A Critical Appraisal of Amaranths and Chenopodium Weeds for Their Harmful and Beneficial Aspects in Context to Food Security in Pastoral Area

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ABSTRACT
Amaranths and Chenopodium species are among the worst weeds in the world. They are annuals competing with many economic crops including cereals and vegetables in different parts of the world including Ethiopia and cause great yield losses. Lack of knowledge about these pseudo-cereal weeds has created an atmosphere of uncertainty among the farmers particularly in pastoral area like Afar. On the other hand, food insecurity is a reality for hundreds of millions of people around the world. As a consequence of globalization and industrialization of agriculture, global food security has become increasingly dependent on only a handful of fertilization and high energy demanding plant species. These two crops, rich in high quality protein content with various essential vitamins and minerals may be an ideal alternative. In Ethiopia, food insecurity is highly prevalent in moisture deficit highland and in the lowland pastoral areas. Even in years of adequate rainfall and good harvest, the people, particularly in lowland agro-pastoral areas, remain food insecure and in need of food assistance. The mentioned facts stimulate the retrieving of alternative crops into the production. Thus, the present paper is a more comprehensive appraisal of these weeds that attempts to provide information on eco-physiology and economic significance of Amaranths and Chenopodium into a new perspective with a special focus on beneficial and harmful impacts on livestock and human.

Keywords: Amaranth, Crop diversification, Food insecurity, Nutritional value, Quinoa.

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1. INTRODUCTION
Amaranths and Chenopodium (pigweed) species are among the worst weeds in the world. They are annuals competing with many economic crops including cereals and vegetable in different parts of the world and cause great yield losses (Bressani, 1989, 2003; Berghofer and Schoenlechner, 2002; Brainard et al., 2007; Collins et al., 2008). Amaranths (Amaranthus spp.) and quinoa (Chenopodium spp.) commonly categorized as pigweeds are pseudo-cereal that have been widely grown by the Aztecs, Incas and Mayas in Latin America since pre-Columbian times for millennia. These grains are endemic to Andes of South America. Cultivation areas extend from Southern Colombia to Northern Chile and Argentina. Currently, Peru and Bolivia are the two largest producers and exporters of quinoa in the world. Amaranths (Amaranthus spp) and Quinoa (Chenopodium) are treated as grains although they have broad leaves, unlike the true grains and corn, which are grasses. Their leaves are among the most nutritious of vegetable greens but it is their grain that put them under a category of crop. Protein content of these two alternative food crops has essential amino acid balance that is near the ideal level. Both of these plant species come closer to meet the genuine protein requirements of the human body than either cow's milk or soybeans. They are high in the amino acid lysine, which is lacking in most cereals such as wheat, sorghum, maize and barley.

On the other hand, food insecurity is a reality for hundreds of millions of people around the world (Webb et al., 2006). About 17 million people in East Africa are highly or extremely food insecure and are in need of emergency humanitarian assistance (FEWS NET, 2010). In Ethiopia food insecurity is highly prevalent in moisture deficit highland and in the lowland pastoral areas. Even in years of adequate rainfall and good harvest, the people, particularly in lowland agro-pastoral areas, remain food insecure and in need of food assistance (Mathewos, 1996). The mentioned facts stimulate the retrieving of alternative crops into the production. In spite of all these circumstances, relevant information on these pigweeds viz., amaranths and quinoa regarding their economic use as food and feed are meager and rather contradictory which create a sense of uncertainty among farmers and affected community.

Thus, the present communication is a more comprehensive review that attempts to bring eco-physiology, cultivation and economic significance of amaranths and quinoa into a new perspective, with a special focus on beneficial and harmful impacts on livestock and human.

