



Herbal Therapies in Cataract Treatment: A Review of Current Research in Public Health Perspective

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Abstract

Cataract is a condition of visual impairment caused by clouding of crystalline lens. Cataract exhibits a significant prevalence across diverse age demographics; however, primarily it is causing substantial welfare concerns in the aging population. Presently available interventions are largely restricted to surgical options, highlighting the need of alternative treatments. This review aims to understand the importance of utilizing traditional herbal therapies beyond conventional treatment. A comprehensive literature review was conducted using a variety of databases, including ScienceDirect, PubMed, Scopus, Embase, Pablon, Europe PMC, Google Scholar and Clinical Trials Registry - India (CTRI) to gather relevant information regarding existing and prospective plant-based treatment alternatives for cataract. The exhaustive review has covered nature of incidence, etiology, development of cataract, commercially available allopathic eye drops and Plant-based formulations for management of cataract. The plant-based clinical studies registered in CTRI database and online published literature were examined. The observations reflected that herbal therapies are increasingly being explored and scientific validations were undertaken towards identifying herbal medicines in management of cataract. The findings emphasize that anticataract mechanisms of plant-based medications are primarily attributed to their antioxidant and free radical scavenging properties. Currently available therapies are protecting lens transparency and are directed towards arresting the progression of cataract from immature to mature and hyper mature stages.

Keywords: Antioxidant; Cataract; Clinical trial; CTRI; Herbal medicine

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Introduction

Cataract is the opacification of the eye's lens, resulting in diminished vision. The term 'cataract' refers to clouding or opaque area over the transparent ocular lens, which occurs when proteins in the lens begin to aggregate resulting in impairment of vision. Cataract can be broadly classified as presenile and senile cataract. Presenile cataract develops any time from early adulthood to 45-50 years of age [1]. Risk factors for presenile cataract include family history, high myopia, diabetes leading to glycation of lens proteins, atopic dermatitis, prolonged corticosteroid usage (dose and duration dependent), smoking, alcohol consumption, severe malnutrition, trauma and exposure to UV-B radiation (290 nm to 320 nm) [2]. While, senile cataract affects older individuals of 50 years and above age [1]. Senile cataract associated with aging represent the most prevalent ocular condition leading to gradual vision loss.

It is estimated that on a global scale, senile cataract contributes for approximately 48% of all causes of blindness [3]. Worldwide, there are over 2.2 billion individuals experiencing either near or distance vision issues and nearly half of them (1 billion) still require treatment for their vision impairment and associated complications. Within this population, the primary eye ailments include cataract (94 million cases), age-related macular degeneration (8 million cases), refractive errors (88.4 million cases), glaucoma (7.7 million cases), and diabetic retinopathy (3.9 million cases) [4].

The predominant therapeutic approach for cataract treatment is surgical lens replacement to restore lens clarity and optimize refractive errors. However, the post-surgery recovery and readaptation might take months and is often accompanied by manageable yet potential complications [5]. Currently, there are no effective non-surgical treatments available for cataract management; however, some promising allopathic eye drops/chemical compounds are under investigation and preliminary findings suggest their potential activity to prevent or slow down cataract progression. Most of these treatments lack established and credible clinical data, as a result, their efficacy and widespread usage remain uncertain.

Presently, people are growing interest in exploring complementary medicines including herbal remedies in hope for non-invasive and safer treatment options to support overall eye health. Medicinal plants serve as potential alternate therapies towards management of cataract due to presence of phytoconstituents with anticataract activity. The utility and efficacy of herbal formulations for management of early stage cataract and post-operative care were found to be encouraging [6]. Cataract surgery is less preferred for aging population because many patients suffer from other associated metabolic disorders such as diabetes, heart disease, and hypertension which can increase the risk of complications and reduce the post-operative recovery. Therefore, non-surgical treatment options

based on herbal remedies are anticipated to be beneficial for elderly patients. Presently, the antioxidant activities of plant-derived metabolites are being explored for potential pharmaceutical compositions [7].

Methods

In this study, we documented medicinal plants and plant-based natural products used for cataract treatment worldwide, sourced from freely accessible online literature and databases. We have extensively explored searches across multiple web databases, including ScienceDirect, PubMed, Scopus, Embase, Publons, Europe PMC, and Google Scholar, utilizing keywords such as "cataract," "blindness," "traditional medicine," "ethnopharmacology," "ethnobotany," "herbs," "medicinal plants," phytochemicals/ phytoconstituents or other relevant terms.

Furthermore, the Clinical Trials Registry - India (CTRI) online platform [www.ctri.nic.in] was searched using the keyword 'cataract' in the advanced search option to identify clinical trials for cataract management including three search areas/criteria 'Public title of study; Scientific title of study; Health condition/Problem studied'. Specific clinical trials investigating medicinal plant-based drugs were manually screened and duplicates were removed, selected for further review and consolidation [Inclusion criteria- patients having age-related cataract with early stage/immature disease condition without any systemic or metabolic disorders; Exclusion criteria- patients with mature and hypermature cataract and/or having glaucoma, corneal ulcers, and retinal/macular diseases; Populations - Male/Female; Study designs - Randomized, Parallel Group; Study outcome- Plant-based therapies consisting interventional and post marketing surveillance trials aimed at preventing progression of cataract].

The overall search strategy aimed to identify the most relevant plant-based studies by combining Medical Subject Headings (MeSH), keywords, and boolean operators (AND, OR, NOT). All databases and literatures were searched up to February 2025. The focus was to investigate etiological factors, global prevalence and types of cataract, identification of plant-based therapies and implication of allopathic and herbal value chain so as to manage this condition and to assist aging patients thereby welfare.

Incidence of cataract and its etiological factors

Cataract emerges as the primary cause of preventable blindness in individuals over 50 years old, accounting for an estimated 15.2 million cases of blindness worldwide in 2020 [8]. Up to two-thirds of adults with significant cataract may go undiagnosed, with half of these cases experiencing bilateral visual impairment, often leading to substantial functional limitations [9].

Cataract can occur at any age; however, their incidence significantly rises among older individuals. Research indicates that the prevalence of any form of cataract stands

at 3.01 percent in individuals aged 20–39, increases to 16.97 percent in those aged 40–59, and further increases to 54.38 percent among individuals aged 60 and above [10]. Further, in developing countries cataract tends to manifest at an earlier age due to genetic predisposition, environment and nutritional deficiencies [3]. Cataracts are particularly significant in middle- and low-income countries, accounting for 50% of blindness cases due to limited access to primary care. Clouding of lens is significantly linked with various age-related ailments such as frailty, increased risk of falls, depression, and cognitive decline [9].

