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Review

Enset a drought-tolerant and food-secure crop: the role of local farmers in managing and conserving its genetic resources

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Abstract
Enset is a significant source of food and a multipurpose crop that is consumed by about 25 million people as a staple or co-staple food crop, mainly in the central, south, and southwest parts of Ethiopia. It grows in different regions of Ethiopia, with a wide range of altitudes and agro-climatic zones. However, limited studies are available on the role of local farmers in the farming system, traditional practices, management, and conservation approaches. Hence, this paper aims to assess the farmers' Indigenous knowledge of enset, covering the local identification system in tandem with the assessments of management approaches to conserve its genetic resources for the sustainable uses of the enset crop for food security and nutritional value. Available literatures have been gathered and reviewed. Farmers have time-honored experiences and practices in cultivation, use, and conservation of a variety of enset landraces to satisfy their needs on the domestic and market fronts in each enset growing region. To distinguish one enset landrace from others, farmers provide local names based on the morphological traits, place of origin, agronomic features, and quality attributes of their products, which also indicate their uniqueness. To sustainably utilize and maintain enset genetic resources, farmers require support from various stakeholders in crop improvement programmes and conservation strategies, which enhances Ethiopia's sustained food security.

Keywords Food crop · Local farmers · Local name · Management practice · Sustainable use

1 Introduction

Enset [*Ensete ventricosum* (Welw.) Cheesman] is a staple or co-staple food security crop for over 25 million Ethiopians [1]. Ethiopia is one of the eight agricultural gene centers [2, 3] and the primary center of origin and diversity for many plant species, including enset [3–5]. The enset crop domestication, perhaps date back as far as 10,000 years ago [6] but its cultivation and utilization as human food are restricted to Ethiopia [7]. In addition to human food, it is employed for many other purposes, including traditional medicine, animal feed, fiber production, and construction materials [8].

Enset is a crop with a wide range of altitudinal adaptability and agro-ecological distribution [9, 10]. This crop can be harvested at any time of the year, from 3 to 12 years; however, it is often done 4–6 years after transplantation [1, 11, 12]. Enset requires considerable lower inputs and management than cereals and provides the highest materials/products per hectare [13–15]. Thus it offers farmers' and their families' food security. This was clear in the Ethiopian famine of 1888–1892 and the 1980s [16, 17], which highlighted the importance of preserving qocho, a staple food, by harvesting mature enset from the same farm over several years, allowing for staggered harvesting. Motivating why enset is known as "The Tree Against Hunger" by its growers and consumers [7]. The edible portions of the enset are the corm

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(underground stem) and pseudostem after being pulverized and fermented into *kocho* (*qocho)* and *bulla,* and fresh or unfermented *amicho* (cooked corm) foods [18]. *Kocho* keeps well in storage for extended periods [7, 19]. The corm of the enset is usually harvested at the young stages of the crop, and it can be prepared and consumed similarly to other roots and tubers [12, 20, 21].

Concerns about food security systems and other issues must be addressed by conserving plant diversity and using it responsibly [22, 23]. According to Gupta et al. [24], the protection of plant diversity is crucial for safeguarding crops in the future since biotic and abiotic stressors are becoming more and more problematic. The enset-based farming approach is an indigenous and sustainable farming system in Ethiopia, defined by the production of enset as the primary staple or as a co-staple with other crops [25], where more than 45 ethnic groups in Ethiopia, practice and use it for food and other household purposes [7, 8, 26]. Thus, for these communities, this unifying crop [27] is valued not only as a food source, feed, and cash income but also considered as part of the people's social, and cultural heritages that symbolizes nature's benefits to communities that care for it [15, 21, 28–31].

Farmers who cultivate enset have preserved and enhanced the crop's diversity by employing their accumulated indigenous knowledge through identification and selection [8, 30], and according to them, the use of enset diversity is closely related to the many ways of generating its end-products that are applied for both food and non-food purposes [31]. This implies that farmers to be the principal conservationists of the enset diversity. Enset exhibits discernible differences in its morphological, agronomic, and use values [8, 15, 21, 29, 30, 32].