2. ECO-PHYSIOLOGY
Pigweeds and Sugar red root are easy to recognize, yet correct identification of pigweed species can be tricky. Two or more pigweed species often occur together in the same field. Significant variation can occur within a species, and inter specific hybrids occasionally occur (Weaver 1980. Sellers et al., 2003). These species may
grow in wheat or other crop as annual weed. Most pigweeds grow into large, erect-to-bushy plants, 2–7 feet in height, with simple, petiolate (stalked) leaves arranged alternately (singly) on stem. Leaf blades are generally oval-to-diamond shaped, and 2–6 inches long. Prostrate pigweed forms a low, spreading mat, with smaller (about one inch) leaves that are distinctly notched at the tip. There are so many similarities between quinoa (keen’ wah) and amaranth that it seems appropriate to describe them together. Quinoa, however, is a cool weather crop and amaranth is a warm weather one.

Physiologically, quinoa or Chenopodium is predominantly halophytic plant belonging to family Chenopodiaceae growing in saline and xeric conditions. It grows as annual herb sometime perennial. On the other hand, Amaranths is a non-halophytic annual herbaceous plant belongs to family Amaranthaceae. Chenopodiaceae is closely allied to Amaranthaceae from which it differs in not possessing membranous perianth and connate stamens. A. tuberculatus (Pratt and Clark, 2001), Newly emerging pigweed seedlings open a pair of long, narrow cotyledons, about 0.5 inch long by 0.1 inch wide, followed by the first true leaves, which are broader in outline. Plants form moderately deep, branching taproots, and may show a distinct reddish coloration on roots, lower stems, and undersides of leaves.

3. BENEFICIAL ASPECTS

3.1 As grain and feed

Although the origin of this grain is old, interest in amaranth has arisen recently because of its useful nutritional qualities. The small seeds contain considerable levels of high-quality protein (rich in lysine) and low levels of saturated fatty acids in their oil moiety, thus winning room on the health food store shelves. The seeds have a protein content of about 16 percent, more than wheat, rice or maize and a digestibility score much higher than soy, milk and wheat.

The grain has some protein (12% to 17%) and is high in lysine, an amino acid that is low in other grain crops. The grain is high in fiber and low in saturated fats, factors which contribute to its use by the health food market. It is an exceptionally rich source of calcium, iron and vitamin C, a very rich source of potassium, vitamin A and riboflavin, a rich source of niacin and an above-average source of protein. Grain amaranth has been used for food by humans in a number of ways. The ground grain is used in breads, noodles, pancakes, cereals, granola, cookies and other flour-based products. The grain can be popped like popcorn or flaked like oat meal. More than 40 products containing amaranth are currently on the market. Little is known about the production and utilization of amaranth as forage. The leaves stem and head are reportedly high in protein (15 to 24% on a dry-matter basis). A relative of grain amaranth, redroot pigweed, has been shown to have 24% crude protein and 79% in vitro digestible dry matter. Vegetable amaranths, which are closely related, produce 30 to 60 t/ha of silage (80% moisture). In areas where corn silage yields are low owing to moisture limitations, grain amaranth may become a suitable silage alternative after further research. There are many species of amaranth in cultivation.
Some types of amaranth are grown for their edible seeds, while others are cultivated for their edible greens. Amaranth is widely cultivated in West Africa for its edible greens, particularly in Sierra Leone. The plant is a fast-growing annual which loves high temperatures, to attain its maximum growth of 5 to 6 feet. *Amaranthus tricolor* is the most commonly grown species in Sierra Leone, preferred for its ability to produce high-quality, tasty green. The grain is processed in various ways for consumption, of which the expanded grain form is perhaps the most popular. Other processes include cooking in water, extruding, toasting, incorporating it into flakes (Bressani *et al.*, 1993; Saunders and Becker, 1984) or pastas and baking into bread. In Mexico, *A. cruentus* cultivars are used to manufacture cookies called “Alegria,” in which amaranth is used in the form of popcorn (Irving *et al.*, 1981). In Asia, the Indian diet finds in amaranth grain a culinary acceptable high protein, high fiber, alternative to wheat, easy to incorporate into the traditional cuisine (Dixit *et al.*, 2011). Despite being gluten-free and having formidable nutritional properties, amaranth and quinoa, are not exploited by the food industry (Izquierdo and Roca, 1998). Amaranth and quinoa possess high quality protein (10-15%, albumin and globulin), considerably amount of fibre (8-10%) and bioactive compounds such as phenolic compounds, tocopherols and folate (Ranhotra *et al.*, 1993; Lopez *et al.*, 1994; Repo-Carrasco-Valencia, 2011b). Repo-Carrasco-Valencia et al. (1993) reported that quinoa var. Amarilla de Marangani had no limiting amino acids. Ranhotra *et al.* (1993) observed that protein quality in quinoa (protein digestibility, protein efficiency ratio and nitrogen balance) was equivalent to that of milk protein casein.

