the rural areas of global societies, plants are the frequently used remedies in the traditional way to cure these diseases and disorders. Minimal side effects are seen when using them (Cakupewa *et al.*, 2022) .

the *Capsicum annuum* L. is a herbaceous plant, even woody and widely cultivated in all tropical regions of the world, especially in Africa and India. The Shrub is believed to have analgesic properties against fever, cough and treats a range of illnesses. The ideal is to allow this plant to be used as a herbal medicine, a promising candidate for the healing of traumatic wounds of the eye and other conditions of the kind.

2. ETHNOBOTANY

2.1. Description

Pepper belongs to the genus *Capsicum*, it is one of the most consumed vegetables in the world. The genus Capsicum has more than 25 species of which only five (*C. annuum* L., *C. chinense* Jacq., *C. frutescens* L., *C. baccatum* L., *C. pubescens*) are the most cultivated in the world (Chales, 2013).

Capsicum *annuum* is an annual plant that is woody at the base and can reach one meter in height. Its leaves are elliptical or broadly lanceolate, acuminate at the top, wedge-shaped at the base, glabrous or glabrescent. Fruits are bacciform and more or less elongated. They can be whitish or brownish green

depending on the red or yellow varieties, orange when ripe; *Capsicum annuum* is a dicotyledonous plant that belongs to the nightshade family. Its classification is as follows (De, 2003):

Kingdom: *Plantae*

Sub-kingdom: *Tracheobionta*

Division: *Magnoliophyta*

Class: *Magnoliopsid*

Subclass: *Asteridae*

Order: *Solanales*

Family: *Solanaceae*

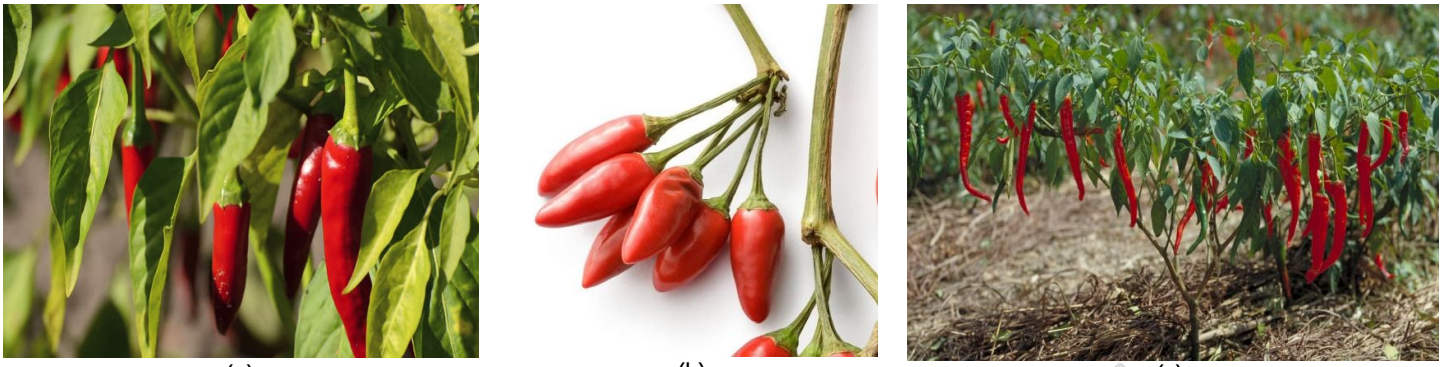
Genus: *Capsicum*

Species: *Capsicum annuum* L., 1753 (Cronquist, 1981)

The pepper is native to America (South and Central) then disseminated in Europe, Africa and Asia (Menichini *et al.*, 2009; Zimmer *et al.*, 2012). It was domesticated 9,000 years ago. The species *C. annuum* is currently the most widespread and the most cultivated among the five mentioned above (Eshbaugh, 1977). It has many varieties ranging from the mildest to the strongest.

