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Anchote (*Coccinia abyssinica* (Lam.) Cogn.): A nutrient rich root tuber crop of Ethiopia

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Abstract

Anchote (*Coccinia abyssinica* (Lam.) Cogn.) belongs to the family cucurbitaceae is indigenous to Ethiopia. It is grown for its edible root tuber and leafy vegetables in western and south western parts of Ethiopia. The objectives of the present review are to collect information on importance of anchote in alleviating food insecurity among small holder farmers in south and south western Ethiopia; and to show the research gaps and indicate future directions. The review highlights the origin, distribution, diversity, conservation, production practices and nutritional contents, medicinal and cultural values of the crop. Traditionally, anchote was maintained for more than thousands of years for its high nutritional, medicinal and cultural values. Diet with anchote when consumed repairs the fractured bones of human and animals; and tuber contains sopnins that is used for treatment of disease such as gonorrhoea, tuberculosis and cancer. The cultivation of the crop is limited to the homestead due to the difficult nature of the crop, diseases, pests and animals; to propagate and cultivate in larger scale. In addition, propagation of anchote was mainly by seeds; however propagation by vegetative parts and tissue culture is not well established.

Keywords: Anchote; *Coccinia abyssinica*; Cultural food; Medicinal; nutrition; Root tuber; Traditional farmers.

Introduction

Anchote (*Coccinia abyssinica* (Lam.) Cogn.), belongs to the family cucurbitaceae is an endemic root crop which had been widely grown throughout the south and south western parts of Ethiopia for centuries (Abera, 1995). The vernacular name of *Coccinia abyssinica* (Lam.) Cogn.) is '*anchote'* and spoken in Oromia in western and south western parts of Ethiopia. It is also known by different vernacular names in different places and tribes such as '*ushushe'* in Walaita, '*shushe'* in Dawero and '*ajo'* in Kaffa (Amsalu *et al*., 2008) and its cultivation as a root crop is common in Wollega, Iluababor, Jimma, Kaffa, and Sidama Zones of Ethiopia (Amare, 1973). Root and tuber crops are important in Ethiopian dishes among which *anchote* is most favourite and cultural food with high mineral contents such as calcium and phosphorus and starch, proteins, vitamins, and antioxidant compounds (Fekadu *et al*., 2014). Millions of people in Ethiopia depend on consumption of root and tuber, and legume crops as their major or supplementary food and sources of cash for small holder farmers (Gelemsa, 2009).

Root and tuber crops give greater yield per unit area than the major grain crops used as basic food. These

crops can support greater density of population than other food crops when produced on small plots of land. Most of the traditional root and tuber crops of Ethiopia are produced by small holder farmers following traditional practices. The genetic resources of traditional root and tuber, and legumes crops are to a large extent left to traditional practices and natural processes, although crops presumed to be of high potential. Among many other crops, Yams (*Dioscoria spp*.), taro (*Colocasia spp*.), cumin, haricot bean (*Phaseolus spp*.), beet root, oromo potato (*Plectranthus edulis* (Vatke) Angew) and anchote (*Coccinia spp*.) believed to have either centre of diversity or centre of origin in Ethiopia (www.ibc-et.org/ibc/dpt/hortic.html/ accessed on 03 Feb. 2011). Coccinia is an endemic species found both cultivated and wild in Ethiopia, though a clear cut differences between wild and cultivated spp. are not yet reported in the country. It has been reported in several research papers that the fruits of cultivated species are not eaten only the root tuber is eaten as cooked vegetable, while the fruits of wild *coccinia sp*. is consumed.

Though the genus in Ethiopia is not well studied, there are more than eight taxa recorded, distributed throughout the country. Other root crops including *Dioscorea spp*. might have their origin in Ethiopia. Even though yams are not staple crops in Ethiopia, there are ten species recorded, distributed throughout the country. Some of the species have both cultivated and wild forms. It was reported that aerial tubers are common than root tubers in western Ethiopia. Some of the species are highly drought resistant (FAO, 1996).

Anchote is one of the root crops available in the fresh local market in western Ethiopia among others (yam, carrot, Oromo potato, sweet potato, green pepper, cabbage, garlic, onion, and beet root, etc). Though, anchote production status is not included in agricultural sample survey report of Ethiopia each year; its contributions to food security in rural and urban/ peri urban communities are paramount important (personal observation). There are other vegetables and root crops which are very important in sustaining food security among the rural community but no attention is given in research and development (for instance; oromo potato (*Plectranthus edulis* (Vatke) Angew); *Dioscoria spp* and taro (*Colocasia esculenta* (L.) Schott) (Mekbib and Deressa, 2016).Generally, root and tuber /underutilized food crops had no attention as compared to other field crops and vegetables and fruit crops in Ethiopia. Moreover, the root and tuber crops are grown as homestead/ home garden which usually produced and taking care by women farmers (Gelemsa, 2009; Jemal and Callo-Concha, 2017). According to GFU (2007), underutilized species are defined as species with underexploited potential for contributing to food security, health and nutrition, income generation and environmental protection. They may have different terms or names such as neglected, underutilized, minor, orphan, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional, niche …… crops. If underutilized crops are continuing forgotten by research and development, the genetic diversities due to lack of attention; might be totally lost . On the other hand, if attention is given, by research and development works the production and productivity is improved and it can support the greater part of the rural communities and to a lesser extent the urban communities. Therefore, the objectives of the present review are to collect and organize available information on production, breeding, agronomic, nutrition, and conservation status of *coccinia abyssinica*.and to show gaps for future works .