### 3.2 As Vegetable

Amaranths and quinoa have been rated considerably higher in minerals, such as calcium, iron, phosphorous (Santos *et al.*, 1997) and carotenoids (Bressani, 2003) than most vegetables. However, these vegetable species received less research attention than grain amaranths. Their use as salad in place of lettuce spinach is quite common in many places. Moreover, pharmacological properties of different amaranth species have also been investigated. It was determined that *Amaranth paniculatus* and *Amaranth cruentus* are good sources of flavanoids, especially for rutin, which are mostly produced in the stage of blossoming. Usage of amaranth as livestock feed indicated relatively high protein qualities (Alegbejo 2013).

### 3.3 As Medicines and Treatments of Diseases

In the last few years, the properties of amaranth in cholesterol reduction, as an antioxidant, anticancer, anti-allergic, and antihypertensive agent; and as a food for patients with celiac disease and immune-deficiencies, have been assessed in clinical studies.

### 3.4 Hypocholesterolemic Activity

Amaranth grain has a hypocholesterolaemic potential (Berger *et al.*, 2003; Plate and Arêas, 2002 Chaturvedi 2000). Several hypotheses have been proposed to explain the treatment ability of Amaranths, Chenopodium and related weeds which is the modulation of the serum cholesterol levels. One of such hypotheses cited the content of unsaturated fatty acids. Concurrently, the amount of total and soluble fiber has also
been mentioned (Danz and Lupton 1992; Plate and Ar’eas 2002; Mendonca et al., 2009), and possibly that the amino acid profile of its protein (Berger et al., 2003) may as well be involved in the mechanism.

3.5 Effect on Hypertension
The renin–angiotensin system is a biochemical system that helps control blood pressure. Amaranth grains may be a potential source of several bioactive peptides with relevant actions on cancer and hypertension.

4. HARMFUL ASPECTS
Besides significant beneficial effects, amaranths and Chenopodium spp. have also serious impacts on agricultural production. It is estimated that in general, these weeds cause 5% loss in agricultural production in most of the developed countries, 10% loss in less developed countries and 25% loss in least developed countries. In Ethiopia also, yield losses due to weeds are more than those from pest and diseases. Yield losses due to weeds vary with the crops. Every crop is exposed to severe competition from weeds. Most of these weeds are self-sown and they provide competition caused by their faster rate of growth in the initial stages of crop growth. In some crops, the yields are reduced by weeds reduce the quality of marketable agricultural produce. Weeds not only reduce yield but also interfere with agricultural operations. Weeds make mechanical sowing difficult and render harvesting difficult, leading to increased expenditure on labor, equipment and chemicals for their removal. In aquatic environment, weeds block the flow of water in canals, water transport system and drainage system, rendering navigation difficult. The dense growth of aquatic weeds pollutes water by deoxygenating it and killing the fishes. Weeds are also a nuisance and a fire hazard along railway lines, roads, right-of-ways, airports, forests and industrial sites.

Many species of Amaranth and quinoa like Palmer amaranth may be consistently high in nitrate and potentially toxic to cattle, so it is important for producers to know these species before using it as a forage crop for livestock. In addition to poisonous plants, some new publications provide information on plants that can cause metabolic disorders in livestock.

5. CULTIVATION
5.1 Soil preference
Quinoa and amaranth grow well in a variety of soil types. They are responsive to nitrogen and phosphorous. Plants grown in average garden soil will be 4-feet to 6-feet tall, while those grown in rich soil or compost may reach over 8 feet. Optimum soil is a well-drained loam but both plants will do well in all but poorly aerated clay soils (Organic Seeds, 2016).

