



Kaali Zeeri (*Centratherum anthelminticum* (L.) Kuntze): Phytochemistry, Pharmacology and Clinical Perspective

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Abstract: Kaali Zeeri (*Centratherum anthelminticum* (L.) Kuntze), also known bitter cumin, is a medicinal plant with a long history of use in traditional medicine systems, particularly in Unani practices. This comprehensive review synthesizes data from classical Unani text and modern scientific literature, electronic database such as PubMed, Science direct and google scholar. This review examines the botanical characteristics, phytochemical composition, traditional applications and modern scientific validation of Kaali Zeeri's therapeutic properties. Kaali Zeeri demonstrates significant pharmacological potential in managing various conditions including diabetes, skin disorders, parasitic infections and inflammatory conditions. Recent research has provided scientific validation for many of its traditional uses, particularly its antioxidant, anti-inflammatory, and antidiabetic properties. This review also addresses safety considerations, dosage forms and future research directions for this important medicinal plant.

Key words: *Centratherum anthelminticum*, Kaali Zeeri, Unani medicine.

I. INTRODUCTION

Kaali Zeeri [*Centratherum anthelminticum* (L.) Kuntze, Synonym-*Vernonia anthelmintica* Willd.] also known as *Kamoon barri*, *Bakuchi* or *Somraji*, is a well-known medicinal plant in Unani and traditional medicine systems ^{1,2}. It has been utilized for centuries in various traditional medicine systems across South Asia, including Unani medicine, which has its origins in Greek medicine but developed extensively in the Persian and Indian subcontinents. The plant belonging to the *Asteraceae* family. The seeds of this plant are particularly valued for their therapeutic properties and have been employed to treat a wide spectrum of health conditions ranging from skin disorders to metabolic diseases as it is rich in essential oils and bioactive compounds like vernodalin and vernolide ^{1,3,4}. The historical significance of Kaali Zeeri in traditional medicine is evidenced by its mention in Unani medicine, it is known as *Kamoon barri* and has been extensively used for its detoxifying

properties and ability to balance humors ^{2,5}. The plant's continued relevance in contemporary herbal medicine and its growing scientific validation highlights the importance of understanding its botanical, phytochemical, and therapeutic properties. The enduring popularity of Kaali Zeeri in traditional medicine systems, coupled with growing scientific interest in its pharmacological properties, makes it a compelling subject for comprehensive review.

II. TAXONOMY AND NOMENCLATURE

TAXONOMIC CLASSIFICATION

Centratherum anthelminticum Kuntze belongs to *Asteraceae* family, which is one of the largest families of flowering plants. The taxonomic classification of Kaali Zeeri is depicted in Table 1 ⁶.

Table 1: Taxonomic classification of Kaali Zeeri.

Kingdom	Plantae
Phylum	Streptophyta
Class	Equisetopsida
Order	Asterales
Family	Asteraceae
Genus	Centratherum
Species	anthelminticum

Nomenclature (Vernacular Names):

Kaali Zeeri is known by various vernacular names across different regions and languages as shown in Table 2 ^{1-4,7}.

Table 2: Vernacular names of Kaali Zeeri across different regions and languages.

Arabic	Kamoon barri
Urdu	Kalijiri, Somraj
Persian	Zeerah dashti
English	Purple Flea-bane, Achenes
Telugu	Adavi-jilakarra, Kalijiri
Hindi	Bakchi, Somraj
Tamil	Kaattu seerakam
Kanada	Kadu-jirige
Malyali	Justan-hutan
Bengali	Somraj
Marathi	Somraj
Gujrati	Somraj

III. GEOGRAPHICAL DISTRIBUTION, CULTIVATION & COLLECTION

Kaali Zeeri is grown throughout India at altitudes of up to 1500 meters. It is native to the Himalayas and Khasi hills and is primarily cultivated for medicinal purposes ¹. Though it is predominantly cultivated in various regions of India, Myanmar and other parts of Southeast Asia, this medicinal plant is observed wastelands and uncultivated grounds on the outskirts of Indian villages ³. The plant thrives in tropical and subtropical climates with well-drained soil and moderate rainfall. It is propagated via seeds sown in summer (June-July) and it requires minimal irrigation. The seeds are harvested when the flower heads have completely dried on the plant, usually toward the end of the winter season ⁸.