It is obvious that farmers cultivate enset mainly as staple or co-staple crops; thus, it ensures food security for millions of people, particularly those inhabiting the central, south, and southwest parts of Ethiopia. It also serves several virtues, which include animal fodder, traditional medicine for humans and cattle, socio-economic importance, as well as cultural values. Enset diversity offers food security and resilience in the face of unfavorable environmental conditions. The key factors in conserving its genetic resources include small-scale farmers their association with their cultural heritages, through their indigenous knowledge and accumulated experiences over the years and many generations.

Considering the possibility of extending production and consumption to other regions of the country and globe, it has attracted more attention recently. The enset-based farming method appears to be becoming more and more understood, though it still has a lot of challenges. The main challenges originate from a lack of understanding referring to the diverse indigenous farming practices, on-farm diversity, crop pathogens, and the crop's long growth cycle. Hence, farmers' local knowledge and management methods, and preservation practices of enset landrace diversity in various ethno-linguistic communities is essential for the sustainable utilization and on-farm conservation of its genetic resources as well as future crop improvement. Moreover, morphological identification and research on the nutritional profile of such diverse and multipurpose landraces is therefore essential for local and regional consumption. Thus, this review paper aimed to document indigenous farmers' knowledge and practices for maintaining enset diversity for food security and assessing the nutritional content of enset landraces.

2 On-farm diversity of enset

Conservation and maintenance of landraces is an essential element of the socio-cultural heritage of a region or country [33]. Understanding the value of a landrace is necessary prior to settling on any conservation approach and its use thereof play a crucial part in promoting its on-farm conservation [34]. On-farm maintenance of plant diversity can reduce risk, stabilize yields, encourage dietary diversity, and maximize profits by employing low levels of technology and scarce resources [35]. Diversity in plants provides an opportunity for plant breeders to develop new and improved varieties with desired characteristics, including traits favoured by farmers (potential for yields) and breeders (resistance to pests and diseases) [36]. Biodiversity offers ways of coping with the uncertainty of changing environments [37]. Thus, the diversity of different species is also maintained by local farmers for cultural, socio-economic, and aesthetic values [38].

Farmers' practices are thought to have a major impact on shaping the genetic structure and evolutionary history of crops in traditional farming systems such as the enset-planting complex [15], and they have maintained the diversity of enset landraces for many generations with little external influences on their home-gardens, almost purely based on indigenous knowledge and skills. Previous studies have shown that Ethiopia is home to a vast diversity of enset landraces [8, 11, 12, 17, 31, 39]. Farmers preserve enset landraces diversity in their home-gardens by exchanging, sharing, and purchasing seedlings for cultivation, thereby continuing to diversify it [21, 40]. According to Maxted et al. [41], on-farm preservation tradition has been indicated as a one of the most suitable approaches for conserving crop genetic resources. Thus, on-farm conservation balances *ex-situ* preservation and it supports and encourages continuing crop evolution while

sustaining ongoing indigenous knowledge schemes related to genetic resources [42]. Moreover, on-farm conservation allows the sustainable preservation of landraces to grow under natural circumstances [15].

Farmers are the primary custodians of enset landraces diversity in Ethiopia. Previous studies have shown that farmers-maintained hundreds of different enset varieties in various growing areas or regions (Table 1). However, it must be noted that the criteria used in enset landrace identification and research intensity or area and culture covered may vary from researcher to researcher.

The on-farm diversity of enset landraces is not distributed evenly, with a small proportion of highly abundant landraces cultivated over wider areas than the majority of moderately frequent or rare landraces [40, 46]. Enset landraces, particularly those with characteristics of better quality and quantity of end-products, are widespread both within and among zones [31]. Furthermore, some enset landraces are maintained more for their traditional medicinal purposes than for food or other purposes [21, 45, 49]. This shows that abundance and utilization of enset are positively correlated, which indicates that enset farmers have established their method of choosing and characterizing landraces with some minor variations depending on their traditions and cultures in terms of use, patterns and values.

3 Farmers management practices to conserve enset genetic resources

Indigenous knowledge is the experience developed over years through practices over generations and is the common resource of the indigenous communities, which is transferred verbally as well as through practices [50]. Over time, each individual in the community contributes to this indigenous knowledge. Farmers have a great deal of experience in assessing, maintaining, and managing their important crops in the traditional agricultural system [51], and they are also linked with these long-term practices for various economic, social, cultural, and religious events [52].

