REVIEW ARTICLE Agricultural Reviews, Volume 43 Issue 3: 348-354 (September 2022)

Production, Challenges, Potential and Prospects of Oromo Potato (*Plectranthus edulis*) and *Anchote* (*Coccinia abyssinica*) in Ethiopia: A Review

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10.18805/ag.R-178

ABSTRACT

Oromo potato and *Anchote* are high-yield potential endemic crops mainly grown in the home garden in Ethiopia. Though the crops have local significance, the information about these crops is very limited. Both crops had high yielding potential per unit area and nutritional value especially in carbohydrates and several essential micronutrients are useful for food security and the potential to combat the effect of climate change. However, their extent of diversity is not well known and recorded. Thus, there is a growing concern about the loss of biodiversity of these crops due to mainly human effects and less research priority. Therefore, to improve the potential benefits of the crops, attention should be given to their research improvement, utilization and their sustainable conservation may be in short term by establishing Mini-genebanks in the nearby agro-ecologies to coordinate and monitor any conservation activities. Moreover, awareness creation of the farmers and strengthening collaboration work with all stakeholders is important. Comprehensive study on the genetic diversity of Oromo potato and *Anchote* in cultivated as well as wild relatives of the crops is required for effective conservation and sustainable use in the future. Hence, a better understanding of the two minor crops is essential. In this review, overview on Oromo potato and *anchote,* nutritional values, their production and potential contribution to food security, challenges, potentials and prospects about the crops were discussed and recommendations are suggested.

Key words: Biodiversity loss, Conservation, Food security, Minor crops, Nutritional value.

There are several indigenous cultivated or semi-cultivated root and tuber crops in Ethiopia but recent reports showed that there is a growing concern about the loss of genetic diversity for these 'minor' root and tuber crops (IBC, 2007) which reduces its contribution to food security of the people. The decline in the use of such crop species by users may cause the loss of genetic base and prevent distinctive and valuable traits being used in crop adaptation and improvement as well as research on minor' crops have been very globally low (FAO, 2010). Oromo potato and *Anchote* are 'among minor' or 'underutilized' crops in Ethiopia (IPGRI, 2002; FAO, 2010) and had little research and conservation attention has been low irrespective of their usefulness and potential contribution to food security regionally (IDRC, 1982). Root and tuber crops are the most important food crops after cereals. They contain the highest rate of dry matter production per day and are major calorie contributors to the human diet including medicinal properties (Burkill, 1960).

The problems of food security are of global significance and are further exacerbated by an increase in the world population resulting in over-exploitation of genetic resources. Nevertheless, these resources are lost at alarming rates due to anthropogenic effects such as climate change, pollution, genetic erosion, gross mismanagement of these resources and population growth. And a vast amount of genetic resources are threatened and endangered and some have even gone extinct due to genetic erosion and environmental changes (Salgotra and Gupta, 2015). Many populations in the south and southwestern Ethiopia use potatoes, sweet potatoes, *Oromo* potato [*Plectranthus edulis* (Vatke) syn. *Coleus edulis* Vatke], (Allemann and Hammes, 2006; IBC, 2007) and *Anchote* (*Coccinia abyssinica*) crop for their daily food consumption both during surplus and/or poor harvest years (Addis, 2005) and *Anchote* is more widely cultivated than Oromo potato (IBC, 2007).

Plectranthus edulis (Vatke) Agnew, locally have different names known as Oromo or Ethiopian potato is one of the native Ethiopian edible tuber crops that has been significantly contributing to household food security for millions of subsistence farmers. However, its current production is declining to the extent of total extinction from several regions where it used to be widely cultivated. It is one of the less researched crops regardless of being

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How to cite this article: Zerihun, J. (2022). Production, Challenges, Potential and Prospects of Oromo Potato (*Plectranthus edulis*) and *Anchote* (*Coccinia abyssinica*) in Ethiopia: A Review. Agricultural Reviews. 43(3): 348-354. DOI: 10.18805/ag.R-178.