IV. BOTANICAL DESCRIPTION

Morphological Characteristics

Kaali Zeeri is an annual, erect herb that typically grows to a height of 2-3 feet. The plant features branching stems with oblong-lanceolate leaves that are irregularly toothed and arranged alternately along the stem. The leaves are membranous, lanceolate, coarsely serrated, and coated with hairs. The inflorescence consists of vibrant purple flower heads that bloom in clusters, each containing 30-40 minute purplish flowers. These give way to the plant's most medicinally valuable part—the achenes (seeds) **Figure 1** ⁸. The morphological characteristics of Kaali Zeeri seeds is detailed in



Table 3.

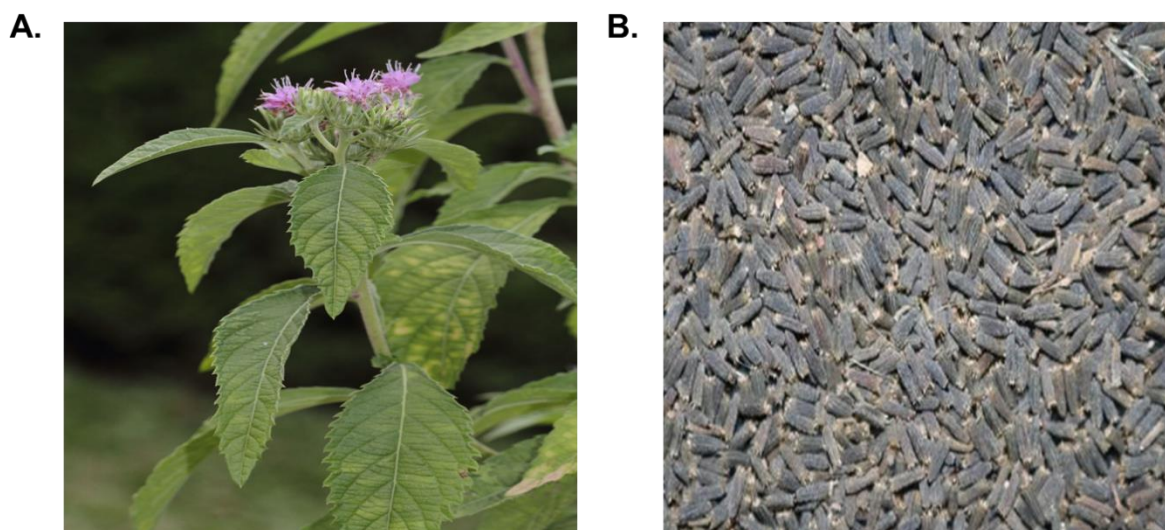


Figure 1: *Centratherrum anthelminticum*. (A) Plant and (B) Seeds.

Table 3: Morphological characteristics of Kaali Zeeri seeds.

Size	Length	3 to 6 mm
	Width	0.5 to 1 mm (at the broadest point)
Shape	Obconical (inversely conical), tapered towards the base	
Surface-key diagnostic feature	Not smooth, covered with a tuberculate or papillate sculpture (appears pitted)- especially visible under a hand lens	
Pappus- biseriate	Outer series	Consists of numerous short, narrow, scarious (membranous) scales
	Inner series	Consists of longer, capillary-like, barbellate (with minute, backward-pointing hairs) bristles which aid in wind dispersal
Base	Pointed and shows a small, pale, circular hilum where the fruit was attached to the receptacle	
Color	Black	
Odor	Faint, characteristic aromatic odor, which becomes more noticeable upon crushing	
Taste	Intensely bitter and slightly acid	

Microscopic Characteristics

The most diagnostically significant microscopic features observed in seeds (achenes) are described in Table 4⁸.

Table 4: Microscopic characteristics of Kaali Zeeri seeds.