Local farmers' contributions to genetic resource conservation are crucial since they help to ensure food security, livelihoods, and agricultural diversity [53]. Farmers' extensive knowledge of enset, gathered over many years, is important for characterizing and maintaining the existing genetic variety of this crop [54]. In an indigenous agricultural system like the enset cultivation complex, farmers' experiences are believed to play an important role in modeling the genetic structure of enset crops and their evolution [15], in which local farmers had constrained access to farming inputs such as pesticides and fertilizers and relied on a wide range of infra-specific diversity to mitigate the risk of crop failure caused by climate whims, diseases, pests, and low soil fertility [55]. Local farmers possess the ability to discern their enset landraces with clarity via agromorphological features, phenological properties, post-harvest features, and varying adaptation performances under biotic and abiotic stresses [31, 56]. Tsegaye and Struik [12], Birmeta [17], and Yemataw et al. [31] found genetic diversity in enset that has been cultivated in a particular area, which appears to be related to the amount of enset cultivation, the culture, and the management patterns of the various ethnic groups. They also identified a large

Table 1 Major enset growing areas and number of documented landraces

Study areas (zone, *woreda*)	Number of Enset landrace	References
Ari (South Omo)	76	[43]
Wolaita, Gamo, Dawro, and Goffa	158	[44]
Keffa and Sheka	146	[8]
Sidama, Hadiya, and Wolaita	166	[12]
Sidama	79	[29]
Keffa	42	[45]
Sidama, Dawro, Gamo, Gurage, Goffa, Hadiya, Kembata-Tembaro, and Wolaita	218	[46]
Silte, Sidama, Dawro, Gamo, Gurage, Goffa, Hadiya, Kembata-Tembaro, and Wolaita	218	[39]
Wolaita	67	[30]
Kembata-Tembaro	111	[47]
Sidama, Dawro, Silte, Gedeo, Gurage, Hadiya, Kembata-Tembaro, and Wolaita	312	[31]
Yem	93	[48]
Sheka	91	[15]
Hadiya, Kembata, Gurage and Silte	282	[40]
Hadiya	99	[21]

number of local farmers' landraces of enset from major growing regions. Furthermore, they have names for them, and it is believed that various landraces have distinct adaptations to various soil types, cultivating times, maturation dates, plant heights, nutritional values, uses, and other characteristics [51].

Farmers give local names to plants according to their opinions through the ethnobotanical naming system, also known as folklore nomenclature. These names are a result of people's willingness to communicate verbally clearly and to discern between various plant species [57]. Given that communities and groups regularly build ethnobotanical names and classification systems in response to their surroundings, these systems are continuously passed down from generation to generation [15]. The local names for plants and animals are the source of indigenous biodiversity knowledge [57].

Various prior studies have indicated that many landraces are cultivated in the homegardens of different enset growing areas [8, 12, 46]. Since no single landrace can satisfy every requirement [32], farmers are able to identify their landraces with clarity based on physical and internal features as well as use values. Thus, each enset landrace has its own local name that is evenly distributed throughout the area where the same language is spoken [58]. The local names also help to distinguish between different plant species [57]. It is widely accepted that for millennia, traditional farmers have used their indigenous knowledge to classify, name, and group their crop types in order to preserve the genetic variety of those crops on the farm [15, 30, 58]. Different communities may have various folk classification systems. They classify plants mainly based on local language, production practices, social customs, legends, economic utilization, morphological characteristics, and growth habits, which have very important economic and functional values [15].

Different enset landraces are consistently cultivated by farmers in the different regions to preserve the diversity of landraces on the farm and to balance the harvest of enset for various uses throughout the year [21, 54]. Farmers typically go through three successive phases of cultivation: vegetative propagation, transplanting, and harvesting (Fig. 1). Compared to specific-use landraces, multipurpose enset landraces were typically more cultivated and highly chosen [31]. Nonetheless, in certain circumstances, there were slight variations among the regions or zones regarding the perceptions of end-product users [40]. However, commonly enset-growers provide more attention and protection for the medicinal enset landraces than others [8, 45, 47, 59].

4 Enset as a food security crop

Food and nutrition insecurity has been a serious problem in sub-Saharan Africa due to climatic extremes and other factors [60], and periodic droughts are not a recent occurrence in the Horn of Africa [61]. Therefore, it has been suggested that, in order to combat food insecurity and malnutrition, diet diversification and the search for alternate food sources be undertaken [60]. In many regions of the world, especially in developing nations, plant-based products serve as the primary source of food for humans [62]. Enset in central, south, and southwest parts of Ethiopia is an indigenous agrisystem that may have developed characteristics that offer resilience techniques to handle environmental change and mitigate food insecurity [63, 64]. Hence, enset-based agriculture is a good illustration of a local agricultural system that has reportedly been adapted to withstand climate change [7, 13, 25].