Submitted: 02-11-2020 **Accepted:** 01-07-2022 **Online:** 27-07-2022

indigenous and its contribution to food security (Gebrehiwet *et al*., 2019). And *anchote* is also a valuable food source and according to local farmers, it helps in the fast mending of broken/fractured bones and displaced joints, as it contains high calcium and proteins than other common and widespread root and tuber crops (Endashaw, 2007). Traditionally, it is also believed that *anchote* makes lactating mothers healthier and stronger (Abera, 1995).

However, since little effort is given to their research and conservation and there is little information about both Oromo potato and *anchote* as they are mainly maintained and utilized by the small scale farmers. Thus, currently, there is a growing concern about biodiversity loss which would reduce their contribution to food security. Considering the current and future potential value of these crops to food security and other uses makes them a priority crop for conservation. Therefore, increasing knowledge on both neglected crops is useful. Thus, in this review paper, an overview of Oromo and *anchote* crops, nutritional values, production and food security, challenges, potentials and prospects were discussed.

Oromo potato [*Plectranthus edulis* (Vatke) Agnew] and its nutritional values

Oromo or Ethiopia potato tuber crop is believed to have been originated in Ethiopia. Oromo potato (*P.edulis*) has both cultivated and wild relatives. The genus *Coleus* (syn. *Plectranthus*) has about 30 wild species in Ethiopia (IBC, 2007). The cultivated species are grown in the wetter south and southwestern regions of Ethiopia whereas the wild species are found throughout the country. It is one of the four economically important tuber crops of the genus *Plectranthus*, together with *Plectranthus esculentus*. *P. edulis* is an ancient Ethiopian tuber crop (Westpha, 1975). It is grown in mid and high-altitude areas in the north, south and west of Ethiopia and is primarily cultivated for its tubers for household consumption and rarely for marketing. Furthermore, the leaves are also used as a cooked vegetable in some western Ethiopian areas. It has different names locally in different areas as *Dinicha Oromo* (Southwest Ethiopia), *Wolaita Dono* (Southern Ethiopia), *Gamo Dinich* (Southern Ethiopia), *Agew Dinich* (Northwestern Ethiopia) (Mulugeta *et al*., 2007).

Morphologically *P. edulis* crop is herbaceous and bushy plants grown in ascending manner from the seed tuber pieces with a maximum height of about 1.5 m. The whole plant is composed of the mother tuber piece, roots, stolons, tubers sprouts, main stems, branches, leaves, inflorescences, fruits and seeds. The stolons are very long and are initiated on buds of main stems and primary branches, first only on below-ground nodes, but later also on the lower aerial nodes. Tubers are produced upon swelling of the tip or middle part of stolons. Most of the tubers that are formed along the stolon are longer than tubers formed at the stolon tip. The tubers of *P. edulis* are stem tubers arranged on the same alternating pattern as the axillary buds on stolons and stems. Stolons of *P. edulis* were much longer than those of Irish potato (*Solanum tuberosum*) (Mulugeta *et al.,* 2012).

Moreover, the study on the nutritional content of 100 gm edible portion of both raw and cooked tubers of Oromo potato showed that relatively higher food energy when cooked than *Solanum tuberosum,* while the fat and calcium contents are almost twice as high as that of *S. tuberosum*. And its protein contents are almost twice as high as that of *Ipomoea batatas* when cooked. The study also indicated that the cooked tubers of *P. edulis* have more amounts of energy, fiber and carbohydrate compared to the raw tuber. Furthermore, the composition of nitrogen, protein, phosphorous, iron, thiamin, riboflavin and niacin was relatively higher in *P. edulis* as compared to *S. batatas* (Yeshitila, 2007). Hence, it is a nutritionally essential crop for the human diet as it contains high carbohydrates, some important micronutrients and vitamins. Besides this, the crop has high drought tolerance, produced under low input management and the tubers can stay long periods underground without deterioration which is useful to harvest and consume during shortage times.

