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Potential of Underutilized Garden Cress (*Lepidium Sativum* L.) Seeds for Fortification of Teff Injera for Improving Nutritional Security and Human Health in Ethiopia: A Review

Legesse Tadesse[1*]

[1]*Department of Biology, Dire Dawa University, E-mail: legesetadese2004@gmail.com*
☎ +251 (0) 973538738; ✉ 1362, Dire Dawa, Ethiopia
**Corresponding author*

Abstract

The demand for gluten-free foods is certainly increasing. Teff (*Eragrostis tef* [Zucc.] Trotter) is one of gluten-free cereal crops. The interest in teff has been increasing noticeably due to its very attractive nutritional profile and gluten-free nature of the grain, making it a suitable substitute for sorghum, maize, and other cereals in their food applications. The possible value-addition and food fortification of *teff injera* using neglected and underutilized seed crops such as garden cress among Ethiopian communities now started to be used at the household level. Of course, there is scanty and very limited empirical evidence on the use of garden cress in food fortification of teff at the household level. This is largely because of a negligence of local micronutrient provision initiatives at the household level. Very few initiatives are in place to promote localized fortification options among rural and urban communities. This review paper consolidated existing indigenous knowledge on potential food fortification, value addition of small grains in general, and neglected garden cress crops in particular. The review explores the fortification potential of garden cress for nutrition enhancement. Such study recommends the promotion of traditional medicinal crops particularly garden cress crop production, their value addition, and their use in the fortification of cereal food products to complement proteins, vitamins, minerals, and phytochemicals. This will significantly contribute in alleviating malnutrition and healing power for different diseases.

Key words/Phrases: Blending, fortification, garden cress, phytochemicals, teff injera

**Corresponding author: Legesse Tadesse; email: legesetadese2004@gmail.com ; Cell phone: +251 973538738*

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Introduction

Food fortification enables an increase in nutrient intake in the general population and has a long history of combating vitamins and minerals deficiencies and their health consequences. Nutritional deficiencies that arise from an insufficient dietary supply of minerals and vitamins are a major public health concern encompassing both poorer and richer world regions, affecting children and adults. According to the 2020 Nutrition Worldwide Report, one in every nine people is hungry or malnourished, whereas one in every three is overweight or obese (Riesgo et al., 2016). Handling this issue from a more comprehensive, interdisciplinary perspective is critical by carefully selecting locally available, low-cost raw food materials. Currently, the most often used food-based techniques are fortification and dietary diversity, which encourage using local resources like garden cress crops to enhance self-reliance and offer market opportunities for locally produced foods (FAO, 2015).

Ethiopians use their traditional expertise, and their abilities and contributions to food preparation, preservation, and processing are underappreciated. Nonetheless, natives have long employed time-tested indigenous techniques for preparing food, preservation, and storage to ensure adequate nutrition and, consequently, as a survival tactic. Additionally, the country is gifted with a wide variety of underutilized medicinal plants and indigenous knowledge systems for processing, preserving, and storing them. Locally produced fortified foods enhance overall nutrient security since they are safe, affordable, and nutrient-dense.

For Ethiopians, injera, or flatbread, is a traditional staple food. The ancient method of preparing injera is still used today, and as such, it is valued and distinguished. Injera is mostly prepared from teff grain, although it can also contain varying amounts of barley, maize, wheat, sorghum, and other grains. The majority of people still like and regularly consume teff injera (Zegeye, 1997; Yetneberk et al., 2004). Bread made with wheat and/or maize flour is the other food that is frequently consumed. Because consumers in both rural and urban areas are less aware of the advantages of using garden cress seeds as a way of maintaining nutritional balance, as Ethiopians do not practice variety in their eating habits.

In developing nations like Ethiopia, the garden cress, *Lepidium sativum* , is a crop that is often overlooked and underutilized but has the potential to improve injera (Teff) and preserve human health and nutritional security. It is commonly known that garden cress seeds are high in nutrients and offer numerous health advantages. The goal of this mini review was to examine the nutritional value and synergy between garden cress and teff seeds use in preparation of teff injera.