Managing Cataract: pathogenesis and anatomical types of Cataract

Managing cataract is a considerable socioeconomic hurdle and surgical intervention go-beyond available public health resources. Cataract gradually develop over years, during which eyes and brain adjust to blurred vision, altered color perception, and other visual changes [5]. Sometimes, cataract surgery may be associated with complications such as posterior capsulorhexis, cystoid macular dystrophy, endophthalmitis and retinal detachment. Consequently, a significant number of patients with cataract remain untreated [11]. Cataract surgery has been positively linked to reduced motor vehicle crash rates; though, further research is needed [12,13]. It is important to understand and develop adequate measures in terms of availability of viable and cost-effective treatment.

Cataract manifest either unilaterally (in one eye) or bilaterally (in both eyes). In addition to presenile and senile types, cataracts can be categorized as pediatric cataract (age <18 years), which develop early in life [14]. The etiology of aging and cataract formation in the mammalian lens involves eight proposed hallmarks, including oxidative stress, loss of proteostasis, altered cell signalling, dysregulated ion homeostasis, mitochondrial dysfunction, cell senescence, genomic instability and intrinsic apoptotic cell death [15]. Age-related cataracts are most prevalent, and are primarily triggered by oxidative stress that adversely affect the lens. Distinguished by the site of opacification within the lens, age-related cataracts are further classified as nuclear, cortical, and posterior sub capsular (PSC) cataracts. Nuclear cataract occurs centrally, cortical cataract typically forms as wedge-shaped opacities initially originating from the eye's cortex and progressing towards the center; while PSC cataract present as plaque-like opacities in the axial posterior cortical layer [16]. Nuclear cataracts are frequently linked with smoking, inadequate nutrition and warmer climates; common risk factors for cortical cataracts include increased exposure to sunlight and diabetes; PSC are positively related with diabetes, use of immunosuppressive, intraocular steroids, and therapeutic

radiation in treatment of head and neck cancer [17].

Pharmacological interventions for cataract: allopathic and herbal treatments

Presently, there are limited pharmacological interventions available for addressing cataract, making surgery the primary recourse. Surgical replacement of cataract affected lenses with artificial intraocular lenses may pose challenges viz., post-operative inflammation and intraocular lens displacement [18]. Moreover, the expense and technical demand restrict accessibility of cataract surgery, particularly in regions with constrained healthcare facilities [19]. Several studies indicate concerning impact of surgery on spectacle corrections which can affect day to day activities such as fall incidences, difficulty adjusting to new multifocal spectacles, and dizziness caused by astigmatic refractive corrections [20-23].

Current status of allopathic therapies available and their mode of action:

The use of antioxidants and reactive oxygen species (ROS) scavengers are considered to have therapeutic impact for management of cataract. Reduced glutathione (GSH) which is naturally abundant in lens provides protecting effect by reducing oxidative stress. Enhanced activity of GSH synthesizing enzymes and high GSH level can help in inhibiting cataract formation. Animal studies have indicated that GSH and L-cystine are potential pharmaceutical agents that can protect the lens from harmful effect of lipid peroxidation and ROS, and have been found effective against early stage of cataract [19,24,25].

Allopathic eye drops

Catalin (pirenoxine), is a commercially available eye drop introduced in 1958 for the prevention of early cataract. Pirenoxine compound reduces the binding of quinoid substances with lens proteins by competitive inhibition thereby prevent protein aggregation, and preserve lens transparency [26]. In the early stages of cataract development, Catalin eye drop had prevented lens opacification induced by UV-C radiation, selenite and calcium [27]. Eye drops, like Quinax (USA) and Vita-Iodurool (France), have been employed in clinics since 1980s [28] and could forestall early onset of cataract [19,29]. Administration of medications like Oftan Catachrom (Santen AO, Finland), Potassium iodide (Unimed Pharma, Slovak Republic) and Taufon (Farmak, OAO, Kiev, Ukraine.) are also reported for treatment of cataract [30]. Oftan Catachrom contains cytochrome C, a heme-containing protein, as well as adenosine and nicotinamide, which inhibits clouding of the eye's lens [31,32]. Taufon contains taurine which aids in protecting the lens from glutathione depletion [31,33]. Potassium iodide (KI) is reported as a potential anti-cataract agent due to its involvement in preventing protein cross-linking through sulfhydryl oxidation and protein

glycation. Additionally, iodide has a protective effect against oxidative alterations in lens during cataractogenesis, by inhibiting the formation of S-S bonds [34]. Although some of these treatments have shown inconsistent clinical outcomes, which has resulted in their restricted use and limited global accessibility in standard ophthalmic care.

Chemical compounds

Several potential chemical compounds *viz.*, Bendazac Lysine, Diosgenin, Bendazaclysine, N-acetylcarnosine, 25-hydroxycholesterol and lanosterol are being studied in animal models for management of Cataract. Bendazac lysine, recognized for its protein anti-denaturant properties, has been employed for many years as a preventive measure against early cataract formation. Moreover, a double-masked placebo-controlled clinical trial has demonstrated that Bendazac lysine eye drops at a concentration of 0.5%, applied as two drops three times daily, exhibited ability to decelerate cataract progression [35]. Diosgenin, a novel compound, significantly reduces osmotic expansion of lens epithelial cells and delay the progression of cataract in rats [36]. Bendazaclysine (0.5%) eyedrop solution, had demonstrated efficacy in stabilizing and slowing progression of cataract [37]. A clinical-grade ophthalmic pro-drug of carnosine, known as N-acetylcarnosine (NAC), has been formulated for early stage cataract. NAC had shown ability to reverse lens opacities in canine subjects by protecting lens proteins due to its antioxidant activities [38]. Pharmacological agents (25-hydroxycholesterol and lanosterol) have been identified for their potential to partially reverse lens opacity. This function is attributed by restoring solubility of alpha-crystallin proteins via intercalating between hydrophobic core of protein aggregates. This suggests that protein aggregation is not essentially an irreversible endpoint and may be partially and gradually reversed using targeted small-molecule drugs which can act as pharmacological chaperons [39,40].

It is noted that these conventional non-surgical pharmaceutical treatment medications typically do not result in restoration of existing opacities but rather aids in slowing down progression of cataract. However, most of supporting evidences are primarily derived from animal studies or lack reliable human data, highlighting the need for well-designed robust clinical trials to confirm their safety and effectiveness.