Furthermore, a survey on an ethnobotanical study on *P. edulis* growing districts of southern Ethiopia, Sodo-zuria district showed that socio-economic status of the households was found to be an important factor affecting the management and conservation of the crop. It was also observed that the older informants were more knowledgeable than the younger ones as they knew much more about the different local cultivars and values of use (Yeshitila, 2007).

Anchote [*Coccinia abyssinica* (Lam.) Cogn.] and its nutritional values

Anchote root crop is believed to have been originated in Ethiopia. *Anchote* (*Coccinia abyssinica*) has wild relatives but the genus in Ethiopia is not well studied despite there being more than eight taxa recorded, distributed throughout the country (IBC, 2007). It is an annual trailing vine plant belonging to the *Cucurbitaceae* family best known and grown for its tuberous root; leaves are also rarely commonly used for food. The genus *coccinia* is made up of 30 species of which eight are reported to occur in Ethiopia (Abera *et al*., 1995) and of these species, only *anchote* is domesticated. And the major center of cultivation and consumption of the tuber is Wallaga (Fekadu, 2011) and wild *anchote* resembles a poisonous wild tuber plant called *kakii* that usually causes serious illness or death when consumed in large quantities. *Kakii* is the local name for *anchote's* wild progenitor. In *Wallaga* traditional medicine, a small amount of processed *kakii* is used to treat intestinal parasites (Wayessa, 2016).

Anchote is an endemic plant with high calcium content grown for its edible tuberous roots in Ethiopia. It is difficult to produce true-to-type *anchote* plants to sustain tuber quality through propagation by seeds as the plant pollinates both self and cross (Yambo and Feyissa, 2013). Historical evidence showed that the *Wallaga* Oromo carries seeds of the anchote tuber with them when they move to a new

location. As a result, *anchote* may have been domesticated in *Wallaga* and the knowledge of its cultivation has diffused to other regions of the country. *Anchote* cuisine is available in the hotels and restaurants owned by the Oromo individuals. *Anchote* dishes are widely distributed, especially in some restaurants owned by Oromo diaspora communities even outside of Ethiopia. Some Oromo Diaspora also cultivate *anchote* and a significant number of Oromo immigrant families USA (Wayessa, 2016).

The crop can yield the maximum amount of yield. For instance, under the application of organic fertilizer, *anchote* yielded an average yield of about 58 t ha^{-1} (at *Jimma* area) and 76 t ha^{-1} (at *Ebantu*) in Southwestern, Ethiopia (Mengesha *et al.*, 2012). *Anchote* crop is an important contributor to human nutrition, income and medicinal value in Southwestern Ethiopia (Galmessa, 2010). It contains an appreciable quantity of carbohydrate, crude protein, crude fiber, calcium, magnesium, iron and low levels of antinutrients (Oxalate tannin and cyanide) except phytate in anchote (Fufa, 2011). Similarly, another report showed that there was higher protein, starch, total sugars, reducing sugars, vitamin-A and vitamin-B contents in peeled than unpeeled anchote samples. While, peeling of anchote reduced the contents of calcium, potassium, phosphorous, iron and magnesium. And the phytic acid, oxalic acid and tannin contents of the whole anchote were higher than those which were peeled by 20%, 22% and 29.6%, respectively and the antinutritional (Oxalate tannin and cyanide) contents were very little and can be destroyed during cooking (Fufa and Urga, 1997), Fufa (2011) reported that *anchote* contains a high amount of calcium and other nutrients. Moreover, anchote also contains alkaloids, phenols, tannins, flavonoids and saponins. And it has a relatively high quality of nutrient composition compared to other tuber crops and is considered the leading proteinous root crop with a high calcium content so that cooked anchote tubers are highly recommended for patients with broken or fractured bones (Tileye, 2020).