Origin, taxonomy and biology

Origin and taxonomy

Coccinia (n= 12**)** has about 30 species, confined to tropical Africa, except C. *grandis* (L.) Voigt (syn. C. *indica* W.), which extends throughout the palaeotropics. This genus is also cultivated in India (Jeffrey, 1980). *Coccinia abyssinica* (Lam.) Cogn. had been cultivated in parts of Ethiopia for its edible tubers (Jeffrey, 1980). It also grows wild; the tubers of wild plants are inedible, but the fruits are eaten. Conversely, the fruits of cultivated plants are not eaten. There are ten species of the genus *coccinia* in the country. Of these, *Coccinia abyssinica* is the only species grown for its edible tuberous roots and leaves as vegetables (https://en.wikipedia.org/w/index.php?title=Special:ElectronPdf&page=Coccinia&action=show-download-screen//accessed in October 2018).

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Taxonomy of (*Coccinia abyssinica* (Lam.) Cogn.).

- Kingdom: Plantae
- *Clade*: Angiosperms
- *Clade*: Eudicots
- *Clade*: Rosids
- Order: Cucurbitales
- Family: Cucurbitaceae
- Subfamily: Cucurbitoideae
- Tribe: Benincaseae
- Genus: *Coccinia*
- Species: C. abyssinica

Biology

Coccinia abyssinica is perennial climbing or creeping herb whose young shoots and tuberous roots are processed and used as vegetables and root crops, respectively (Abera, 1995; Endashaw, 2007; Tufa *et al*., 2017). Climbing is supported by simple of unequally bifid tendrils. It develops a tuber from the hypocotyls, sometimes on roots. The cotyledons are simple, entire and have a blunt tip. The leaves are usually stalked, rarely sessile. The leaves are simple to deeply lobed, usually with teeth along the margin. The lower leaf side often bears small nectar

producing glands (https://en.wikipedia.org/w/index.php?title=Special:ElectronPdf&page=Coccinia&action=show-download-screen//accessed in October 2018).

Anchote is reproduced by cross fertilization in which the male flowers are found in solitary or racemes and are located on different parts of the same plant (Holstein and Renner, 2011; Holstein, 2015). The pollination is effected by the insects which feed on the pollen of the flowers. However, according to the same authors anchote with diocious are available. *Coccinia spp*. has tendrils which help to climb the tree or any other structural support. The root tuber can stay in the soil during dry season without deterioration and it gives vegetative re-growth when the rain comes or moisture in the soil. The root tuber is the part of the plant where the starch and other nutrients are accumulated and used for consumption/ or reservoir for vegetative re-grows when moisture is available in the soil (Tufa *et al*., 2017).

Propagation

Coccinia can be propagated both vegetatively and by seeds although propagation by seed is commonly employed. Vegetative propagation is achieved by planting either the whole tuber or by slicing it into two or more pieces, each piece having rootlets and an external covering. This is usually done to establish mother plants, called GUBOO, to serve as a seed source for further plantings. Vegetative propagation is usually practiced on anchote tubers purchased from the market for consumption. Few tubers are planted and produce new shoots usually more than one. These newly emerging shoots depend on the reserve food within the tuber making the tuber less suitable for consumption, especially during the early growth. But after the stems are well grown, the shoots start manufacturing their own food, and the tubers again become suitable for consumption. Propagation by stem cutting may be effective for anchote though it is short of report in this regard so far. This technique is very common in root and tuber crops such as sweet potato, potato, etc and it is essential when the mother plant is for commercial use and free of diseases. Moreover, propagation of anchote by stem cuttings is not well established and practiced by the growers (Endashaw, 2007; Daba *et al*., 2012; Meseret, 2018).

Seed propagation involves taking out of seeds from fully mature red-ripe fruits which are harvested before they start rotting. Such fruits are macerated or sliced to separate the seeds from the fleshy juicy part. The seeds are then mixed with an equal quantity of wood ash, and dried in sun. The wood ash may protect the seeds from insects and diseases. The moisture content of the seeds, for storage, is based on subjective assessment by the woman of the household. When it has dropped to the desired level, the woman takes the seeds indoors and stores them until the next growing season comes. During this storage period the seeds are usually kept in either clay or wooden pots or wrapped in a sheet of cloth (Endashaw, 2007; Tufa *et al*., 2017; Meseret, 2018).

