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Analysis of proximate composition, mineral contents, and anti-nutritional factors of enset (*Ensete ventricosum*) landraces commonly used for *amicho* preparation in Hadiya Zone, Southern Ethiopia: Implications for food security and mineral bioavailability

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ABSTRACT

Enset (Ensete ventricosum) is a primarily starchy staple food crop for over 20 million people. Some landraces are widely favored for amicho (boiled corm) preparation and consumption. However, little information is available on its nutritional profile. Therefore, this study was aimed at identifying the proximate, mineral, and anti-nutritional contents of the seven commonly consumed corms of the cultivated enset landraces. The proximate was determined using the Association of Official Analytical Chemists (AOAC) standard methods. Minerals, phytate, and tannin contents were determined using the different models of spectrophotometer method, and oxalate was analyzed using the standard procedure. Also, the physiochemical parameters and the molar ratios were estimated to the relevant standards. The results revealed that the proximate composition (%) ranged in moisture content from 68.2 to 79.4, crude protein (2.43–11.90), crude fat (0.61–0.89), crude fiber (2.42–4.11), and total ash (2.01–4.60), while the total carbohydrates came to 80.89–89.92, and gross energy was 369.96–385.12 kcal/100 g. The mineral concentrations (mg/100 g) were also varied and ranged: calcium (22.46–49.74), potassium (28.51–86.56), magnesium (16.46–29.34), phosphorus (3.10–13.58), sodium (7.13–8.67), iron (0.9–3.85), and zinc (0.38–1.44) on a dry weight basis. The anti-nutritional contents (mg/100 g) for phytate, tannin, and oxalate ranged from 221.75 to 276.12, 27.97–113.74, and 5.69–9.10, respectively. Hayiwona and Gishira had the highest values in most proximate and minerals than other tested landraces, respectively. Compared to other landraces, Astara had higher total carbohydrate and phytate contents. Except for phytate × calcium to zinc, and oxalate to calcium, the molar ratios were above the critical values, which indicated that the studied enset corms had a considerable phytate value, which reduces mineral bioavailability. Overall, the present study revealed that the corm of the evaluated enset landraces contains appreciable amounts of nutritional value and can subsidize Ethiopia's sustained food security.

1. Introduction

Enset *(Ensete ventricosum* (Welw.) Cheesman) is a large herbaceous monocarpic evergreen perennial root crop that has pseudostems above the ground and an underground corm that closely resembles the banana plant. Borrell et al. [1] described *Ensete* as a genus of the banana family domesticated and cultivated only in Ethiopia. Enset is a multipurpose, drought-tolerant, adaptive plant with a diverse range of altitudes and uses for both nutritional and non-nutritious purposes [2], and the crop is traditionally ranked first in its significance for Ethiopian enset farmers.

Food insecurity prevails in parts of Ethiopia [3], facing frequent drought and other calamities with about 28.8% of the undernourished population as indicated by data from 2014 to 16 [4]. Increased and improved production and use of enset is an important choice to pull the

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country out of such a food insecurity loop. Enset cultivation is a straightforward strategy to facilitate people's achievement of independent livelihood security [5], and it is an important staple crop for more than 20 million people living in the central, south, and southwest highlands of Ethiopia [4,6]. The region where enset is consumed as the main food is distinguished by a large number of people, which cannot be maintained by any other form of land use in Ethiopia and is inhabited by more than 45 ethnic groups with a great variation in culture and agricultural practices [7]. Pijls et al. [8], and Tsegaye and Struik [9] stated that in comparison to the yields of other food crops, enset has a reasonably high yield.

The reports of Yemataw et al. [6] and Bloome et al. [10] indicated that a wide diversity of cultivated enset landraces exists in Ethiopia. Of the different farmer's landrace selection criteria in enset, quantity and quality of its food product are two of the most important criteria [11]. The edible part of enset is the pseudostem and corm after processing and fermenting into *qocho and bulla,* and fresh or unfermented *amicho* (cooked corm) foods [12]. Some prior studies indicated that enset products are rich in carbohydrates and mineral sources. However, its yield and nutrient contents differ among enset varieties, the age of enset plants, management practices, and environmental factors [12,13], as do its different organs such as leaves, pseudostem, and corm.

The majority of enset landraces are produced mainly for processing starch through fermentation, *qocho,* or *bulla,* while some others are produced entirely for their *amicho* or cooked corm [6,12,14]. *Amicho* is an unfermented form of *enset* obtained from the immature enset plant corm, and it is boiled before consumption, similar to many other root and tuber crops [4,14]. *Amicho* is a trustable food source since it may be uprooted and used at any time during the plant's growth [15]. Moreover, corms of several different enset landraces are considered traditional medicinal values for various health problems in humans and cattle in the south and southwest parts of Ethiopia [11,16].

Although enset landraces are more diverse in terms of farmers' selection, cultivation, and consumption rate in Ethiopia, few scientiflc studies have been performed on the nutritional constituents of widely cultivated and commonly used enset landraces. The available information is more restricted to fermented products of enset, known as *qocho*. As far as we know, only a very few published articles [12,15,17–21] are available on the nutritional and other compositions of the corm of enset as a general or unspecified small number of landraces also with limited parameters. Thus, it is necessary to have an understanding of the nutritional profile of such diverse and multi-use landraces for local and regional consumption. Moreover, that will contribute to food security and the sustainable use of the enset plant. Furthermore, the tedious harvesting and processing steps, as well as the sour flavor of its fermented *qocho,* may make it difficult for some new consumers. Hence, consuming *amicho* is appropriate for overcoming these challenges; furthermore, its preparation does not involve special skills and procedures to ensure the community's food security. Therefore, considering these facts, the present study was designed to identify the proximate composition, mineral content, anti-nutritional factors, mineral bioavailability, and physicochemical properties of the seven different widely consumed and locally favored corms of enset landraces representing the sweet, moderate, and bitter but traditionally medicinal corm types of the cultivated enset landraces.

2. Materials and methods

2.1. Source of plant materials

Seven healthy enset landraces: *Astara*, *Gishira*, *Hayiwona*, *Leqeqa*, *Qiniwara*, *Separa*, and *Soqido* were selected based on their suitability as corms' consumption and other purposes for identified by local farmers (Table 1) [11]. All of them were gathered from one farmer's enset field to minimize the variability that could happen due to management practice and soil fertility at the age of five years from the Lemmo district Shurmo Dacho *kebele* in Hadiya Zone, Ethiopia, at the end of September 2020. The district lies at an altitude between 2105 and 2510 masl, and according to the meteorological data obtained from the Hossanna (administrative town of Hadiya Zone) meteorology station, the maximum and minimum mean annual temperatures (22.57 °C and 10.38 °C) and the mean annual rainfall range between 950 and 1540 mm, with a bi-modal pattern (March to May short and June to September main rain seasons). Most of the soil types are vertisol, with pH ranges of 5–6, according to reports from the Agricultural Office of the Lemmo district (unpublished data).