Current status of cataract-related herbal studies registered at Clinical Trials Registry-India

In India, clinical trials need to be essentially registered in the publically available Clinical Trials Registry-India (CTRI) database. CTRI is a primary registry within the International Clinical Trial Registry Platform (ICTRP) of World Health Organization (WHO) [41]. CTRI con-

tributes in maintaining transparency in clinical data and establishes open access of healthcare information for patients, medical professionals and scientists [42]. The present study explored medicinal plant-based CTRI trials focused on the management of cataract.

A total of 36 registrations focused on medicinal plant-based interventions for cataract management or prevention were identified and retrieved (Table 1). The majority of studies [30 clinical trials] were interventional in nature, highlighting the ongoing search for novel therapeutic options while 6 clinical trials were focused towards post-marketing surveillance. The analysis (Figure 1) indicated that the investigational herbal drugs are primarily effective in managing only the early stages of cataract (incipient, immature), preventing its further progression. A large number of traditionally used medicinal plants are currently under investigation for cataract management, with Triphala (*Terminalia chebula* Retz., *Terminalia belirica* (Gaertn.) Roxb., and *Embllica officinalis* Gaertn.) being a key component in most investigational formulations.

Additionally, key observations from published studies conducted in the Asian region (Japan and China) also highlight the impact of Plant-based therapies in diverse population of cataract patients (Table 2). The formulations of the herbal medications (eye drops, powders, tablets/pills, capsules) assessed in clinical trials are provided below:

Natural compounds having anti-cataract potential

Antioxidants are substances documented to have the capability to impede advancement of cataract. Subsequent to oxidative stress, these compounds engage with radical and non-radical species initiating defence mechanisms so as to safeguard intracellular and extracellular constituents [49]. This section gives a brief overview of key herbal compounds used in cataract management, highlighting their possible mechanisms of action, affected biochemical pathways, molecular targets, and cellular effects (Figure 2).

Phytochemicals

In herbal medicines, naturally occurring substances containing antioxidants, and free radical scavengers or anti-glycation metabolites are being explored as potential anticataract agents (Table 3). Typically, lens opacity is induced by free radicals, with protein modification by these radicals being an effect of heightened oxidative stress. Certain plant-derived compounds demonstrate ability to arrest protein insolubilization, thereby delay the onset of lens opacity [18,59]. A *in silico* investigation revealed that phytochemicals including 3,5-DiO-caffeoyl quinic acid, Puerarin, Ellagic acid, Silybin, Silicristin, Kudzuisoflavone-B, Pseudobaptigenin, Alizarin, and Di-caffeoyl putrescine exhibit favorable drug-like properties

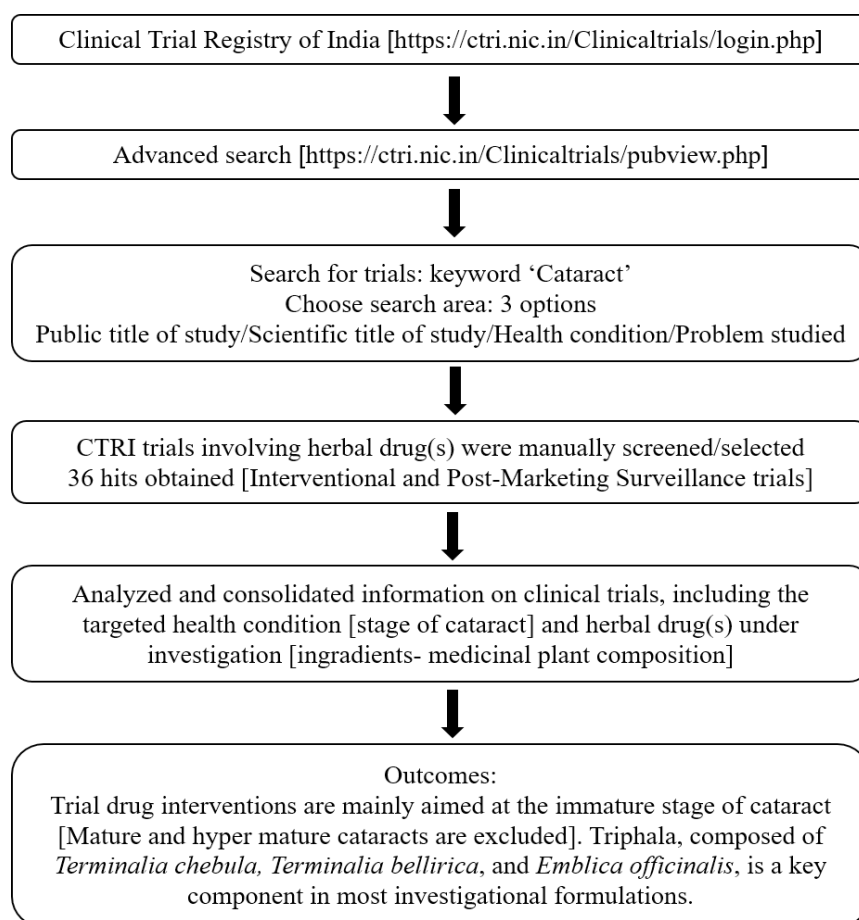


Figure 1. Overview of medicinal plant-based clinical trials for cataract management

and strong binding affinity for inhibition of glycation of γ -crystallin lens protein, encouraging further research on arresting diabetic cataract [60].

Nutraceuticals and dietary natural products

Studies have shown that oral administration of genistein at a dosage of 15 mg/kg can prevent development of cataract in rats. Long-term supplementation with multivitamins, vitamin E, or vitamin C has been associated with a notable reduction in the risk of cortical cataract. The use of zeaxanthin and lutein have demonstrated effectiveness in combating cataract [61]. Plant-derived natural products such as Epigallocatechin gallate (EGCG) at a concentration of 50 μ M, Quercetin at 10 μ M, and Resveratrol were found to inhibit progression of cataract [62].

Plant extracts and metabolites

The effects of *Ginkgo biloba* L. extract (GBE) at a daily dose of 40 mg/kg on radiation-induced cataracts in the lenses of Sprague-Dawley rats were studied. GBE significantly inhibited apoptosis and promoted corneal wound healing by counteracting oxidative damage generated by free radicals and reactive oxygen species (ROS). It also protected oculus against retinal damage and increased the velocity of ocular blood flow in ophthalmic artery. The

positive effects of GBE appear to be attributed to its antioxidant, antiapoptotic, and cytoprotective capabilities, which shield the lens from radiation-induced cataracts [63].