Teff injera

Teff comes in various colors, from light to dark, depending on the kind (Fig 1). White, brown, and red teff are the three most popular colors. White teff is used to make the most popular injera because of its color, favored flavor, softer texture, and ability to roll without breaking. However, higher-income urban residents eat white teff injera more frequently than rural areas (Assefa, et al., 2015). Numerous

gluten-free teff-based food products, including injera, porridges, and unleavened bread (kitta), have been developed. These food items typically offer the appropriate nutritive qualities, such as balanced amino acid composition, low glycaemic index, and high dietary fiber amounts. It has a high iron and calcium mineral content and is a rich source of unsaturated fatty acids. Of all the cereals, teff has the highest calcium content (Kaleab Baye, 2014). In general, teff offers numerous health advantages, including the prevention of osteoporosis, diabetes, anemia, and celiac disease. There is still more research to be done on how different teff varieties differ in their nutritional makeup, how eating teff can help control and prevent diabetes, and how the human adsorption (bioavailability) of iron in teff can help prevent iron deficiency disorders in foods made with teff (Gebremariam et al., 2014).

Fig 1. The different varieties of Teff (Eragrostis tef [Zucc.] Trotter) grain colors for teff injera making (photo from market)

Garden cress (*Lepidium sativum*) as a food supplement

Garden cress (*Lepidium sativum*) is usually referred to as garden cress, or locally as shinfo (Afan oromo) or fetto (Amharic). Several therapeutic qualities, including antioxidant, anti-anemic, anti-diabetic, anti-inflammatory, hepato-protective, and antibacterial qualities, are present in garden cress. Its multipurpose has received a lot of attention to provide a variety of functional foods that preserve nutritional security in developing nations such as Ethiopia (Prajapati and Dave, 2018). In addition, garden cress seeds are a promising source of bioactive chemicals that, when fortified with teff seeds, have a larger potential to prevent under nutrition and preserve human health at a reasonable cost in both urban and rural settings (Sheehy et al. 2019).

As the nutritional profile of traditional food is unknown, and enhancing its nutritional content is realized by supplementation of garden cress seed on a locally available teff, maize/sorghum and wheat food formulation in making injera. Garden cress seed is used as a complementary food, making it rich or enhanced in carbohydrates, fats, proteins, vitamins, and minerals in the formulated diet of injera (Kaleab Baye 2014;Tufail et al, 2024). In blended forms of mixed dough, the flour from garden cress seeds has binding, dissolving, suspending, emulsifying, and retaining qualities. The seeds quickly absorb the flavorless liquid when soaked in water, giving the injera a smooth, flexible texture and preventing the spread of fungal mold. The seeds are reported to have over six different colors (Fig. 2), making them perfect for combining with others such as teff seed colors. They also offer several physiological benefits, such as hepatoprotective, hypoglycemic, antioxidant, and anti-inflammatory properties (Abdulmalek et al., 2021) by adding 5 to 10 percent of garden cress seed on teff before grinding.

Fig.2: The different color of garden cress seeds used for fortification (Legesse, 2017)

Nutritional and chemical composition

Garden cress seeds have been utilized in traditional food and medicinal supplements since ancient times, particularly in India (Mali et al., 2007). This plant seed is abundant in various phytochemicals that contribute to its medicinal properties and numerous beneficial physiological effects on human health when incorporated into fortified injera. Categorized as oilseeds, garden cress seeds are rich in both macro and micronutrients (Vaishnavi and Gupta, 2021). It provides an essential fatty acids, amino acids, and minerals, including iron, potassium, calcium, and phosphorus. The seeds are composed of carbohydrates (33–54%), protein (21-25%), lipids (14–24%), and dietary fiber (3%) (Moser et al., 2009; Tufail et al,

2024). The carbohydrate content in garden cress seeds consists of 90% non-starch polysaccharides and 10% starch.