Table 1
Enset landraces suitable for *amicho* consumption and used for nutritional and anti-nutritional analysis with their major characteristics and additional use values.

Local names of enset landrace	Characteristics of their corms (*amicho*)	Recommended use value	Additionally, recommended by farmers to treat to ailment
Astara	Sweet	Food and medicinal for humans	Bone fractures and joint displacements
Gishira	Bitter	Medicinal for humans, food and medicinal for cattle	Bone fractures and joint displacements
Hayiwona	Moderate	Food and medicinal for humans and cattle	a painful infected swelling, to heal the damaged part of the body, and stimulate milk production in cattle
Leqeqa	Sweet	Food for humans	–
Qiniwara	Sweet	Food, medicinal for humans	Bone fracture and joint displacements
Separa	Moderate	Food for humans	–
Soqido	Sweet	Food for humans	–

Note: no known additional recommendation by farmers of the study area.

The rationale for selecting these landraces was based on their: local community favorites and frequency of consumption, wide distribution, and well-known for their consistent vernacular names in different districts of the Hadiya Zone and other adjacent zones of southern Ethiopia [11]. The parent landraces of these enset crops had traditionally been vegetatively propagated over several generations, and the plants were not supplied by chemical fertilizers rather by animals' dung twice a year.

2.2. Sample preparation for laboratory analyses

For the laboratory analysis (Fig. 1A–D), the corms were trimmed carefully by using locally modified sharp knives to remove all roots, soil residues, and other adhering materials (Fig. 2A–C). Then the corms were pulverized by using a *jango* (a locally made instrument) until the parts became a small portion about two kg each (Fig. 2D). Each of the remaining central non-pulverized corm samples was placed in a zipped polyethylene bag, preserved in an ice box to avoid moisture loss, and delivered to the Addis Ababa University Center for Food Science and Nutrition Laboratory. The cleaned and washed corms were sliced to a uniform size of about 2 mm in thickness using stainless steel knives. Before drying, the moisture content of each enset corm was measured. Corm samples were laid out on an aluminum foil tray and dried in an oven (DHG 9055A) at 60 °C for 24 h prior to analysis for further laboratory tests with little modification [17]. Each dry sample was ground in an electric grinder to a fine powder and filtered using a 0.425 mm sieve. The powdered samples were then put in zipped polyethylene bags and kept at room temperature until they were needed for proximate, mineral, and anti-nutritional analysis.

2.3. Proximate analysis

All analyses were carried out on a dry weight basis since the majority

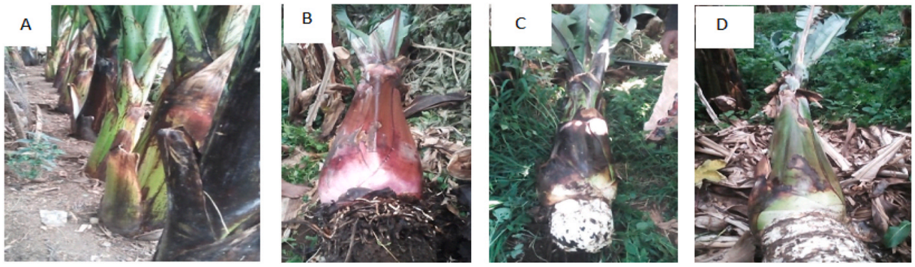

Fig. 1. Some examples of enset landraces used for *amicho* consumption and laboratory analysis: A) before uprooting; B- D) after uprooting *Astara*, *Soqido*, and *Hayiwona, respectively.*

Fig. 2. Some examples of the corms of the enset used for the laboratory analysis: A) *Astara*, B) *Gishira*, C) *Hayiwona*, D) *Leqeqa*.

of the fresh leafy and root crops are made up of water [22]. Therefore, the samples' dry matter contents were determined after they had been dried and turned into flour. Each sample was examined in triplicate.

The proximate composition of the enset corm samples was carried out following the Association of Official Analytical Chemists [23] standard procedures for nutrient analysis. The moisture content of the corm samples was determined by the drying air oven (DHG 9055A) at 105 °C for an hour by taking about 5.0 g of the sample as described in the AOAC [23] method 925.09. The analysis of crude protein was determined by the Kjeldahl method (nitrogen content multiplied by 6.25) by taking about 0.5g of corm sample according to AOAC [23] method 979.09. The crude fat content was determined by taking about 2.0 g of the sample and using the Soxhlet extraction method with Diethyl ether as a solvent according to standard method 920.39 of the AOAC [23]. The official method 923.03 was employed to determine the total ash content following AOAC [23] by taking 2.5 g of the corm sample. The crude fiber content was measured by using the steps of digestion, filtration, washing, drying, and combustion according to standard method 962.09 of the AOAC [23].

The total carbohydrate content was analyzed by difference from proximate composition, using the formula as follows: Carbohydrate (%) = 100 – (% crude protein + % crude fiber + % total ash + % crude fat).

2.4. Gross energy value

The gross energy content of enset corm samples was determined from the values of protein, fat, and carbohydrates using Atwater's conversion ratios: 16.7 kJ/g (4 kcal/g) for protein, 37.4 kJ/g (9 kcal/g) for fat, and 16.7 kJ/g (4 kcal/g) for carbohydrates [24]. Gross energy can be expressed mathematically as follows:

$$\text{Gross energy Kcal/100 g} = (4 \times g \text{ protein}) + (9 \text{ x fat}) + (4 \times g \text{ carbohydrate})$$

2.5. Mineral analysis

The mineral content of the powdered corm samples of seven enset landraces was ignited to ash at 550 °C for 5 h in a muffle furnace, dissolved in 20% HCl, boiled to bring the ash into solution form. The digested sample was filtered into an acid-washed volumetric flask of 100 ml after cooling, and the volume was then adjusted with distilled, deionized water. The concentrations of minerals were determined with calibration curves prepared with their standard solutions. The calcium, magnesium, iron, and zinc content in the sample were determined using an atomic absorption spectrophotometer (Shimadzu, model AA-6800), while sodium and potassium contents were determined using flame photometry (Jenway model; pfp7, UK) as per [25]. Phosphorus was analyzed by using a UV-VIS spectrophotometer (Thermo Scientific model; Evolution 220, USA).

2.6. Anti-nutrient analysis

The phytate content of the samples was determined using [26] as modified by Ref. [27]. About 1.0 g of corm sample was extracted with 10 ml of 0.2 N HCl for 1 h, followed by 30 min of centrifugation at 3000 rpm. To 3 ml of the supernatant solution, 2 ml of Wade reagent was added, and the mixture was centrifuged. The absorbance at 500 nm was measured using an ultra violet spectrophotometer (Lambda 950) (Thermo Scientific model Evolution 220, USA).

