Keywords: Nutritional profile Unconventional food plant Proximate analysis Physical characteristics

ABSTRACT

This study aimed to determine the chemical composition and the vitamin, carotenoid, and mineral profile in dandelion (Taraxacum officinale) collected from the Middle Doce River region ( Médio Rio Doce) in the state of Minas Gerais, Brazil. To accomplish this, the physicochemical parameters, such as titratable acidity, pH, and soluble solids were determined, in addition to the evaluation of the plants’ proximate composition (moisture, ash, proteins, dietary fibers, and lipids). The vitamin E, carotenoids and vitamin C were determined by HPLC and the minerals were analysed by inductively coupled plasma atomic emission spectrometry. The T. officinale samples presented a low content of macronutrients, a total energy value of 27.88 kcal.100 g 
1 FW, a high fiber content (3.7 g.100 g 
1 FW), low levels of total vitamin E (43.67 μg.100 g 
1 FW), total carotenoids of 11.95 g.100 g 
1 FW, and did not present vitamin C in detectable levels. The mineral analysis revealed a high concentration of iron, manganese, copper, zinc, and selenium, and small amounts or traces of aluminium, cadmium, nickel, and chromium. In conclusion, T. officinale was shown to be an important source of nutrients, especially fiber, iron and manganese.

1. Introduction

Brazil has a diverse range of flora, with plants frequently studied as to their nutritional potential. Among these, non-conventional edible plants (NCEP) stand out as an important resource to diversify the human diet. Despite the NCEP’s economic, social, and environmental value, there is a demand for new studies to elucidate their nutritional and functional potential.

One NCEP found among the Brazilian flora is the dandelion ( Taraxacum officinale F.H. Wigg.), which belongs to the Asteraceae family. This plant, originally from Western Europe and Asia, grows spontaneously in the South and Southeast regions of Brazil during the winter and spring (Fatima et al., 2018; Polesi et al., 2017). Taraxacum officinale is frequently found in agroforestry yards of family farming areas in the Middle Doce River region ( Médio Rio Doce), in Minas Gerais. Agroforestry yards are used according to agroecological principles, with sustainable management practices which aim to preserve the naturally-occurring diversity of the land by applying appropriate cultivation techniques. In addition, agroforestry yards have been considered an important form of food production, with a unique potential to complement the dietary needs of communities, which contributes to food sovereignty and the conservation of agrobiodiversity found in and around family farming areas (Duque-Brasil et al., 2012; Gonçalves et al., 2021; Lameirada et al., 2020).

T. officinale possesses serrated edge pinatipart leaves and yellow flowers. It is often considered a type of “bush” or “weed”, due to its easy propagation in pastures, gardens, crops, backyards, and lawns (Biondo et al., 2018). Despite this, in some areas of Brazil, T. officinale leaves are eaten fresh in salads or mixed in other preparations, such as angu, a...
typical Brazilian dish prepared from boiled corn meal (Polesi et al., 2017). Due to this potential in the human diet, recent studies have evaluated the chemical profile of *T. officinale* grown in the United States of America and in countries in Asia and Europe by identifying some minerals, phenolic compounds, flavonoids, coumarins, terpenoids, lactones, sesquiterpenes, carotenoids, chlorophylls, dietary fiber, and alkaloids (Fatima et al., 2018; Gomez et al., 2018; Pâdures et al., 2016; Qureshi et al., 2017). Some of these compounds are beneficial to human health and contribute to the functional effects exerted by *T. officinale* in the treatment of liver disease and its action as an antimicrobial, antirheumatic, and anticonvulsant agent (Habb et al., 2018).

Nevertheless, the nutritional profile of *T. officinale* specimens from Brazil, so far, still needs to be investigated in relation to the vitamin C and vitamin E content, as well as the composition of macronutrients and micronutrients. Such is the case because the composition of Brazilian NCEP's may differ considerably from those observed in other regions of the world, since the cultivation mode, geographical characteristics, and other influential factors can affect the plant’s nutrient concentrations (Jahb, 2019; Li et al., 2020).

The lack of information on the diversity and nutritional composition of NCEP's contributes to their underutilization and, therefore, to the waste of their potential for human utilization. Thus, knowledge about the nutritional value of *T. officinale* aims to set a scientific foundation to justify its consumption by people. Therefore, this study aimed to determine the proximate composition and the carotenoids, vitamins e minerals profile of *T. officinale* from family farming located in the municipality of Governador Valadares, Minas Gerais, Brazil.

2. Materials and methods

2.1. Chemicals and reagents

The standards of lycopene, β-cryptoxanthin, α- and β-carotenes, and ascorbic acid were obtained from Sigma-Aldrich (St. Louis, MO, USA). Standards of vitamin E (tocotrienols and tocopherols) were purchased from Calbiochem®, EMD Biosciences, Inc. (USA). Standard multi-element solutions of minerals were purchased from Merck (Brazil).

The carotenoids and vitamins were extracted using analytic-grade reagents (VETEC, São Paulo, Brazil) and analysed using HPLC-grade reagents (Tedla, São Paulo, Brazil). For the analyses of minerals, nitric acid purchased from Sigma Aldrich (Germany) was used.

2.2. Characterization of the regional socio-environmental context

*T. officinale* samples were collected at the Cachoeira da Fumaça camp, which has an area of around 1 hectare, located near the Baguari Hydroelectric Plant, between the municipalities of Governador Valadares and Periquito, in eastern Minas Gerais, on BR 381, KM 172, at the entrance to hydroelectric plant.