Pepper cultivation is therefore very old (**Fig. 1**). Originally, the cultivation of peppers was only done for decorative purposes; subsequently, it was used in medicine and then appreciated for its culinary value. Adapting very easily, its culture spread rapidly, especially thanks to Magellan who introduced it to Africa and Asia. Chili is a perennial plant in tropical and temperate regions. This species is cultivated mainly in the southern states of the United States (in particular in California), southern Europe (more particularly in Hungary, Spain, Italy, ex-Yugoslavia, Bulgaria and Romania), as well as North Africa, Central America and Brazil (De Silva *et al*., 2011; Dima *et al*., 2013).

The leaves of *C. annuum* are used in traditional medicine in DR Congo, in potion, are bechic and treat heart ailments. Their juice is recommended in eye drops against conjunctivitis, headaches and friction would minimize joint pain and in Rwanda, the whole plant, except its roots, is said to have antimalarial properties. But it is the fruits which, both in Africa and in the West Indies, prove to be versatile: antiscorbutic, appetizers, stimulants, etc. And the fruits are also used against hemorrhoids, lumbago, neuralgia, rheumatism. Capsicum is a fresh vegetable and spice used in food (Oh *et al.*, 2008). The food industry uses chilli as a coloring and as a spice. Fruit juice is used as a better wound healing (Grunwald and Christof, 2004).



(a) (b) (c)

(d) (e) (f)

Figure 1: Leaves and fruits (a), fruits (b and f), whole plant (c), leaves (d) and flowers (e) of *C. annuum.*

3. PHYTOCHEMICAL PROPERTIES

Column chromatography associated with spectroscopy have demonstrated that *Capsicum annuum* consumed fresh, dried or powdered is rich in carbohydrates, proteins, lipids, mineral salts (Ca, P, Fe), vitamins (A, D3, E, C, K, B2 and B12) and fibers. It is an excellent source of health-related phytochemicals, such as: Diterpene Glycosides (Capsianosides) (**Fig. 2**), Furastanol Glycoside (Capsicoside), many Carotenoids (Capsanthin, Capsorubin, Capsanthinone, Crytocapsin) (**Fig. 3**), Lutein

Figure 2: Capsianoside Chemical Structure

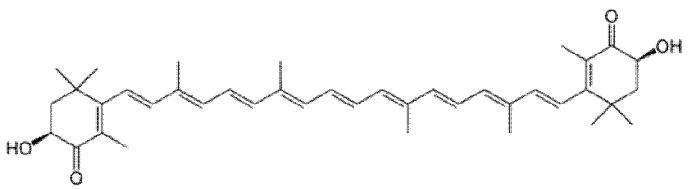


Figure 3: Chemical structure of Carotenoid

Zeraxanthin and Violaxanthin as dyes and pungent principles which are amides (capsaicinoids) represented by Capsaicin. In small quantities, there are Vitamins B1 and B2, Flavonols (Quercetin–3–0–rhamnoside) and numerous flavones (Luteolin 7–O (2-0–apioxyl–6-0– Malon glycoside).

Capsaicinoids are very important in the prevention of chronic diseases such as cancer, cough, asthma, sore throat, toothache, cardiovascular disease and diabetes (Zhang *et al.*, 2012). Chili contains considerable amount of potassium, magnesium and iron (Sinha and Petersen, 2011; Chales, 2013). The nutritional value of chili pepper is high and given in (**Table 1**).

Table 1: Nutritional composition of *Capsicum annuum* (Charles, 2013)

Nutrients	Unity	Value per 100g
Water	-	8.5
Energy	calories	318
Proteins	g	12.01
Total lipids	g	17.27
Carbohydrates	g	56.63
Fibers	g	27.2
Total sugars	mg	10.34
Calcium (ca)	mg	148
Vitamin C	mg	76.4
Vitamin B6	μg	2450
Vitamin B12	UI	0.00
Vitamin A	UI	41,610
Vitamin D	mg	0.00
Vitamin E	g	29.83 (Alpha Tocopherol)
Saturated fatty acids	g	3260
Monounsaturated fatty acids	g	2750
Polyunsaturated fatty acids	g	8370
Fe	g	2.9
β-carotene	μg	71.4
P	mg	101
Mg	mg	24

It is an excellent source of vitamin C, vitamin A and most of the B group vitamins (particularly B6) whose content is higher when the fruit is ripe. Vitamins C and B have a particularly high antioxidant activity, which reduces the level of free radicals and stops peroxidation reactions in humans and therefore reduces the risk of cardiovascular disease and certain types of cancers (Baenas *et al.*, 2018). Indeed, recent studies confirm that the consumption of fresh chilli facilitates the digestion of starches (Bhattacharya *et al.*, 2010).

