

Review Article

Nutritional Potential and Antnutritional Factors of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* Tubers: A Review

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Abstract: In Ethiopia, root and tuber crops play a significant role for food and nutritional security by filling food shortage that might exist until harvest of major crops. The objective was to review the *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* tubers which are indigenous crops to Ethiopia with good nutritional value and drought tolerance. *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* are a good sources of carbohydrate, minerals and fiber. Little is known about the contribution of these crops to food and nutritional security, nutritional value and major limiting factors to their wider utilization in Ethiopia. These crops are generally regarded as poor man's food and remain neglected compared to other food crops in human diet. The anti-nutritional factors available in these indigenous crops can be reduced by different processing methods like fermentation, boiling and cooking to tolerable level. The generated information will give insights for their development, promotion and wider utilization to support food insecurity crises and calorie gap for the fast growing population in Ethiopia. Generally, the *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* tubers crop have appreciable nutritional composition of foods, minerals, ant nutritional factors and they are also used to maintain the fractured bone of human being. Thus, the crops should be included in people's daily diet and solve the food insecurity problems in the country. All the stakeholders should give due emphasis to these indigenous crops and process to different food products.

Keywords: Nutritional Potential, Anti Nutritional Factors, Indigenous Crops and Food Insecurity

1. Introduction

Several agricultural crops are known to be originated from Ethiopia and it is also stated that Ethiopia is well known for its diversity of indigenous food plants, of which 27% are cultivated vegetables by traditional farmers in home gardens and about 29% are non-cultivated vegetable species [1]. They can contribute to food security of rural dwellers either through direct consumption or as a source of cash income. However, food insecurity crisis is still persisting being prevalent in many parts of Ethiopia [25]. This is mainly due to highly selective and restricted food consumption habit of the population as well as less

exposure to important indigenous food plants such as *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* tubers [23].

Ethiopia has abundant natural food sources that can be used to mitigate malnutrition and food insecurity among which root and tuber crops are the pillars [28]. Root and tubers crops are consumed by one third of the world population next to cereals being a good source of carbohydrates worldwide [14]. They provide a substantial part of the world's food supply, animal feed and processed products for human consumption and industrial uses [14].

Food insecure and subsistence farmers of developing countries depend highly on root and tuber crops as a principal food source of nutrition and cash income [36]. These crops

are used as a major food sources during the failure of other food plants during erratic rainfall since they are drought tolerant and high yielding in harsh weather conditions [37]. Since indigenous crops like *Coccinia abyssinica*, *Plectranthus edulis* and *Dioscorea abyssinica* have good nutritional value and also resist drought climatic conditions their potential productivity and the way of consumption of these crops should be changed. *Coccinia abyssinica*, *Dioscorea abyssinica* and *Plectranthus edulis* are very important in South and South Western Ethiopia [6]. Although these crops are drought resistant and food security crops in drought prone areas, their potential as a human food medicine has not yet been fully recognized and utilized [24].

Though this species has promising importance and easily grown in areas where it is stapled and co-stapled food item, it has been an underutilized plant by Ethiopians. Food and nutritional insecurity are the major challenges in developing countries including Ethiopia. To solve this problem, the search for alternative food that is neglected, underutilized, and wild edible food crops has the potential to address food insecurity [41]. Thus, purpose of this review is that to review nutritional composition, anti-nutritional factors of *Coccinia abyssinica*, *Dioscorea abyssinica* and *Plectranthus edulis* underutilized tubers crop indigenous/ Native to Ethiopia.

2. Methods

To evaluate the Nutritional Potential and Anti-nutritional Factors of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* tubers a narrative review was applied. Recent and specific articles about *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* were exhausted. The historical background, agricultural and traditional development, antinutritional factors and processing methods to reduce antinutritional factors, current status and future perspectives of the roots and tubers as food crop have been also thoroughly assessed.

3. *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* as Food and Nutrition Security Crops

3.1. Agricultural Performance of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica*

Ethiopian potato (*Plectranthus edulis*) is one of the underutilized tuber crops indigenous to Ethiopia [43]. Eating underutilized edible plants has been looked as a sign of poverty which is largely due to lack of knowledge on their nutritional benefits. The crop is widely grown in South and South Western parts of the country. The tubers of *Plectranthus edulis* are clearly stem tubers with the pairs of “eyes” (that is compound auxiliary buds) being arranged in the same alternating pattern as the axillary buds on stolon and stem [35]. *P. edulis* is an old crop according to the information from the growers. *Plectranthus edulis* is important

to the cultural, social and economic life of the household. It is particularly important in local diets mainly between September and November [28]. It is highly valued for its contribution to food security in these periods since other food crops will not be ready for consumption.