Tannin content was determined using the method of Burns [28], as modified by Maxson and Rooney [29]. The extracted supernatant solutions from 1 g of corm were mixed with 5 ml of vanillin-HCl reagent after centrifuging at 1000 rpm for 5 min. After the reaction was accomplished, the absorbance was measured using a spectrophotometer at 500 nm. The oxalate content of the corm sample was determined using the procedures described by Ref. [30], which include three steps: digestion, oxalate precipitation, and permanganate titration.

2.7. Determination of molar ratios and bioavailability of minerals

The bioavailability of calcium, iron, and zinc was predicted by the molar ratios between anti-nutrients and minerals, that is, phytates: calcium, phytates: iron, phytates: zinc, phytates x calcium: zinc, and oxalates: calcium, using the method described in Ref. [31].

2.8. pH value and titratable acidity analysis

After calibrating the pH meter at 7.00, 4.00, and 9.2 with a known buffer solution, the pH of the corm samples of the enset flour was determined by homogenizing a 1/10 dilution of sample (10 g of flour samples in 90 ml of distilled water) and by attaching a glass electrode to a digital pH meter at room temperature. The experiment was conducted in triplicate.

The total titratable acidity of corm flour of the enset was determined by titrating the sample with the addition of a standard base (0.1 N NaOH) to 3–4 drops of 1% phenolphthalein indicator until the endpoint identified by the color of the sample changed to pink. The equation below uses the volume of NaOH to calculate the percent titratable acidity based on lactic acid, which is the main organic acid in enset samples [32].

$$\text{Titratable acidity}(\%) = \frac{Vol.NaOHused(ml) * 0.1NNaOH * 0.009 * 100}{\mathrm{W}}$$

Where Vol = volume of the 0.1 N NaOH used, N = normality of the NaOH used, 0.009 = milli-equivalent factor for lactic acid, W = weight of the corm sample.

2.9. *Statistical* ***analysis***

Data obtained through laboratory tests for proximate composition, mineral contents, and anti-nutritional factors of seven enset landraces suitable for corm consumption were computed using the analysis of variance (ANOVA) procedures using SPSS version 26.0 (IBM Corporation, Armok, USA), software for Windows. Mean differences were statistically significant at $p < 0.05$ (5% probability levels), and the means of each parameter were compared using Duncan's multiple range test procedures to separate the means that existed among the enset landraces.

3. Results and discussion

3.1. Proximate composition

3.1.1. Moisture contents

The mean values for moisture content among the corms of seven enset landraces showed significant variations, ranging from 68.2 to 79.4 wet bases (Table 2). The highest value was obtained for raw corm samples prepared from the *Hayiwona* landrace, while the lowest moisture content was recorded for corm samples prepared from *Qiniwara* landraces (Table 2). Moisture measurement is one of the most representative tests in foods since the amount of water in foods has a significant effect on preservation and the occurrence of chemical, physical, and microbiological changes during storage [22]. The moisture content of the enset corm in the current study is consistent and slightly higher than the value (65–72%) reported by Nuraga et al. [17], but this is lower than the 85% reported by Mohammed et al. [15]. Such differences may be attributed to genetic variation, environmental factors, and agronomic practices. Our result indicated that the moisture content of enset corm is comparable with other root and tuber crops, such as anchote (*Coccinia abyssinica*) and sweet potatoes (*Ipomoea batatas*) [33]. Crops, particularly roots and vegetables with high moisture content, provide a greater role for water-soluble enzymes and coenzymes required for metabolic processes [22]. Besides, a higher moisture level helps to eliminate hydrogen cyanide (HCN) content by stimulating glycosidase enzymatic activity [34].

3.1.2. Protein content

The mean crude protein content of corm samples obtained from seven different enset landraces is summarized in Table 2. The mean value of crude protein content of the corm samples analyzed ranged from 2.43 to 11.90% (Table 2). Our result showed the existence of large differences within landraces in the protein content of the studied enset corms. On a dry matter basis, the highest crude protein value was found from the *corm* sample of enset landrace *Hayiwona* (11.90%), followed by *Qiniwara* (9.63%) and *Separa* (9.1%), whereas the lowest value was documented from the corm sample taken from *Astara (2.43%)* landraces. This value was higher even compared to 8.23% in the *Nobo* landrace by Foesido et al.*[*20] *and* 8.3% in *Neqaqa* corm by Daba and Shigeta [12]. The higher protein contents of *Hayiwona* in this study indicate that its consumption may be useful for healing and replacing the tear and wear of body tissues. Farmers also claim that this landrace is bodybuilding in humans and stimulating milk production after delivery in cattle [11]. The mean value of crude protein content obtained from *Astara (2.43%)*, *Gishira (2.45%)*, and *Leqeqa (4.36%)* landraces in the present study is almost comparable with the findings of Mohammed et al. [15] and Nuraga et al.[17], which range from 2.40 to 4.74%. Tsegaye [21] indicated that the protein contents of corm ranged between 0.9 and 2.39%, which is lower than the findings of this study and what was noted in different literature. The crude protein content obtained in this study from the *Hayiwona, Qiniwara, Separa, and Soqido* landraces is higher than the value reported for other root and tuber crops from Ethiopia. For instance, Abebe et al. [35], Bekele and Bekele [36], Mitiku and Teka [37], and Bayeta [38] reported 4.8% of Irish potato (*Solanum tuberosum*), 3.1–5.4% for yam (*Dioscorea* spp), 2.1–2.8% for sweet potato (*Ipomoea batatas*), and 1.3–1.9% for cassava (Manihot esculenta) crude protein in percentage, respectively. This indicated that the corm of some enset landraces has appreciable value in protein content; hence, it is important for the growth and replacement of the lost body tissues and may have a good potential to serve as an affordable supply of protein in areas where protein-energy deficiency is an issue.

3.1.3. Total ash contents

The mean values of total ash contents from corm samples prepared varied between 2.01 and 4.6% (Table 2). Corm prepared from the *Gishira* landrace (4.6%) had the highest total ash content, followed by *Astara* and *Soqido* (4.2%) for each landrace. But the lowest total ash value was recorded at 2.01% from the corm sample prepared by *Qiniwara* (Table 2). According to Samydurai and Thangapandian [39], ash content represents the total mineral content in foods, and it plays a key role in the physicochemical and nutritional content, which represents a small proportion of dry matter, often less than 7% of the total. In the current study, the total ash content of the corms of three enset landraces; *Astara* (4.2%), *Gishira* (4.6%), and *Soqido* (4.2%), increased almost twice in comparison with the *Hayiwona* and *Qiniwara* landraces (Table 2), and it exhibited higher values than the reports of Tsegaye [21], Daba and Shigeta [12], and Nuraga et al. [17]. However, Forsido et al. [20] reported the ash content of the corm of enset as 5.12%. These differences may be attributed to genotypic, environmental, agronomic practices, and the age of the enset crops. The corm of the enset showed comparable

Table 2
Proximate composition (%) and gross energy (Kcal/100g) of corms of seven enset landraces suitable for *amicho* consumption.