All these operations, from harvesting of the fruits to seed extraction and storage, are usually carried out exclusively by women. The women also purchase seeds of sowing if they have failed to store seeds. As practiced, it is the women's responsibility to harvest, prepare, process and store anchote seeds and/or either purchase or request seeds from their friends and make them available for sowing well ahead of the beginning of the rainy season. It is after having the seeds that the women urge their male partner to plough the land. The main reason the women farmers concentrate on the production of root and tuber crops is the crops are grown as home garden or nearby home to protect from wild animals attack. Hence, the women in rural areas are taking care of their children at home and easy to produce home garden crops as the same time (Jale and Desalegn, 2016).

In addition micro propagation is possible at laboratory level and research results have been reported (Kahia *et al*., 2016). The same authors reported that the highest frequency of micro shoot induction (84%) and mean number of microshoots (3.4) were recorded from explants cultured on medium supplemented with thidiazuron (TDZ) 0.025 µm. Similarly, induction of roots was highest (86%; 4.6 roots per shoot) when shoots were transferred to half strength MS medium containing 0.5 µm α-naphthalene acetic acid (NAA) after 12 days. A survival rate of 83% was recorded in the greenhouse and the plantlets appeared to be morphologically normal. According to Yambo and Feyissa (2013), culture was initiated from anchote seedlings on MS-basal medium and the highest number of shoots per explant (13.13 ± 3.90) was obtained on MS medium containing 0.25 mg/L BAP and 0.1 mg/L IBA. The maximum mean root number (7.00±2.75) and root length (5.97 ± 1.13 cm) per explants were obtained on MS medium containing 0.025 mg/L and 0.05 mg/L IBA, respectively. Among acclimatized plantlets, 68.75% survived. Micro propagation of food crops could avoid diseases transmission from mother plant to the propagates. Therefore, natural and artificial propagation methods of anchote shall be worked in the future as followings:

- Efficient seed propagation methods and protocols
- Efficient vine propagation methods
- Micro-propagation protocols using deferent media and protocols
- Efficient and economical root tuber propagation methods

Production and uses

Production

In Ethiopia, anchote is naturally grown in all regions (Amhara, Oromia, Southern Nations, Nationalities and People's Region, and Tigray). It grows at elevation 1300–2800 m and on different kinds of soil types (on limestone, sandstone, black soil, chromic nitisol, loam, on deep to shallow soil) (Daba *et al.* 2012). Along lake shores among Typhasp., in Podocarpus-Celtisforest (clearings) and degraded forms of these, evergreen shrubs (e.g., Eucleasp.).Edwards (1991) indicated that *Coccinia abyssinica* is found in many parts of the country, including the western, south eastern and northern parts Ethiopia. The different vernacular names indicate that the crop is widely grown in different parts of Ethiopia. Vernacular names (Dawuro: shushe, ushushe (Abera 1995); Oromo: anchote (Amare, 1974); Kaffa: ajjo (Abera, 1995); Tigrinya: wouchich; Wolleyta: ušuše (Holstein, 2015). The Kaffa name is not exclusive for *C*. *Abyssinica* but also used for another crop, *Plectranthus edulis*(Vatke) Agnew (Holestein, 2015). However, it is locally restricted in use and cultivation in small holder farmers as homegardens (Amare, 1973; Mekbib and Deressa, 2016). Moreover, the crop is grown and much liked in all parts of Wollegga, lllubabor, Jimrna, Kafa and Sidamo (Amare,1973). Maundu et al. (1999) reported that the presence of anchote wild relatives, whose fruits are consumed, in Kenya, e.g. *Coccinia grandis* and *Coccinia triloba*.

Uses

Nutrition

Anchote is a valuable food source and locally it is believed in fast mending of broken bones due to its good content of calcium. Tubers of the wild form of *C. abyssinica* are inedible but the fruits can be eaten but not specifically mentioned in Ethiopia. However fruits of cultivated anchote are not normally eaten. *Coccinia abyssinica* is mainly an Ethiopian tuber crop. Anchote, starch contains (c. 20%) tubers is an important staple food in the South western semi-humid highland regions (Abera 1995; Aga and Badada 1997; Asfaw 1997). The tubers contain a relatively high amount of calcium, which might explain the local belief that the plant helps with repairing bone fractures and displaced joints. Locally (around Dembi Dolo, western Oromia), young shoots and leaves are also eaten (Abera, 1995). Although the fruits of the cultivated landraces are not eaten (Amare, 1973), the use might be beneficial due to the carotenoid content, which are likely to be comparable to those of *C. grandis*. However, fruits of wild races of *C. abyssinica* are already used (Asfaw and Tadesse, 2001). Edibility of fruits is disputed and may differ between wild and cultivated forms (Westphal,1974; Holstein, 2015). Tuberous roots boiled for food, young shoots and leaves are eaten when cooked (Abera, 1995). According to Ayalew *et al*. (2017) anchote leaves are more nutritious (higher protein and amino acids) than other root and tuber crops.

Cultural values

Anchote dish is known for its cultural food in south western and Western region of Ethiopia. On occasion like celebration of Ethiopian Meskel Holiday (the finding of True Cross), and other holidays anchote food is the first to be served in the town and rural communities of the south and south western regions of Ethiopia (Mekbib and Deressa, 2016; personal observation). The food from anchote is prepared in the form of boiled tuber, or peeled raw chopped and then boiled and spiced with different spices of green pepper paste (kochkocha) and ghee and eaten with different bread made of teff, wheat, or any other cereals bread. Anchote dish is considered as unique and cultural food which specifies Wollega region of Ethiopia.The region is one of the wettest agro-ecology zones and known for different root and tuber crops cultivation (Parmar *et al*., 2017).