The elevated levels of protein and lipids suggest that the seeds act as a valuable high-energy alternative source. The protein found in garden cress seeds is high-quality, featuring essential amino acids including histidine, threonine, arginine, valine, methionine, phenylalanine, and isoleucine. Alpha-linolenic acid is the predominant fatty acid in the seeds, comprising 32-34%. Moreover, the seeds are abundant in omega-3 fatty acids, that can aid in reducing cholesterol levels in individuals with high cholesterol (Agarwal and Sharma, 2013; Angel and Devi, 2015). The primary fatty acids present are oleic acid (30.6%) and linolenic acid (30.2%), accompanied by a minimal amount of erucic acid (3.9%). The oil extracted from garden cress seeds is highly advantageous due to its well-balanced proportion of polyunsaturated fatty acids (PUFA, 46.8%) and monounsaturated fatty acids (MUFA, 37.6%) (Prajapati and Dave, 2018).

It is more stable because the oil has a high concentration of antioxidants and a more balanced ratio of MUFA to PUFA. Garden cress seed`s oil guards against oxidation and rancidity, and its vitamin A and E content helps shield cells from harm (Ahmad et al., 2021). Magnificent amounts of phosphorus, calcium, iron, folic acid, vitamin A, and vitamin C can be found in garden cress seeds better than teff seeds (Malar et al., 2014). Thus, fortification with teff grain improved the acceptance of the product created with them and decreased the bitterness of the garden cress seed throughout the teff injera manufacturing process. Using garden cress as a fortifier for teff grain is a very easy, small in amount, and secure method that increases the antioxidant activity and overall phenolic and flavonoid contents by a factor of many.

Anti-oxidant properties of garden cress seed and teff

Tocopherols, which are phenolic chemicals found in garden cress seeds, are antioxidants that function as biological scavengers of free radicals, preventing oil oxidation. Antioxidants are a recently utilized food preservation ingredient that has received a lot of interest in the nutrition business. In addition to their widespread use in neurological processes, natural antioxidants also lower the incidence of osteoporosis, cancer, cardiovascular disease, and a number of degenerative disorders (Angel and Devi, 2015). The maximum antioxidant activity was found in the ethyl acetate fractions of L. sativium seeds, and the methanolic extract of L. sativum exhibited notable antioxidant activity due to the presence of flavonoids and tannins (Wadhwa et al., 2012; Prajapati and Dave, 2018). The different treatments such as roasting, popping, and germination of garden cress seeds improved the nutraceutical properties, total polyphenols and condensed tannins contents and its antioxidant activities (Vaishnavi and Gupta, 2021). The garden cress seed seedlings enhanced the amounts of tocopherol, antioxidant enzymes, and lipid peroxidation. Tocopherol, or vitamin E, is a vital antioxidant that shields vitamin A and other vital fatty acids from oxidation and stops bodily structures from breaking down (Chatoui et al., 2020; Al-Saad and Al-Saadi, 2021). Because garden cress seed has a strong capacity to scavenge free radicals, adding it to a balanced diet may assist in incorporating and utilizing its rich nutritional and therapeutic value in the created meal as it contains a wide range of antioxidants

(Prajapati and Dave 2018). It contains phytochemicals that can function as both direct antioxidants and modulators of antioxidant-response genes. Teff also has antioxidant action, suggesting that it may help treat oxidative stress-related disorders.