Plectranthus edulis is an indigenous plant to Ethiopia growing in mid and high altitude areas [46]. It is known to Ethiopia due to its horticultural uses since it is fast growing, produce lovely flowers which are resistant to most pests and plant diseases [46]. Though *plectranthus edulis* is mainly cultivated for its edible tuber, the leaves are also eaten after cooking like vegetables in some parts of Ethiopia, particularly important in local diets mainly between September and December since other food crops are not ready for consumption [52].

Coccinia abyssinica is an annual trailing vine belonging to the *curcubitaceae* family. It is native to Ethiopia and local known as Anchote [1]. The crop is widely grown and utilized in Western, Southern and Southwestern parts of Ethiopia [17]. *Coccinia abyssinica* produce a single tuber and the size of the tuber gets bigger as the plants are maintained longer in the field (personal communication with farmers). The tubers could remain in the soil with little quality loss until the next planting season [39]. This shows that the crop can be harvested at any time of the year once it attains full maturity. *Coccinia abyssinica* is the highest yielding root crop [15]. Thus, the crop demands comprehensive research attention so as to develop a high yielding variety using the existing germplasm through breeding.

Different Studies revealed that *Coccinia abyssinica* is high yielding crop compared to the other root and tuber crops found in Ethiopia [29]. The plant has been grown over a wide range of environments for a long time, and its cultivation and utilization have been passed from generation to generation through oral tradition with very little record information [1, 44]. *Coccinia abyssinica* is produced on several hectares of land in Western Oromia zones, with an average yield varying from 100-180 quintals per hectare [2, 22].

Dioscorea abyssinica, belongs to the family Dioscoreaceae and the genus Dioscorea, is a climber plant twining to the right, with an herbaceous stem and a large tuber [13, 26]. It is cultivated during the raining season in the South, West and the South-West highlands of Ethiopia [39]. Tubers of *Dioscorea abyssinica* have long been used as food as a major source of starch in human nutrition [39]. Locally, *Dioscorea abyssinica* is commonly known by its vernacular name “Boyna” which is equivalent to the common English name “Yam”. The plant is serving as a source of food within a restricted region of the country (Southern Nations Nationality Peoples Regional State) and few neighboring cities and rural areas to this region [10]. This might be due to lack of information on its potential as a source of important nutrients such as starch which are the main source of calorie. It is also known that Ethiopia is one of sub-Saharan countries with various indigenous resources but poorest country in the Horn of Africa.

3.2. Benefits of *Plectranthusedulis*, *Cocciniaabyssinica* and *Dioscoreaabyssinica*

The importance of root and tuber crops as staple foods is linked to particular agronomic advantages; they are well adapted to a diverse soil and environmental conditions and a wide variety of farming systems [30]. They are also a high efficient source of edible carbohydrates when compared with other food crops. With diversification of conducive agro-ecologies that enable all year round production, reliable water source the country has will enable to produce these root and tubers.

Plectranthusedulis good sources of carbohydrates, proteins and also used as a source of income in regions of Ethiopia where it is cultivated. It also contains secondary metabolites including phenolics, terpenoids, cardiac glycosides and flavonoids that are needed to combat various kinds of diseases like asthma [52]. Eating underutilized edible plants has been looked as a sign of poverty which is largely due to lack of knowledge on their nutritional benefits.

Plectranthus edulis is used for household consumption. Women farmers play major role in food preparation and food preparation of these crops involves boiling peeled or unpeeled tubers. The peeled tubers are also used for preparing stew, which is consumed with bread or enjera (thin bread prepared from grains cereals). *Plectranthus edulis*, apart from regular uses as food the crop is used also as cultural and medicinal uses.

Cocciniaabyssinica with its potential productivity has advantages that encourage its development and utilization. The diversified advantages of the crop are nutritional, economic, medicinal and social values [21, 29]. The crop contains relatively high protein with good amino acid composition, and provides good composition of important nutrients like calcium, potassium and iron beside the abundant carbohydrate and fiber content [1, 11].