Testa (seed coat)	Outermost layer	Single layer of thick-walled, elongated, and columnar palisade-like cells-the epidermis
	Hypodermis	Composed of heavily lignified sclerenchymatous cells
	Inner layer	Composed of thin-walled parenchymatous cells
Endosperm	Massive, polygonal, thin-walled parenchymatous cells, packed with fixed oil globules and aleurone grains	
Embryo	Small, dicotyledonous and embedded in the endosperm	
Trichomes (hairs)	Pappus consist of scabrous bristles which are multicellular and hairy structures	
Crystals	Cluster crystals of calcium oxalate- present in parenchymatous tissue of seed coat	

V. KAALI ZEERI IN UNANI MEDICINE

Philosophical framework

Unani system of medicine has its origins in ancient Greek medicine but developed extensively in the Persian and Indian subcontinents. The *Umūr al-Kulliyā min 'Ilm al-Ṭibb* (basic principles of Unani medicine) include *Mizāj* (temperament) and *Akhlāṭ* (humors / body fluids) such as *Dam* (blood), *Balgham* (phlegm), *Ṣafrā'* (yellow bile), and *Sawdā'* (black bile) and their balance within the body. Similarly, drugs used in Unani medicine also possessed different *Mizāj*. Kaali Zeeri holds a respected position as a multifunctional therapeutic agent having hot and dry temperament, which makes it particularly useful for conditions caused by excess moisture and cold humors^{2,5,9}.

Mahiyat: Kaali Zeeri is a black seed and has a grain as long as two *zeerah* (*Cuminum cyminum* Linn.) plump like *Kasni* (*Cichorium intybus* Linn.), but longer, aromatic, and extremely bitter. The plant is about two cubits long, leaves are somewhat elongated and lobed^{2,5}.

Rang (Colour): Seed of Kaali Zeeri plant is black colored, while the color of flowers is same as *Gul-e-Kasni* (light purple hue)^{2,5,7}.

Boo (Odor): Seed of plant has a sharp, strong (pungent) odor^{2,5}.

Mazah (Taste): Seed is extremely bitter-flavored^{2,5}.

Mustamil Ajza (Part used): Seed, Leaves, Stem/Twig⁵.

Mizaj (Temperament): Unani physicians categorize the temperament of drug into four types— *Hār* (Hot), *Bārid* (Cold), *Raṭb* (Moist), and *Yābis* (Dry)^{9,10}.

The temperament as per *Hakeem Najmul Ghanī* and *Hakeem Muḥammad A'zam Khān* is Hot 3°, dry 3°^{2,5}.

Nafa-e-Khas (Main Action): *Muḥallil* (resolvent), *Musakkin al-Waja* (analgesic)^{2,5}.

Afaal (other actions):^{2,5,7,11}.

1. *Dāfi 'i-Tashannuj* (Antispasmodic)
2. *Qāṭi 'i-Mawād* (Remover)
3. *Mufattiḥ* (deobstruent)
4. *Muḥallil* (resolvent)
5. *Qātil-i-Dīdān-i-Am 'ā'* (anthelmintic)
6. *Mukhrij-i-Dīdān-i-Am 'ā'* (vermifuge)
7. *Munaffith-i-Balgham* (expectorant)
8. *Musakkin al-Waja* (analgesic)
9. *Mulayyin-i-Waram* (swelling softening drug)
10. *Muṣaffī-i-Dam* (blood purifier)
11. *Muqawwī-i-Mi'da* (Stomachic)
12. *Mudirr-i-Bawl* (Diuretic)
13. *Hāḍim* (digestive)
14. *Mushtahī* (appetizer)

Since *Mizāj* (temperament) of Kaali Zeeri is *Hār Yābis* (Hot and dry), therefore according to Unani principles, it is included in *Adwiya Murra / Karvī Dawā* (drugs with bitter taste) and such kind of drugs have properties like *Jālī* (detergent), *Mujaffīf* (drying agent) and *Mulaṭṭif* (attenuant) which indicates its potency in purging excess moisture from the body and purifying organs. Its *Laṭīf* (subtle) qualities enable it to penetrate

deep tissues and facilitate the removal of waste products. These properties underlie its traditional applications for conditions ranging from skin disorders to metabolic imbalances ^{2,9,12}.

***Mauqa-e-Istemaal* (Therapeutic indications):** ^{2,5,7,11,13}

Unani medicine's fundamental therapeutic framework is contingent upon principle of '*Ilāj bi'l Ḍidd*' (Heterotherapy). This principal involves counteracting a disease by administering therapeutic agents, diets or employing strategies with qualities opposite to those of the disease itself. Thus Kaali Zeeri, due to its hot temperament, is very useful in people with diseases of cold temperament.

