

REVIEW ARTICLE OPEN ACCESS

Status of Black Cumin Development, Use, and Its Future Prospects: Insights Into Conservation and Sustainable Utilization

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ABSTRACT

Black cumin (*Nigella sativa* L.) is a spice crop from the Ranunculaceae family and is produced extensively across the Mediterranean region, Asia Minor, Northern Africa, and Southern Europe. It has significant nutritional and pharmaceutical values, and global popularity and demand are increasing due to its widespread use in traditional and modern medicine in diverse forms. In Ethiopia, black is the largest cash crop, ideal for its medicinal properties and economic benefits. Ethiopians continue to produce and consume a relatively small amount of black cumin, despite its widespread use for medicinal purposes and its cultural significance. This is due to a lack of improved technology, insufficient germplasm, and improved varieties, limiting research extension. The present review highlights the current status of black cumin cultivation, its therapeutic potential, and its traditional use in Ethiopia, as well as the challenges to its production and commercialization. The text emphasizes the significance of genetic resource conservation, sustainable utilization, and the need for further research to improve production and commercialization. Addressing these issues will allow black cumin to reach its full potential, contributing to food security and economic development in Ethiopia. Therefore, this review aims to assess and document the status, use, conservation, and sustainable utilization of black cumin, as well as their gaps and prospects.

1 | Introduction

Black cumin (*Nigella sativa* L.) is a spice crop from the Ranunculaceae (buttercup) family [1]. It is grown as wild throughout Southern Europe, Northern Africa, Asia Minor, and the Mediterranean region [2]. Black cumin is also referred to as black seed [3]. It is classified as a small seed spice, has been extensively cultivated, and is identified to be grown from Morocco to Northern India, in sub-Saharan Africa, primarily Niger, and Eastern Africa, in particular Ethiopia [4]. For many years, black seed has been utilized as a spice and food preservative, as well as a protecting and curative remedy for a variety of ailments [5].

Black cumin has numerous nutritional and pharmaceutical applications [6]. The popularity and global demand for black cumin for medicinal and aromatic plants are on the rise due to its widespread utilization in various fields, including traditional and modern medicine, in diverse forms [7]. Both seeds and oil have a long history of folklore use in Ethiopia and other countries, and they have traditionally been used to treat a variety of diseases and ailments, such as asthma, bronchitis, rheumatism, and other inflammatory conditions [8]. Additionally, in Ethiopia, the aroma of 10–15 black cumin knotted in a clean cloth or a little bit of black cumin fatty oil is a popular headache remedy [9]. In Ethiopia, it is the second largest cash crop exported to the international market, following ginger [10].

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Their seed can be mixed into tea, coffee, casseroles, bread, canned, or extracted in wine or vinegar. The ground seed can be combined with honey or sprinkled over salads. Furthermore, most people looking for the benefits of black cumin take the oil in capsule form [6]. The oil made from black cumin is so beneficial because it contains more than a hundred active components [11]. Nowadays, black cumin oil has received a lot of attention, and as a result, consumption has increased, particularly in Middle Eastern countries [12]. In recent years, the growing use of fixed oil extracted from seeds has heightened the significance of black cumin cultivation [7]. Black cumin has been widely used for its therapeutic potential, which includes diuretic, antihypertensive, antidiabetic, anticancer, immune-modulatory, antimicrobial, anthelmintic, analgesic, anti-inflammatory, spasmolytic, bronchodilator, gastroprotective, hepatoprotective, and renal protective properties [3]. Black cumin has a significant economic value in producing countries and is particularly sought after in developed countries [13]. Regardless of their high economic potential and the government's current focus on promoting the production and export of spices such as black cumin, their share of export revenue is among the lowest in total income from exports [14]. Its seed and oil are in high demand in the local, national, and international markets for medicinal, consumption, and commercial purposes, making it the best alternative crop for Ethiopian smallholder farmers [15]. Consumption of black cumin has increased as their seed and oil yields have received increased attention [10].