The effects of *Ocimum sanctum* L. on sugar-induced cataract formation in rat lenses were investigated *in vitro*; the findings showed that *O. sanctum* strongly suppressed polyol accumulation and aldose reductase activity, suggesting its potential anti-cataract properties [64]. According to another study, the aqueous extract of fresh *O. sanctum* leaves delayed the development of cataract which was induced in rats with 30% galactose; whereas rabbits were induced with 1 g/kg of naphthalene. The extract has strong free radical scavenging activity that helped restore lenticular permeability and prevent lipid peroxidation, which may be the contributing factor for its anticataract effects [65].

Luteolin, a flavonoid isolated from *Vitex negundo* L. has demonstrated efficacy in preventing selenite-induced cataracts in animal models. This herb is believed to mitigate cataract formation by augmenting the activities of antioxidant enzymes, thereby shielding against oxidative stress and lipid peroxidation. Luteolin also helps to reduce Malondialdehyde (MDA) levels and enhances Glutathione Peroxidase (GSH-PX) enzymes [66]. The impact of a

Table 1. Plant-based clinical trials for cataract management listed at CTRI, India

SN	CTRI No.	Public Title (Brief)	Trial drug(s)/ Herbal medication(s)	Scientific names of medicinal plants	Type of Trial	Health Condition
1	CTRI/2013/01/003324	Anti-cataractogenic activity	Drishiti eye drop	<i>Allium cepa</i> , <i>Zingiber officinale</i> , <i>Citrus aurantifolia</i>	IV	Grade I and grade II cataract
2	CTRI/2014/01/004357	Management of immature cataract (timira)	Triphaladi compound Elaneer kuzhambu anjana	<i>Terminalia chebula</i> , <i>Terminalia bellirica</i> , <i>Embllica officinalis</i> , <i>Z. officinale</i> , <i>Glycyrrhiza glabra</i> , <i>Tribulus terrestris</i> , <i>Tinospora cordifolia</i> , <i>Curcuma longa</i> , <i>Berberis aristata</i> , <i>Ocimum sanctum</i> , <i>Boerhavia diffusa</i> <i>B. aristata</i> , <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>G. glabra</i> , <i>Coccus nucifera</i>	IV	Senile immature Cataract
3	CTRI/2015/12/006427	Anti-cataract effect	Elaneer eye-drops Triphaladi capsule	<i>B. aristata</i> , <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>G. glabra</i> , <i>C. nucifera</i> <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Z. officinale</i> , <i>G. glabra</i> , <i>T. terrestris</i> , <i>T. cordifolia</i> , <i>C. longa</i> , <i>B. aristata</i> , <i>O. sanctum</i> , <i>B. diffusa</i>	IV	Immature cataract
4	CTRI/2016/03/006708	Management of immature cataract (timira/motiyabind)	Triphaladi compound Elaneer kuzhambu anjana	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Z. officinale</i> , <i>G. glabra</i> , <i>T. terrestris</i> , <i>T. cordifolia</i> , <i>C. longa</i> , <i>B. aristata</i> , <i>O. sanctum</i> , <i>B. diffusa</i> <i>B. aristata</i> , <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>G. glabra</i> , <i>C. nucifera</i>	IV	Senile immature Cataract
5	CTRI/2018/05/013749	Treatment of kaphaja timira with reference to senile immature cataract	Kokilavarti anjana	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Piper longum</i> , <i>Piper nigrum</i> , <i>Z. officinalis</i> , <i>B. aristata</i>	IV	Senile immature cataract
6	CTRI/2018/08/015205	Effect in kaphaja timira (immature cataract)	Hareetakyadi anjana	<i>T. chebula</i> , <i>P. longum</i> , <i>B. aristata</i>	IV	Immature cataract
7	CTRI/2019/03/018184	Comparative study of vasaghrita drops and calcium chloride eye drop in senile cataract	Vasaghrita drops	<i>Adhatoda vasica</i>	IV	Senile immature cataract
8	CTRI/2021/06/034262	Effect on cataract	Dhatryadi eye drops	<i>E. officinalis</i> , <i>P. longum</i> , <i>P. nigrum</i>	IV	Senile immature cataract
9	CTRI/2020/02/023536	Ayurvedic management of senile immature cataract	Triphala choorna	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i>	IV	Senile immature cataract
10	CTRI/2021/07/034523	Effect in immature senile cataract	Haritakyadi eye drop	<i>T. chebula</i> , <i>P. longum</i> , <i>B. aristata</i>	IV	Senile immature cataract
11	CTRI/2020/04/024668	Role in first stage of cataract	Pippalyadi anjana Triphala rasayana	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>P. longum</i> , <i>Eclipta alba</i> <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i>	IV	Senile immature cataract
12	CTRI/2020/06/025511	Management of immature cataract	Shwetha palandu eye drop	<i>A. cepa</i>	IV	Immature cataract
13	CTRI/2021/01/030200	Effect in kaphaja timira	Kokoila anjana	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>P. longum</i> , <i>P. nigrum</i> , <i>Z. officinalis</i>	IV	Senile immature cataract
14	CTRI/2021/01/030699	Clinical study on cataract	Isotine plus eye drops	<i>Leptadenia reticulata</i> , <i>E. officinalis</i> , <i>Butea monosperma</i> , <i>Santalum album</i> , <i>Foeniculum vulgare</i> , <i>Achyranthes aspera</i> , <i>B. diffusa</i> , <i>E. alba</i> , <i>Terminalia arjuna</i> , <i>T. cordifolia</i> , <i>Mentha spicata</i>	IV	Immature uncomplicated cataract
15	CTRI/2021/03/032222	Ayurvedic treatment of diminished vision due to opacity in lens	Phalatrikadi ghrita	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Asparagus racemosus</i> , <i>G. glabra</i>	IV	Senile immature cataract
16	CTRI/2022/01/039422	Ayurvedic management in cataract	Nirgundi patra arka eye drop Amalaki rasayana	<i>Vitex negundo</i> <i>E. officinalis</i>	IV	Senile immature cataract