Medicinal values

Amare (1976) reported *C. Abyssinica* tuberous root is used as medicine by traditional practioners and dietary food in south and south western Ethiopia. In addition, Engels and Hawkes (1991) reported the lists of medicinal plants of Ethiopia and among which Anchote is one. The authors reported that the juice produced from anchote tuber contains saponin and this compound is used to treat disease such as gonorrhea, tuberculosis and cancer. Saponins are widely distributed in many plant species and have complex chemical structures consisting of a variety of tri-terpenoidal or steroidal aglycons and various carbohydrate moieties (Admasu, 2009). They are bitter tasting, foam producing tri-terpene glycosides and serve as natural anti-biotics for plants. Saponins are a diverse group of compounds commonly found in cereals and legumes, e.g. chick peas, soya beans, lentils, peanuts, Phaseolus beans and alfalfa sprouts; and in some plants commonly used as flavorings, herbs or spices, e.g. ginseng, fenugreek, sage, thyme and nutmeg (Admasu, 2009).

In Wollega (Western Ethiopia), *C. abyssinica* is also used to treat gonorrhea, tuberculosis, and cancer, as well as in traditional ceremonies and celebrations and for animal fattening (Dawit and Estifanos, 1991; Gelmesa, 2010). The diet of anchote is known to bind fractured bones of human and domestic animals and this especially for anchote tubers with two or more years old (called Gubo). As anchote root tuber stays in the soil longer as raton crop, it grows in size and more fibrous and high in calcium, phosphorus and macro and micro elements.

Production constraints

The low productivity and production of anchote tubers and seed could be due to many factors including diseases,

insect pests and low soil fertilities and attacks by wild animals like monkeys, porcupines**,** rodents, wild pigs and others. The major diseases and pests of anchote include bacterial leaf bight, powdery mildews and insect such as beetles which feed on the fruits and induce premature drop and decay of fruits. Anchote demands high soil fertility which is rich in organic matter, nitrogen and phosphorus for vigorous growth of the vegetative and tubers parts (Tufa *et al.,* 2017). Anchote production might have declined in the recent years due to replacement of the land with other food crops; pests, low yields, less fertile soils and other stresses like moisture stresses and wildlife attacks (Mekbib and Deressa, 2016; Tufa *et al*., 2017).

Genetic resources and conservation

In Ethiopia, genetic diversity studies have been done for *C. abyssinica* on different collections using molecular and morphologically markers (Bekele *et al*., 2014, Wondimu *et al*., 2014). The results showed that in all cases diversity exists within and among populations though among populations diversity is higher than within populations. According to Bekele *et al*. (2014) populations sampled from Gimbi and Ilu Ababor showed higher genetic diversity than other regions. According to parmar *et al*. (2017) two types of anachote have been found based on tissue colour of tuber (white and red colour). White tissue anchote seems to be more popular, due to its soft texture and ease of cooking. However, the red variants was considered for flour making (by dehydration), for use in porridge and soups for various medicinal and supplementary food applications. According to the same author red anchote tubers contained significantly higher protein content (16.85 mg/100 g dry matter basis) than the white variant.

Efforts to conserve the traditional root and tuber crops of the country are short of what is desirable. Demissie (1998) reported that enset (*Ensete ventricosum)*, anchote (*Coccinia abyssinica)*, Oromo dinich (*Plectranthus edulis)*, *Amorphophallus abyssinica* and *Abelmoschus esculentus* are some of the little known but potentially useful crop species in Ethiopia. They, however, have received little attention by research and development activities. Mathenge (1995) indicated that proper documentation of the available information related to under-utilized crops on distribution, use and traditional knowledge is essential. The information will be valuable in order to maximize the conservation and further utilization of these crops. Some genetic resources conservations of anchote and other root and tubers crops of Ethiopia have been done by National Biodiversity Institute of Ethiopia (Table 1) (Engels and Hawkes, 1991). Nevertheless, due to their perisheabiliy nature and intensive management systems, it is not satisfactory in conserving genetic resources as compared to other field crops. Hence alternative solution has to be devised for future conservation practices such as in situ and on farm conservation approaches. Therefore, future conservation of the root and tuber crops shall be done in ecology where traditional farmers are cultivating:

- Establishing *in situ* / on farm conservation of anchote in south and south western Ethiopia.
- Collection and conservation of exhaustive seed samples in national gene banks for long time regeneration of varieties for different uses