Name of Landrace	Moisture[1] content	Total ash	Crude protein	Crude fat	Crude fiber	Total[2] CHO	Gross energy
Astara	72.42 ± 0.91[b]	4.21 ± 0.32[a]	2.43 ± 0.17[d]	0.61 ± 0.12[b]	2.87 ± 0.05[c]	89.92 ± 0.70[a]	374.77 ± 2.17[b]
Gishira	71.35 ± 1.10[b]	4.60 ± 0.28[a]	2.45 ± 0.23[d]	0.68 ± 0.12[b]	3.76 ± 0.02[b]	88.51 ± 0.85[a]	369.96 ± 3.05[c]
Hayiwona	79.43 ± 0.78[a]	2.20 ± 0.41[b]	11.90 ± 0.68[a]	0.9 ± 0.25[a]	4.11 ± 0.10[a]	80.89 ± 0.90[c]	379.26 ± 1.18[b]
Leqeqa	78.65 ± 0.85[a]	2.80 ± 0.50[b]	4.36 ± 0.32[d]	0.61 ± 0.15[b]	2.42 ± 0.06[c]	89.81 ± 0.80[a]	382.17 ± 1.68[a]
Qiniwara	68.25 ± 0.65[c]	2.01 ± 0.32[b]	9.63 ± 0.8[b]	0.60 ± 0.33[b]	2.47 ± 0.03[c]	85.32 ± 0.65[b]	385.12 ± 2.14[a]
Separa	77.05 ± 0.88[a]	2.63 ± 0.35[b]	9.11 ± 0.8[b]	0.59 ± 0.25[b]	3.45 ± 0.02[b]	84.26 ± 0.70[b]	378.75 ± 3.18[b]
Soqido	76.25 ± 0.90[a]	4.21 ± 0.25[a]	6.67 ± 0.48[c]	0.62 ± 0.15[b]	2.75 ± 0.03[c]	85.76 ± 0.88[b]	375.33 ± 3.20[b]

Reported values in each cell are triplicate analysis. Means with different letters in the same column are significantly different ($P < 0.05$). [1] Wet basis, [2] Total Carbohydrate.

ash contents with most tubers and roots and an even better amount with most cereals. This implies that the higher ash content of corm means enset plants have the potential to raise mineral consumption in the diet, which directly contributes to the health of consumers. According to Jacob et al. [40], high mineral elements in foods enhance growth and development and also catalyze metabolic processes in the human body.

3.1.4. Crude fat contents

The crude fat content in corm samples obtained from the seven enset landraces was not significantly different ($p < 0.05$). All the corms had low crude fat contents below 1.0% and they oscillated between 0.61 and 0.89%, as presented in Table 2. A relatively higher crude fat content of 0.89% was recorded from the corm sample of the *Hayiwona* landrace, but all other landraces showed a nearly equal amount of crude fat content. This value is higher than the previous study by Tsegaye [21] (0.18%) and Mohammed et al. [15] (0.4%) but comparable with the reports of Daba and Shigeta [12] (0.6%). However, Forsido et al. [20] found a relatively higher fat content of 1.24%. The observed differences may be due to genetic or environmental factors. In most root and tuber crops, the crude fat content is less than one. In like manner, enset corm contains a higher fat value in comparison to the anchote (*Coccinia abyssinica*) (0.26%), cassava (Manihot esculenta) (0.26%), and sweet potato (*Ipomoea batatas*) (0.05%) [33].

3.1.5. Crude fiber content

The mean crude fiber content in the raw corm samples of the seven enset landraces was shown (Table 2). The crude fiber value of *corm* samples revealed a remarkable variation, ranging from 2.42 to 4.11%. *The corm* sample made from *Hayiwona* had the highest crude fiber content, followed by *Gishira* (3.76%) and *Separa* (3.45%) landraces, while the lowest crude fiber contents were observed from the corm sample of *Leqeqa* (2.42%) landrace. Our results revealed that crude fiber was found to be the fourth largest proximate composition present in the corms of enset in this study after total carbohydrate, crude protein, and total ash contents on a dry weight basis. The percentage of crude fiber in the present study was in agreement with the findings of Nuraga et al. [17], who observed a fiber content in the range of 2.38–4.47%. Likewise, Mohammed et al. [15] reported slightly higher crude fiber (5.65%), but a very high value was observed by Daba and Shigeta [12] (17.4%) from the corm of *Neqaqa* enset landrace. On the other hand, a lower crude fiber value that ranged from 0.8 to 1.1% was reported by Tsegaye [21]. Such a high variation may occur due to the age of the plant or analytical procedures. Our findings and also the literature reveal that enset corm has an appreciable amount of crude fiber and also better contents than some other tuber and root crops like Irish potato, cassava, and anchote [33]. According to Mackowiak et al. [41], the presence of crude fiber in the diet is essential for the digestion and removal of wastes. Similarly, Millar et al. [42] reported that dietary fiber maintains normal bowel function and can prevent gastrointestinal disorders. Crude fiber is becoming more widely acknowledged as a helpful instrument for the regulation of oxidative processes in food substances and serves as a functional component of foods [43]. Jacob et al. [40] and Millar et al. [42] also suggested that fiber lowers blood cholesterol levels and the risk of several diseases in humans.

3.1.6. Total carbohydrate content

The mean value of the total carbohydrate value on the dry basis of the corms of the seven enset landraces is shown in Table 2 and differs significantly ($p < 0.05$). The mean total carbohydrate contents of raw corm samples ranged from 80.89% for the *Hayiwona* landrace to 89.92% for the *Astara* landrace. However, the total carbohydrate contents of *Astara*, *Leqeqa*, and *Gishira* landraces with the value of 89.92%, 89.81%, and 88.51% on a dry weight basis, respectively, did not show significant differences ($P > 0.05$). Likewise, no significant difference ($P > 0.05$) was also observed for the total carbohydrate value (%) in the corms samples of *Qiniwara*, *Soqido*, and *Separa* enset landraces. Tsegaye and Struik [9] and Mohammed *et* al. [15] stated that enset corm has nutritional values similar to potatoes and is rich in carbohydrates. The laboratory analyses in the present study also revealed that the corm samples taken from each enset landrace showed high values of carbohydrate content; this supports the notion that root crops are typically high in carbohydrates. Similarly, Padhan et al. [44] described that most root crops have a dry matter content that is 60%–90% carbohydrate. Daba and Shigeta [12] reported the total carbohydrate contents (64%) of the corm sample of *Neqaqa* enset landrace, which is by far lower than the total carbohydrate contents of enset corm in this study. However, the present value is closely comparable with the findings of Mohammed et al. [15] and Nuraga et al. [17]. In the same manner, the carbohydrate content in corms of enset in the present study was comparable to those reported for other root and tuber crops from Ethiopia, such as sweet potato (*Ipomoea batatas*) (83–89%), anchote (*Coccinia abyssinica*) (74–84%), and taro (*Colocasia esculenta*) (73–76%) Dako et al. [45], Ayalew [46] and Temesgen [47], respectively.