There are areas of Ethiopia that experience droughts and other natural disasters in different years, which contributes to a growing number of undernourished people and food insecurity [65]. Nonetheless, the area where enset is the primary crop is characterized by a low frequency of droughts and a high population density per hectare [7, 65]. Enset food products are rich in carbohydrates and mineral sources [13, 18, 66]; however, their nutrient contents differ among the landraces [18, 20, 67].

Enset farming is a direct strategy for assisting individuals in achieving independent livelihood security [9], and for the more than 25 million residents in the central, southern, and southwestern mid and highlands of Ethiopia, it is a major staple crop [1, 31]. Many people are living in the area where enset is the primary food source, which cannot be supported by any other type of land use in Ethiopia [12, 26]. In the same manner, Pijls et al. [13], and Tsegaye and Struik [12] indicated that enset has a relatively high yield when compared to the yields of other food crops.

Enset may be harvested all year round, thus ensuring a constant supply of nourishment. The major food types from enset are *qocho* (prepared through fermentation), *bulla* (produced through extraction), and *amicho* (boiled corm) (Fig. 2). Its abundant, relatively cheap, and long-term storable carbohydrates are important for Ethiopia, where 25–35% of the population is undernourished [66].

Studies revealed that different community groups in their regions or administrative zones in Ethiopia have maintained and utilized many enset landraces [12, 15, 31, 68]. For particular uses, specific landraces are recommended by enset growers.

Fig. 1 Different stages of enset in enset cultivation system; **A** corm ready for propagation, **B** suckers, **C** and **D** transplanted enset at different stages, **E** and **F** harvesting stages

The majority of enset landraces are grown primarily for their *qocho*, or *bulla*, which can be processed through fermentation, but certain others are grown mainly for their *amicho,* or cooked corm [12, 18, 31, 40, 67]**.** *Amicho* is a fresh or unfermented type of enset product that is prepared from the young or immature enset plant corm and is cooked before eating like many other root and tuber crops [1, 12]. It can be uprooted and utilized as food at any point in the plant's growth, making it a reliable supply [20, 69]. In addition, in the central, southern, and southwestern regions of Ethiopia, corms of certain enset landraces are regarded as having traditional medicinal benefits for a variety of ailments in both people and cattle [8, 40, 45, 49].

5 Nutritional contents of enset food products

The nutritional value of food must be taken into account to maintain human health and well-being as well as to address the issue of deep-rooted malnutrition [70]. Previous studies [13, 18, 20] have suggested that enset products are good sources of minerals and carbohydrates (Tables 2 and 3). However, the production and nutrient content of enset varies according to the variety of landraces, age of the plants, management system, and environmental conditions [18, 66, 67].