5.2 Varieties
Named varieties of amaranth and quinoa are increasingly available from seed companies. Most North Americans would be hard-pressed to describe the subtle differences in flavor between cultivars. Black-seeded varieties of amaranth stay quite
gritty when cooked, so it is best to use these varieties just for their leaves. Amaranth is a heat-tolerant green that is often called vegetable amaranth to distinguish it from the similarly named but different landscaping amaranth. The smaller varieties planted as decoration will not produce any usable seed, but can still be eaten as salad greens. Unlike most salad greens, this one thrives in hot weather, so if we grow amaranth, Malabar spinach, orach, or purslane for that matter- we can keep the salads coming all year long. Amaranth delivers salad greens when lettuce and spinach have long since bolted. Besides to tasting somewhat spinach like, amaranth is healthful: lots of protein, vitamins, minerals, and dietary fiber. In addition to growing for salad greens, it is grown for its grain (Robinson, 1989).

5.3 Planting and Sowing
Quinoa, however, is a cool weather crop and amaranth is a warm weather one. Quinoa grows best where maximum temperatures do not exceed 32°C and nighttime temperatures are cool. For most southern Canadian and northern U.S. sites, the best time to plant quinoa is late April to late May. When soil temperatures are around 15°C seedlings emerge within three to four days. However, when quinoa seeds are planted in soil with night-time temperatures much above that, quinoa, like spinach, may not germinate. In this instance, it's best to refrigerate seeds before planting (Organic Seed, 2016). Amaranth is a warm season crop that requires full sun. Best germination occurs when soil temperatures range from 24-32°C. The small seeds of amaranth and quinoa will germinate more successfully with a finely prepared surface and adequate moisture. Seeds should be sown no more than one-quarter inch deep in rows 45-60 cm apart or wide enough to accommodate a rototiller between the rows without damaging the plants. Planting can be done by hand or with a row seeder. Plants should eventually be thinned to 15-45 cm apart. One gram of seed will sow 15 m of row.

5.4 Management
Quinoa resembles lamb's-quarters and amaranth resembles red-rooted pigweed, especially in the early stages of growth, so it is best to sow seed in rows to make weeding less confusing. Sowing amaranth cultivars with purple leaves also simplifies weeding. Since seed is small, we can avoid considerable thinning by mixing it with sand or radish seed before sowing, as is sometimes done with carrots. Amaranth and quinoa are low-maintenance crops but weeds, especially at the beginning, should be discouraged by cultivation or mulching.

Quinoa and amaranth are very easy to grow. They are fairly maintenance free, but their slow initial growth leaves them susceptible to competition among weeds until they are established. Flowers are produced on long straight stems, are long lasting and will bloom from mid-summer until the first hard frost (Organic Seed, 2016). They appear slow growing at first but both are extremely drought tolerant and do well on a total of 25 (cm) of long. As the plants reach about one foot in height, they start to grow very rapidly, the canopy closes in, weeds are shaded out and less moisture is lost through evaporation.
The major pests of Amaranth and Quinoa are i. *Tarnished plant bug* - congregate around the growing seed heads and by sucking the fluid out, they can stunt the seed production. ii. *Amaranth weevil* - The weevils are a 2-stage threat with the larvae chewing on the roots and the adults going after the leaves. However, disease is seldom a problem in both of these crops.

5.5 **Harvesting**
Quinoa is ready to harvest when the leaves have fallen, leaving just the dried seed-heads. Seeds can be easily stripped upwards off the stalk with a gloved hand. Quinoa resists light frosts especially if the soil is dry. So long as maturing seed passes the green stage, frost will cause little damage and harvesting can be done a day or two later. Extreme hot weather and warm nights inhibit fruit set. It is important to watch the weather when quinoa is ready to be harvested: if rained on, the dry seed can germinate. If the heads are not completely dry, harvest them when you can barely indent the seeds with the thumbnail (Scoop, 2017).