3.1. Phytotherapy of bioactive compounds and their biological activities.

Chili is one of the most consumed vegetables in the world. It contains a high level of phytochemicals that can contribute to its antioxidant activity, it represents a rich source of phenolic compounds,

capsaicinoids, carotenoids, chlorophyll and vitamins (A, B1, B2, B3, C and E) (Sanogo, 2013; Alvarez–Parrilla *et al.*, 2012).

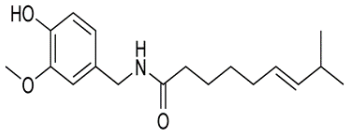
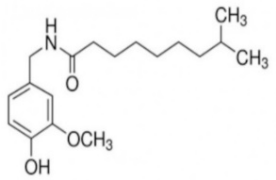
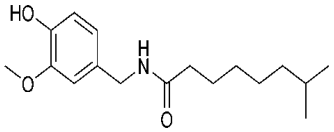
Capsaicinoids are compounds that differ in their structures from the branched fatty acid (acyl) groups attached to the benzene ring of Vanillyalamine. There are in fact several Capsaicinoids, present in different proportions in red pepper which are: Dihydrocapsaicin (or Capsaicin 2), Nordihydrocapsaicin, Homodihydrocapsaicin and Homocapsaicin (Wahyuni *et al.*, 2013) (Table 2).

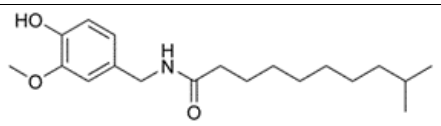
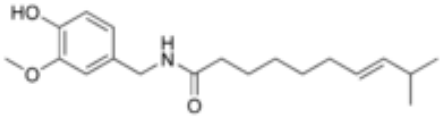
Capsaicin ($CH_{27}NO_3$), is the molecule most present in pepper, which is an irritating substance from the group of vanillyl-amides located in the placenta and whose highest concentration is found near the seeds. It represents 71% of the total capsaicinoids for the majority of hot pepper varieties (Al-Othman *et al.*, 2011)

The hotness (pungency) of peppers is expressed in the Scoville Heat Unit (SHU) developed by Wilbur Scoville, based on the concentration of Capsaicin in the food (Zimmer, 2012).

Most C-apsaicinoids are pungent, but there are also non-pungent capsaicinoids, such as β-hydroxycapsaicin). In addition, another group of non-pungent Capsaicinoids, named capsinoids, has been found in sweet pepper (*Capsicum annuum)* (Wahyuni *et al*., 2013). Capsinoids have the same structure as Capsaicinoids, except they have an ester instead of the amide function (Wahyuni *et al*., 2013)

Table 2: Different proportions of Capsaicinoids in red pepper (Wahyuni *et al*., 2013)

Capsaicinoid	Skeletal formula	Average concentration in % for a pepper	Scoville scale (Scoville Units)
Capsaicin (E)-8-Methyl-N-vanillyl-6-nonenamide		69	$15\text{-}16.10^6$
Dihydrocapsaicin (8-methyl N-vanillyl nonamide)		22	15.10^6
Nordihydrocapsaicin (7-methyl N-vanillyl octamide) HC		7	91.10^5
Homodihydrocapsaicin		1	86.10^5

(9-methyl N-vanillyl decamide)			
Homocapsaicin (trans-9-methyl N-vanillyl 7-decenamide)		1	86.10^5

3.1.1. Capsaicinoids

S have alkaloids with very interesting biological activities. They fight against obesity. According to Date *et al.*, (2002), the administration of capsaicin would promote weight loss by reducing the secretion of a hormone called or Requirement.