1. *Istisqā'* (dropsy)
2. *Ḥummā Balghamiyya* (phlegmatic fever)
3. *Ḥummā Muzmina* (chronic fever)
4. *Waja' al-Mafāṣil* (arthritis/arthritis)
5. *Qarḥa Khabītha* (malignant ulcer)
6. *Qulā'* (Mouth ulcer)
7. *Fuwāq / Hichkī* (hiccup/hiccough)
8. *Nafkh* (flatulence)
9. *Maghṣ / Maror* (intestinal colic)
10. *Dīdān al-Am 'ā'* (intestinal worms like earthworms and tapeworms)
11. *Bawāsīr* (haemorrhoid)
12. *Ṣalāba al-Waram* (hardening of swelling)
13. *Waram al-Khuṣyatayn* (orchitis)
14. *Jarab wa Hikka* (scabies and pruritis)
15. *Judhām* (Leprosy)
16. *Baraṣ* (vitiligo)
17. *Amrāq-i-Jild* (skin diseases)

Administration of Kaali Zeeri and its preparation for specific ailments:

Unani medicine employs Kaali Zeeri in both systemic and topical routes for therapeutic purpose which include various forms, such as *Safūf* (crude powders), *Maṭbūkh/ Joshānda* (decoctions), *Naqū' / Khīsānda* (infusions), *Tadhīn* (medicated oiling), *Ḍimād* (poultice) and *Dharūr* (dusting powder) ^{2,5}. Traditional formulations often combine Kaali Zeeri with other complementary herbs to enhance efficacy or mitigate potential side effects. A common preparation for worm infestations (*Qātil-i-Dīdān-i-Am 'ā'*) combines Kaali Zeeri with Baobarang/ Barang Kaabuli (*Embelia ribes* Burm. f.) ⁵.

The detoxifying properties of the seeds help in *Tasfiya al-Dam/ Tanqiya 'i-Khūn* (blood purification), which Unani physicians believe to be the root cause of many chronic skin conditions and other diseases such as *Judhām* (leprosy). For this purpose, Kaali Zeeri should be soaked in fresh water along with *til* (*Sesamum indicum* L.), then after maceration resulting preparation should be strained and administered ².

Kaali Zeeri along with *Barg-e-Neem* (*Azadirachta indica* A. Juss.) and turmeric (*Curcuma longa* L.) is traditionally considered to be beneficial in management of smallpox ⁵.

A traditional preparation involving *Khīsānda* (infusion) of six-gram of Kaali Zeeri and twenty-four gram of *Barg-e-Neem* (*Azadirachta indica* A. Juss.) soaked in new earthenware pot overnight is considered to be efficacious and time tested by Unani Physicians for managing different episodic or undiagnosed *Humṁā Muzmina* (chronic fever) ^{2,5}.

Administration of strained *Khīsānda* (infusion) of Kaali Zeeri in cold water facilitate *Idrār-i-Bawl* (diuresis) ².

Topical application of a paste prepared by grinding Kaali Zeeri and *Kalonji* (*Nigella sativa* Linn.) alleviates *Dard-i-Sar* (headache) ².

Applying a paste made from Kaali Zeeri, olive oil and honey have a restorative effect on *Hār Waram al-Khuṣyatayn* (orchitis) ¹³.

Maḍarrat (Side effects): As stated by Unani Physicians frequent consumption of Kaali Zeeri has *Akkāl* (corrosive) effect, causes harm to stomach and intestine, also an overdose of it induces *Maghṣ* (intestinal colic) and severe distress ^{2,5}.

Muṣliḥ (Corrective): Musk, murgḥ ka shorba (chicken stew), cow milk, fresh Amla (*Emblīca officinalis* Gaertn.) juice- if fresh is not available than administer after making its Naqū'/*Khīsānda* (infusion) ^{2,5}.

Badal (Substitute): Kutki (*Picrorhiza kurroa* Royle ex Benth) ^{2,5}.

Miqdar-e-Khurak (Dosage): 1-3 gram ⁴.

Mashoor Murakkabat (Compound formulations): Habb-e-man-e-hamal ¹⁴, Habb-e-mohallil ¹⁵, Habb-e-bawaseer khooni ¹⁶.