Table 1: Some minor native species with potential value

Scientific name	Common name	Uses	distribution
***Abelmoschus spp*.**	Okra (incl. wild species)	vegetable	Ilubabor, wollega
***Arisaema sp*.**	Burie	Root crop	Gamu Gofa, Sidamo
Oryza longistaminata	Wild rice	Food grain	Gojam, Ilubabor
Brassica oleracea	Gurage gomen	Leaf vegetable	Shewa, Sidamo
Coccinia abyssinica	anchote	Tuber crop	Wollega, shewa
Plectranthus edulis	Oromo dinich	Tuber crop	Wollega, shewa
Ensete ventricosum	ensete	Edible pseudostem	Harerge, gamo gofa, sidamo, shewa
Ipomoea batatas	Sweet potato	Root crop	Harerege, gamo gofa, sidamo, shewa
Moringastenopetala	Cabbage tree, shiferaw, haleko	Leaf Vegetable	Gamo gofa,
Sauroma tumnubicum	banshalla	Root crop	Gamo gofa, sidamo
Trigonellafoenum-graecum	fenugreek	Baby food	Spread over the country

Source: Engels and Hawkes, 1991

Breeding and agronomic management practices

Breeding and local variety selection

Crop research in Ethiopia has largely concentrated on the more important cereal, oil and industrial crops. The rather localized importance of indigenous root and tuber, legume crops seems to be part of the reason for the lack of national research focus. They are not fully documented

and/few programmes are currently aimed at their development and production. Some of these species are already at risk owing to land degradation and habitat destruction. Most of Ethiopia's important traditional root and tuber crops have thus far been out of the main stream of scientific research, together with their main traditional repositories, i.e. home gardens (Nebiyu and Awas, 2006; http://agris.fao.org/agris-search/search.do?recordID=ET2007000287 accessed Feb. 2019).

However, research on root and tuber crops at Jima Agricultural Research Centre was started nearly four decades ago as part of the coffee diversification programme. In addition, other agricultural research centers like Hawasa, Areka, Melkassa and Holeta have been doing on variety development and agronomic management practices. The major areas of research given attention were collection and/or introduction, maintenance, screening of adaptable and high yielding varieties, identification of agronomic and compatible management practices. Taro, yam, cassava, aerial yam, and sweet potato were the major crops given attention. As a result, some remarkable accomplishments have been made with regard to variety improvement and identification of appropriate agronomic and cultural practices. Therefore, three taro, two cassava, twenty five sweet potato, six enset and three yam varieties were identified as high yielding, adaptable and quality materials in south-western Ethiopia (Nebiyu and Awas, 2006; http://www.eiar.gov.et/index.php/en/crop-research/ accessed date August 21, 2018).

The productivity of tuber yield of anchote varies across the landraces and the average productivity of the local varieties is very low which could be attributed to the low genetic potential as well as the low management practices. Anchote root tuber is single and only single tuber is found per single plant and on the contrary above ground part is higher in biomass and it is a trailing plant which can climb the tree or other support structures if it is provided and it grows up to 5 meters and above. This would indicate that the vegetative parts of anchote are higher as compared to the root tuber yield. The fruits are not eaten though it is rich in anthocyanins (Holestein, 2015). The above ground part is high in biomass while the underground part is a single root tuber systems and the size of the tuber increases as it stays longer in fertile soil while the fibre content increases. The fruit size is small and non sweet (personal observation) and in the future activities of breeding for variety selection of fruit characteristics and the sweetness shall be considered. The breeding methodology for anchote can consider of other cucurbitaceae family, and the size of the fruit shall be increased when desired for consummation.

Efforts were also put into the development of anchote to increase the yield by selection of local cultivars with larger tubers and by improving crop growing with better suited fertilizers (Abera and Gudeta, 2007; Daba *et al*., 2012; Bekele *et al*., 2014; Tufa *et al*., 2017). The future breeding objectives of the anchote shall concentrate as other *Coccinia spp*. for fruit size and quality since the available fruits of anchote is not eaten though it contains phytochemicals with health benefits.

- Variety development through hybridization and successive selection for higher fruit yield, quality, seed size and fruit tastiness, etc.
- Variety identification for higher root tuber yields and other related agronomic traits
- Characterization, and conservation of the available landraces for future use
- Genetics of *Coccinia spp*. especially the cytogenetic analysis and other molecular characterization of the species and biological classification of the species
- Collection of the wild types, characterization and conservation for future uses

Agronomic management practices

Seed bed preparation

Anchote could be planted on fine seed bed prepared before planting. The frequency of tillage depends on the types of soil in which it can be cultivated two to three for ease of seed germination directly or for seedling growth. With this regard there was no research recommendation but, traditionally farmers use fine seed bed for ease of seed planting (Meseret, 2018).

Planting

Coccinia is planted traditionally by farmers by broadcasting the seeds and mixing with the soil (Mekbib and Deressa, 2016). However, at research plots, it is planted in rows with different intra and inter row spacing. For instance Abera and Gudeta (2007) reported that reduction of intra and inter row space from 30cm to 10 cm and from 100cm to 40 cm increased the total tuber yield by 137% and 37.4% respectively.

Soil fertility and weed management

Though much has not been done regarding the soil nutrient demand of anchote some research results showed that Coccinia needs highly fertile soil and for efficient tuberous growth (Meseret, 2018). With this regard Abera and Gudeta (2007) reported that application of 5 to 8 tons/hectare of FYM or 46/20 kg/ha N/P increased root tuber growth from 44 to 63%.Weed management is also important in any crop and it is also important for Coccinia. However, early weeding is important to reduce the competition for nutrients. At latter stage anchote leaves can suppress the weeds in the plot since it has high biomass and broad leave and many branches. Therefore,

weeding and other management recommendation was not so far available for anchote production.