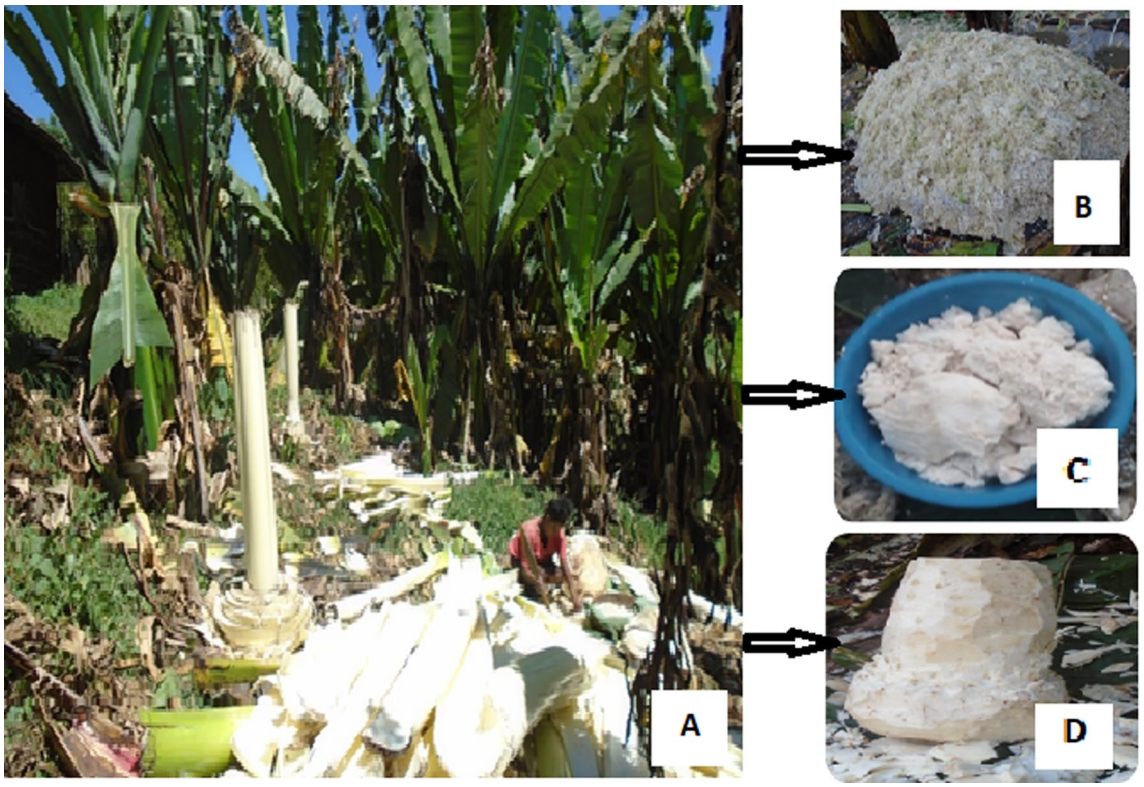

Fig. 2 Harvesting process and the primary food products of enset; **A** Enset with detached pseudostem which is ready for scraping, **B** unfermented *qocho*, **C** *bulla*, **D** trimmed corm (Pictures collected by author)

The nutritional compositions of the three primary enset food products vary, and it has been a topic of very few study publications.

5.1 Nutritional contents of *kocho* (*qocho*)

Qocho is the most widely consumed and produced of the main enset products. It is made from the decorticated pseudostem and grated corms after fermentation. According to Sahel et al. [72], an enset plant can yield 16.2 kg of *kocho* on average, or 417 tons/ha. The unfermented pseudostems hold a significant amount of water, between 85 and 90% [20, 73]. The moisture content of the fermented enset *kocho* also varies in different studies. Yimerga et al. [74] (45.50–60.20%) and Karssa and Papine [75] (59.90–63.30%) reported the moisture contents for the different enset landraces. Likely, Urga et al. [76] reported 60% of its moisture content. *Kocho* loses water content as it ferments longer; this is probably because of excessive permeation during pit fermentation [66, 77, 78]. Punchay et al. [79] reported that crops with high moisture content play a larger role in water-soluble enzymes and coenzymes, which are vital for metabolic activities. The mean crude protein content of the *kocho* in different studies indicated higher variations. The values reported by Atlabachew [80], 1.1% to 2.8%, Bosha et al. [66], 1.54%, and Tuffa [81], 1.59% to 1.67% were slightly lower than the findings of Urge et al. [76], 3.47%, Forsido et al. [71], 2.57%, and Karssa and Papine [75], 2.97% to 3.53%. Unlikely, Yimerga [74] notified 5.09% protein at 30 days of fermentation. The difference may result from age, fermentation length, or varietal variations among the chosen enset landraces. The mean content of the total ash value observed notable differences among the studies with the findings of Atlabachew [80], Forsido et al. [71], Yimerga [74], Karssa and Papini [75], and Tuffa [81]; it ranged from 1.25 to 2.35 g/100 g. In contrast, the lowest total ash contents (0.63%) and the highest value (4.47%) were reported by Urga et al. [76] and Bosha et al. [66], respectively. The total mineral concentration of food is signified by its ash value, which is vital for its nutritional value and physicochemical while making up a small percentage of dry matter [82]. Regarding crude fat contents, most literature indicated that *qocho* samples had low values, falling below 1.0%. However, a slightly higher crude fat content in the range of 1.04–1.39% was reported by Forsido et al. [71] and Yimerga [74]. The crude fiber content in the fermented *kocho* also varies by different reports. Urge et al. [76], Bosha et al. [66], and Karssa and Papini [75], reported that the fiber content of enset landrace *qocho* ranged from 3.22 to 5%. However, a lower