VI. PHYTOCHEMICAL COMPOSITION

The medicinal properties of Kaali Zeeri are attributed to its rich and diverse phytochemical profile, which comprises numerous bioactive compounds belonging to different chemical classes. Modern analytical techniques have identified over 50 significant compounds in Kaali Zeeri seeds, explaining its multifaceted therapeutic actions ^{3,4,17-19}.

The seeds of Kaali Zeeri contain a complex mixture of bioactive compounds with different medicinal properties which is documented in Table 5.

Table 5: Major bioactive compounds in Kaali Zeeri seeds and their medicinal properties.

Compound Class	Specific Compounds	Medicinal Properties
Flavonoids	Butin, Quercetin, Kaempferol	Antioxidant, Anti-inflammatory, Antidiabetic
Phenolic Acids	Caffeic acid, Gallic acid, Protocatechuic acid, Ellagic acid, Ferulic acid	Antioxidant, Hepatoprotective, Nephroprotective
Fatty Acids	Vernolic acid, Linoleic acid, Oleic acid, Palmitic acid, Stearic acid	Anti-inflammatory, Skin barrier repair
Terpenoids	Phytosterols: Stigmasterol, Stigmastatrienol acetate, stigmastadienol, Brassicasterol, β -Sitosterol, Delta-7-avenasterol	Cholesterol-lowering, Anti-inflammatory
	Sesquiterpenoids: Vernodalol, Germacranolide, Centratherin, Demanolide	
Alkaloids	Vernoine	Anthelmintic, Antimicrobial
Bitter resins	Demanolide lactone	Diuretic, Antiseptic, Stimulant
Oil	Fixed oil (18%)	Anti-inflammatory, Antimicrobial
	Volatile oil (0.02%)	Vernasterol

VII. MODERN SCIENTIFIC VALIDATION AND CLINICAL APPLICATIONS

Kaali Zeeri has a historical basis in Unani traditional medicine for treating various conditions, its therapeutic properties are now being substantiated by evidence from modern *in vitro*, *in vivo* and clinical studies. The major pharmacological action is summarized below:

Antioxidant activity: Kaali Zeeri has been found to contain high levels of antioxidants that helps to neutralize reactive oxygen species in the body. The seeds demonstrate remarkable antioxidant potential, which correlates with their high phenolic content. The phenol extract of Kaali Zeeri contains an array of phenolic compounds which may be responsible for its antioxidant activity ²⁰. Treatment with Kaali Zeeri fixed oil and its fractions enhanced the activity of endogenous antioxidant enzymes including superoxide dismutase, catalase and glutathione peroxidase. Additionally, it upregulated the expression of genes involved in the Nrf2/Keap1/HO-1 pathway, which represents a crucial cellular defense mechanism against oxidative stress. These antioxidant activities contribute to their protective effects against oxidative stress-induced damage in various tissues, particularly in the context of diabetic complications ²¹.

Anti-inflammatory effect: The anti-inflammatory properties of Kaali Zeeri have been demonstrated in multiple experimental models, including carrageenan-induced paw edema, cotton pellet granuloma and Freund's adjuvant-induced arthritis in rats. These studies have shown that Kaali Zeeri extracts inhibit the production

of pro-inflammatory cytokines and reduce the levels of inflammatory mediators such as nitric oxide. This scientific evidence supports the traditional use of Kaali Zeeri for inflammatory skin conditions like eczema and psoriasis^{22,23}.

Analgesic and antipyretic effect: *Centratherum anthelminticum* (L) Kuntze seed's petroleum ether and alcohol extracts has shown analgesic and antipyretic activities in brewer's yeast-induced fever model in rats, acetic acid-induced writhing and Eddy's hot plate methods in mice²⁴.

Diabetes management: Multiple *in vitro*, *in vivo* and clinical studies has demonstrated Kaali Zeeri's beneficial effect in type-2 diabetes²⁵⁻²⁷. Clinical experience suggests that regular use of Kaali Zeeri powder can help reduce postprandial blood glucose spikes and improve insulin sensitivity. Kaali Zeeri fixed oil and its fractions has been demonstrated that its administration significantly reduced fasting blood glucose levels and improved parameters of diabetic nephropathy, one of the most common and serious complications of diabetes. Kaali Zeeri fixed oils and its fractions reduced the lipid peroxidation, and improved the antioxidant parameters: enzymatic (SOD, CAT, and GPx) and non-enzymatic (GSH) in Type-2 diabetes mellitus rat model. Histological examination of kidney tissues confirmed these biochemical findings, showing preserved renal architecture in treated animals compared to diabetic controls²¹. Kaali Zeeri seeds extract is capable of exhibiting glycemic control through its inhibitory effect on glycogenolytic enzyme, glycogen phosphorylase which is a key enzyme in the glycolytic pathway^{28,29}.