3.2. Gross energy value

The gross energy value (kcal/100 g) of samples prepared from the raw corms of seven enset landraces ranged from 369.96 to 385.12, which is differed significantly ($p < 0.05$) (as presented in Table 2). The highest and lowest total energy values have existed in raw corm samples prepared from *Qiniwara* and *Gishira* enset *landraces*, respectively. According to Lowe [48], the body requires food according to its energy value, which assesses the chemical energy contained in the bonds of food's organic compounds such as its protein, carbohydrate, and fat constituents. Similarly, roots and tubers are typically great providers of dietary energy from a nutritional point of view [45]. The energy values of the corm samples of enset found in this study are higher than the values described by Daba and Shigeta [12] for the corm sample of *Neqaqa* (333 kcal/100 g) enset landrace. This variation might be attributed to genetic, environmental, and management differences. However, the energy values of corms of enset observed in the present study were nearly comparable with the values reported from other energy-rich roots and tubers: sweet potato (*Ipomoea batatas*) 361.86–376.90 kcal/100 g; taro (*Colocasia esculenta*) 376.30 kcal/100 g; and anchote (*Coccinia abyssinica*) (349–368) kcal/100 g [45–47]. Hence, the corm samples taken from each landrace revealed substantial levels of energy content. This shows that enset corms are an excellent source of energy for both humans and livestock. A similar finding was also reported by Temesgen and Ratta, [49]. In general, roots and tubers provide a significant contribution by offering the least expensive source of energy for the underprivileged in developing countries.

3.3. Mineral content

The results of the mean mineral contents (calcium, potassium, magnesium, phosphorus, sodium, iron, and zinc) of raw corm samples from seven selected enset landraces are compiled in Table 3. The mean values for calcium content among analyzed corms of enset landraces showed statistically significant variations, ranging from 22.46 mg/100 g for *Hayiwona* to 49.74 mg/100 g for *Gishira* landraces on a dry weight basis. Abebe et al. [18] reported the calcium contents of unspecified enset landrace corm at 25 mg/100 g, which is in the range of our findings in this study. However, Forsido et al. [20] and Daba and Shigeta [12] reported higher calcium content of *Nobo* (100 mg/100 g) and *Neqaqa* (99.7 mg/100 g) respectively, *enset corm* landraces. On the other hand, Nurfeta et al. [50], Debebe et al. [19], and Nuraga et al. [17] reported far higher calcium contents of different enset landraces ranging from 3610 to 11,400 mg/100 g. The variation could be attributable to environmental or genetic factors and analytical apparatus used for determination. The calcium contents in the current study were also slightly comparable to those previously published for other common root and tuber crops by Parmar et al. [33], who reported 30 mg/100 g in

Table 3
Mineral composition (mg/100g) of corms of seven enset landraces suitable for *amicho* consumption on a dry weight basis.

Landrace	Calcium	Potassium	Magnesium	Phosphorous	Sodium	Iron	Zinc
Astara	38.48 ± 1.15[b]	64.44 ± 2.03[b]	23.84 ± 0.70[b]	12.16 ± 1.20[a]	8.19 ± 1.10[a]	1.11 ± 0.25[b]	0.38 ± 0.05[b]
Gishira	49.74 ± 1.25[a]	57.25 ± 1.30[c]	26.16 ± 1.03[ab]	13.58 ± 1.08[a]	8.67 ± 1.00[a]	3.82 ± 0.60[a]	1.09 ± 0.25[a]
Hayiwona	22.46 ± 0.50[d]	86.56 ± 2.05[a]	19.06 ± 0.80[c]	3.83 ± 0.65[b]	8.52 ± 0.81[a]	3.85 ± 1.00[a]	1.44 ± 0.20[a]
Leqeqa	22.51 ± 0.75[d]	31.63 ± 1.05[d]	16.46 ± 0.50[c]	4.17 ± 1.15[b]	7.13 ± 0.55[a]	0.90 ± 0.15[c]	0.58 ± 0.03[b]
Qiniwara	29.30 ± 1.09[c]	28.42 ± 0.82[d]	29.34 ± 1.15[a]	3.10 ± 0.88[b]	7.71 ± 0.45[a]	1.29 ± 0.40[b]	0.50 ± 0.06[b]
Separa	29.87 ± 0.86[c]	37.29 ± 1.05[d]	22.59 ± 0.50[b]	3.29 ± 0.90[b]	7.42 ± 0.78[a]	1.23 ± 0.38[b]	0.52 ± 0.02[b]
Soqido	36.24 ± 1.20[b]	59.37 ± 1.25[c]	23.46 ± 1.00[b]	12.08 ± 1.50[a]	7.87 ± 0.88[a]	1.06 ± 0.15[b]	0.74 ± 0.06[b]

Values are mean of triplicate analysis. Means not followed by the same superscript letters in the same column are significantly different ($P < 0.05$).

sweet potato (*Ipomoea batatas*) and 55 mg/100 g in taro (*Colocasia esculenta*) but it was better than cassava (Manihot esculenta). Calcium concentrations are necessary for bone constituents, tooth development, and blood coagulation in humans [40,51], and they also maintain the biological roles of nerve transmission, muscle contraction, and glandular secretion [52].

The mean value for potassium content among corms of seven enset landraces (Table 3) indicated significant variations, ranging from 28.51 to 86.56 mg/100 g on a dry weight basis. *Hayiwona* landrace had the highest value of potassium content, while the lowest value was observed in *Qiniwara* landrace raw corm samples. The current finding appeared to be far lower than the potassium contents of raw corms of enset landraces reported by Debebe et al. [19], Forsido et al. [20], and Mohammed et al. [15], which ranged from 2000 to 3200 mg/100 g. Unlikely, Daba and Shigeta [12] reported a far lower potassium content (1.24 mg/100 g) in the unfermented enset corms of *Neqaqa* landraces. Such higher variation seemed to be due to analytical procedures rather than environmental or genetic factors. Potassium is essential in the regulation of heartbeat, neurotransmission, and water balance in the human body and in controlling hypertension [40,53].