17	CTRI/2022/04/042158	Treatment of senile immature cataract	Vasa ghrita	<i>A. vasica</i>	IV	Senile immature cataract
18	CTRI/2022/06/042977	Effect of ayurvedic medicines on senile immature cataract	Lauha guggulu	<i>T. chebula, T. bellirica, E. officinalis, Cyperus rotundus, Z. officinale, P. nigrum, Embelia ribes, Inula racemosa, Acorus calamus, Plumbago zeylanica, G. glabra, Commiphora wightii</i>	IV	Senile immature cataract
19	CTRI/2022/07/043707	Role in timira	Chandraprabha varti (ointment) Shreshthadi kwath (tablets)	<i>C. longa, Azadirachta indica, P. longum, P. nigrum, E. ribes, C. rotundus, T. chebula, T. bellirica, E. officinalis, A. indica, Trichosanthes dioica, C. rotundus, C. longa, Gentiana kurroo, Mesua ferrea, T. cordifolia</i>	IV	Senile immature cataract
20	CTRI/2022/07/043790	Safety and performance of eye preparations	Sodium chloride eye drop (0.75%) (<i>Calendula</i> plus <i>Hamamelis</i> extract)	<i>Calendula officinalis</i> , and <i>Hamamelis officinalis</i>	PMS	Cataract (stage not specified)
21	CTRI/2022/07/043792	Safety and performance of eye preparations	Sodium chloride eye drop (0.5%) (<i>Chamomile</i> plus <i>Euphrasia</i> extract)	<i>Matricaria chamomilla</i> and <i>Euphrasia officinalis</i>	PMS	Cataract (stage not specified)
22	CTRI/2022/07/043793	Safety and performance of eye preparations	Sodium hyaluronate with <i>Euphrasia</i> extract eye drops	<i>Euphrasia officinalis</i>	PMS	Cataract (stage not specified)
23	CTRI/2022/07/043857	Safety and performance of eye preparations	Distilled witch hazel eye wash	<i>Hamamelis virginiana</i>	PMS	Cataract (stage not specified)
24	CTRI/2022/07/043860	Safety and performance of preservative free eye drop preparations	<i>Chamomile</i> and <i>Euphrasia</i> extract	<i>M. chamomilla, Euphrasia officinalis</i>	PMS	Cataract (stage not specified)
25	CTRI/2022/07/043861	Safety and performance of preservative free eye drop preparations	<i>Calendula</i> and <i>Hamamelis</i> extract	<i>C. officinalis, H. officinalis</i>	PMS	Cataract (stage not specified)
26	CTRI/2022/08/045010	Kalikkam for eye disease (cataract)	Kan kaasa mathirai kalikkam	<i>Z. officinale, P. nigrum, P. longum, G. glabra, Pungamia glabra, Thalictrum foliolosum, Tabernaemantana divaricata</i>	IV	Immature cataract
27	CTRI/2023/02/049927	Comparison with antioxidant therapy in kapahaj kaach- senile immature cataract	Pippalyadi gutika anjanam	<i>T. chebula, T. bellirica, E. officinalis, P. longum, E. alba</i>	IV	Senile immature cataract
28	CTRI/2023/03/050531	Herbal medication (eye drop) for senile immature cataract	Herbal eye drop	Composition not mentioned	IV	Senile immature cataract
29	CTRI/2023/05/052165	Management of timira - cataract	Triphaladi ghana vati	<i>T. chebula, T. bellirica, E. officinalis, Z. officinale, G. glabra, T. terrestris, T. cordifolia, C. longa, B. aristata, O. sanctum, B. diffusa</i>	IV	Senile immature cataract
30	CTRI/2023/05/052541	Management of kaphaja kacha with reference to senile immature cataract	Pathyadi varti Shreshthadi kwatha	<i>T. chebula, G. glabra, Moringa oleifera, Albizia lebeck, Solanum xanthocarpum, G. glabra, A. vasica</i>	IV	Senile immature cataract
31	CTRI/2023/08/056376	Efficacy of dhatriyadi rasakriya and triphaladi ghana vati in kacha with special reference to immature senile cataract	Triphaladi ghana vati	<i>T. chebula, T. bellirica, E. officinalis, Z. officinale, G. glabra, T. terrestris, T. cordifolia, C. longa, B. aristata, O. sanctum, B. diffusa</i>	IV	Senile immature cataract
32	CTRI/2023/07/055063	Post-operative pain management of cataract	Dashmoola ghanvati	<i>Aegle marmelos, Premna integrifolia, Gmelina arborea, Oroxylum indicum, Stereospermum suaveolens, Solanum indicum, Desmodium gangeticum, Solanum xanthocarpum, T. terrestris, Uraria picta</i>	IV	Cataract (stage not specified)

33	CTRI/2023/07/054990	Effect in kacha (immature senile cataract)	Nalikeranjana Kachyapananjana Triphala kwath	<i>B. aristata, T. chebula, T. bellirica, E. officinalis, G. glabra, C. nucifera, G. arborea, Cinnamomum camphora</i> <i>Saccharum officinarum, Spongia officinalis, P. longum, P. nigrum, Crocus sativus, C. camphora, Rosa centifolia</i> <i>T. chebula, T. bellirica, E. officinalis</i>	IV	Senile immature cataract
34	CTRI/2023/07/055316	Ayurvedic management of senile immature cataract	Kantalikadyanjana Chitrakadi kashaya	<i>Solanum surattense, E. officinalis</i> <i>P. zeylanica, T. chebula, T. bellirica, E. officinalis, T. dioica, Hordeum vulgare</i>	IV	Senile immature cataract
35	CTRI/2024/02/062852	Effect in dwitiya patalgata timira with special reference to immature cataract	Chitrakadi kashaya Nilotpaladi anjana	<i>P. zeylanica, T. chebula, T. bellirica, E. officinalis, T. dioica, H. vulgare</i> <i>Nymphaea nouchali, Salmalia malabarica, Mimosa pudica, Nelumbo nucifera</i>	IV	Immature cataract
36	CTRI/2024/03/063455	Management of timira - immature senile cataract	Chandrodaya varti	<i>T. chebula, Acorus calamus, P. longum, P. nigrum, Saussurea lappa, T. bellirica</i>	IV	Senile immature cataract

Abbreviations: IV- Interventional, PMS: Post-Marketing Surveillance

Table 2. Plant-based clinical trials for cataract management at Asian region (Japan and China)