Table 2 The proximate composition (%) of corms of various enset landraces by different authors

Landrace	Moisture1	Protein	Fat	Fiber	Ash	CHO	Source	References
Nobo	–	8.2	1.24	–	5.12	–	Jimma Zone	[71]
–	–	3.33	0.41	5.65	8.57	82	Sidama region	[20]
Askala,Gossalo,Made etc.,	–	0.9–2.4		0.8–1.1	–	27–39	Sidama region	[69]
Neqaqa	–	8.3	0.6	17.4	3.2	64.8	AARC	[18]
*Amerat Astare Guarye Kibnare Yeshi**	65–72	2.4–4.1	0.5–0.6	2.4–4.4	2.2–3.2	76–80	Gurage Zone	[59]
Astara Gishira Hayiwona Leqeqa Qiniwara Separa Soqido	68–79	2.43–11.9	0.6–0.9	2.4–4.1	2–6.6	81–90	Hadiya Zone	[67]

1 Wet basis,CHO Carbohydrate, *Yeshi** Yeshirakinqe, *AARC* Areka Agricultural Research Center, – Undefined or not indicated

Table 3 The mineral contents (mg/100 g) of corms of different enset landraces as reported by different authors

Landrace	Ca	K	Mg	P	Na	Fe	Zn	Source	References
–	25	–	–	–	–	0.7	1.33	Sidama region	[72]
Nobo	100	-	80	90	15	–	–	Jimma Zone	[70]
Askala, Gossalo, Made, etc.,	–	–	–	–	–	1.1–4.3	6–16	Sidama region	[69]
Neqaqa	99.7	1.24	59.6	80.4	5.2	12.3	22	AARC	[18]
Astara Gishira Hayiwona Leqeqa Qiniwara Separa Soqido	22–50	29–87	16–29	3–14	7–9	0.9–4.0	0.4–1.4	Hadiya Zone	[67]

crude fiber value of 1.89% was notified by Yimerga [74] from the *qocho* samples of the *Astare* and *Kinnare* landraces at 30 days of fermentation.

There are significant variations in the mineral content of *kocho* among studies. A comparative mineral concentration analysis of *kocho* exhibited that Ca, K, Mg, P, and others exist in higher contents in the *kocho* than in other common root and tuber crops [12, 18]. Tuffa [81] indicated the calcium concentrations of two enset landraces *qocho* from 88.00 to 108.88 mg/100 g. However, Urga et al. [76] and Bosha et al. [66] described higher calcium values (142.3 mg/100 g) and (179.92 mg/100 g), respectively. Conversely, lower calcium contents of *kocho* from different cultivated enset landraces, ranging from 48.90–58.40 mg/100 g, were reported by Atlabachew [80]. Similarly, Atlabachew [80] and Tuffa [81] reported the mean potassium content of fermented *kocho* samples, which ranged from 275.30 to 482.30 mg/100 g. Unlikely, Bosha et al. [66] notified that the fermented *kocho* of different enset landraces had a much lower potassium content (63.92 mg/100 g). Bosha et al. [66] found a lower magnesium content in *kocho* samples (1.84 mg/100 g) compared to Atlabachew [80] and Tuffa's [81] findings (15.00–29.00 mg/100 g). In the same manner, Urga et al. [76] found a higher mean phosphorous content (128.30 mg/100 g) in enset *kocho* after seven weeks of fermentation compared to Tuffa's [81] 49.3 mg/100 g. According to Bosha et al. [66] and Tuffa [81], the fermented *kocho* samples had mean sodium values of 3.56 mg/100 g and 2.97 mg/100 g, respectively. However, these values were much lower than the reported values for the raw corm samples by Forsido et al. [71] (15 mg/100 g) and by Mohammed et al. [20] (30 mg/100 g) for the different enset landraces. Comparable iron contents were reported by Abebe et al. [83], Bosha et al. [66], and Tuffa [81], which ranged

from 3.3 to 9.3 mg/100 g for the *qocho* samples of different enset landraces. Nevertheless, Urga et al. [76] reported far lower iron concentrations (1.60 mg/100 g) from seven-week fermented *qocho* samples of *Nobo* enset landraces. Tuffa [81] also reported the zinc contents (0.73 mg/100 g). In contrast, a higher mean zinc content that ranged between 2.28 and 3.20 mg/100 g was reported by Atlabachew [80] and Bosha et al.[66]. Overall, the nutritional contents of *kocho* reveal notable variations among studies due to environmental factors, genotypic differences, agronomic practices, harvesting and processing variations, and fermentation time.