In Ethiopia, black cumin is a highly valued medicinal plant because the country has a suitable climate and agroecology for producing a variety of food crops, including other spices [16]. Many areas in the country, including Amara, Oromia, SNNP, and Gambella, are used to produce black cumin seeds. The diverse distribution of black cumin at various altitudes in Ethiopia indicates the species' potential for agroecosystem growth and genetic diversity [17]. Similarly, production potentials and factors vary across the region's agroecology [18]. Regardless of the country's favorable ecological circumstances and economic importance, the black cumin cropping system has been underutilized due to a lack of emphasis on increasing production and productivity [10]. The inconsistent production of black cumin seeds and prolonged storage can impact their germinability, oil yield, and quality attributes due to fluctuating demand.

Additionally, smallholder farmers in Ethiopia do not improve their cultivation practices, and their techniques are heavily based on knowledge passed down through generations, resulting in low production levels [19]. Ethiopian agriculture has undergone significant social, economic, and technical changes because the introduction of advanced cultivars has led to genetic erosion, even among minor crops [20]. Field crop diversity is currently decreasing at a startling rate. The field crop diversities that are primarily threatened are the replacement of farmers' varieties by a few genetically uniform crop cultivars, invasive species, drought, and climate change [21]. The challenges of agricultural modernization include the gradual loss of crop diversity and genetic base due to the widespread adoption of uniformly high-yielding varieties [22].

To prevent crop genetic erosion, the Ethiopian Biodiversity Institute has conducted exploration and collection operations across the country at various times. Natural disasters, crop economic importance and diversity, threat level, and, to some

extent, national research priorities were used to establish collection priorities [20]. The institute has collected more diversity of crops including black cumin from various locations across the country over the past few decades. The distribution of black cumin accessions was carried out for local research activities, research centers, universities, private researchers, and others at various times depending on their request and the accessibility of the accessions. In addition to collection, distribution, and conservation, the Ethiopian Biodiversity Institute conducted regeneration, multiplication, characterization, development of line, and evaluation at various times depending on germination potential, active collection quantity, and collection times per year.

Black cumin is grown in different areas of Ethiopia at different altitude ranges, indicating that there is genetic diversity of black cumin species that deserve conservation [23]. Black cumin's oil and seed outputs have garnered a lot of interest in recent years. Black cumin is the best crop to grow on smaller plots of land in Ethiopia because of the rising demand for the seed due to its importance for both local consumption and other uses, such as oil and oil rosin for medicinal purposes, the export market, the potential for crop diversification, the ability to generate income, and the lessening of crop failure risk [24].

However, black cumin is grown in Ethiopia on untested soil and fragmented terrain that has a long history of agricultural techniques without the use of technology. When compared to other crops, there is also little information about land coverage, drought, disease, insect resistance, seed rate, row spacing, and fertilizer use. Numerous constraints hamper the conservation and sustainable utilization of black cumin. There are insufficient farmer variety collecting and inclusive investigations on the genetic diversity of black cumin, mostly in diverse agroecological areas. This constraint limits the identification of the most productive and adaptable black cumin accessions within the specific agroecology. Limited linkage of technologies, such as the absence of participatory variety selection and improvement of cultivation activities, further restricts productivity and adaptability to climate change.

Commercial constraints, which include insufficient financial support for small-scale farmers and limited market access, exacerbate these issues. Furthermore, the lack of policies supporting its preservation and incorporation into national agriculture goals left a major gap. Environmental risk, such as the nondiversification of landrace resources and habitat degradation, enhances the risk to the genetic resources important for the next generations. To overcome these limitations, it requires interdisciplinary research focused on agronomy and conservation strategies. Teamwork among stakeholders is essential for guaranteeing the sustainable utilization of black cumin crops. These factors contribute to black cumin's lower productivity and production compared to the nation's grain harvests. Therefore, this review aims to assess and document the status, use, conservation, and sustainable utilization of black cumin, as well as their gaps and prospects.