Indeed, Capsaicin plays a role which consists in burning fat, because it transforms the white adipose cells, responsible for overweight, into brown cells. Its action accelerates the metabolism and thus makes it possible to limit the risks of obesity. Chili-induced weight loss is also the result of better insulin control, which supports weight management and has positive effects for the treatment of conditions such as obesity, diabetes, and cardiovascular disorders (Sharon *et al.,* 2017).

3.1.1.1. Pain treatment

The treatment of neuropathic pain with capsaicin, as well as prolonged exposure to this compound, leads to a reversible desensitization of cutaneous nociceptors and therefore an inhibition of the transmission of the pain message (De Silva *et al*., 2011).

It has been shown that the use of capsaicin orally or locally can reduce the heat of the inflammations and the pains of rheumatoid arthritis or fibromyalgia.

Additionally, Capsaicin provides relief from osteoarthritis (Fraenkel *et al*., 2004; De Silva *et al*., 2011).

3.1.1.2. Antimicrobial activity

Capsaicin has antimicrobial properties that open doors to explore its potential as an inhibitor of pathogenic microorganisms in food (Xing *et al.*, 2006).

Capsaicin has good antimicrobial activity against *Staphylococcus aureus, Salmonella typhimurium, Bacillus cereus, Listeria monocytogenes, Helicobacter pylori* (Dima *et al.*, 2013).

3.1.1.3. Anti-cancer activity:

Capsaicin exhibits good antitumor activity in cell cultures. It is able to block the migration of breast cancer cells and kill those of the prostate; whereas dihydrocapsaicin induces autophagy in HCT116 (Human Colon Tumor 116) human colon cancer cells (Oh *et al*., 2008; Yang *et al*., 2010).

3.1.2. Polyphenols

Phenolic compounds or polyphenols are molecules that belong to secondary metabolism and constitute an important group of secondary metabolites. About 100,000 compounds have been characterized, most of which are mainly formed from two aromatic amino acids, tyrosine and phenylalanine (Guignard, 2000).

Polyphenols are highly diversified molecules, made up of one or more benzene rings bearing one or more hydroxyl functions. The simplest forms are represented by two main groups from which many compounds derive: Hydroxycinnamic acids and Flavonoids (**Fig. 4**) (Macheix *et al*., 2005).

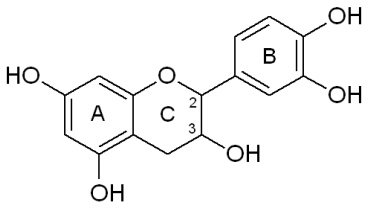


Figure 4: Chemical structure of Flavonoids

In addition to capsaicinoids, three types of phenolic compounds have been characterized and quantified in different varieties of peppers, namely flavonoids, phenolic acids and a stilbene (**Table 2**).

According to Materska and Perucka (2005), their contents differ according to the variety, but also according to the stage of maturation.

Table 3: Contents of phenolic compounds of some varieties of peppers (Bae *et al*., 2012)

Strength (mg/100g)		Variety			
	Anaheim	Bell	Caribbean	Jalapeño	Serrano
Total polyphenols (TEA)	97, 99	103, 26	154, 30	59, 34	94, 85
Gallic acid	69, 30	81, 80	101, 30	49, 10	94, 60
Caffeic acid	2, 20	1, 10	1.00	0, 20	0, 20

3.1.2.1. Antioxidant activity

The chemical texture of phenolic compounds such as flavonoids and certain phenolic acids such as gallic acid makes them lend themselves as potential antioxidants. The antioxidant activity of peppers has been the subject of various studies; it mainly depends on the variety and the solvent used (Materska and Perucka, 2005; Date *et al*., 2002; Bae *et al*., 2012; Chen and Kang, 2013).

3.1.2.2. Antimicrobial activity

Some phenolic compounds such as flavonoids and phenolic acids possess remarkable microbial activity (Özçelik *et al.*, 2011).