SN	Title	Subject (n)	Study design	Mode of administration	Herbal medications	Scientific names of medicinal plants	Study outcome	Trial location	Reference
1.	Effect of herbal eye drop on senile diabetics in woman	65 year old woman with DM	Case study	Eye drop	Goshajinkigan eye drops	<i>Cornus officinalis, Poria cocos, Aconitum carmichaeli, Rehmannia glutinosa, Alisma orientale, Cinnamomum cassia, Evodia rutaecarpa, Paeonia suffruticosa, Plantago asiatica, Dioscorea japonica</i>	Effective in cataract management, improved blurred and misty vision	Institute of clinical medicine, University of Tsukuba, Japan	[43]
2.	Effect of Shezhu Mingnu Powder on early senile cataract	100 (> 45 years)	RCT	Eye drop	Shezhu Mingnu powder	<i>C. camphora, Blumea balsamifera, Coptis chinensis, Schizonepeta tenuifolia, Phellodendron chinense, Rheum palmatum, Perilla frutescens</i>	Improved visual acuity of early senile cataract, inhibited the degeneration of lens protein.	Ophthalmology Department of Guanganmen Hospital, China Academy of TCM, Beijing, China	[44,45]
3.	Effect of Zhenzhu Jingming tablets on early senile cataract	877	RCT	Oral	Zhenzhu Jingming tablets	<i>Radix notoginseng, Rhizoma atracylodes, Rhizoma coptidis, Fructus citri, Cortex eucommiae, Radix salviae, Radix cirsii, Fructus ligustri</i>	Tablets found to be effective for early senile cataracts	School of Public Health, China Medical University	[45,46]
4.	Effect of GF-DHW pills on cataract in aging population	22 (> 60 years)	Pilot Study	Oral	Gui Fu Di Huang Wan pill	<i>Rhizoma dioscoreae, Cortex cinnamomi, Radix rehmanniae, Rhizoma alismatis, Aconiti lateralis, Fructus corni, Cortex moutan</i>	No effect observed on cataract development/ progression. Notable positive change: reduced frequency of nocturnal urination	School of Optometry, Hong Kong, Polytechnic University, Hung Hom, Kowloon, Hong Kong SAR, China	[47]
5	Effect of mixed herb capsule to treat Presbyopia	200 (42-72 years)	RCT	Oral	Mixed herb capsule	<i>Lycium barbarum (Wolfberry), Dendrobium huoshanense, Cassia obtusifolia (Cassiae semen)</i>	Inhibited development of presbyopia, enhanced the optical power, prevents cataract formation and slows their progression	Department of Ophthalmology, Fooying University Hospital, Pintung 928, Taiwan	[48]

Abbreviations: RCT - Randomized controlled trial, DM - Diabetes mellitus

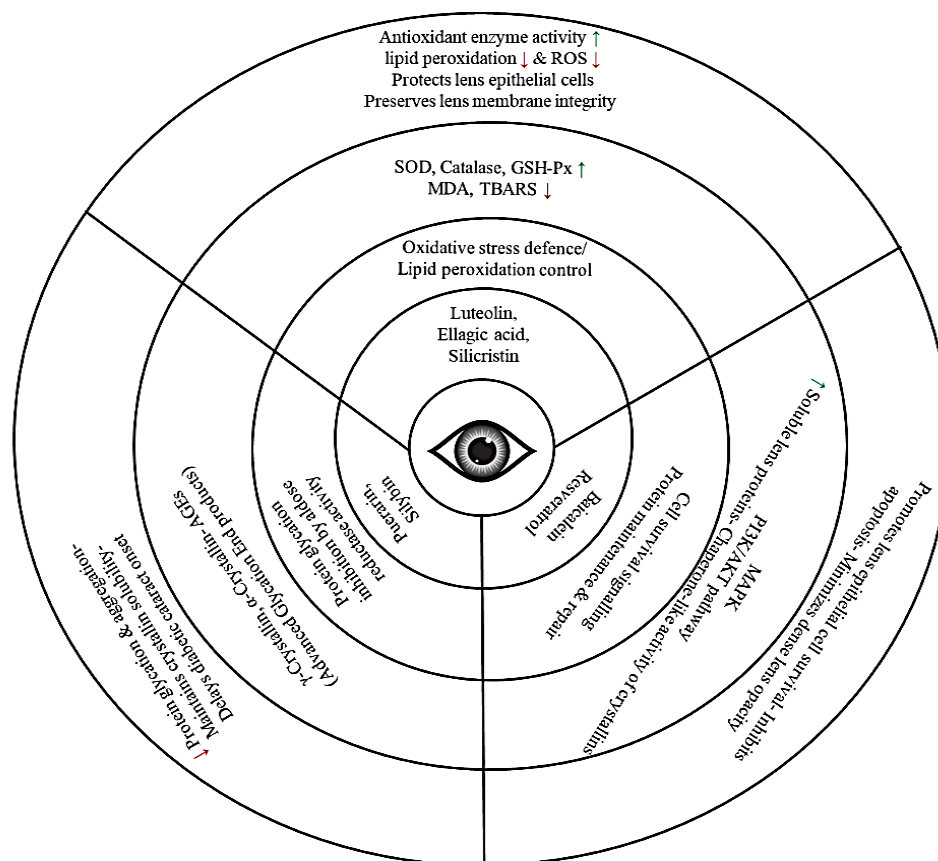


Figure 2. Herbal compounds and their cellular mechanisms in cataract management Abbreviations: ROS - Reactive Oxygen Species, SOD - Super Oxide Dismutase, GSH-Px - Glutathione Peroxidase, MDA - Malondialdehyde, TBARS - Thiobarbituric Acid Reactive Substances, MAPK - Mitogen Activated Protein Kinase, PI3K - Phosphoinositide 3 Kinase, PKB/AKT - Protein Kinase B

methanolic extract of *V. negundo* on the selenite-induced oxidative stress in Sprague-Dawley rat pups was examined. As compared to the selenite-induced group, the treated group's opacification was less. The treated group demonstrated a significant increase in the activities of SOD, catalase, and Ca^{2+} ATPase, as well as a decrease in levels of ROS, Ca^{2+} , and thiobarbituric acid reactive substances (TBARS) [67].

The intraperitoneal injection of *Cineraria maritima* (L.) L. extract had shown to inhibit generation of free radicals in selenite-induced cataract in rats [68]. Extracts of *C. maritima* prevented cataract development in 66% of rats, however, it did not reverse lens opacification [69]. Baicalein (BAI), an essential flavonoid found in *Scutellaria baicalensis* Georgi, studied in rats with Na_2SeO_3 -induced cataract have demonstrated elevated levels of the soluble proteins in lens leading to improved lens opacity. These effects were potentially mediated through the mitogen-activated protein kinase (MAPK) and phosphoinositide 3-kinase (PI3K)/protein kinase B (PKB/AKT) signaling pathways [70].

Plant-based commercial formulations having anti-cataract potential

Currently, commercially available plant-based eye drops

having potential for cataract management are mainly used for post-operative care, vision problems, and other eye conditions. Table 4 provides a consolidated overview of 13 commercially available eye formulations, detailing their plant-based compositions, intended medicinal uses, and manufacturing companies. The compositions of these eye formulations revealed that Triphala is considered to be the most effective and commonly utilized ingredient in ophthalmology products [71]. However, use of such herbal eye drops is largely limited for slowing the progression or minimizing the impact of cataracts.