2 | Development of Black Cumin

Black cumin is cultivated globally, predominantly in nations that border the Mediterranean Sea [25]. Farmers cultivate it in arid

climates; for instance, in Turkey, it grows on high clay soils with low salt, organic matter, nitrogen, and phosphate content, as well as limited rainfall (349.4–424.1 mm per year). These areas classically have high pH (7.8) with low temperatures ranging from 9°C to 10°C. Similarly, in Jordan, black cumin is grown at elevations of 530–880 m above sea level, where the average temperature is 6.9°C–17.4°C and the rainfall is 319.2–462.5 mm per year [26]. However, cultivating in these areas often produces low seed yield and quality due to insufficient rainfall and the requirement to complete their life cycles. Black cumin is also growing in highland areas known for low temperatures below 20°C, insufficient rainfall, and alkaline soils [25].

Black cumin cannot grow or germinate in the middle and lowlands (550 and 350 m above sea level) where temperatures range from 22.47°C to 29.83°C and from 22.73°C to 31.73°C, respectively [27]. However, Herlina et al. [28] reported that lowlands (220 m above sea level) might support the growth and production of black cumin genotypes from Kuwait and India, signifying variation between genotypes. Underwater shortages, black cumin indicates significant reductions in seed yield and oil contents. Therefore, applying irrigation strategy, especially full irrigation practices, is necessary to obtain optimal seed yield and oil contents under semiarid climate conditions [29].

The cultivation and commercialization of black cumin in Ethiopia is possibly the most romantic story of any plant product, legendarily known to date back to the times of the Queen of Sheba [30]. Nowadays, extensive research using modern scientific techniques is carried out by various researchers on black cumin as it is believed to be a miraculous herb that can cure multiple ailments and disorders. Black cumin seed and oil are becoming increasingly popular in Ethiopian marketplaces for consumption [31]. Currently, there is a growing interest in naturally occurring and therapeutically powerful phytochemicals as they are relatively nontoxic, affordable, and available in an edible form [2].

However, climate and soil conditions have a considerable impact on the growth and development of plants, their physiological growth, the synthesis of active chemicals, and the quantity and quality of essential oils acquired. Especially, environment-related factors have a greater impact on black cumin seed output and essential oil than on other spices [32]. However, the cultivation process and technique are heavily reliant on expertise passed down from generation to generation, and production levels are minimal. Similarly, expensive weeding frequency, expensive input requirements, such as seed and fertilizers, and high production costs may result in a loss of market pricing because of abnormalities [30].

The key problems during the production stage are the low level of availability of improved and high-yielding varieties, poor quality of processed products in the international market, very low involvement of private investors in commercial spice crop production; very little and erratic supply of raw spices from backyards and forests to processors; substantial waste from improper postharvest processing techniques; absence of incentives for growers as well as processors from the government; low effort made to adapt forest species; and the key issues are the lack of clearly defined farm management practices for spice including black cumin and a lack of effective strategic interventions for spice development [33]. As a result, the value

addition of black cumin in Ethiopia is negligible, with all exports consisting of whole grain crops [31].

3 | Nutritional and Biological Properties of Black Cumin

The nutritional composition of black cumin differs with the topographical distribution, harvesting time, and agronomic activities [34]. Numerous scientific studies have identified the existence of different compositions, such as vitamins, oil, total carbohydrates, proteins, fat, dry matter, moisture, and ash contents [35]. Additionally, black cumin is abundant in minerals, such as potassium, calcium, phosphorus, and magnesium with significant amounts of sodium, iron, manganese, zinc, and copper also found [25]. Aside from its nutritional value, black cumin contains a variety of biological qualities, including antibacterial, antihypertensive, antioxidant, antidiarrheal, anti-inflammatory, diuretic, anticancer, analgesic, hunger stimulant, and treatment for skin problems [36].

Genetic diversity and topographical distribution are extremely significant concerning the yield and quality composition of black cumin [26]. However, the research conducted in different countries has discussed its chemical composition, showing that the black cumin seed contains 5.89%–7.12% moisture, 20.3%–22.8% protein, 31.2%–45.4% fat, 5.07%–7.39% ash, 19.7%–25.47% total carbohydrate, and 92.9% dry matter [37, 38].