In this perspective, the work of Gurnani *et al.*, (2015) on the antibacterial and antifungal activity of pepper extracts demonstrated an interesting effect on the inhibition of certain pathogenic strains.

3.1.3. Carotenoids

Carotenoids represent a group of micronutrients that can be found in several fruits and vegetables where they are the source of their color which varies from yellow to purplish red (Maiani *et al.*, 2009). They are widely distributed in nature and are synthesized by all photosynthetic organisms (cyanobacteria, algae and plants) as well as non-photosynthetic microorganisms, such as fungi and some bacteria (Gómez-García and Ochoa-Alejo, 2013).

Carotenoids are isoprenoid compounds that constitute eight isoprene (ip) units attached in a head-tail pattern where the order of the double bonds is reversed at the center of the molecule (Gómez-García and Ochoa-Alejo, 2013).

Lycopene is a linear molecule (C40H56) which represents the starting point of which all the carotenoids derived from it by cyclization, oxidation and dehydrogenation (Tanaka *et al.*, 2008; Cazzonelli, 2011).

3.1.3.1. Pepper carotenoids

The unique ketone carotenoids are Capsanthin, Capsorubin and Cryptocapsin which produce brilliant red colors or bright colors in Capsicum annum, while yellow or orange colors come from β-carotene, Zeaxanthin, Violaxanthin and β-cryptoxanthin (Arimboor *et al.*, 2011).

Capsanthin represents 30 to 70% of the carotenoids in most varieties and cultivars of pepper. The proportions of Capsanthin and Capsorubin increase in the advanced stages of the plant.

3.1.3.2. Anti-cancer activity

Observational studies describing the inverse relationship between incidents of chronic disease in humans and the consumption of carotenoid-rich diets have been proven. Carotenoids reduce oxidative stress, inhibit cancer cells and provide protection against cardiovascular disease, muscle degeneration and cataracts (Alvarez *et al*., 2011).

Since 1981, Moukouni *et al*. (1991) have demonstrated that carotenoids are involved in cancer prevention and explain that cancer prevention can be achieved via a diet rich in β-carotene.

A diet rich in β-cryptoxanthin has been reported to affect colon carcinogenesis after accumulation in the clonic mucosa. Studies in rats have shown that administration of 25 ppm β-cryptoxanthin for 30 weeks in the nutritional diet suppresses N-methylnitrosulfide, which is responsible for colon cancer (Materska and Perucka, 2005).

Lycopene is a linear acyclic carotene that exhibits inhibitory effects for certain colon and bladder cancers). Lycopene intake reduces the risk of prostate cancer by 53%.

In another study conducted on a human model, the authors showed that the daily intake of 30 mg of lycopene per day decreases the growth of prostate cancer.

Intake of 30 mg of lycopene per day increases its concentration in serum and prostate 2-fold and 2.9-fold respectively, and prostate-specific antigen (PSA) decreased by 17% (Tanaka *et al*., 2008; Giovannucci *et al*., 2002)

3.1.3.3. Antioxidant activity

Carotenoids are pigments that play a major role in the protection of plants against photo-oxidative processes. They are effective antioxidants that scavenge singlet molecular oxygen and peroxyl radicals. In the human body, carotenoids are part of the antioxidant defense system. They interact synergistically with other antioxidants (Sharon *et al.,* 2017).

4. Traumatic eye injuries

Ocular traumatology includes a set of well-individualized lesions. Hel Veston defines ocular traumatology as a pathological phenomenon which affects the eyeball and its annexes, the orbit, the optical pathways.

These traumas may consist of bruises, wounds, foreign bodies and burns. Thus, ocular trauma is increasingly becoming a subject of concern, particularly in developing countries. It takes on a character of seriousness and great importance, for even if it does not always result in complete blindness, it leads in many cases to incapacity for work. The conditions of modern life have greatly increased the frequency, among others: accidents on the public highway, play and work accidents, DIY and sports accidents, assaults and brawls, chemical product splashes (Regis *et al.,* 2004).