Cocciniaabyssinica has a special place in the traditions and customs of the oromo people in the crop growing areas. According to Abera Hora [1], the inclusion of *Cocciniaabyssinica* in dishes served at ritual ceremonies is prestigious. The crop dishes in different forms are usually served in special occasions such as 'masqal' celebration in September, Weddings, Marriage ties, Circumcision, birth days and thanks giving days at the start of a New Year or harvest time. During such occasions and/or at times of physical injuries, a neighbor that has no *Cocciniaabyssinica* for that season may get a present of Anchote tubers from those who have it. This is done to share their happiness and strengthen social relationships. Anchote (*Cocciniaabyssinica*) has considerable social importance in the Anchote growing societies.

Apart from their regular uses as food, *Cocciniaabyssinica* have cultural and medicinal uses. For example, the crop is used to maintain bone fracture in humans [28, 3]. This could be associated mainly with high calcium content of the crops [39]. The crop is known to cure various human diseases in different areas of Wollega zones [16]. PremKumar Singh *et*

[34] reported that the effective uses of traditional food plants that meet the nutritional requirements also used as a remedy for various diseases.

Study carried out by EHNRI [19] on the nutritional content of the edible portion of both raw and cooked tubers of root tuber crops showed that the crops are rich in various micro macro nutrients. For instance, Amsalu *et al.* [8] reported that *Cocciniaabyssinica* help to alleviate protein sources. Thus, growing indigenous root and tuber crops will have significant roles in ensuring food and nutrition security, for diversification of local food bases, for income generation and maintaining people's cultural practices.

Dioscoreaabyssinica a tuber have a dual agricultural function. It is used as source of food and as a planting material [27]. The most common use of the crop is as boiled vegetable with some kind of sauce, but the skin is not eaten. It may be removed before or after boiling. In West Africa, *Dioscoreaabyssinica* is often pounded into a thick paste after boiling and is eaten with soup [47]. It is also processed into flour and baked, fried, roasted or mashed to suit regional tastes and customs [10]. There are various ways of *Dioscoreaabyssinica* preparation for food in respect to differences in its growing regions of the country. At Sheko districts, South West of Ethiopia, cooking methods relate to the gender of the cooker to prepare for consumption [20].

3.3. Nutritional Composition of *Plectranthus edulis*, *Cocciniaabyssinica* and *Dioscoreaabyssinica*

The nutritional composition of *Plectranthus edulis* tuber were; the ash content of the tuber on dry matter basis varied from 4.47 to 7.03% [57], which was higher than the range reported (4.45 to 5.68%) (for *Solanum tubersum* [7] and *Manihotesculenta* (1.44 to 3.19%) on dry matters basis [61]. The crude fat content of the tuber was varied from 5.01 to 10.87% as reported by [57]. Their findings were higher than white unpeeled *Solanum tubersum* (0.43%) *Colocasiaesculenta* (0.69%) and *Manihotesculenta* (0.12 to 0.69%) on dry matter basis (Charles *et al.*, 2005; USDA Food Composition Databases) standard refernces release. This relatively higher fat content might be related with the presence of a high amount of essential oils (>0.05% volatile oil on dry matter basis) in the genus *Plectranthus* [5]. The crude protein and crude fiber were ranged from 9.85 to 15.8% and 1.15 to 4.16% as reported by Abera *et al.*, [57]. Allemann and Hammes [7] reported in which the protein contents were higher than *Solanum tubersum* (5.13 to 8.36%), raw *Manihotesculenta* (5.03%) cassava (3.37%) raw taro (5.11%) calculated on dry matter basis (USDA Food Composition Databases) standard refernces release.

Cocciniaabyssinica is a good source of carbohydrates, proteins, minerals and fibers. *Cocciniaabyssinica* could be a healthy food crop with potential source of equal or better elements as compared to other root and tuber crops [3]. Its content is by far greater than other root crops [11]. It is also rich source of calcium which is an important constituent of our bones and teeth [3, 48]. It was reported that the nutrient concentrations in *Cocciniaabyssinica* tuber are higher than that found in equal

weight of *Solanum tuberosum*, *Dioscorea abyssinica* and *Manihot esculenta* tubers [34, 3].