Weight management: Research suggests that Kaali Zeeri may contribute to weight management through multiple mechanisms, including boosting metabolism, suppressing appetite and inhibiting fat formation³⁰. The compounds in Kaali Zeeri, particularly thymoquinone, have been shown to increase metabolic rate, potentially aiding in more efficient calorie burning. Additionally, Kaali Zeeri may help reduce cravings and overeating by promoting satiety and it may inhibit the formation of new fat cells while reducing fat accumulation in the body. A formulation combining Kaali Zeeri with ajwain (*Trachyspermum ammi*) and methi (*Trigonella foenum-graecum*) in a 1:2:4 ratio shown to be effective in weight management. This combination appears to work through multiple mechanisms including enhanced metabolism, improved fat mobilization and reduced lipid absorption^{21,31}.

Dermatological therapy: Kaali Zeeri remains a valuable natural option for various chronic skin conditions, particularly those characterized by inflammation and itching. Both internal supplementation and topical application are employed, often providing relief where conventional treatments have failed or caused undesirable side effects. Modern scientific research has substantiated Kali Zeeri's traditional use for various skin conditions. A study investigated the antipsoriatic activity of Kaali Zeeri extracts using both *in vitro* and *in vivo* models. The dichloromethane extract demonstrated significant activity in the mouse-tail model of psoriasis, showing effects equivalent to retinoic acid (a standard treatment). The researchers attributed this activity to the presence of essential fatty acids and other bioactive compounds that help restore normal epidermal differentiation and reduce inflammation²¹.

Antimicrobial effect: Kaali Zeeri has also demonstrated significant antimicrobial properties against a range of pathogenic bacteria and fungi^{23,32-37}. The bioactive compounds responsible for these effects include flavonoids, alkaloids and phenolic acids, which disrupt microbial cell membranes and inhibit essential enzymes.

Several of the bioactive compounds present in Kaali Zeeri has been shown to interact with anti-oxidant proteins of parasites which in turn leads to worm mortality ¹⁷.

Antitubercular activity: In vitro studies has shown that ethanol extract significantly inhibits gram positive and gram-negative bacteria and also showed antitubercular activity ³⁵.

Anti-asthmatic property: Shah *et al* has demonstrated that the methanolic extract of Kaali Zeeri significantly decreased bronchospasm, protected the mass cell degranulation, decreased the total leukocyte and differential WBC counts in egg albumin induced asthma. Anti-asthmatic action of Kaali Zeeri could be due to its antihistaminic, mast cell stabilizing property and preventive effect on infiltration of inflammatory cells ³⁸.

Anthelmintic effect: Aqueous decoction of Kaali Zeeri at 5-15 mg/mL found to be more effective than the marketed formulation at same concentration (Mebendazole) ³³.

Anticancer activity: The isolated sesquiterpene lactone vernodaline, derived from the seeds of Kaali Zeeri, has been demonstrated to trigger apoptotic cell death in human breast cancer cell lines via activation of the caspase pathway. Anti-cancerous potential of Kaali Zeeri seeds extract has been demonstrated due to its oxidative properties ^{39,40}.

Polycystic ovarian syndrome (PCOS): Kaali Zeeri demonstrates efficacy against estradiol and high-fat diet (HFD)-induced PCOS in a rat model. This effect is attributed to its multifactorial pharmacological properties, including antidiabetic, anti-inflammatory, antihyperlipidemic, and antioxidant activities ⁴¹.

Hepatoprotective: The ethanolic and hexane-soluble fractions of Kaali Zeeri seeds shown to have antioxidant and hepatoprotective effects against carbon tetrachloride-induced hepatotoxicity in albino rats ^{42,43}.

Anti-nephrolithiatic activity: Anti-nephrolithiatic activity of Kaali Zeeri seeds against calcium oxalate stones has been reported. In this study, 70% methanolic extract of Kaali Zeeri seeds has higher capacity to inhibit the crystal formation and aggregation ⁴⁴.