Anti-nutritional properties of garden cress seed and teff

Anti-nutritional substances found in garden cress seeds lower food intake and nutrient availability and utilization (Agarwal and Sharma 2013; Thakur et al., 2019). Garden cress seeds have a few anti-nutritional compounds such as phytic phosphorus, oxalates, tannins, protease inhibitors, saponins, phytic acid, lectins, and amylase inhibitors (Al-Saad and Al-Saadi, 2021). Among these compounds, phytic phosphorus and oxalates are mainly present in raw garden cress seeds (Azene et al., 2022; Samtiya et al., 2020). The two main anti-nutritional substances found in raw garden cress seeds were oxalates (134.0 mg/100 g) and phytic phosphorus (447.2 mg/100 g) which are lower than those of cereal with a high oxalate concentration (143–232 mg/100) and within the range of the majority of cereals with reported phytic acid contents of 29.5–1310 mg/100 g (Satheesh and Fanta 2018). But when it comes to teff, the only acids that are commonly documented are tannic and phytic including protease inhibitors and phenolic compounds that reduce the digestibility of proteins and minerals (Wang et al., 2010; Singh et al., 2018).

Value added injera from garden cress seed and teff

Improving cereals' nutritional content through fortification, milling, and fermentation will boost their value and improve people's diets. Mixing small grains with oilseeds like garden cress offers a cheaper, local way to add essential vitamins, phosphorus, and calcium (Faiza et al., 2022). The inclusion of garden cress seed in injera making teff seed alone or in combination with other flours such as Sorghum has been reported to improve nutritional value of traditional teff injera (Fikadu et al., 2022). As there is a huge socio-economic benefit of promoting value addition and fortification of cereals using neglected food crops among smallholder farmers. Garden cress seed is more popular in consumers and producers because of its peppery taste and the presence of health-promoting substances such as glucosinolates and sterols (Tuncay et al. 2011; Al-Saad and Al-Saadi, 2021). Even though garden cress seeds are abundant in many vital nutrients (Chatoui et al., 2020), they are not as well-known and are often overlooked in many nations' typical foods. This calls for increased consumer education and awareness in order to fully utilize the seed (Meseret et al., 2022). Due to high free radical scavenging potential of garden cress seed, its fortification to prepare balanced diet may help in incorporating and exploiting its rich nutritional as well as medicinal value to the developed food (Singh et al., 2015). Garden cress seed is regarded as a member of the "superfood" family due to its high nutritional content, which is essential for increasing the medicinal and nutritional value of prepared and blended food products such as fortified injera (Tufail et al., 2024). Several conventional processing techniques could be used to improve this (Meseret et al., 2022). Garden cress seeds have been used to treat a variety of illnesses, including moderate glycemia, kidney disease, hypertension, and cancer prevention. It is frequently used to promote milk production during lactation and to treat fractures (Doke and

Guha, 2014). For postmenopausal women with cardiovascular disease symptoms such as elevated blood pressure and cholesterol, regular ingestion of garden cress seed is highly advantageous (Vaishnavi and Gupta, 2021). When used with teff seed products, garden cress seed oil helps reduce coronary heart disease. Because GC seeds contain linoleic and arachidic acids, they are thought to improve memory (Sharma and Agarwal, 2011).

In addition to being necessary for healthy growth and development, omega-3 fatty acids also have beneficial effects on the heart, brain, eyes, joints, skin, mood, and behavior (Doke and Guha, 2014; Saini et al., 2021). These natural antioxidants, which are found in good amounts in GCS, include carotenoids, tocopherols, and sterols. In addition to their traditional uses, Garden cress seed (GCS) and teff seeds are working together to improve the food product's nutritional value, bioactive, functional and pharmacological advantages as well as therapeutic effects (Kaleab Baye 2014;Tufail et al, 2024) when blended teff injera is made into value-added goods as both crops are diversified in terms of seed colors which are suitable for fortification. The functional health benefits of Garden cress seed (GCS) may be exploited by incorporating it in several food formulations and health drink preparations. Therefore, garden cress seeds will subject to further investigations for their potential preventive effects towards chronic diseases and also as interesting ingredients for new functional food formulations (Singh et al., 2015). However, none of the authors reported the details of the interaction and synergy for enhancing the nutritional contents of fortified injera. Hence, subsequent studies on the use of garden cress seed should therefore be properly designed and optimized to account for the possible sources of variations such as mixing time, mixing speed, initial chemical composition of the base material and the use of a larger sensory panel need to be given due attention for further refining to quantify what is gain