The magnesium content in the corms of the enset ranged from 16.46 mg/100 g for *Leqeqa* to 29.34 mg/100 g for *Qiniwara,* as shown in Table 3. The observed values showed no significant difference between the landraces of *Leqeqa* and *Hayiwona*, *Separa*, *Soqido*, and *Astara* (Table 3). The differences most probably appear due to genetic factors rather than environmental ones since the crops had grown within the same environmental and management systems. The magnesium content of corm samples in the present study was lower than that reported by Daba and Shigeta [12] (59.6 mg/100 g) and Forsido et al. [20] (80 mg/100 g). This could be attributed to many factors, including the environment in which the enset grows, its genetic makeup, and the analytical methods used. However, the values found from this study are consistent with Parmar et al. [33], who provided a comparable range of values for cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*). Magnesium is necessary for the healthy functioning of the nervous and muscular systems. It aids in maintaining a strong immune system, strengthens bones, and aids in blood sugar regulation, which supports appropriate blood pressure [54].

Mineral analysis of the examined raw corm samples of the enset landraces exhibited a remarkable difference ($p < 0.05$) in phosphorous content; the highest value of 13.58 mg/100 g was recorded from Gishira landrace, followed by Astara (12.16 mg/100 g) and Soqido (12.08 mg/100 g) landraces on a dry weight basis. These landraces provided three times greater phosphorous contents than those of Qiniwara, Separa, and Hayiwona (Table 3). The content of phosphorous in this work was lower than the value indicated by previous authors. Forsido et al. [20] and Daba and Shigeta [12] reported phosphorus values of 90 mg/100 g and 80.4 mg/100g, respectively, when they analyzed the corm of enset landraces. The observed variation in the earlier study and the current findings might be attributed to the genetic differences of landraces and/or environmental factors such as soil types, agronomic practices, and the age of enset plants. A similar idea had been reported by Laya et al. [55]. Phosphorous plays a crucial role in the formation of nucleic acid, normal cell growth and repair, and the ossification of bones by being deposited as calcium phosphate [56].

The sodium levels were not differed significantly ($P > 0.05$) among the landraces from a range of 7.13 mg/100 g in *Leqeqa* to 8.67 mg/100 g in *Gishira* (Table 3). The results of the present mineral analyses revealed slightly higher sodium contents than the finding by Daba and Shigeta [12] for *the Neqaqa* enset landrace *(5.*2 mg*/100 g),* but these values were significantly lower than the reported figures for the *Nobo* enset landrace by Forsido et al. [20] (15 mg/100g) and by Mohammed et al. [15] (30 mg/100 g) for the corm samples of unspecified enset landraces. The variation may result from a difference in genetics or the growing environment [50,57]. Sodium controls bodily fluid and maintains the tissue's electric potential [53].

In this study, the iron contents also differed significantly ($P < 0.05$) among the landraces in raw corm samples of enset, ranging from 0.9 mg/100 g in the *Leqeqa* landrace to 3.85 mg/100 g in *Hayiwona*. The corms of *Hayiwona* and *Gishira* provided three times more value than other landraces based on their iron contents (Table 3). Compared to other minerals analyzed in this study, iron and zinc were found in low amounts in raw corms on a dry weight basis, as shown in Table 3. Tsgaye [21] reported that the iron contents of the corms of different enset landrace ranged between 1.1 mg/100 g and 4.3 mg/100 g, which, except for landraces *Leqeqa*, is closely consistent with our results. Similarly, this study exhibited a higher iron value than the level (0.7 mg/100g) reported by Abebe et al. [18]. However, Daba and Shigeta [12] found far higher iron contents (12.3 mg/100 g) in the raw corms of *Neqaqa* enset landrace. It appears that either genetic or environmental factors were responsible for such higher variation (e.g., application of organic or inorganic fertilizers). The human body requires a smaller quantity of key trace elements, like iron and zinc, for vital biochemical processes. Iron is important for the production of hemoglobin, which is crucial for oxygen transport throughout the body and for the oxidation of carbohydrates, proteins, and fats [58–60].

As shown in Table 3, zinc content differed significantly ($p < 0.05$) among the enset landraces and ranged from 0.38 to 1.44 mg/100 g. The *Hayiwona* landrace had the highest zinc content, and *Astara* had the lowest. However, the zinc contents of the analyzed corms of enset landraces showed no significant difference ($p > 0.05$) between the remaining five landraces. Abebe et al. [18] also reported the zinc contents (1.33 mg/100 g), which was slightly comparable with the value of *the Hayiwona* landrace in this study. On the other hand, higher zinc content that ranged between 6.2 and 15.6 mg/100 g and 22 mg/100 g was also reported by Tsegaye [21] and Daba and Shigeta [12], respectively, which may be related to various factors such as agronomic practice, genetic factors, environmental variations, and analytical procedures used for determination. Zinc is a vital trace element that is crucial for many cellular functions, such as healthy growth, brain development, behavioral response, bone production, and wound healing [60]. Minerals are important constituents of the human diet as they serve many physiological and metabolic processes [61,62]. According to reports by Ratsavong et al. [63] and Nurfeta et al. *[*50], the mineral content of crops varies greatly depending on factors including disease, several transplantations, hygiene, plant variety, and soil contamination.

3.4. Anti-nutritional factors

Anti-nutritional factors (anti-nutrients) are chemical substances generated in natural feedstuffs by the normal metabolism of plants [64,65]. Some of these plant chemicals can be beneficial or harmful to human and animal health, depending on the amount of intake [66]. Previous studies on anti-nutritional factors (e.g., phytate, tannin, and oxalate) on enset corm (*amicho*) have not been conducted so far, except Abebe et al. [18] reported for unspecified enset phytate content from the Sidama region, Forsido et al. [20] for *Nobo* landrace total phenolic contents, and Nurage et al. [17] for five enset landraces phytate and tannin from the Wolkite area of Ethiopia. The phytate, tannin, and oxalate contents of the corm samples of the seven enset landraces (*Astara*, *Gishira, Hayiwona*, *Leqeqa*, *Qiniwara*, *Separa*, and *Soqido*) are shown on a dry weight basis in Table 4. The mean phytate levels of the studied enset landraces were significantly different ($P < 0.05$) and ranged from 221.75 to 276.12 mg/100 g for *Astara* and *Soqido* landraces, respectively, as presented in Table 4. These values are far below the values reported by Nuraga et al. [17] for phytate (14,900–19,500 mg/100 g) for corms of five enset landraces on a dry weight basis and by a far higher value (0.9 mg/100 g) from the reports of Abebe et al. [18]. Such a great variation seems likely to be due to analytical procedures rather than environmental or genetic factors. Bekele [67] indicated that fresh *bulla* (extracted enset product) contents of four enset varieties ranged between 84.25 mg/100 g and 112.56 mg/100 g, which is lower than the phytate contents of enset corm in this study. This implies that the various enset products may have different phytate contents. Similarly, raw enset corm exhibited a higher phytate value than the level (115.43 mg/100 g) reported by Adane et al. [68] on raw taro (*Colocasia esculenta*) flour. However, Fekedu et al. [69] reported a higher value of phytate in raw anchote (*Coccinia abyssinica*) tuber, which contained 389.30 mg/100 g on a fresh weight basis compared with the mean phytate contents of raw corm of enset landraces on dry weight basis. According to Chandrasekara and Kumar [70], the level of phytic acid in a crop can differ based on the crop variety, location, climate, irrigation system, type of soil, and growing season of the plant. The principal mineral absorption inhibitor in plant-based diets is phytate, which also lowers the bioavailability of dietary minerals by producing insoluble mineral chelates in food and the body [71,72]. Therefore, phytate levels must be minimized to concentrations of less than 200 mg/100g DM to mitigate the negative impact of phytates on mineral absorption [73]. For vegetarian diets, the daily consumption of phytate was reported to be between 2000 and 2600 mg and 150–1400 mg for mixed diets [74].