5.2 Nutritional contents of *bulla*

Bulla is the extracted form of enset product derived by squeezing a mixture of the unfermented scraped pseudostem and pulverized corm. In terms of nutritional composition, it is one of the least studied enset food products. Daba and Shigeta [18] analyzed the proximate composition and different mineral contents in *bulla*. They found that bulla contains 0.65% crude protein, 1.08% total ash, 0.11 crude fat, 1.08 crude fiber, 97.17% carbohydrates, and 393.71 kcal of energy. Similarly, Tuffa [81] reported 0.45% crude protein, 0.58% ash, 0.10% crude fat, and 0.64% crude fiber from *bulla* of the two different enset landraces. 30-days fermented *bulla* of four enset genotypes contains 0.56–0.91% crude protein, 0.88–1.27% total ash, 1.04% crude fiber, 0.3% crude fat, and 97.7% carbohydrates [84].

Daba and Shigeta [18] also determined the content of minerals in unfermented *bulla* with the following values in mg/100 g: 63.67 calcium, 387 potassium, 12.91 magnesium, 32.65 phosphorus, 4.01 sodium, 7.58 iron, and 0.22 zinc. On the other hand, Tuffa [81] notified that the lower contents were 7.32–15.52 mg/100 g calcium, 211–331 mg/100 g potassium, 4–6.4 mg/100 g magnesium, 32–34 phosphorus, 1.88–3.3 iron, and 0.41–0.48 zinc. However, Bekele et al. [84] noted a higher value of calcium (168–317.9 mg/100 g) than other reports and slightly comparable values of magnesium, iron, and zinc.

5.3 Nutritional contents of *amicho* (cooked corm)

Amicho is the cooked corm of enset, commonly harvested from medium-aged enset or before it flowers. The proximate composition and mineral contents of different enset corms are summarized in Tables 2 and 3.

6 Conclusions

The enset system is a widely recognized, environmentally sound, and sustainable farming system that contributes to the food security of farmers who live in the central, southern, and southwestern regions of Ethiopia. It is one of the important crops that could be used to positively respond to the US Sustainable Development Goals (SDGs) that relate to food, agro-biodiversity, environment, and climate change in particular. Understanding local farmers' indigenous knowledge about enset's cultural and economic values is crucial for managing landrace diversity in their gardens, enhancing crop diversity and usability. Farmers' indigenous knowledge has continued to be the fundamental source of information concerning all issues and historical data for the existing enset crops. This implies that a great extent of enset landraces and most of their genetic diversity are also traditionally conserved on-farm by farmers'. Moreover, farmers understand the need to grow a mixture of enset landraces, as this has roles in the crop's adaptability as well as the socio-economic and cultural life of communities. Considering the significance of enset in the main enset-growing regions of Ethiopia's farming and food production system, sustaining current traditional knowledge and genetic variety is essential for achieving food security and sustainable development.

7 Opportunities for further work

- Establishing an enset *ex-situ* center with local, regional, and/or national institutions is crucial to supporting farming community efforts to conserve enset genetic resources in the many indigenous communities.
- The cultural roots of the various administrative zones and localities in enset farming communities are different. This is useful for drawing parallels, classifying shared ancestries, identifying commonalities, and examining the distinctive knowledge of various groups.

- The existing farmers' knowledge in enset crop diversity on naming, classification, and management practices should be further documented from uncovered areas and also complemented with research for building sustainable utilization and transmission of the knowledge from one generation to the next through both formal and informal learning systems.
- For the continued preservation of enset bio-cultural resources, community participation methods and the engagement of both younger and older generations must be strengthened.
- The continued identification and more thorough analyses of nutritional and chemical profile on enset based food (*kocho*, *bulla*, and *amicho*) are crucial for consumption and to sustain enset cultivation for food security.
- The harvesting and processing of enset is human-based (mostly women), with traditional equipment and laborious. So, there is a need for improved processing technology.
- The popularity of enset in Ethiopia is increasing due to its adaptability and versatility, and studies on its agronomic features could expand its global reach as a sustainable food.

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