Cataract is a real public health problem and is characterized by partial or complete opacification of the normally transparent lens. It creates progressive decline in vision and can be unilateral or bilateral. This disease occurs most often in people over 60 and it also affects younger people, sometimes children.

According to data published by the WHO in 2004, cataracts are the main cause of global blindness in the world (Resnikoff, 2004).

In industrialized countries, the main causes of cataracts are: glaucoma, muscle degeneration and diabetes. While in developing countries, the main causes are due to the existence of specific diseases such as trachoma, vitamin A deficiency or onchocerciasis. Finally, trauma and glaucoma are more frequent there than elsewhere (Limburg, 2000).

Symptoms characterizing cataracts are: progressive BAV, blurred or obscure vision, double vision (monocular diplopia) or glare in the presence of bright light in some cases. (Dolo, 2004)

In reality, there is no effective preventive treatment against cataracts. But certain measures could delay the onset or even the evolution of an incipient cataract. Among these measures, we can mention: the good balance of diabetes, the avoidance of tobacco and alcohol, the protection of the eyes against blue and infrared ultraviolet rays, the supply of antioxidant nutrients (lutein), vitamins C and E. Drug treatment has not yet proven its effectiveness until today. The installation of certain eye drops seems to delay the evolution of a beginner cataract. The current treatment for cataracts remains surgical treatment (Thy and Resnikoff, 1998).

According to the WHO, nearly 1.5 million are blind as a result of eye trauma, a simple traumatic ulcer of the cornea which can lead to hypopyon and perforation. A seemingly small sting that can lead to cataracts and its complications places ocular trauma, alongside other scourges, as a major public health problem with significant socio-economic repercussions (Moukouri and Mol, 1991; Thy and Resnikoff, 1998).

These traumas occur at any age, but children and adolescents are the main victims and pay the heaviest price despite the improvement of prevention and treatment techniques. Currently, it is recommended for better management of trauma to apply the theory of 3 T: everything, immediately and at the same time.

Several studies carried out in the world and in Africa have highlighted their prevalence and seriousness.

In Paris, Regis *et al.* observed a frequency of 12 to 25% after simple delivery and 17 to 40/50% after forceps delivery (Regis *et al.*, 2004)

In the United States, Urvoy *et al.* estimated that 55% of injuries occur before the age of 25 (Gain and Tchaplu, 2003). In Niger according to Kabo, they are the third cause of blindness with a frequency of 8.40% (10.1992) And according to Zacharie, they are the cause of 5% of non-infectious blindness in 1990 (Kyelem, 1992)

In developing countries where the population lives below $0.20/person/day. The population practices self-medication by using certain non-steroidal anti-inflammatory eye drops in order to reduce or relieve pain). Most of the population resorts to the use of certain medicinal plants, including *Capsicum annuum* L., which is an excellent remedy capable of healing traumatic eye wounds.

The purpose of the present investigation is to review the literature on ethnobotany, phytochemistry, phytotherapy and traumatic wounds of the eye related to the excellent plant " *Capsicum annuum* L., in order to expand its field of action in the treatment of certain conditions and traumatic wounds of the eye.

Conclusion

Here we come to the omega of this bibliographic survey. We believe that certain abiotic factors are favorable to the development and multiplication of pathogenic germs. Sub-Saharan Africa is confronted with multiple endemic diseases, for lack of substantial means allowing access to primary health care, its population resorts to other more rudimentary practices (self-medication) in order to treat or relieve certain pathologies. At the end of this review, the objective of which was to identify the photochemistry and phytotherapy of *Capsicum annuum* L., the prospective study of the bibliography showed that this plant has many promising virtues for reducing and healing the wound of the eye and treat certain diseases such as asthma, bronchitis, cough, runny nose, flu, colds, fever, respiratory and cardiovascular diseases, etc. This is how we are advocating that the small molecules which are the drugs currently used to cure the various conditions and diseases mentioned above can also help as a potential drug candidate in the treatment of traumatic wounds of the eye and as well as certain viral conditions such as Covid-19.

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