Results from statistical analysis showed that the mean values for tannin content among seven enset landraces varied significantly ($p < 0.05$); they ranged from 27.97 to 113.74 mg/100 g in raw corm samples on a dry weight basis. The maximum tannin value (113.74 mg/100 g) was recorded in the *Hayiwona* landrace, and it was followed by the *Astara* (77.64 mg/100 g) and *Qiniwara* (71.93 mg/100 g) landraces. The lowest tannin level was observed in the *Gishira* (27.97 mg/100 g) landrace (Table 4). The tannin content for the raw corms of the enset landrace (5048–10,356 mg/100 g) reported by Nuraga et al. [17] was too high for our current value on a dry basis. These variations might be due to analytical approaches, environment, and age differences in the enset-crop. Tannin, which has a high molecular weight and is a water-soluble compound, greatly affects nutritional values. Because they precipitate proteins and prevent the activity of digestive enzymes and reabsorption, foods high in tannin are regarded as having low nutritional value [40]. For humans, a daily maximum of 560 mg of tannin is acceptable [74]. Accordingly, based on the results of this study, all of the enset corm samples had low tannin contents and are safe for human consumption.

In the present study, the oxalate content obtained from corm samples of seven different enset landraces ranged from 5.69 to 9.11 mg/100g but did not differ significantly ($p > 0.05$) among enset landraces. A relatively high oxalate content (9.11 mg/100g) was obtained in the corm sample of the *Gishira* landrace, while a lower amount (5.69 mg/100g) was found in the corm sample of the *Separa* landrace on a dry weight basis. These contents are less than those for other root and tuber crops from Ethiopia that have been reported. High oxalate diets can be detrimental to human nutrition and health, particularly since they decrease calcium absorption and promote the development of kidney stones [40,42,75]. According to the reports of Massey et al. [76], patients are recommended to consume fewer foods with a daily oxalate intake of no more than 50–60 mg. In humans, 3000–5000 mg of oxalate is fatal [74]. As a result of the findings of this study, oxalate levels in enset corm are not high enough to pose a risk to human health.

Table 4
Anti-nutritional factors (mg/100g) of corms of seven enset landraces suitable for *amicho* consumption (dry weight basis).

Landrace	Phytate	Tannin	Oxalate
Astara	276.12 ± 1.35[a]	77.64 ± 1.21[b]	5.97 ± 0.25[a]
Gishira	235.92 ± 0.87[c]	27.97 ± 1.30[e]	9.11 ± 0.52[a]
Hayiwona	232.51 ± 1.05[c]	113.74 ± 2.38[a]	6.26 ± 0.33[a]
Leqeqa	229.04 ± 1.15[cd]	67.27 ± 1.35[c]	5.79 ± 0.13[a]
Qiniwara	241.75 ± 0.87[b]	71.93 ± 1.16[b]	7.97 ± 0.28[a]
Separa	230.21 ± 0.17[c]	59.86 ± 0.94[c]	5.69 ± 0.13[a]
Soqido	221.75 ± 0.75[d]	37.78 ± 1.27[d]	6.54 ± 0.30[a]

Values are mean of triplicate analysis. Means not followed by the same superscript letters in the same column are significantly different ($P < 0.05$).

3.5. Molar ratios and bioavailability of minerals

The molar ratios of phytates to calcium, iron, zinc, phytates x calcium to zinc, and oxalate to calcium for corm samples of the seven enset landraces were shown significant variation ($p < 0.05$) among landraces in the present study, and the results for each of the landraces are presented in Table 5. The highest phytate to calcium molar ratios (0.63) and (0.62) were recorded for the landraces *Hayiwona* and *Leqeqa*, respectively, and the lowest value belonged to the *Gishira* (0.28) landrace. Relatively, the highest phytate to iron (21.69) and (21.13) molar ratios

Table 5
Calculated molar ratios of phytate to Ca, Fe, and Zn and oxalate to Ca of corms from seven enset landraces suitable for *amicho* consumption.

Landraces	(Phy:Ca)[a]	(Phy:Fe)[b]	(Phy:Zn)[c]	(Phy·Ca:Zn)[d]	(Oxa:Ca)[e]
Astara	0.43 ± 0.01[b]	21.13 ± 0.27[a]	72.14 ± 0.53[a]	69.41 ± 0.62[a]	0.07 ± 0.01[b]
Gishira	0.28 ± 0.00[d]	5.24 ± 0.12[d]	21.28 ± 0.08[c]	26.46 ± 0.42[c]	0.08 ± 0.00[b]
Hayiwona	0.63 ± 0.02[a]	5.12 ± 0.09[d]	15.87 ± 0.21[d]	8.91 ± 0.08[d]	0.13 ± 0.02[a]
Leqeqa	0.62 ± 0.03[a]	21.69 ± 0.24[a]	38.99 ± 0.32[b]	21.94 ± 0.28[c]	0.12 ± 0.03[a]
Qiniwara	0.50 ± 0.00[b]	15.93 ± 0.32[c]	41.16 ± 0.73[b]	34.85 ± 0.54[b]	0.12 ± 0.00[a]
Separa	0.47 ± 0.01[b]	15.88 ± 0.16[c]	43.58 ± 0.41[b]	32.54 ± 0.32[b]	0.09 ± 0.01[b]
Soqido	0.37 ± 0.00[c]	17.68 ± 0.37[b]	29.47 ± 0.62[c]	27.07 ± 0.52[c]	0.08 ± 0.02[b]

Means not followed by the same superscript letters in the same column are significantly different ($P < 0.05$). Notes.