Therefore, the two minor crops are important not only for their high content of carbohydrates and other nutrients but also for they contain essential micronutrients which have health significance to reduce nutrient deficiency diseases. For instance, traditionally a person with any physical damage is advised to consume *anchote* recipes as a remedy that can be substantiated with And *Oromo* potato contains some antinutritional factors making it less palatable. Therefore integration of Oromo potato and *Anchote* minor root and tuber crops could be very useful to improve food security in Ethiopia. The crops are home garden crops which can be grown under low input agriculture producing high yield potential per hectare, nutritional value, their drought tolerance, the suitability for intercropping with other perennial horticultural crops and the growing cycle of these root and tuber crops fit well to the various cropping systems makes important for resource-poor farmers.

Production of oromo potato and *Anchote* and food security

Ethiopia is a country of great geographic diversity. The macro- and micro-climatic conditions of the country are highly variable. The cultural diversity of the country is immense and there are ten ecosystems, 18 major and 49 minor agro-ecological zones that are inhabited by an amazingly great diversity of animal, plant and microbial genetic resources that make the country one of the biodiversity hotspots of the world. The country possesses an estimated number of 6000 species of higher plants of which 10% are endemic. Therefore, in Ethiopia, biodiversity plays vital and diverse roles in economic, ecological and social fabrics. Biodiversity and its ecosystem services are the bases for agriculture, where agriculture is the core driver of the country's growth and long-term food security. However, the rich biodiversity of the country is under serious threat from natural and human degradation factors (FAO, 2013).

Roots and tuber crops are important cultivated staple energy sources, second to cereals, in tropical regions of the world. Their adaptation to diverse soil and environmental conditions, grown under different farming systems with low agricultural inputs makes them preferable to cereals (Chandrasekara and Josheph Kumar, 2016). Food insecurity and malnutrition remains some of the most fundamental challenges facing the world (FAO, 2019). Food security has increasingly come to be recognized as a multifaceted concept (FAO, 2006). The 2009 World Summit on Food Security identified availability, access, utilization and stability as the four dimensions of food security which also indicated that the nutritional dimension is integral to the concept of food security (FAO, 2009). Moreover, several people in developing countries including Ethiopia are deficient in micronutrients which makes them more vulnerable to nutrient deficiency diseases. It has been suggested that supplementation, food fortification, dietary diversification, nutritional education and food production are better strategies to reduce micronutrient deficiencies (Workneh *et al.*, 1999).

Root and tuber crops are most important in the south, southwest, eastern and northwest parts of Ethiopia in terms of production area, distribution and consumption. *Anchote* (*Coccinia abyssinica*) and Oromo or Ethiopia potato [*Plectranthus edulis* (Vatke) Agnew] are among the principal root and tuber crops grown in Ethiopia. Small-scale subsistence farmers grow the crops, under resource-poor conditions. They are parts of the traditional food of Ethiopians and their contribution to family food-self-sufficiency, income generation and soil-based resource conservation is indispensable. There is a growing importance of these crops due to their high yielding ability and the fact that their production and processing activities are environmentally friendly (Gebremedhin *et al.*, 2008).

Moreover, underutilized and neglected species are often considered 'minor crops' are important for the subsistence farmers and continue to be maintained by socio-cultural preferences but neglected by research and conservationists.

Furthermore, minor crops are highly important in local farming systems and have great potential in the future sustainable global food system. Such species are useful to diversify and get a healthy diet to combat micronutrient deficiencies, the so-called 'hidden hunger and other dietary deficiencies of small-scale farmers (IPGRI, 2002). Root and tuber organs are rich in carbohydrates and are commonly used as a dietary staple, livestock feed, raw material for the production of industrial products such as starch and alcohol, or processed into various food products (IBC, 2009) and important during food shortage periods and failures of staple crops (FAO, 2001).