Different scholars reported that nutritional content of *Dioscorea abyssinica* varies with species [40]. Atinafua and Endashaw [10] reported that the protein, fat, fiber, moisture and ash content ranges from 3.13 to 5.37%, 0.31 to 1.22%, 1.94 to 4.91%, 9.83% to 12.71% and 32.31% to 3.58% respectively. Similar findings were also reported that presence of higher protein contents in *Dioscorea abyssinica* a tuber compared to other tropical root and tuber crops like cassava, sweet potato and taro which highlights its nutritional superiority as a staple food [38, 40, 32]. *Dioscorea abyssinica* proteins have a better amino acid balance compared to other tropical root crops [12]. The mineral contents of *Dioscorea abyssinica* were ranged from 20.3 to 69.7 mg/100g for iron, 0.48 to 0.77 mg/100g for zinc, 31.02 to 118.8 mg/100g for calcium, and 15.1 to 56.2 mg/100g for phosphorus according to Atinafua and Endashaw [10].

3.4. Anti-Nutritional Factors of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica*

Anti-nutritional factors have been defined as substances, which by themselves, or through their metabolic products arising in living systems, interfere with food utilization and affect the health and production of animals [49]. Root crops, in common with most plants, contain small amounts of potential toxins and antinutritional factors [41]. Phytate, tannin, oxalate and cyanide are common antinutritional factors, which mostly occur in various root crops.

Plectranthus edulis contains terpenoids, flavonoids, phenolics, and cardiac glycoside while, alkaloids, tannins, and anthraquinone glycosides were absent [45]. The presence of phenols, terpenoids, cardiac glycosides and flavonoids are recorded and the percent inhibition of the methanol extract of the tuber of *P. edulis* was 84% at 100 µg/mL which is comparable with ascorbic acid (90% at 100 µg/mL), indicating its strong activity as radical inhibitor [45]. The presence of phenols, terpenoids, cardiac glycosides and flavonoids were found in *Plectranthus edulis* and known to have some positive effects on health Yadessa and Tolessa [52]. For instances, the presence of phenols and flavonoids in *Plectranthus edulis* is important as it is reported to decrease the incidence of some cancers and cardiovascular diseases [53]. The presence of phenols received much attention as potential natural antioxidant [51]. Their antioxidant activity is due to their ability to act as radical scavengers and metal chelators.

Ant-Nutritional factors may reduce the nutrient utilization of plants or plant products used as foods. They can limit the digestibility and solubility of certain nutrients such as proteins, minerals and vitamins [6]. Some anti-nutritional factors such as phytate, oxalate, tannin and cyanide in *Coccinia abyssinica* were investigated by different scholars [22, 11]. Even the raw *Coccinia abyssinica* contains low level of anti-nutrients except phytate, when compared to other roots and tubers such as potato, cocoyam and taro [22]). The cyanide content of *Coccinia abyssinica* tuber falls far below the lethal dose of cyanide [11]. Fekadu [22] reported that the tannin content of

raw *Coccinia abyssinica* tuber is very low compared to its critical toxicity effect and further reduced during processing. Despite this, since further processing of the crop is required; the anti-nutrients could be reduced more to the safest level for consumption. Even traditionally *Coccinia abyssinica* is not eaten raw where it is consumed.

The anti-nutritional factors found in *Dioscorea abyssinica* like free phenolics, tannin, hydrogen cyanide, total oxalate, amylase inhibitor and trypsin inhibitor activities were reported by Shajeclaet *et al.*, 2011. They reported 0.26 to 2.20 g/100g for total free phenolics, 0.04 to 1.48 g/100g for tannin, 0.16 to 0.34 mg/100g for hydrogen cyanide, and 0.26 to 0.78 g/100g for total oxalate respectively. The presence of phenols has been suggested to indicate that *Dioscorea* species could act as anti-inflammatory, antioxidants, anti clotting, immune enhancers and hormone modulators [33].

Afiukwaet *et al.* [50] reported that protein digestibility and palatability are reduced when tannin forms complexes with protein. However, their contents in foods are known to reduce through cooking [56]. The trace quantities of tannin available which were reported by Udensilet *et al.* [59] (20 to 255 mg/100g) tubers acts as a repellent against rot in *Dioscorea abyssinica* [31]. Phytates and oxalates have been reported to adversely affect the bioavailability of mineral in humans [60]. Abdul-Rasaqet *et al.* (2018) reported that the value of phytic acid (58.6 to 198 mg/100g) and oxalate were ranged from (9.02 to 49.3 mg/100g) which is low compared to the report of Wanasundera and Ravindran [38].