Limitations of herbal treatments and scope for further research:

Till date, large number of plants are being assessed for their anti-cataract properties; however, only a few herbal formulations had undergone necessary technological readiness level/regulatory approvals to reach commercial potential. These formulations primarily address the early-stage cataract progression or at least found beneficial in associated vision related issues. The majority of such formulations lack high quality clinical evidences, with inconsistent dosages or poor manufacturing standards and quality control factors (substandard raw materials and final products), leading to variable efficacy. Further research

is needed to generate experimental data to validate and identify mechanism of action towards therapeutic claim of herbal medicines and develop scientifically credible formulations to address regulatory concerns posing challenges for commercialization perspective [73].

Conclusions

The present study reiterates the need to address cataract, a

persistent public health and welfare concern. This review has comprehensively consolidated the currently available treatment options for cataract management, with special emphasis on medicinal plant-based therapies and their potential anticataract mechanisms. An exhaustive examination of the Clinical Trials Registry–India (CTRI) identified a substantial number of clinically registered plant-based interventions, an area that has remained rela-

Table 3. Phytochemicals with anti-cataract properties

SN	Phytochemicals	Source -Scientific name (Common name)	Plant part	Model organisms	Cataractogenic stimuli/ cataract inducing agent	Pharmacological action	References
1	β-Glucogallin	<i>Emblica officinalis</i> (Indian Gooseberry)	Fruit	Wistar-NIN rats	Sugar induced osmotic stress in rat lens organ culture Streptozotocin (STZ)-induced diabetic cataract	Inhibition of aldose reductase	[50,51]
2	1,3-di-O-caffeoylquinic acid	<i>Artemisia iwayomogi</i> (Russian wormwood)	Whole	Sprague-Dawley rats	Alloxan induced diabetic cataract	Inhibition of aldose reductase & advanced glycation end products	[52]
3	1,5-Di-hydroxy-1,5-di-[(E)-3-(4-hydroxyphenyl)-2-propenoic]-3-pentanonyl Ester	<i>Lysimachia christinae</i> (Zixin)	Whole	Sprague-Dawley rats	Osmotic stress in rat lens organ culture	Inhibition of aldose reductase	[53]
4	1,3,6-Trihydroxy-2-methoxymethylanthraquinone	<i>Knoxia valerianoides</i> (Hongyadaji)	Roots	Sprague-Dawley rats	25 mM glucose/fructose	Inhibition of advanced glycation end products & rat lens aldose reductase inhibitory activity	[54]
5	1,3,5,8-Tetrahydroxyanthone	<i>Swertia mussotii</i> (Zang Yin Chen)	Whole	Sprague-Dawley rats	Oxidative stress	Inhibition of advanced glycation end products & aldose reductase inhibitory activity	[55]
6	Genistein	<i>Pueraria lobata</i> (Kudzu)	Roots	Sprague-Dawley rats	20 mmol/l xylose	Inhibition of aldose reductase & cellular oxidation, prevent the induction of c-jun and c-fos genes in cornea	[56]
7	C-Phycocyanin	<i>Spirulina platensis</i> (Spirulina) *Algae	Whole	Human lens epithelial cells (SAR01/04 cells)	125 mM D-galactose	Inactivation of caspase 3, alteration of the Bax/Bcl2 ratio, and down-regulation of p53, GRP78 and CHOP on lens epithelial cells	[57]
8	Puerariafuran	<i>Pueraria lobata</i> (Kudzu)	Roots	Sprague-Dawley rats	20 mM D-xylose	Inhibition of aldose reductase, xylose-induced lens opacity, and oxidation in lenses	[58]