[a] mg of phytates/molecular weight of phytates: mg of calcium/molecular weight of calcium.

[b] mg of phytates/molecular weight of phytates: mg of iron/molecular weight of iron.

[c] mg of phytates/molecular weight of phytates: mg of zinc/molecular weight of zinc.

[d] (mg of calcium/molecular weight of calcium)*(mg of phytates/molecular weight of phytates)/(mg of zinc/molecular weight of zinc).

[e] mg of oxalates/molecular weight of oxalate: mg of calcium/molecular weight of calcium.

were recorded for *Leqeqa* and *Astara*, whereas the lowest was recorded for the *Gishira* and *Hayiwona* landraces, respectively. Similarly, the highest and lowest phytate to zinc ratios were exhibited in the landraces *Astara* and *Hayiwona*, respectively. A significant difference ($P < 0.05$) was observed among the analyzed corm samples of enset landraces in the phytate x calcium: zinc molar ratio; the highest and lowest ratios were recorded for *Astara* and *Hayiwona* varieties, respectively. The oxalate to calcium molar ratios of the corm samples of enset landraces ranged from 0.07 to 0.13. The highest value was observed in landrace *Hayiwona*, followed by *Leqeqa* and *Qiniwara* with the same molar ratio value (0.12), whereas *Astara* had the lowest value (Table 5).

The molar ratios of anti-nutrients to minerals are used to assess their inhibitory effect on the bioavailability of minerals in food and diet [77]. Bioavailability is the proportion of an ingested nutrient in food that is absorbed and utilized through normal metabolic pathways, particularly minerals [78]. It is influenced by the presence of phytates, oxalates, tannins, and dietary fiber [79], and due to these, only a small portion of the minerals in the diet will be absorbed in the gastrointestinal tract [31]. The phytate to calcium, iron, and zinc molar ratios above 0.24, 1, and 15, respectively, will impair these minerals and be indicative of poor bioavailability [31,80]. According to WHO [81], phytate × calcium to zinc is a more reliable assessment of zinc bioavailability than the phytate to zinc molar ratio alone.

In the present study, the molar ratio of phytate to calcium, iron, and zinc of all the analyzed corms of enset landraces was above the critical values (Table 5). This suggests that phytates may have a negative impact on the dietary materials of the corms of the analyzed enset landraces. However, the phytate × calcium to zinc molar ratio in corm samples of enset landraces was all below 200. This is good in terms of bioavailability [31]. Likewise, the oxalate to calcium molar ratio in corm samples of enset landraces in this study was less than the critical value (1), and this implies that the bioavailability of calcium in corm samples is good, as indicated by Bhandari and Kawabata [82].

3.6. pH and total titratable acidity

The pH and total titratable acidity of the seven enset landraces are presented in Table 6. Among enset landraces, the highest pH value (6.48) of corm flour samples was recorded from *Astara*, but the lowest pH value (5.34) was obtained from *Separa* landraces. This shows that the pH values of the corm samples of this study were slightly acidic, which met the standards for quality and was acceptable. Since flour with a pH of 4 or less would have a distinctively sour aroma and taste from fermentation, which is undesirable for use in culinary items [83], the pH is a suitable quality indicator for corm flour. Similarly, Bekele [67] reported that the pH value of fresh unfermented *bulla* flour from four varieties of enset ranged between 5.23 and 6.01. However, the fermented enset product *qocho* exhibited a 3.79 pH value after 30 days of fermentation [84].

Concerning the total titratable acidity, in this study, there was a significant difference in percent among the tested enset landraces (Table 6). The highest titratable acidity percent (0.39%) was recorded for corm prepared from *Gishira* and *Separa,* while the lowest titratable acidity percent (0.24%) was found from *Leqeqa* landraces. Bekele [67] reported the titratable acidity content of fresh *bulla* (0.22–0.30%), which was comparable with the corm of enset titratable acidity, in our study. However, our result is lower than the titratable acidity reported by Yirmaga [84] (0.87%) for the 30-day fermented enset product *qocho*.

Table 6
The pH value and titratable acidity (%) of corm obtained from seven different enset landraces.

Landraces	pH value	Titratable acidity(%)
Astara	6.48 ± 0.02^{a}	0.28 ± 0.03^{c}
Gishira	5.81 ± 0.04^{b}	0.39 ± 0.04^{a}
Hayiwona	6.13 ± 0.07^{a}	0.28 ± 0.03^{c}
Leqeqa	5.85 ± 0.04^{b}	0.24 ± 0.02^{d}
Qiniwara	5.79 ± 0.05^{b}	0.33 ± 0.04^{b}
Separa	5.34 ± 0.11^{c}	0.39 ± 0.03^{a}
Soqido	6.25 ± 0.03^{a}	0.29 ± 0.03^{c}

Values are mean of triplicate analysis. Means not followed by the same superscript letters in the same column are significantly different ($P < 0.05$).

4. Conclusion

This study has shown notable variation in corm samples prepared from the seven cultivated enset landraces in the proximate, mineral, and anti-nutritional contents. Among the analyzed landraces, *Hayiwona* had the highest mean values of moisture, crude protein, crude fat, crude fiber, potassium, iron, zinc, and tannin contents compared to other tested landraces. On the other hand, the corm sample prepared from the *Gishira* landrace had high total ash, calcium, phosphorous, and sodium contents, but its gross energy content was significantly lower than the other tested landraces. Total carbohydrates and phytate contents obtained from the corm samples of *Astara* were relatively higher than those of other tested landraces in this study. Commonly, the corms of these landraces were highly considered by the farmers for their high *amicho* consumption as food as well as traditional medicine. *Qiniwara* was one of the most favored landraces by local users for its sweet *amicho* and was also traditionally suggested to treat bone-related problems in humans. However, its laboratory results indicated lower contents in total ash and most minerals except gross energy value and magnesium contents. The current study also shows that all of the analyzed corm samples of enset landraces contained a low level of anti-nutritional contents, which is favorable from a nutritional point of view. On the other hand, the molar ratios of the enset corms in this study were above the standard values, except for phytate × calcium to zinc and oxalate to calcium, which show low mineral bioavailability. Enset corm is typically eaten after being cooked with various leafy vegetables and dairy products, which raises the mineral content and boosts the bioavailability of minerals in the enset diet. Therefore, our findings will provide a basis for continued identification and nutritional evaluation, which is necessary to distinguish the nutritious corm for *amicho* preparation from different enset landraces to sustain and improve enset cultivation for food security.

Authors contributions

Tesfaye Dilebo: Conceptualization, Designing and Performing the experiments, Analyzing and Interpreting the data, Writing the original draft and final manuscript. Tileye Feyissa, Zemede Asfaw, Ashagire Zewdu: Data curation, Supervision, Validation, Contributing reagents, Review & Editing the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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