Harvesting

Coccinia root tuber can mature after 4 months depending on the varieties and environments in which it is planted. However, the root tuber can stay for longer time since it is very resistant to drought in the soil (Mekbib and Deressa, 2015). In addition, root tuber stays in the dry season in soil and can give rise to vegetative parts when the moisture is available or the rain comes. The root tuber size varies depending on the age of the tuber. As it stay in the soil more the size and fibre content increases. The report from Girma and Dereje (2015) indicated that extending the harvesting date from 4 to 7 months increased fresh and dry matter yield on average by 450%. Moreover, the same authors indicated that delayed harvesting date improved nutrient concentrations especially Ca and Fe. Future works regarding agronomic traits include:

- Establishing standard use of chemical and organic fertilizers for optimum root tuber and fruit yields
- Establishing standard for improved cultural practices (cultivation, planting time, plant population, harvesting and post harvesting technologies)
- Establishing standard for offseason production (moisture or irrigation frequencies)
- Establishing standard for alleviating integrated pest and weed management
- Establishing standard for seed harvesting and drying procedures for higher germination percentage

The nutrient contents of anchote root tubers and leaves

The food staff

Anchote is believed to be nutrient rich (protein, carbohydrates, oils, minerals and vitamins) (Aga and Badada, 1997; Beruk *et al*., 2015; Girma and Dereje, 2015; Parmar *et al*., 2017). The protein content of anchote on average is higher than other food crops. Similarly the total carbohydrate and minerals (macro and micro nutrients) of anchote are high. According to (Aga and Badada, 1997) anchote contained good nutrient composition with good supplements of vitamins and minerals. Its anti-nutritional contents are probably of little nutritional significance and they may be still minimized or destroyed during cooking processes.

Anchote leaves and tubers have considerable protein contents and the leaves had more values than the tubers (Ayalew *et al*., 2017). Based on the same authors' report the total amino acid were 45.12 to 62.89 and 67.31 to 75.69 g/100 g protein for tuber and leaf samples, respectively. The leaves of anchote are consumed as vegetables in Denbi Dollo areas of western of Ethiopia. The extent of use of leaves of anchote for human consumption was not presented and need further studies. However, it is usual and important to present that the above ground part of the crop is higher and gives high fresh biomass per single plant than tuber. This is an opportunity for using the green leaves for human consummation and animal feed. The nutrient contents of anchote are presented in Tables 2, 3; and Fig.1. According to Fekadu *et al*. (2014; 2013) raw and boiled before peeling anchote tubers contain significantly high amounts of minerals (Ca, Fe, and Zn) as compared to peeled anchote before boiled; while highly significantly higher for raw anchote for magnesium and phosphorus. Similarly, Girma and Dereje (2015) reported significantly high miner contents (N, K, P, Ca, Fe, protein and ash) for *coccinia sp*. (cucumber and anchote) as compared to other leafy vegetable (swiss chard) and root crops (yam and potato). Further anchote nutrition should be encouraged and supported with research based products including:

- The root tuber and leafy vegetable processing technologies for consumption
- Blending standards and technologies for anchote root tuber flour with other food staff to prepare nutrient rich diet

Table 2: Nutrient concentration of anchote as compared to other edible vegetables

Element	Leaf nutrient concentration (g/kg)			Tuber nutrient concentration (g/kg)		
	Cucumber	Swiss chard	Anchote	Yam	Potato	Anchote
Nitrogen	56	-	41.80	13	1.5-2.2	19
potassium	45	25.5	30.50	-	20	123
phosphorus	9	-	7.30	-	2.40	7.40
Calcium	24	7.80	30.0	0.45	0.78	5.10
Iron	3	0.29	1.29	0.15	0.075	0.316
Protein	284	323	260	-	15.0-20.20	96-138
Ash	176	176.20	221	-	11.08	50-70

Source: Girma and Dereje, 2015

Table 3: Nutritional contents of raw and processed anchote samples

Nutrients	Treatment		
	Raw	Boiled after peeling	Boiled before peeling
Moisture content (mg/100g)	74.93 (+/-) 0.345c	81.74 (+/-) 0.395a	76.73 (+/-) 0.465b
Crude protein (mg/100g	3.25 (+/-) 0.061a	2.67 (+/-) 0.145b	3.14 (+/-) 0.187a
Total ash (mg/100g)	2.19 (+/-) 0.014a	1.33 (+/-) 0.406b	1.99 (+/-) 0.168a
Crude fibre (mg/100g)	2.58 (+/-) 0.048b	3.71 (+/-) 0.135a	2.77 (+/-) 0.216b
Crude fat (mg/100g)	0.19 (+/-) 0.020a	0.13 (+/-) 0.017b	0.14 (+/-) 0.010b
Utilizable (mg/100g)	16.86 (+/-) 0.410a	10.42 (+/-) 0.310c	15.23 (+/-) 0.410b
Gross energy (Kcal/100g)	82.12 (+/-) 1.300a	53.48 (+/-) 1.340c	75.26 (+/-) 2.390b