Table 4. Plant-based formulations for cataract management

SN	Product	Composition Scientific name (Common name)	Manufactured by	Potential Usage	Weblink
1	Elaneer kuzhampu (Narikelanjana) eye drop (10 ml)	<i>B. aristata</i> , <i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>G. glabra</i> , <i>C. camphora</i> , <i>G. arborea</i>	Vaidyaratnam Oushadhasala, Thrissur, Kerala	Early stage of cataract, corneal ulcer, pterygium, eye infection	Europe Ayurveda - http://www.europeayurveda.com/index.php?route=product/product&path=76&product_id=118
2	Vimalanjanam eye drop (10 ml)	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Cedrus deodara</i> , <i>B. aristata</i>	Sreedhareeyam Farmherbs India Pvt. Ltd., Koothattukulam, Kerala	# Mature cataract, burning sensation and dry eye	Sreedhareeyam Ayurveda Group - https://www.sreemed.com/product/vimalanjanam/?srsltid=AfmBOopF-CzsZ4sNullZZNq8oPuzyhj28yfOhFYC-stX_75_A9oSZexDon
3	Triphala drishti eye drop (10 ml)	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>Rosa centifolia</i> , <i>A. cepa</i> , <i>Z. officinale</i> , <i>A. indica</i> , <i>Cucumis sativus</i>	Basic Ayurveda Ltd., Ghaziabad, Uttar Pradesh	Helpful in cataract, watering of eyes, conjunctivitis, eye allergies, maintain the acuity of vision	Basic Ayurveda - https://basicayurveda.co.in/productingd-more.php?id=442
4	Cineraria maritima eye drop (10 ml) (Homeopathy)	<i>Cineraria maritima</i>	Bakson Drugs & Pharmaceuticals Pvt. Ltd., Parwanoo, Himachal Pradesh	# Early symptoms of incipient cataracts, soothing dryness, blurring of vision and corneal opacity	TATA 1mg - https://www.1mg.com/otc/bakson-s-homeopathy-cineraria-maritima-eye-drop-for-blur-vision-eye-care-eye-drop-otc327278?srsltid=AfmBOooTi_9AoVmMUCf8OE-5sIglz9sMVE7pz81cnrDAvpAsAomJFm4uN&wpsrc=Google+Organic+Search
5	Euphrasia 10% eye drop (10 ml) (Homeopathy)	<i>Euphrasia officinalis</i>	SBL Pvt. Ltd., Jaipur, Rajasthan	# Cataracts, blur vision, eye strain, chronic conjunctivitis, glare, sand-like sensation in the eyes and lachrymation	TATA 1mg - https://www.1mg.com/otc/sbl-euphrasia-10-eye-drop-for-eye-care-eye-drop-otc326104
6	I-Guard eye drops (10 ml)	<i>T. chebula</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>C. longa</i> , <i>O. sanctum</i> , <i>B. diffusa</i> , <i>A. indica</i> , <i>V. negundo</i> , <i>B. aristata</i> , <i>C. camphora</i> , <i>Rosa centifolia</i>	Shree Dhanwantri Herbals (SDH), Amritsar, Punjab	# Developing cataract, corneal ulcer, night blindness, corneal opacity, misty vision	Healthmug - https://www.healthmug.com/product/sdh-i-guard-eye-drops-10ml/1026770050?srsltid=AfmBOooa2teTukjrbcgkjb15nLZXDNS-JfKsjrcIwPDMepXPhmAPz9Ym https://www.madanapalas.com/-p-921.html
7	Drishti eye drops (10 ml)	<i>A. cepa</i> , <i>Z. officinale</i> , <i>C. aurantifolia</i>	Patanjali Ayurved, Haridwar, Uttarakhand	# Cataract, eye allergy, double vision, glaucoma, retinitis pigmentosa	Indiamart - https://www.indiamart.com/proddetail/patanjali-10-ml-drishti-eye-drop-23043829855.html https://www.madanapalas.com/-p-1491.html
8	Al-Shams eye drops (10 ml)	<i>E. officinalis</i> , <i>C. aurantifolia</i> , <i>B. diffusa</i> , <i>Solanum virginianum</i> , <i>Z. officinale</i> , <i>C. longa</i> , <i>E. alba</i> , <i>Coptis teeta</i> , <i>V. negundo</i> , <i>B. aristata</i> , <i>Butea monosperma</i> , <i>Jasminum officinale</i> , <i>Strychnos potatorum</i> , <i>T. chebula</i> , <i>T. bellirica</i> , <i>Rosa centifolia</i> , <i>G. glabra</i> , <i>A. aspera</i> , <i>P. longum</i>	Satya Pharmaceutical, Sonapat, Haryana	Cataract, allergy, itching, myopia, conjunctivitis, burning eyes, night blindness	Indiamart - https://www.indiamart.com/proddetail/satya-pharma-al-shams-eye-drop-2853869383191.html?srsltid=AfmBOorsQp-K0OVFqvA7gO3rPy_cv3dq05V91mc-D4uHxAjEdlm4piB4u9 https://www.madanapalas.com/-p-2865.html
9	Trikul eye drops (10 ml)	<i>T. bellirica</i> , <i>T. chebula</i> , <i>E. officinalis</i> , <i>B. diffusa</i> , <i>C. camphora</i> , <i>O. sanctum</i>	Trimed Ayurvedicals Pvt. Ltd., Mumbai, Maharashtra	To check for senile progressive cataract, redness, eye strain, acute and chronic conjunctivitis	Indiamart - https://www.indiamart.com/proddetail/trikul-eye-drops-15-ml6897988888.html?pos=1&kwd=trikul&tags=B-B Loc 0.0 Price product lucknow NA rs-f:gl -qr_nm:splt-gd res:RC4 comcf:n-l ptrs:na ktp:N0 mc:190825 cat:32 mt-p:S qry_typ:P lang:en wc:l cq:luc-know cs:8480 v=4 r=3 https://www.madanapalas.com/-p-1729.html
10	Diamond eye drops (10 ml)	<i>B. diffusa</i> , <i>Butea frondosa</i> , <i>C. camphora</i> , <i>Nelumbo nucifera</i> , <i>S. album</i> , <i>A. indica</i>	Dr Grover Eye Hospital, Ferozepur, Punjab	Eye disorders such as cataract, reflective problems and glaucoma	Amazon - https://www.amazon.in/DIAMOND-EYE-DROPS-PACK-12/dp/B0CY6MM8TV Apollopharmacy - https://www.apollopharmacy.in/otc/diamond-e-drops-10ml?doNotTrack=true

11	Eye amrut ayurvedic eye gel (10 ml)	<i>Aloe vera</i> , <i>B. diffusa</i> , <i>A. cepa</i> , <i>T. chebula</i> , <i>E. officinalis</i> , <i>T. bellirica</i> , <i>Rosa centifolia</i> , <i>B. aristata</i>	Yashika Trading and marketing Pvt. Ltd. (YMT), Raipur, Chhattisgarh	Reduce cataract, eye irritation and itching, useful in myopia	Flipkart - https://www.flipkart.com/eye-amrut-ayurvedic-gel-mascara-kajal-irritation-itching-reduce-cataracts-drops/p/itmd1b59a0fba264 Amazon - https://www.amazon.in/ayurvedic-mascara-irritation-itching-cataracts/dp/B0CHF-DZHDM
12	Ophthacare® Eye drop (10 ml)	<i>Carum copticum</i> , <i>T. bellirica</i> , <i>E. officinalis</i> , <i>C. longa</i> , <i>O. sanctum</i> , <i>C. camphora</i> , <i>R. centifolia</i>	Himalaya Drug Co. Pvt. Ltd., Tumkur, Bangalore	Useful for postoperative cataract patients [95% efficacy in reducing inflammation] and general eye health, relieving eyestrain, redness, and dry eyes	TATA 1mg - https://www.1mg.com/otc/himalaya-ophthacare-eye-drop-for-eye-strain-redness-dryness-eye-care-otc131470?srltid=AfmBOoqTtMU19743Q69K-T56wGvhaNXESTsUJAPuzA2iFtAl-9hyK41A2T&wpsrc=Google+Organic+-Search [72]
13	Eye drops-Gulbakawali (Netramritam)	<i>Hedychium coronarium</i>	World Wide Enterprise, Kolkata, West Bengal	Prevention of cataract and improvement in eye vision	Tradekey - https://www.tradekey.com/product-free/Eye-Drops-gulbakawali-hedychium-Coronarium--3397761.html Indiamart - https://www.indiamart.com/worldwideenterprise/eye-drops-ulbakawali.html?srltid=AfmBOopjlvryGZroyLwMu0ISoY9QL-RVcGf95gJP6oXWivNZOOfYq-5r [7]

Note: # indicate 'needing further validation'. The web links were accessed on 17th August 2025

tively underexplored until now. Additionally, the review elaborately discusses phytochemicals, plant extracts and market-available eye care formulations, including their compositions and potential impact in cataract and associated vision related issues. The exploration of herbal therapies revealed that a large number of traditional plants are presently being used and further investigated to better understand their role in cataract management. However, their efficacy has primarily been demonstrated only in the early stages of cataract and for general eye health maintenance. This review emphasizes the importance of herbal value chain, and the need to generate scientific rationale and to bring cost effective health care solutions to address cataract. Overall, the use of herbal medications having tremendous therapeutic potential, could prove highly advantageous in the development of future anticataract therapies.

Conflict of Interests

All authors declare no conflict of interest.

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