Wound healing property: Ethanolic extract of Kaali Zeeri shown to have wound-healing activity in excision and incision wound models in albino rats ⁴⁵.

VIII. SAFETY, TOXICITY, AND CONTRAINDICATIONS

Safety and toxicity Profile

Kaali Zeeri has demonstrated a favorable safety profile in both traditional use and modern toxicological studies. Traditional texts describe it as a substance of low toxicity when used at recommended doses, though its hot and sharp qualities necessitate careful dosing and appropriate combination with other herbs in certain constitutions.

Animal	Extract / Fraction	Dose	Toxic effects	References
Rat	Fixed oil (Hexane, chloroform and ethanol)	Upto 2,000 mg/kg	Not reported (100% survival rate)	²¹
Mice	Petroleum ether and alcohol	Upto 2,000 mg/kg	No signs of acute toxicity	²²
Rabbit	Crude seed extract	Upto 3,000 mg/kg	No signs of acute toxicity	^{46,47}

Filariasis worm (in vitro)	Methanolic extract	LC50: 118.8 mg/mL	None (used to treat subclinical mastitis)	¹⁷
Cancer cells (in vitro)	Chloroform extract	IC50: 8-31 µg/mL	Not applicable	¹⁹
		IC50: <10 µg/ml in A375 cells	Not applicable	⁴⁰
	Aqueous extract	IC50: 35 MDA-MB-231 cells	Not applicable	³⁹

IX. QUALITY CONSIDERATIONS

Quality assurance remains a significant challenge in the Kaali Zeeri trade adulteration issues. Kaali Zeeri is frequently subject to unintentional or deliberate adulteration with similar-looking seeds from other plants, particularly *Nigella sativa* Linn. (Black cumin) and *Bunium persicum* (Boiss.) Fedts. (Black caraway) ⁸. These substitutions may significantly alter the therapeutic effects and safety profile of the product.

X. FUTURE RESEARCH DIRECTIONS

Despite the considerable scientific exploration of Kaali Zeeri, several knowledge gaps remain that warrant further research:

- **Clinical trials:** While numerous preclinical studies exist, well-designed randomized controlled trials in human populations are limited. Rigorous clinical research is needed to establish standardized dosing protocols, efficacy for specific conditions and comparative effectiveness relative to conventional treatments.
- **Mechanistic studies:** Further investigation is required to elucidate the precise molecular mechanisms underlying Kaali Zeeri's multifunctional effects, particularly its interactions with cellular signaling pathways involved in inflammation, metabolism and oxidative stress response.
- **Phytochemistry:** More comprehensive phytochemical characterization is needed to identify novel bioactive compounds and clarify structure-activity relationships that could guide drug development efforts.
- **Formulation optimization:** Research into novel drug delivery systems could enhance the bioavailability and targeted delivery of Kaali Zeeri's bioactive components, potentially improving efficacy and reducing required doses ³³.
- **Long-term safety:** Systematic post-market surveillance and long-term toxicological studies would provide valuable data on the safety of extended Kaali Zeeri use, particularly in vulnerable populations and those with chronic health conditions.

XI. CONCLUSION

Kaali Zeeri (*Centratherum anthelminticum* (L.) Kuntze) represents a compelling example of how traditional medicinal knowledge can inform and enhance modern therapeutic practice. Its extensive history of use in Unani medicine provides a robust foundation for scientific exploration, while contemporary research methods are progressively validating its efficacy and elucidating its mechanisms of action. The multifunctional properties of Kaali Zeeri spanning antidiabetic, anti-inflammatory, antioxidant, antimicrobial, and dermatological effects make it particularly relevant in addressing the complex, multifactorial health challenges of the modern era. Its favorable safety profile and botanical origin further enhance its appeal for an increasingly health-conscious

global population. The continued study of Kaali Zeeri not only offers promise for drug discovery and development but also serves to preserve and validate important cultural knowledge systems. As we move forward in exploring the therapeutic potential of traditional remedies like Kaali Zeeri, we embrace a more inclusive, holistic approach to health that recognizes the value of diverse healing traditions while subjecting them to appropriate scientific scrutiny.

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Conflicts of interest

There are no conflicts of interest.

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