In terms of mineral composition, black cumin is rich in potassium (659.15–1498.3 mg/100 g), phosphorus (17–704.78 mg/100 g), sodium (17.60–106.22 mg/100 g), calcium (366.7–570 mg/100 g), magnesium (265–355.20 mg/100 g), zinc (5.39–7.37 mg/100 g), iron (9.7–66.47 mg/100 g), manganese (3.1–8.53 mg/100 g), copper (1.5–8.53 mg/100 g), cadmium (0–0.006 mg/100 g), and molybdenum (0–0.03 mg/100 g) [37, 38]. Black cumin seed oil has the most valuable fats and oils in manufacturing because of its nutritional value and positive effects on biological activities. There are different techniques for the extraction of black cumin oil from seeds to get a high yield with acceptable quality, such techniques are microwave-assisted extraction, Soxhlet, cold press, and solvent extraction [36, 39]. The oil yield of black cumin ranges from 27.2% to 72.10%; however, it is affected by time, temperature, and extraction techniques, and it affects the composition and quality of oils [7, 12, 38, 39].

The black cumin oil contains saturated and unsaturated fatty acids [26]. Nevertheless, the proportion of fatty acids in black cumin seeds varies depending on the country of origin [37]. The major fatty acids are linoleic 45.45%–57.67%, oleic 18.83%–25.01%, palmitic 6.95%–12.24%, and stearic 3.34%–4.77% [7, 26]. The oil is also an abundant source of polyphenols, offering protection against cancer and heart disease, with higher polyphenols than the majority of edible oils, except olive oil [40]. Muzolf-panek & Anna [41] discovered that temperature, time, and methanol concentrations have a significant impact on the total polyphenol contents of oil. Black cumin oil consists of 315.68 mg GAE/kg of polyphenols [40]. Black cumin oil exhibits antioxidant properties, reducing reactive oxygen species, increasing antioxidant enzymes, such as superoxide dismutase and catalase, and increasing antioxidant molecules, such as glutathione [42, 43].

Plant growth-promoting bacteria are crucial for enhancing seed yield, essential oil, thymoquinone, and carvone contents in black cumin, especially, in arid and semiarid regions [44]. For instance, seed treatment with the combination of *Azospirillum*, phosphate-solubilizing bacteria, and *Pseudomonas fluorescens* has been indicated to significantly enhance the yield and yield-attributing characteristics of black cumin [45]. Additionally, the use of these bacteria in the cultivation of black cumin enhances the essential fatty acid content from 52.68% to 57.11%, increases the total polyphenol content from 517.9 to 571.6 $\mu\text{g GAE mL}^{-1}$, and raises the total flavonoids from 1.47 to 1.90 $\mu\text{g GAE mL}^{-1}$ [46].

4 | Utilization of Black Cumin

These days, the fast growth of the global food industry is based on the use of numerous spices to provide flavor and taste. Furthermore, consumers in industrialized countries who are health-conscious are gradually pushing products in this direction by favoring natural colors and flavors derived from plants over synthetic ones [47]. Black cumin was selected as one of the natural herbal seeds because of its diverse medicinal properties and nutritional purposes [48]. In addition to being a helpful element in soup bases, sausages, cheese, cakes, and chocolates, black cumin seed or residue has an aromatic smell and bitter taste [49]. Many cultures and civilizations have utilized black cumin seeds as an herbal remedy to treat and prevent a variety of illnesses. There are significant amounts of unsaturated fatty acids, particularly polyunsaturated fatty acids, in black cumin seed fixed oil [50]. Because of its high protein and carbohydrate content, the black cumin residue is more significant [51].

5 | Traditional Uses

Many civilizations use black cumin as a seasoning in their curries [52]. Black cumin is traditionally used in Ethiopia to treat a variety of illnesses, diseases, and ailments affecting the kidney and liver, immunological system, respiratory system, digestive tract, cardiovascular system, and general well-being [8]. Because they are less expensive, easier to obtain, and with lower adverse effects than manufactured medications, traditional medicinal herbs have drawn a lot of interest. In addition, different religious and cultural traditions dictate the usage of different medicinal flora and their products.

Black cumin is one of the many plants that have been utilized for ages to treat a wide range of illnesses by many human cultures worldwide, particularly among Muslims [53]. In Ethiopia, black cumin production was important and commonly utilized as a spice, medicine for common colds, headaches, diarrhea, and asthma attacks, as well as a means of generating higher income and a higher market price per kilogram than other crops [10]. Dried cumin seeds are ground and utilized in a variety of ways in Ethiopian cuisine. They are used to flavor spiced gravies, such as chili and stews, as well as to give meals a comforting and aromatic touch when added to bread.

Black cumin seed is also important as an ingredient in several pickles and pastries. In addition to being used in tea, coffee, casseroles, and pickles, black cumin is also used as a flavoring ingredient. Blending black cumin with other components can help treat dyspepsia, reflux, obesity, and dyspnea, and improve

breath freshness [52]. Ghee, or semifluid clarified butter, is used to prepare dried cumin seeds and used medicinally in the Ayurvedic medical system. It is utilized both internally and externally on occasion. Also, black cumin is well known for improving breastfeeding, vision, strength, taste perception, appetite, and digestion. Furthermore, black cumin is useful in the treatment of illnesses including edema, vomiting, fever, nausea, abdominal distension, and puerperal problems [54].

6 | Pharmaceutical Importance of Black Cumin

Black cumin has been extensively investigated in recent decades, and research has revealed that it contains a variety of therapeutic qualities and pharmacological activities. Black cumin oil is appropriate as it can be utilized to make formulations that are enhanced with phytochemicals that possess good health-promoting properties [55]. Black cumin oil is a great oil to utilize in pharmaceutical and nutritional applications because it contains active ingredients, such as thymoquinone, tocopherol, and phenolic compounds, which are thought to have positive effects on human health, including antioxidant properties [36]. The essential oil of black cumin is rich in bioactive components, including carvacrol, α -pinene, β -pinene, α -thujene, p-cymene, and longifolene [55]. The oil of black cumin exhibited different biological activities, such as antimicrobial (bacterial, fungal, and parasitic) activity; antioxidant, antidiabetic, antihypertensive, neuro-protective, anti-inflammatory, and analgesic effects; anticancer activity; and effect on male infertility [53, 55].

According to the experiment studied by Thilakarathna & Nawarathna [56], a proximate analysis of Ethiopian black cumin seeds had higher levels of fat and fiber, but Indian black cumin seeds had much higher moisture content, crude protein, and total carbohydrates. A different study revealed some variation in the oil of black cumin from different places, suggesting that the oil has to be standardized [36]. As indicated in Table 1, the mineral composition of black cumin seeds was different between the two countries except for the ash contents. The color of the seeds before and after ornamentation varies significantly, resembling the mineral composition of black cumin cultivated in Ethiopia and India [57]. This variation may be due to the climatic conditions and geographical variations of both countries. Furthermore, this difference is increasing the acceptance of black cumin more widely accepted on international markets.

Additionally, samples that are kept for extended periods are more likely to experience phytochemical degradation as a result of incorrect storage, storage at unfavorable temperatures and humidity levels, and shipment [58]. Another study using proximate analysis of black cumin seeds revealed that the seeds' ash levels (3.7%) and extractable lipid (34.8%) were lower, although their total carbs (33.7%) were slightly higher than those found in earlier reports [59].

As indicated in Table 2, the Indian sample had the highest percentage of acid-insoluble and water-soluble ash (0.63% and 3.89%), followed by the Pakistani (0.48% and 3.68%) and Saudi Arabian (0.27% and 3.40%) black cumin samples from different ecologies. According to these studies, the Indian black seed sample had a high (5.16%) overall ash content followed by Pakistan (4.35%) and Saudi Arabian black cumin (4.16%).

TABLE 1 | Mineral composition discrepancies between black cumin genotypes grown in India and Ethiopia.

No.	Characteristics	Country	
		India (%)	Ethiopia (%)
1	Moisture content	8.13	7.06
2	Crude protein	23.13	20.57
3	Fat	33.03	37.03
4	Fiber	6.03	6.90
5	Total carbohydrate	32.70	31.16
6	Ash	4.00	4.10
7	Dry matter content	98.89	99.76

Note: Source: [56].

7 | Insights Into Conservation

Many studies showed that a conservation strategy must have a comprehensive documentation system that gives all of the necessary information associated with the accession, such as passport information, collection, characterization, and other socioeconomic information for any crops [60]. The Ethiopian Biodiversity Institute is the constitutionally required organization in charge of accessing genetic resources and community knowledge for both commercial and noncommercial purposes [8]. Plant genetic resources (PGR) are the primary natural resources on which humans have relied for survival, and their demand is expected to rise in the future as the population grows [22].

Crop diversification is an important technique for farmers around the world to ensure their sustenance [60]. Farmers have harnessed genetic variety in wild and cultivated plants to create crops that might potentially feed humans while also meeting the needs of a civilized lifestyle [22]. Crop germplasm exploration and collecting operations have been conducted throughout the country at various times [20]. Natural disasters, crop economic importance and diversity, threat level, and, to some extent, national research plans were used to define collection priorities. The majority of collecting missions completed thus far were not crop-specific.

Diversification of crops is one of the world's most important resources, ensuring human food security and well-being. Recognizing the dangers posed by global change, the international community has taken steps to guarantee that crop genetic variety is adequately protected and used sustainably [60]. Since its inception, the Ethiopian Biodiversity Institute has conserved about 87,000 accessions of diverse crops collected from various agroecologies in the country and imported from other countries. Only

307 accessions of the saved crop were black cumin, which was collected from various regions of the country (Table 3).

8 | Sustainable Utilization

Crop diversity conservation and utilization in food and agriculture is becoming more important as a result of climate change, rising food prices, and other environmental issues [60]. There is no denying that items made from plants are in greater demand worldwide. For their medical needs, over 85% of people in the Middle East, Latin America, Africa, and Asia mostly rely on traditional medicine, particularly herbal treatments [61]. Similarly, in the food coloring, cosmetics, pharmaceutical, essential oil derivative, and textile industries, there is currently an increasing demand for organic spices (including black cumin) in Europe, the United States, and Japan [62]. However, in Ethiopia, the major products of black cumin (80%) are consumed locally [62].

9 | Evaluation

9.1 | Strengths

- Availability of germplasm collected from different agroecologies in national gene banks and community seed banks.
- Participatory variety selections in the community seed bank.
- Exporting black seed to foreign countries.
- Acceptance of Ethiopian black seeds on the international market.
- Production of organic seed for good oil quality.
- Characterization of black cumin accessions by research centers and universities.

9.2 | Weaknesses

- Diversity in field crops is currently disappearing at a startling rate. A few genetically homogeneous crop cultivars replacing farmers' varieties, invading species, drought, and climate change are the main challenges to field crop diversity.
- The most productive and versatile black cumin accessions within the particular agroecology were not identified. Because of this, more investigation is required to ascertain which alternate, adaptable, productive, and promising genotypes are ideal for every Ethiopian growing region.
- Researchers must have specialized exposure to postharvest technologies in different regions. The other study topics that

TABLE 2 | The study investigates the variation in ash value among black cumin genotypes grown in Saudi Arabia, Pakistan, and India.

No.	Ash value	Country		
		Saudi Arabia (%)	Pakistan (%)	India (%)
1	Total ash	4.16	4.35	5.16
2	Acid-insoluble ash	0.27	0.48	0.63
3	Water-soluble ash	3.40	3.68	3.89

Note: Source [58].

TABLE 3 | Black cumin accession numbers were collected from different regions of Ethiopia.

No.	Country name	Region name	Amount	Percent (%)
1	Ethiopia	Oromia	176	57.32
2	Ethiopia	Amhara	83	27.04
3	Ethiopia	SNNP	29	9.45
4	Ethiopia	Tigray	10	3.26
5	Ethiopia	Benishangul-Gumuz	4	1.30
6	Ethiopia	Unknown	5	1.63
Total accession				307

Note: Source: <https://ebi.gov.et/biodiversity/conservation/genetic-material-holdings/>.

have not received a thorough analysis on black cumin include studies on soil nutrition and crop protection.

- Inadequate policy framework
- Establishing modern laboratories to conduct quality assessments is also crucial. Lack of planting material has also been a significant barrier to these crop species' increased distribution among farmers.
- It was also critical to prioritize market development for these low-volume, high-value crop species.
- Research findings and information regarding integrated pest management strategies for black cumin are insufficient.
- There is no better technology available, such as management, varieties, IDM, and IPM.
- Limited knowledge of seed and oil extraction techniques.
- Limited germplasm and improved varieties for diverse agroecologies.
- The available technologies for this important crop with significant economic implications are not sufficiently shown or made popular. Critical attention should be paid to emerging problems, such as wilt, which decimated the yield of black cumin.
- Additional collections are needed from all regions to enhance the number of black cumin accessions in the national gene bank.
- Further research is needed with inclusive accession from all areas of the country to evaluate the existence of black cumin genetic diversity.
- A significant obstacle to their large-scale cultivation and improved variety creation is the dearth of information regarding their genetic diversity, intra- and interspecific variability, and genetic linkages among Ethiopian accessions that have been gathered. In order to increase crop quality and breeding, it is vital to make efforts to examine potential untapped genetic diversity.
- From cultivated crops in Ethiopia, black cumin is not commonly cultivated on large-scale farms rather than cultivated on the side of different crops and more cultivated in home gardens. This suggests that the purpose of the black

cumin value chain study is not to increase the producers' desire to grow a single crop on a particular land.

10 | Future Prospects and Research Directions

- The collection from suitable environmental conditions, diverse agroecology, and the development of promising black cumin varieties present an opportunity to expand and multiply available technologies within the nation's suggested agroecologies.
- Black cumin is one of the most important revenue crops for both flavor and therapeutic purposes.
- Future interest in the crop is guaranteed by the extensive application of black cumin in traditional medicine and oriental cooking.
- Increase the formal seed system among farmers.
- Develop integrated pest and disease management (IPM and IDM) system.
- Establish continuous linkage among different stakeholders.
- Private investors should participate in the production and processing of black cumin seeds.
- Black cumin oil and essential oils are recommended for topical antiaging skincare compositions due to their antioxidant, antiaging, antibacterial, anti-inflammatory, anticarcinogenic, antiallergy, and moisturizing properties. However, acceptance of black cumin is on the rise in both traditional and pharmaceutical applications.
- The black cumin extraction and processing of essential oil in Ethiopia are insignificant. Processing and producing essential oil with a quality output will generate income by exporting it to countries outside of the country. As reviewed in several articles nowadays, a huge amount of black cumin is sold to Middle Eastern countries. Exporting oil will generate more revenue than exporting seeds, and it is crucial to assess the oil yield in each accession that has been gathered. In all situations, future perspectives should be directed toward improving agroecology collection, characterization, participatory variety selection, evaluation, and extraction of black cumin oil and essential oils.
- The process of making technology more widely available to users.

11 | Conclusion

Black cumin (*Nigella sativa* L.) is a small seed spice crop that has a significant role in pharmacological, nutritional, and economic purposes worldwide. In Ethiopia, black cumin is a highly valued medicinal plant because the country has a suitable climate and agroecology for producing a variety of food crops. Despite its greater genetic diversity and the increasing demand for their seed and oils, the production and productivity remain underutilization in Ethiopia. The constraints of cultivation include inadequate postharvest technology, limited research findings, and inadequate improved varieties and policy framework. The Ethiopian Biodiversity Institute conserves black cumin's genetic resources, but a comprehensive collection is needed for its

continued cultivation. Resolving these issues through targeted research, new farming techniques, and market development will be critical to realizing the full potential of black cumin in Ethiopia's agricultural environment.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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