3.5. Limitation in Utilization of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica*

The review revealed that the available information on the indigenous root and tuber crops of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* are minimal. Thus, Integration of root and tuber crops into the food system of the people may help to minimize the problem of food insecurity [29]. Mekibib and Deressa [28] listed the major broad spectrum factors limiting production and sustainable use of root and tuber crops are displaced by other crops, little research attention, drought, short shelf life, shortage of planting materials, limited knowledge of youth and pests. It was noted that inappropriate agronomic packages, such as lack of recommended optimum fertilizer rates [2] and other agricultural practices may be some of the factors limiting productivity; quality and nutritive value of the crops *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica*. Generally, the main challenges for utilization of the crop in Ethiopia may be ignorance to the tuber crops, lack of awareness of the society and lack of support by policy direction.

3.6. Effect of Processing on Nutritional Value of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica*

Different processing technology of treatment conditions

are reported to eliminate or minimize anti-nutrients in root crops. Reduction or inactivation of anti-nutritional factors through process technology requires knowledge of the type, distribution, chemical reactivity and thermal sensitivity of these factors within the seed matrix and complex knowledge of process technologies.

The processing method of tuber *Plectranthus edulis* has significant effects on anti-nutritional factors [55]. This researcher reported that, cooking process such as boiling, steaming, and baking are known to improve the palatability and digestibility of tubers of *Plectranthus edulis*. Gifty and Bruno [55] reported that different processing methods reduces the anti-nutritional factors available in tubers and enhance the palatability and digestibility of the *Plectranthus edulis*.

Coccinia abyssinica was commonly processed traditionally by boiling after or before peeling [22]. The traditional processing methods were found to be effective methods to reduce anti-nutrient contents of *Coccinia abyssinica* tubers [22]. Additionally, Shebabaw [48] reported the effects of three processing methods (boiling, roasting and fermentation) on anti-nutritional contents of *Coccinia abyssinica* and reported that fermentation was the most efficient in reducing all the anti-nutritional factors (phytate, oxalate, tannin and cynade) found in *Coccinia abyssinica*.

Coccinia abyssinica Boiling was stated to increase crude fiber content and improve the bioavailability of zinc and on the other hand, processing was reported to decrease the crude protein, total ash, calcium, iron and zinc content of the crop [21]. *Coccinia abyssinica* tuber conserved majority of nutrients since this method prevents them from leaching out into the cooking water. Fermentation of *Coccinia abyssinica* tuber enhanced protein, fat, ash, potassium (K) and zinc (Zn) content [48].

The *Dioscorea abyssinica* tuber treated with species, pretreatment and drying methods had significant effect on most of the anti-nutritional and vitamin contents of the *Dioscorea abyssinica* flour (Abdul-Rasaq *et al.*, 2018). The anti-nutritional factors were significantly reduced by blanching compared with the use of potassium metabisulphite as the method of pretreatment. Fermentation is a very interesting process used in plant foods to increase the nutritional quality and remove undesirable compounds. Fermentation enhances the nutrient content of foods through the biosynthesis of vitamins, essential amino acids and proteins, by improving protein quality and fiber digestibility. It also enhances micronutrient bioavailability and aids in degrading anti-nutritional factors [54]. Fermentation enhances the nutritional quality of foods and contributes to food safety particularly under conditions where refrigeration or other food processing facilities are not available [58].

Generally, processing methods could be effective to reduce the amount of anti-nutritional factors available in tubers down to tolerable levels. Among the alternatives that can reduce the toxicity of anti-nutrients to the minimum level and ensure the safety of consumers, the use of effective processing methods including cooking, fermentation, soaking and drying are quite

viable.

4. Conclusions

Plectranthus edulis, *Coccinia abyssinica* and *Dioscorea abyssinica* have a great potential for contributing to food security. Especially, they play major role to fill food gaps that might exist until harvest of major crop. The crops are source of carbohydrate, fibers and minerals and also used as medicine for human being and contains some anti-nutritional factors. The toxic substances like anti-nutritional factors found in those crops can be reduced by fermentation, boiling and cooking to tolerable level. The potential uses of indigenous *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* crops for food security and income generation has not been fully exploited. Taking into account their roles of crops in traditional agriculture system and people's culture, better attention need to be given by all actors to fully utilize in daily diet. Promotion of *Plectranthus edulis*, *Coccinia abyssinica* and *Dioscorea abyssinica* crops in different areas, could play a crucial role in improving the food and nutrition security of the fast growing population of the country.

Conflict of Interest

There is no conflict of interest

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