Sensory attributes of the Garden cress fortified injera

Sensory quality such as color, taste, and aroma is an important parameter that determines to a great extent the acceptability of a product. Color seems to be the most important of all as an attractive product will get the attention of the consumer before other properties may play a role. It is important to remember that the food to be fortified teff (Eragrostis tef [Zucc.] Trotter) and the fortifier (garden cress seed) must be compatible, regardless of the fortification's intended use. As indicated, whatever is to be added to any food is fortificant, it must not improve the nutritional value of the food at the expense of the sensory properties (Allen et al., 2006; Afify, 2022). To improve the nutritional quality of the food supply and offer a public health benefit with little risk to consumers' health, food fortification is the deliberate increase in the content of an essential micronutrient, such as vitamins and minerals (including trace elements) in food. Studies prove that garden cress seeds are safe to consume in nutritional composition at a 10% level as it did not cause toxic effects on analytical parameters or growth (Faiza et al., 2022).

It is also very important to comment on the acceptability of the garden cress seed fortified teff to form injera may require larger sensory panel members above what was reported by these authors in other traditional food. Otherwise, combining Garden cress seed (GCS) with teff is essential for treating the problems of

micronutrient shortages at the household level and adding vitamins A, E, and K, among other therapeutic benefits of Garden cress seed (GCS). Color, flavor, taste, texture, and other sensory characteristics are used to evaluate the quality of food (Elizabeth and Poojara, 2014; Afify, 2022).

Teff and Garden cress seed (GCS) have different colors (Fig.1 and 2), which are used to create several recipes for making injera with varied colors. Uniformity in color and look are essential elements of both fresh and processed foods' visual quality and greatly influence consumer choice (Elizabeth and Poojara, 2014). As a blend of taste, smell, and mouth feel, flavor has a complex effect on the injera's sensory quality (Amerine et al., 1980). Injera fortified with garden cress flour retained its typical flavor and acceptability without any negative effects from the addition of garden cress seed powder (0.5–5g/kg body weight of consumer) at 1.0–10% (Singh et al., 2015; observation by the author). Acute and subchronic feeding of GC seed powder at the specified concentration is therefore regarded as safe and non-toxic (Datta et al. 2011). The slight bitterness and astringency of garden cress greatly reduce its acceptability to be incorporated into food products. To overcome the problem of bitterness processes such as roasting or heat treatment or a combination of both methods were commonly used (Elizabeth and Poojara, 2014).

Without adding any unique flavors, Garden cress seed (GCS) can be combined with the majority of both classic and innovative food. The combination of 94.5 percent teff flour and 5.5 percent garden cress seed was determined to be more acceptable for both cookies across all samples (Singh et al., 2015; Gaikwad et al., 2021).

Conclusions

Garden cress (GC) seeds are a highly nutritious, underutilized crop with considerable potential to address nutritional insecurity, particularly in developing countries. While sharing some nutritional similarities with teff, a staple grain, GC seeds exhibit superior antioxidant properties and have been shown to increase iron levels and combat anemia. However, their widespread adoption is hampered by a lack of consumer awareness and limited research on optimal incorporation into food products.

This necessitates a multi-faceted approach. Further research is crucial to determine the ideal formulations for blending GC seeds with other ingredients, particularly in traditional foods like injera. Studies should focus on the synergistic effects of these blends, optimal processing and storage techniques to preserve nutritional value, and the development of scalable and cost-effective production methods. Such activities required collaboration between nutritionists, food scientists, and food technologists, leveraging both traditional knowledge and scientific advancements. Furthermore, targeted consumer education campaigns are needed to increase awareness of GC seeds' nutritional as well as medicinal benefits and encourage their wider adoption. Ultimately, unlocking the full potential of this underutilized crop requires a comprehensive strategy that integrates research, development, and consumer engagement to improve food security and public health.

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Conflict of Interest

There is no any conflict of interest.

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