In Amaranth, pick individual leaves as needed for greens. Younger greens are great for salad; older greens are better cooked as a substitute for spinach. Seed will often ripen many weeks before the first hard frost, usually after about three months from planting time. The best way to determine if the seed is able to be harvested, to gently but briskly shake or rub the flower heads between your hands to see if the seeds fall readily. Numerous small and appreciative birds may give hints as to when to start doing this. The best time to harvest the amaranth grain is on a dry day 3 to 7 days after a hard frost. After harvesting it is important to further dry the crop to ensure it won't grow mold in storage (Scoop, 2017). It can be left on trays in the hot sun, or placed near an indoor heat source. Stir occasionally until it is as dry as possible. Store seeds in an air-tight container in a cool dry place. Amaranth grain is fairly high in fat, and can go rancid eventually. The best way to store it is in the fridge, in a tightly sealed container. The grain should last up to 6 months this way.

5.6 **Threshing**
Unlike beans or true grains, quinoa and amaranth have no hulls to remove. However, quinoa is covered with a bitter substance called saponin, which birds and deer won't touch. Because of this coating, quinoa requires thorough rinsing before cooking. One method is to put the grain in a blender with cool water at lowest speed, changing the water about five times until it is no longer soapy. We can also get away with less or no rinsing by mixing quinoa with other grains or pulses, rendering the saponin hardly noticeable. Amaranth has no saponin and no hulls, so can be cooked without additional preparation (Scoop, 2017).

5.7 **Yield**
Normal commercial yields for amaranth and quinoa are 500-900 kg per acre. Combiner machines are still being adapted to the lightness of the seed, and full harvest potential is yet to be realized. Much higher results are obtained from labor-intensive harvesting: yields of over 3,000 kg per acre have been reported from Central and South America (Scoop, 2017).
6. NUTRITION

Quinoa and amaranth have exciting possibilities for the home gardener looking for hardy, easy to grow, high-protein foods. They have higher food quality than our common grains such as wheat and oats, and they don't have hulls that need to be removed by machinery prior to cooking. A number of reports suggested that the difficulties in cultivating and preparing these two grains are relatively minor and that the pleasures obtained in growing and eating them are definitely major. With a protein content of about 16 percent, amaranth seed compares well with the conventional varieties of wheat (13 %), rice (8 %), maize (9 %), and other widely consumed cereals. Amaranth seed also contains protein of unusual quality, mainly because of its high lysine content. Cereals are considered "unbalanced" in terms of amino acid composition because generally they lack sufficient amounts of lysine for optimum health (Berghofer and Schoenlechner, 2002). Amaranth protein, however, has nearly twice the lysine content of wheat protein, three times that of maize, and in fact as much as is found in milk-the standard of nutritional excellence. It is, therefore, a nutritional complement to conventional cereals (Berghofer and Schoenlechner, 2002). Amaranth protein itself is low in leucine, but this amino acid is found in excess in conventional plant protein sources. Amaranth grain, however, contains little functional gluten, so that it must be blended with wheat flour to make yeast-leavened baked goods "rise." When heated, the tiny amaranth grains pop and taste like a nutty flavored popcorn.

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Amount</th>
<th>Vitamins</th>
<th>Proportion</th>
<th>Minerals</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>371 kcal</td>
<td>Vitamin B1</td>
<td>10%</td>
<td>Calcium</td>
<td>16%</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>65.25 g</td>
<td>Vitamin B2</td>
<td>17%</td>
<td>Iron</td>
<td>59%</td>
</tr>
<tr>
<td>Starch</td>
<td>57.27 g</td>
<td>Vitamin B3</td>
<td>6%</td>
<td>Magnesium</td>
<td>70%</td>
</tr>
<tr>
<td>Sugars</td>
<td>1.69 g</td>
<td>Vitamin B5</td>
<td>29%</td>
<td>Manganese</td>
<td>159%</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>6.7 g</td>
<td>Vitamin B6</td>
<td>45%</td>
<td>Phosphorus</td>
<td>80%</td>
</tr>
<tr>
<td>Fat</td>
<td>7.02 g</td>
<td>Vitamin B9</td>
<td>21%</td>
<td>Potassium</td>
<td>11%</td>
</tr>
<tr>
<td>Protein</td>
<td>13.56 g</td>
<td>Vitamin C</td>
<td>5%</td>
<td>Zinc</td>
<td>30%</td>
</tr>
</tbody>
</table>

Quinoa and amaranth both contain about 16 percent protein, vitamin E and B, calcium, iron and phosphorous. They are easy to digest and have wonderful flavor. Their simple distinctive taste gives them great versatility for cooking purposes. They can be substituted for other grains in many recipes, though they are much more filling. Because they are not true cereal grains, they can be eaten by people who suffer from cereal grain allergies.
7. CONCLUSION

According to the Thorogood (1995); Jew et al., (2009); American Dietetic Association (2003) and Micha et al. (2018), the over reliance on conventional cereals like corn or wheat, and meat products may not only have negative impact on human health but increase carbon emissions associated to the food industry. Therefore, the adoption of alternative grains, legumes and tubers will become a necessity in the coming years as the population grows into nine billion by 2050, water become increasingly scarce and new food borne diseases appear (Eckstein, 2009; Suk and Semenza, 2011). Alternative foods such as amaranth, quinoa are naturally resistant to extreme weather conditions, high salinity soils and require little water for its cultivation (Jacobsen, 2003). In fact, quinoa’s potential to contribute to world food security has been widely acknowledged (National Research Council, 1989; FAO, 2011), and amaranth is considered as ‘food for a future’ given its high quality protein and resistance to drought and heat (European commission, 2011).

In recent years, pseudocereals and alternative cereals have been attracting increased interest, both from the agricultural point of view and from aspects regarding food insecurity. One of pseudo- cereals with the worldwide major importance is amaranth (Amaranthus sp.). Amaranth grain provides an ideal amino acid composition for human nutrition. In particular, the content of lysine is high. Remarkable is also the high content of essential vitamins, antioxidants and fibers, which makes amaranth interesting for child nutrition. The fat of the grain is characterized by a high content of unsaturated fatty acids. Moreover, concentration of minerals is higher than in other cereals. In particular, the grain is rich in calcium, magnesium, iron, potassium and zinc. Moreover, grain amaranth has some agricultural advantages and noted ability to grow successfully in adverse environmental conditions such as high irradiance, temperature and drought. The enumerated attributes confirmed with numerous, above all fundamental, scientific information ultimately govern its food, feed, as well as some industrial application potentials. With growing concern among farmers about these pseudo grain weeds have become a topic of interest for discussion.

8. RECOMMENDATIONS AND FUTURE PROSPECTS

In spite of all the difficulties caused by quinoa and pigweeds, these plant species can offer some beneficial properties, particularly when occurring at low densities. These aspects should be utilized in the farming system, although this may make organic management more complicated than chemical based systems. Some of the potential benefits of weeds are listed below: Helping to conserve soil moisture and prevent erosion. A ground cover of weeds will reduce the amount of bare soil exposed helping to conserve nutrients, particularly nitrogen which could otherwise bleached away, especially on light soils. Food and shelter can be provided for natural enemies of pests and even alternative food sources for crop pests. The actual presence of weed cover may be a factor in increasing effectiveness of biological control of pests and reducing pest damage. Weeds can also be valuable indicators of growing conditions.
in a field. With growing concern among farmers, these pseudo grain weeds have become a topic of interest for discussion. Many farmers see a potential danger in rapid invasion of these weeds in crop fields. They consider it as dangerous as other weeds like *Prosopis, Parthenium*, etc. which have become a permanent threat to their crop production. Many articles and opinion published recently have also pointed out the risks and after effects of these weeds. Other plants that can poison cattle are lupin and amaranth. Lupin is a good source of protein and energy in livestock feeds, but its use should be limited.

Thus, taking into account all aspects of its worth, we recommend the regional government, Agricultural organizations, Research institutions, Universities, NGOs and other concerned bodies to give a due attention to the farming and expansion of this blessed crop as a means of sustainable agriculture and a solution for food security and malnutrition in the region.

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