#rows followed by same letters are not significantly different at P</=0.05. Source: Fekadu *et al*., 2013

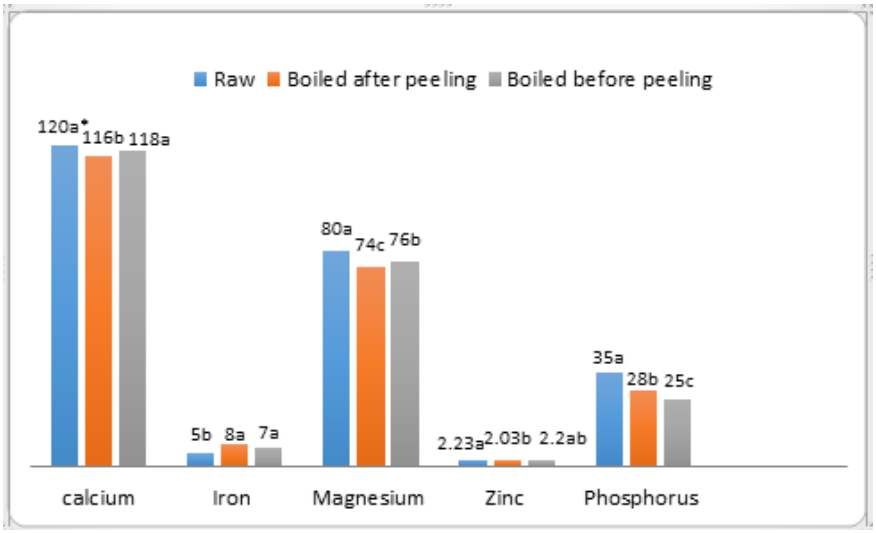

Figure 1: Mineral content of raw and processed anchote tubers samples (mg/100g) (*bar charts followed by different letters for each cluster is significantly different at p=0.05; source: Fekadu *et al*., 2014)

Phytochemicals and anti-nutritional factors

Legume, fruit, root, tuber and vegetable crops are complete sources of nutrition for human diets. Diversity on the field will result diversity in feeding habit. Mal nutrition is not the complete absence of food but also lack of appropriate combination of diet. Complete or healthy foods are mainly from fruits, vegetables, and root and tuber crops. In addition to supplying with vitamins, minerals, proteins, fats and carbohydrates, diets containing fruits, vegetables, root and tubers promote healthy aspects in the human body. They contain phytochemicals which protects the body from different diseases (cancer, eye blindness due to age related diseases, different cardiovascular diseases, neural diseases, etc). Root and tuber crops have good nutritive value and phytochemical contents which are beneficial to the human health. These include the phytochemicals are alkaloids, tannins, phenols, flavonoids and saponins (Okwu and Ukanwa, 2007; Admassu, 2009).

Phytate, oxalate and tanin are some of the anti-nutritional factors which could have negative impacts on human health when consumed with food staff. Anchote contains anti-nutritional factors with different amounts and are affected or decreased during cooking processes (Fig. 2

and 3) (Fekadu, et al., 2014). According to the same authors boiling of anchote tubers after peeling significantly reduced phytate, oxalate, cyanide and tanin as compared to raw and boiling before peeling of tuber. Therefore, further processing of anchote for different food recipes will reduces anti-nutritional factors to the levels which might not bring hazard to human health. However, this needs further research areas.

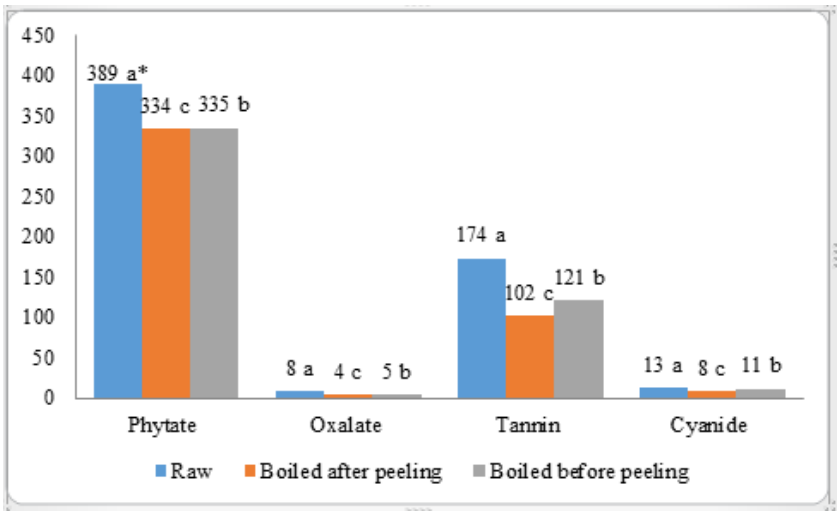

Figure 2: Phytochemicals and anti-nutritional factors of raw and processed anchote tubers (mg/100g) (*bar charts followed by different letters for each cluster is significantly different at p=0.05; source: Fekadu *et al*., 2014)