The samples were donated by family farmers through the Centro Agroecológico Tamanduatei (CAT), an institution that for more than three decades provided technical advice and enabled outreach programs to rural communities and agrarian reform settlements. In the center, in partnership with the UFJF-GV Agroecology Center (NAG), the project called the Tamanduatei Network of Agroecological Prospects is developed to promote direct marketing of agroecological products and allow the exchange of knowledge and social technologies. Currently, CAT family farmers have participated in academic activities in educational institutions in Governador Valadares, including the donation of regional agrobiodiversity products for research and extension activities.

2.3. Collection and preparation of samples

The *T. officinale* specimens were collected in December 2018, in the municipality of Governador Valadares, in the Middle Doce River region of the state of Minas Gerais. They were packed in polyethylene bags at room temperature for transport. The samples were later photographed and identified with the help of specialised bibliography (Kinupp and Lorenzi, 2014), and the botanical nomenclature was verified according to the interactive database of the List of Species of Flora of Brazil (Monge, 2020).

The intact *T. officinale* plants were transported to the laboratory in polyethylene bags and then the leaves were manually separated from the plant. The intact leaves were selected, and those with yellow or damaged parts were discarded. The selected leaves were washed in running water to remove dirt. Soon after washing, the leaves were dried with paper towels and chopped using a stainless-steel knife and a polyethylene board. The samples were stored in a freezer (−18 °C ± 1 °C) until the moment of analysis.

2.4. Proximate composition

The proximate composition of *T. officinale* fresh leaves was evaluated according to AOAC (2016). Moisture was determined by drying the leaves at 105 °C in an oven and ash was quantified by burning the leaves in a muffle furnace (Químis, Q320M was model, Brazil). The protein was evaluated by the micro-Kjeldahl method, with digestion, distillation, and titration of samples. The gravimetric non-enzymatic method was used to determine the total dietary fiber in leaves. Lipids were extracted in ethyl ether in a Soxhlet extractor (Elettrothermo, 500WX model, Brazil). The following equation was used to estimate the content of carbohydrates:

\[
100 – (\% \text{ moisture} + \% \text{ lipids} + \% \text{ protein} + \% \text{ total dietary fiber} + \% \text{ ash})
\]

The results of proximate composition were expressed in grams per hundred grams (g.100 g⁻¹) of fresh sample. Using the conversion values of 4 kcal·g⁻¹ of protein or carbohydrate and 9 kcal·g⁻¹ of lipid (Mahan and Raymoun, 2018) was estimated using the total energy value.

2.5. Determination of carotenoids and vitamins

The samples and extracts were protected from sunlight and artificial lights using non-transparent amber glass, aluminium sheets, and blackout curtains. To protect the extracts from oxygen were used flasks with lids and nitrogen atmosphere.

2.5.1. Carotenoid extraction and analysis

The occurrence and content of lycopene, β-cryptoxanthin, α- and β-carotenes were investigated in *T. officinale*. The methods proposed by Rodriguez-Amaya et al. (2008) were modified for the extraction of carotenoids. Briefly, five grams of chopped *T. officinale* leaves were added 20 mL of chilled acetone homogenized in a micro-shredder (Marconi, MA 102, Brazil) for 3 min and vacuum filtered. The solid residue from the filtration was subjected to the extraction procedure twice more. The filtrate was added in fractions to 50 mL of cooled petroleum ether and, subsequently, washed with distilled water for acetone removal. To the carotenoid in petroleum ether extract kept in the funnel was added anhydrous sodium sulfate to remove residual water. Lastly, the extract was concentrated to 10 mL, at a temperature of 35 °C ± 1 °C. For analysis, a sample of the extract (10 mL) was evaporated, redissolved in 2 mL of HPLC-grade acetone, filtered through filter units with 0.45 μm porosity (Millipore, Brazil) and injected (50 μL) into the chromatographic column.

A high-performance liquid chromatography system (HPLC) (Shimadzu, SC 10 AT VP, Japan) with the following chromatographic conditions (Pinheiro-Sant’Ana et al., 2011) was used: diode array detector (DAD) (Shimadzu, SPD-M10A, Japan) at 450 nm, Phenomenex Gemini RP18 column (250 mm × 4.6 mm, 5 μm) equipped with a Phenomenex ODS (C18) guard column (4 mm × 3 mm); the mobile phase composed by methanol: ethyl acetate: acetonitrile (70:20:10, v/v/v), flow rate of 1.7 mL·min⁻¹, and running time of 11 min.

2.5.2. Extraction and analysis of vitamin C

The ascorbic acid (AA) content was investigated in the leaf of *T. officinale* using the extraction and analysis protocols proposed by
The results for the carotenoid and vitamin C content were expressed in milligrams per hundred grams of fresh sample (mg.100 g⁻¹), and for vitamin E, the result was expressed in micrograms per hundred grams of fresh sample (μg.100 g⁻¹).

2.6. Determination of minerals and trace elements

The acid digestion of the sample was carried out according to Ekholm et al. (2007), using previously demineralized materials and glassware. Approximately 1 g of the lyophilized sample was transferred to a digestion tube and 10 mL of nitric acid was added. The mixture was kept at room temperature for 24 h and then heated to 50 °C for 6 h and 120 °C for 14 h. The tubes were then cooled to room temperature (22 °C – 25 °C) and the volume of the solution was adjusted to 25 mL with deionized water. