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Current Status of Spice Genetic Resources Conservation and Utilization in Ethiopia: A Review

Alemnew Muchie

Ethiopian Biodiversity Institute, Hawassa Biodiversity Center, Hawassa, Ethiopia

Email address:
muchiealex@yahoo.com

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Abstract: Ethiopia is a source country for many spice exports, with a long history of spice. The average land covered by spices is approximately 222,700 ha with production reaching 244,000 tons per year. More than 50 spices are produced in Ethiopia, and a total potential for low land spice framing estimated to be 200,000 hectares. Spices are considered as minor crops their significance for Ethiopia can hardly be overestimated. Around 12 species which is originated Ethiopia or were introduced very long ago and are considered to be of important. The social, economic and technical situation of Ethiopian agriculture has changed drastically, with the introduction of advance cultivars into country genetic erosion is very likely to occur even in the group of minor crops. In addition extensive erosion of genetic resources of indigenous species with destruction of the natural forest and their habit threaten to the resources. Therefore to solve this problems conservation and utilization of spice genetic resources are crucial. Ethiopian biodiversity institute conserved spice germplasm in ex situ conservation such as seed gene bank and Field gene bank. In addition to this farmers also conserve the spice diversity in the Home garden. Ethiopian Biodiversity Institute, since its establishment, has distributed seed samples to various users. Each year, the gene bank dispatch seed samples for local research activities. 75% of the users are research centers; followed by universities (17%), private researchers (6%) and others (0.1%). The tissue culture development has been taken by different research center and university. This review concluded that in Ethiopian different spice are produced under domesticated and natural categories. Building sustainable in terms of plant genetic resources conservation and utilization should be agenda of international as well as national conference, and also farmers should be educated on why they should conserve diversity in home garden. Ex situ conservation should be more focused on complementing in-situ conservation through in the genetic diversity of very rare species can be better understood.

Keywords: Spices, Genetic Resources, Conservation, Utilization, In Situ Conservation, Ex Situ Conservation

1. Introduction

1.1. Spice in Ethiopia

A spice is a dried seed, fruit, root, bark or vegetative substance used in nutritionally insignificant quantities as a food additive for the purpose of flavouring, and sometimes as a preservative by killing or preventing the growth of harmful bacteria [1]. Spices can be defined as 'vegetables products used for flavouring, seasoning and imparting aroma in foods' [2]. Ethiopia is a source country for many spice exports, with a long history of spice. The average land covered by spices is approximately 222,700 ha with production reaching 244,000 tons per year. More than 50 spices are produced in Ethiopia, and a total potential for low land spice framing estimated to be 200,000 hectares [3].

In Ethiopia, the production and use of spices is perhaps the most romantic story of any plant product, legendarily known to go back to the times of Queen of Sheba. Studies showed that, spice crop such as Korarima cardamom, Ethiopia long pepper, black cumin, bishop's weed, coriander, thyme and fenugreek are also attached to Ethiopia either as a center of orgin or diversity. Spices in Ethiopia are also many things and the role they played could be viewed proportional to the level of their utilization. For centuries, they have been used

as one of the major livelihoods and life-giving foods of both the rural and urban populations. Besides, since most of them are labor intensive, small in bulk and so cheap to transport, of high value per unit, they present a special opportunity to hasten both rural and urban development [4].

Spices have major stake in the production system in the foreign earning of the country. Spices have great role in transforming farmers as producers for market instead of producing merely for subsistence [5]. Spices are important additive to Ethiopian dishes. The production and use of spices in Ethiopia go back to time immemorial. Ethiopia has become one of the largest consumers of spices in Africa. People use to flavour bread, butter, meat, soups, and vegetables. They also use spices to make medicines and perfumes [6]. Ethiopia also a homeland for many spices, such as Korarima (*Aframonum korarima),* long red pepper, balck cumin, White cumin/bishops weed, coriander, fenugreek, turmeric, sage, cinnamon and ginger [6].

The diverse agro ecology in Ethiopia supports growing a wide variety of crops in general and spices crops in particular. Thus, the country hosts several indigenous common and exotic spice crops, which are cultivated widely since time immemorial. Spice crops are produced in various regions in of the country and predominantly by small holder farmers as a cash crop traded primarily in domestic markets, but with increasing success also entering foreign markets. The spice sub-sector has an immense potential for economic development and poverty production through creation and expansion of employment opportunities and distribution of income and foreign exchange earnings. [6]

1.2. Spice Genetic Resources in Ethiopia

Although spices are considered as minor crops their significance for Ethiopia can hardly be overestimated. Spices are needed every day in considerable amounts for the preparation of the main dish of the day [7].

Most of the spices needed in Ethiopia are grown as field or garden crops, although some grow in the wild. Classical spices are also used but have to be imported, mainly from India. The following 12 spices, which originated in Ethiopia or were introduced very long ago and are considered to be of importance, mention below the table 1.

Table 1. *Lists of Spice germplasm in Ethiopian.*

S.N	Botanical Name	Common Name	Amharic Name
1.	*Capsicum annuum*	red pepper	berbere
2.	*Trigonella foenum-graecum*	fenugreek	abish
3.	*Nigella sativa*	black cumin	tikur azmud
4.	*Trachyspermum ammi*	Ethiopian caraway	nech azmud
5.	*Coriandrum sativum*	coriander	dimbilal
6.	*Aframomum korarima*	false cardamom	korarima
7.	*Cuminum cyminum*	cumin	kamun
8.	*Foeniculum vulgare*	fenne	-
9.	*Pimpinella anisum*	anise	insilal
10	*Ruta chalepensis*	rue	tena-addam
11	*Ocimum basilicum*	basil	basobila
12	*Piper longum*	Indian long pepper	timiz

Source (Goettsch, 2009).

In a broader sense Shallots (Allium Cepa) and garlic (A. Sativum) can be considered as spices. They were introduced very long ago and recently genetic erosion has started in areas where improved varieties are coming into use. Nevertheless, since the two species can be regarded as both spice and vegetables, the latter use being the more important, they are not treated her. [7]

As mentioned earlier spices play a very significant role in the daily food preparation of Ethiopia. So far, small scale production or harvesting of wild plants has been sufficient to satisfy the demand of the people. It is only very recently that the social, economic and technical situation of Ethiopian agriculture has changed drastically, with the introduction of improved farming methods, the destruction of natural habitats and the introduction of advanced cultivars into country, genetic erosion is very likely to occur even in the group of minor crops. [7]

Species of spices which still also exist as wild types often show remarkable degrees of disease resistance. For example, a severe attack of an unidentified fungal disease was observed in cultivated fennel but did not attack wild plants [8]. Thus the collection of wild germplasm and its careful screening afterwards should go hand in hand.

In addition Extensive erosion of genetic resources of indigenous species with destruction of the natural forest and their habit threaten to the resources [9]. Ginger due to bacteria wilt disease which spread throughout the country in 2014, production level are expected to decrease from 92,000 MT in 2013 to only a few hundred MT in 2015 [10]. The incidence of ginger bacterial wilt disease because of Ralstonia solanaceurum in 2011/12 has been devastating to ginger in the country and almost all ginger producing areas had been affected by the disease and production reduced by more than 90 percent [11].

According to the survey results conducted in 2012, the wilt incidence in some of the survey areas such as Sheka zone was 93.5% [12]. Turmeric production in Ethiopia mainly concentrated at southeast part of the country (Sheka, benchmaji and keffa zones) however, recently major ginger producing areas including Wolayta zone shifts the land to turmeric production because of ginger bacterial wilt and good demand for turmeric.

Ethiopia grow more than 60 varieties of Spices out of the 109 spice types of grown globally that are listed by the ISO or the international standard organization for standardization. Currently, Chilli Capsicum, and black pepper are traded largely and account for more than 44% of the global market which is 16 billion USD. This is a huge potential [13].

This paper reviewed and summarized the current status of spice genetic resources conservation and utilization in Ethiopia.

2. Current Status of Spice Genetic Resource Conservation in Ethiopia

2.1. Need for Conservation Plant Genetic Resources

Through there is growing realization, that plant biodiversity is fundamental for agricultural production and food security, as well as valuable ingredient of ecological stability. However, plant genetic resources associated with agricultural and food production is being eroded and disappearing throughout the world due to development change. These changes jeopardise productivity, threaten food security and result in high losses related to this, and equally alarming, is the loss of biodiversity in 'natural' habitats with expansion of agriculture production into new frontiers. [14]

Korarima and long pepper exist both under cultivation and in the wild states. However, the bulk of the product comes from the natural forests in the south and south western parts of the country where coffee grows. Farmers collect these spices from these forests and sale at the local market. These days, however, the destruction of the natural forests for various uses has significantly reduced the diversity of these shade obligate spice [15] Therefore, Genebanks play a major role in the conservation of germplasm, considering the potential value in facilitating their sustainable use in increasing food production and development in the present and future. [14]

Germplasm conservation provides multiple benefits:-

1) Increase productivity and food security (and consequence economic return).
2) Reduce pressure of agricultural of fragile areas, forests and endangered species.
3) Build stability, robustness, and sustainability of farming systems.
4) Contribute to sound pest and disease management and sustainable intensification.
5) Diversity products and income opportunities from farms.
6) Reduce/spread risks to individuals, communities, and nations.
7) Help maximise effective use of the resources and environment (restore ecological health).
8) Reduce dependency on external inputs.
9) Increase nutritional values, and provide sources of medicine and vitamins.

In addition, the genetic diversity provides building blocks for further genetic improvement of crop and other economical important species to increase productivity and their use in food security and overall economic and social sustainable development alleviating poverty [14].

2.2. Conservation Strategies

Based on the place, size of sample, nature and breeding behaviour of species and the objective of conservation, the conservation strategies can be broadly classified in to two: In situ conservation and Ex situ conservation. [14]

In situ conservation is defined as conservation of ecosystem and natural habitats, the maintenance of viable populations of the species in their natural surroundings and, in the case of the cultivated species, in the surroundings and, in the case of cultivated species, in the surroundings and in the case of the cultivated species, in the surrounding where they have developed their distinctive properties. In situ conservation can be done in farms' fields, in pasture lands, and in protected areas [16]. In situ conservation includes Biosphere reserves, on farm management, Home garden, National parks,

Ex situ conservation is a technique of conservation of biological diversity outside its natural habitats, targeting all levels of biodiversity such as genetic, species, and ecosystem [17-19]. Its concepts was developed earlier before its official adoption under the convention on Biological Diversity signed in 1992 in Riode janeiro [18]. In general ex situ conservation is applied as an additional measure to supplement in situ conservation, which refers to conservation of biological diversity in its natural habitats [19]. Ex situ conservation include Seed Gene bank, Field gene bank, tissue culture, Cryobank and DNA library DNA bank.

2.3. Current Status of Spice Germplasm Conservation in Ethiopia

2.3.1. Ex Situ Conservation

(i). Seed Gene Bank

Systematic crop germplasm exploration and collection operations have been undertaken throughout the country at different times. Collection priorities were set based on factors such as natural disasters, economic importance of the crop and its diversity, the level of threat and to some extent the national research priorities. Most collection missions conducted so far were non-crop specific. (IBC). A major inventory on the genebank's holding and associated information has been carried out in 2010. The current holding of the genebank is 68,014 accessions (increased by 13% in the past 5 years (Table 2).

Table 2. *Spice Germplasm holding of the genebank and their distribution.*

Crop type	Total holding (Accessions)	Number of Sample distributed	Reference
Onion Shallot	140		
Hotpepper	493	125	[16]/Sample distributed
Nechazmud	56		
Coriander	245	109	[16]/Sample distributed
Cumin	16		
Fennel	1		
Fenugreek	880	3524	[16]/Sample distributed/
Black cumin	303	50	[16]/Sample distributed
Basil	114		
Total	2,604	3,808	[16]/Sample distributed

/Source EBI from Database/

(ii). Field Gene Bank

The institute has established field gene banks in different agro-ecological zones of the country as part of the ex situ conservation program meant to especially conserve vegetative propagated species and species with recalcitrant types of seed. Over 6,704 accessions of coffee, spices, root and tuber crops, medicinal plants and forage species are being conserved in the field gene banks [20]. (Table 3).

Table 3. *Numbers of accessions conserved in the field gene banks.*

Field genebank	Size of the area (ha)	Type of species	Type of spice	Number of accessions
Choche	21	Spice		
			Turmeric	76
			Ginger	178
			Long pepper	22
			Korarima	169
			Pepper	57
			cardomomum	1
			Total	503

Source: Ethiopian Biodiversity Institute (EBI) Database.

(iii). Tissue Culture Biotechnology in Ethiopia

Plant tissue culture is currently a powerful tool that plays a major role in fast commercial production and propagation of new plant which are genetically uniform (true to type) and free from any disease through in vitro technique on continuous year rounded basis [21]. Plant tissue culture offers an alternative sources of the conservation of endangered genotypes. It is also used for development of douple hploid line for crop improvement [22]. Micropropagation trough invitro geremination of seed is a vital for cryopeservation of endangered multi purpose plants [23].

In 2000, a more comprehensive and concerted emphasis was given for a protocol of optimization for mass propagation, disease cleansing and invitro conservation of economically important crop species. The major achievements from these works include the distribution of large number tissue plants to farmers in various parts of the country (see Table 4).

Table 4. *Overview of plant tissue culture protocols development for important spice crops in Ethiopia.*

Centres	Common and Botanical Name	Explant Used	Main Purpose	References
JARC	Ginger (*Zingiber officinale*)	Shoot tips	Micropropagation, Virus cleaning	[24]
JU	Hot Pepper (*Capsicum annuum* L.)	Node	Micropropagation	[25]
JARC	Korarima (*Aframomum corrorima*)	Shoot tips	Micropropagation,	[26]
EIAR	Black pepper	Shoot tip	Micropropagation	[27]
EIAR	Cardomom	Rhizome lateral bud	Micropropagation	[27]
EIAR	Garlic	Shoot tip	Micropropagation	[27]
EIAR	Ginger	Rhizome lateral bud	Micropropagation	[27]
EIAR	Cardamon aframomum	Rhizome lateral bud	Micropropagation	[27]

JARC= Jimma Agricultural Research, JU=Jimma University). EIAR=Ethiopia Institute of Agriculture Research.

(iv). DNA Bank

Genome resource banking is another management technique used for biodiversity conservation. Different types of gene banks have been established for the storage of biodiversity, depending on the type of materials conserved. The principal aim of gene bank conservation is to maintain genetic diversity alive as long as possible and to reduce the frequency of regeneration that may cause the loss of genetic diversity [28]. With the rapid development in the field of

molecular genetics and genomics, DNA is becoming more and more in demand for molecular studies and is one of the most requested materials from gene banks. Establishing DNA storage facility as a complementary "backup" to traditional *ex situ* collections has been suggested [28].

(v). Cryopreservation

The other genome conservation technique is cryopreservation, in which living tissues are conserved at very low temperatures (−196°C) in liquid nitrogen to arrest mitotic and metabolic activities [28]. It is now realized that cryopreservation method can offer greater security for long-term, cost effective conservation of plant genetic resources, including orthodox seeds [28]. The storage in liquid nitrogen clearly prolonged shelf life of lettuce seeds with half-lives projected as 500 and 3400 years for fresh lettuce seeds stored in the vapor and liquid phases of liquid nitrogen, respectively [28].

2.3.2. In Situ Conservation

In situ conservation is demands the establishment of nature or biosphere reserves, national parks, or special legislation to protect endangered species. [29] Defined it as the conservation of ecosystem and natural habitats, and the maintenance and recovery of viable population of species in their natural habitats or where they have developed their distinctive properties.

Homegardens

Homegarden plays a vital role for the livelihood of the people living in town. Homegarden agrobiodiversity was studied to highlight homegarden frequency, types, plant species, and growth form and associated indigenous knowledge. Homegardens are important in the conservation of useful plant species since they contain very large numbers of species which are often absent or disappearing from other production systems [29]. Homegardens also provide a wide range of ecological benefits and services and a valuable set of products for the rural poor [29]. Homegardens provide people with supplementary food, fuel and fodder [30]. They are used to grow medicinal, spice, ornamental and stimulant plants [31]. Homegardens are widely spread in the tropical and subtropical regions of Asia [32], Africa [33] and Central and South America [34] Ethiopia is one of the eight world centers of origin and diversity of agricultural products [35] which is partly the result of *in situ* conservation of plants traditionally grown in homegardens [35, 36]. However, homegardens are currently threatened mainly due to genetic erosion, loss of traditional knowledge of different management practices, man-made habitat changes, and drought [37, 38].

Abebayehu [39] of the recorded plant species (125) in the plots of the sample homegardnes 9 (72%) spices and 23 (18.4%) medicinal plant. [40] Surveyed homegarden a total of 258 useful plant species were observed from this 15 (5.8%) was spices plant species and 41 (15,89%) medicinal plants. [31] of the recorded plant species (214) in the plots of the sampled 100 home gardens, about 43 spices were recorded with 13 use in and around home gardens. [41] study, *Catha edulis, Rosmarinus officinalis* and *Rhamnus prinoides* were the preferred marketable plants in the Sebeta-Awas area. [42] Out of 112 plant species identified in the study area, 43 species distributed among 36 genera and 17 families were documented as food plants which accounted for 41.07% of the total. Among these, 45.50% were fruits, 30.23% vegetables, 13.95% pulses & cereals, 10.32% tubers and roots and 4% were spices.

3. Current Status of Utilization Spice Genetic Resources

3.1. Utilization of Conserved Plant Genetic Resources

IBC is distributing germplasms mainly to agricultural centers to be used for national breding programms. Researchers and students in higher learning institution also utilize the plant genetic resources already collected and conserved at the genebank for their research and study objectives. Though well characterized materials save both energy and money for the users, so far evaluation of the germplasm for desirable traits (specific biotic and abiotic stress) is not extensively conducted by IBC. Besides, researchers/users who accessed germplasm rarely give feedback to IBC. Hence information on the genetic materials' yield potential, agronomic performance, stress, pest and disease resistances etc are lacking.

IBC, since its establishment, has distributed seed samples to various users. Each year, the genebank dispatch seed samples for local research activities. 75% of the users are research centers, followed by universities (17%), private researchers (6%) and others (0.1%). Though the majority of these samples are requested by agricultural research centers, there is no mechanism to monitor the contribution of the accessions to the national crop breeding programs. Upon formal request and agreement, germplasms can also be distributed to international research centres such as the International Centre for Agricultural Research in the Dry Areas (ICARDA) and International Crop Research Institute for Semi−Arid Tropics (ICRISAT) [20].

3.2. Spices Research Achievements

National spices research team of Ethiopia, with limited capacity achieved several results on germplasm enhancement, crop management, post-harvest handling and quality management on spices. Lowland spices and highland seed spices were given special research attention. Performances of most of these spices were proved promising in yield and quality. From evaluation, two black pepper, two ginger, one cardamom, one turmeric, one vanilla, three black cumin, three coriander and three fenugreek varieties had been registered or released and promoted to their respective agro ecologies. The average yield of lowland spices was proved promising as presented in table (Tables 5&6) while yield of seed spices such as black cumin, coriander and fenugreek ranged from 1.5 to 1.7t/ha. Quality parameters were also

promising except in turmeric, cardamom and vanilla that require further improvement.

Table 5. *Spice accessions in National Spice research.*

Name		Numberof of Accessions	Varieties Released	References
Common	**Scientific**			
Black pepper	*Piper nigrum* L.	13	Gacheb Tato	
Ginger	*Zingeber officinale Rosc*	92	Yali Boziab	
Cardamom	*Elettaria cardamomum*	3	Gene	[43]
Turmeric	*Curcuma domestica*	8	Dame	
Vanilla	*Vanilla planifolia*	4	YEKI-1	
Korarima	*Aframomum corrorima*	71	Pipeline	
Long pepper	*Piper capense*	20	Pipeline	

(Source: Edossa, 1998b).

Several improved technology had been generated and distributed to different agro ecologies of the country. These include improved varieties, suitable agronomic practice, drying or processing techniques, packaging techniques and quality standards. The suitable climatic conditions for the production of these invaluable spices in the country are the other opportunity to be further exploited by smallholder farmers and private sector. [44]

Table 6. *List of Recommended Spice.*

List of Species	Propagation Method	Requirement (shade/support)	Commercial product	Yield (t/ha)	References
Black pepper	Cutting	Support	Fruits/berries	2.4 (dry)	
Ginger	Rhizomes	Open sun	Rhizomes	19.6 (fresh)	
Cardamom	Seed (capsule)	Shade	Capsules	0.16 (dry)	
Turmeric	Rhizomes	Open sun, intercrop shade	Rhizomes	23 (fresh)	
Vanilla	Cutting	Support, shade	Pods		[45, 46]
Black cumin	Seed		Seed	1.5 (dry)	
Coriander	Seed (capsule)		Seed	1.7 (dry)	
Fenugreek	Seed		Seed	1.5 (dry)	
Garlic	Bulb		bulb	9.8 (fresh marketable	
Hot pepper (chili)	Seed		Pod	2.1. (dry)	

(Source: Edossaa, 1998b, Girma etal, 2008).

Turmeric (Curcuma longa.) is One of exported spice in Ethiopia, Southwest Ethiopia produce this spice as a cash crop and many lively hood had been depend on it for a living. India is the world biggest exporter and producers of turmeric, whereas, Ethiopia is the biggest exporters and producers of turmeric in Africa [47].

Having only one variety of turmeric nowadays is very dangerous as the outbreak of disease and challenging environment become a treat for our varieties. Always it is advantageous to have more than one variety so that these trials at least get a choice if this treats happen because of their different genetic makeup. And also currently there is a high demand of turmeric from different stake holders as its importance in local and international market is increasing and it has been long time since the current variety registered. So for satisfying the increasing demands as this varieties have better yield advantage and to have a very recent variety it is important to have additional variety. The result of Turmeric variety Trial showed that two genotypes HT3/2002 and BONGA (51/71) are identified have been promising and evaluated by variety evaluating committee for official release. [48]

4. Conclusion

Spice is one of the most important crops for Ethiopia. In Ethiopia different spices are produced under domesticated and natural categories. Building sustainability in terms of plant genetic resource conservation and utilization should be on the agenda of international as well as national conferences. There is need to improve conservation science to impact on monitoring erosion, vulnerability and developing indicators of diversity can guide against extinction and promote utilization. More so, strengthening local capacity to undertake collective action may thus allow farmers and communities to maintain greater genetic resource diversity. Knowledge of eco-geographic factors combined with the analysis of diversity patterns can support the identification of useful traits among lines present in large collections thus enhancing their utilization. Most farmers produce spice under homegarden. Farmers should be educated on why they should maintain diversity. The compilation, documentation and interpretation of data on the current status of the endemic flora and its habitats should be

accorded priority. Ex-situ conservation should be more focused on complementing in-situ conservation through it the genetic diversity of very rare species can be better understood.

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