In Ethiopia, central statistics authority data indicated the estimated area coverage of root and tuber crops was generally about 231,551.95 hectares with a production of 4,535,754.9 tons/ha. However, the specific data on Oromo potato and *anchote* was not available (CSA, 2019). Another report indicated in *Wallaga* areas of Ethiopia, Oromo potatoes and *anchote* crops are among the major tuber crops consumed. The tubers are boiled in steaming pots and served in different ways (Wayessa, 2016). Although anchote has a very high potential as a food security crop, it is neglected and underutilized and has received very limited research attention (Tileye, 2020).

Challenges

Currently there is an increasingly global food security challenge due to a growing world population. Priority must be given to how to ensure a sustainable supply of food under changing environmental and climatic conditions as well as changing needs. Genetic diversity is associated with a wide range of environmental and economic benefits which are essential for sustainable agricultural production but correspond also to a wider range of societal interests. Counteracting the abandonment of traditional, locally adapted breeds and crops, requires farmers to recover the know-how linked to selecting and breeding and other traditional agricultural practices (European Commission Report, 2013).

Diversity loss

There is a growing share of food is provided by a limited number of crops and varieties of each crop species, it is important not only to conserve the existing diversity but also to sustainably use its components to meet present and future needs (FAO, 2019). A report on Ethiopia's biological diversity status showed that the rich biodiversity of Ethiopia is under serious threat from natural and human degradation factors. The major threats (overexploitation, overgrazing, expansion of cultivation, settlements, population pressure, *etc*) are accompanied by several driving forces that aggravate the changes and trends in the decline and loss of biodiversity resources at all levels. The population, distribution and genetic diversity of wild foods are dramatically declining (IBC, 2007; FAO, 2013) and these driving forces for genetic losses were also a global pattern. Furthermore, the replacement of farmers of traditional varieties with new, improved uniform varieties has been recognized as an issue in many country reports including Ethiopia (FAO, 2010). However, there has been an inadequate achievement in technology generation and dissemination on minor root and tuber crops.

The diversity of crop wild relatives has decreased in some areas and appears to be particularly threatened in places where the climatic conditions are changing but species migration is prevented by ecogeographical barriers (FAO, 2019). Over the last decade's temperature in Ethiopia has increased at about 0.2°C per decade. Climate change has caused adverse ecological, economic and social Impacts in the country. One of the impacts is a reduction in the length of growing seasons that has resulted in the loss of many long-duration varieties. Moreover, it has made large marginal agricultural areas out of production. Climate change also alters the underlying agroecosystems through elevated temperature and CO_2 levels, leading to changes in crop pests and disease occurrences (EBI, 2015).

Few reports on Oromo potato showed that the genetic diversity within and among populations using EST-SSR markers among 12 Oromo potatoes (Ethiopia potato (collected from various agro-ecologies showed *Wenbera*, *Awi* and *Wolaita* types a higher genetic diversity as compared to other populations and hence can be considered as hot spots for *in situ* conservation as well as useful in breeding programs (Gadissa *et al.*, 2018). Another study on 20 accessions of Oromo potato collected from northwestern, southwestern and southern parts of the country showed the existence of wide overall morphological diversity, involving several traits (Yeshitila, 2007). A recent evaluation of 174 Oromo potato accessions collected from diverse agro-ecologies indicated varied morphotypes (Gadissa, 2018). While, a research study on 49 *Anchote* landraces collected from south and western Ethiopia showed morphological diversity (Wondimu *et al.*, 2014). However, it is difficult to get comprehensive studies covering all growing areas in cultivated and wild species of the crops as the studies were merely for academic purposes.

Lack of research priority and policy on root and tuber crops

Though underutilized and neglected species are important for the subsistence farmers and continue to be maintained by socio-cultural preferences but neglected by research and conservationists (IPGRI, 2002). According to Tileye (2020) anchote has very high potential as a food security crop since it is a neglected and underutilized crop, it has received very limited research attention (Tileye, 2020) and root and tuber crops are among the neglected climate-resilient food security crops in Ethiopia requiring policy attention which could substantially contribute to improving the livelihoods of resource-poor farmer's (Semeredin and Tsegaye, 2018).

Conservation of minor crops in Ethiopia

A recent report showed that about 90% of the total germplasm holdings of the Ethiopian Biodiversity Institute

is the *ex situ* gene bank consisting of field crops. The total collection is composed of cereal seeds, pulses, oil crops, spices and species of medicinal and industrial value. While over 9,000 accessions of horticultural crops, medicinal plants and herbs are maintained in field gene banks at various centers which are managed under the Ethiopian Institute of Agricultural Research (EIAR) and Universities and Ethiopian Biodiversity Institute (Kasso and Balakrishnan, 2013). However, currently, the sustainability and functionality of these field gene banks are not known. This is because field gene banks are vulnerable to pests and diseases and to changing climatic conditions (Taylor *et al.*, 2005) and there is an increasing concern about the loss of genetic diversity of minor root and tuber crops in Ethiopia due to the increasing use of improved cultivars of staple crops, the current change in sociocultural and farming practices, population growth, unsustainable patterns of utilization, land degradation, ecosystem destruction and climate change (IBC, 2007). Though there is an encouraging effort by the Ethiopian biodiversity Institute to conserve horticultural crops especially coffee, *enset*, some spices and medicinal plants, the attention is given to Oromo potato and *Anchote* endemic crops are inadequate which requires further solutions.

POTENTIALS AND FUTURE PROSPECTS

The contribution of minor crops, Oromo potato (*Plectranthus edulis*) and *anchote* (*Coccinia abyssinica*) to the food security of millions of resource-poor farmers are high in the south and southwestern Ethiopia region. Because the nutritional content of these crops is high, contains essential; health benefits to reduce the risks of micronutrient deficiency. Furthermore, the crops are produced under low input agriculture, capable of providing a relatively high amount of yield per unit area, drought tolerance and sociocultural importance makes them specific and they can be suitable crops for climate change adaptation and mitigation. The crops can be easily produced in the home garden and also fits the intercropping system which can increase their multiple benefits to the local farmers. Therefore, these minor crops are highly valuable crops to the local people which may require to expand to other areas.

The genetic resources of the two crops have been maintained and developed by the local farmers and their wild relatives also exist in the natural habitat in similar agroecology mainly in south and southwestern Ethiopia. So, there is great potential to maintain their diversity in the area by creating awareness among farmers and participatory approach, collaboration work with development agencies and regional and international conservationists is important. Besides this, scientific research and development on these crops are crucial to improve the potential benefits that could be obtained from the crops including its utilization and income Comprehensive genetic diversity study on these minor crops is also required for effective conservation and sustainable use.

CONCLUSION AND RECOMMENDATIONS

Oromo potato and anchote crops are important endemic minor crops produced under low input agriculture and high yield potential with a useful contribution to food security and to cope with climate change. Furthermore, they have high nutritional value and are essential in reducing nutrient deficiency diseases. Regardless of their importance, these crops are neglected by research and development which eventually would result in genetic erosion and vulnerability. The crops were not adequately conserved and there was little information on their biodiversity and documentation which requires an urgent solution. An Ethiopia with large several ecosystems and agro-ecologies needs to establish more gene banks to sustainably conserve and cover large biodiversity root and tuber crops. Thus, to conserve the minor root and tuber crops including Oromo potato and *anchote* crops, the Ethiopian Biodiversity Institute must take a lead in widening its operation and services by establishing new mini-gene banks in the representative agro0ecologies or suitable sites of Oromo potato and *anchote* crops to coordinate and monitor the conservation activities in the nearby areas. Moreover, attention should be also given to developing effective policy on research on the improvement of Oromo potato and *anchote* crops as valuable crops for sustainable conservation and utilization which could increase the potential benefits obtained from these crops. Generally, Oromo potato and *anchote* crops can play an important role in contributing to the food security of the local people under changing climate and thence sustainable conservation and improvement are crucial. Furthermore, awareness creation among the local communities about the crops and collaborative work with all stakeholders is required.

Conflict of interest

The author declares that there is no conflict of interest.

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