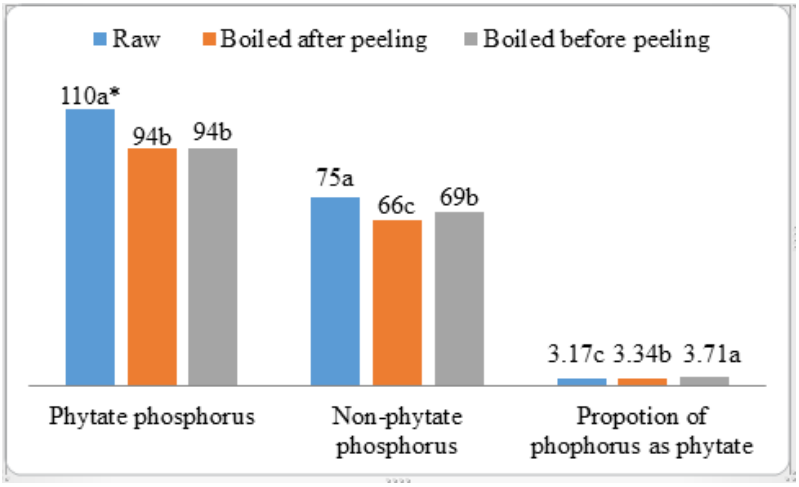

Figure 3: Effect of anchote root tubers processing on different anti-nutritional factors (*figures followed by different letters for each compound is significantly different at p=0.05; source: Fekadu *et al*., 2014)

Conclusion

Anchote (*Coccinia abyssinica*) is an endemic root tuber crop of Ethiopia and grown for edible vegetable roots and leaves in western Ethiopia. The crop is rich in nutrients (starch, proteins, ca and p among the others). It is widely consumed by the rural and urban communities in western Ethiopia. There are about ten species found in Ethiopia and among which *c. abyssinica* is cultivated for consumption. The crop has nutritional, cultural and medicinal values. The male and female flowers of *C. abbysinaica* is found on separate parts of the same plant which is dependent on insects for cross pollination. Propagation of the crop is mainly by seeds while root tubers are also used. Other methods (tissue culture and vine cuttings) are not well established for propagation purposes. The major production constraints include lack of high yielding varieties resistant to diseases and pests, low soil fertility and drought. Besides, conservation of landraces are left for traditional famers. The crop has also health benefits since it has phytochemical such as carotenoids. Anti-nutritional factors (phytate, oxalate and tanins) are present in the root tubers. However, research reports indicated that processing of root tubers (cooking after peeling) could significantly reduce the anti-nutritional factors to the level which could not cause damage to

human body. The review indicated the gaps for future works for improving the landraces for tuber yield and quality, and conservation of the landraces.

Future research works

Anchote (*coccinia absyssinica* (Lam.) Cogn.) is a root tuber crop grown in western and south western Ethiopia for edible tuber as vegetable. The crop is cultivated since long ago in the rural communities of the region as home garden crop. In these regions, the crop is used as supplementary food with other cereal crops and source of cash for small holder farmers. However, its production is limited to small plots of land near homes. Wide cultivation is limited due to crop growth nature of climbing on other trees and crops and makes its management difficult. Moreover, its seed production is limited because of limited fruit setting due to diseases and pests. On the other hand, anchote plant gives rise to single root tuber which is uneconomical to use as planting material and need huge tuber seeds and also limited the productivity per unit area of land.

Breeding and other improved management practices are not well established by research. Therefore, no improved anchote variety was released for production. Root and tuber crops in Ethiopia research priority areas did not encompass so far anchote while other crops like enset, sweet potato, cassava, and other are getting due attention.

In the future, like other *Coccinia sp*. fruits of the cultivated anchote may be eaten and contains beneficial nutrients compounds for human health like carotenoids, other macro and micro nutrients and phytochemicals; hence it needs attention with regard to research priorities. Breeding shall consider fruit production parallel to improvement of the tuber yield and quality. One aspects of the tuber quality in breeding should consider its processing quality like time for cooking and taste. On top of that as leafy vegetables, further leaf processing and consumption and its nutrient compositions should be investigated. In the future, anchote processing and blending with other food sources for complete diet preparation for infant and adults when mixed with other ingredients and substantiated or corroborated with research findings for technological aspects. Hence, the following points need due attention in the future to improve anchote production, productivity and consumption:

- Develop food processing technology packages containing anchote food sources for domestic consumption and for export as different snacks like biscuits.
- Application of biotechnology supported conventional breeding for anchote improvement
- Investigations for nutrients and food sources and anti-nutritional factors
- Breeding varieties for reduced anti-nutritional compounds and quality
- Developing improved agronomic practices
- Effect of anchote production on soil and other ecologies
- Development of micro-propagation or tissue culture technologies for vegetative propagation
- Develop varieties for fruit production
- Develop varieties with more tubers yield and quality
- Develop market channels for processed and packed anchote food sources

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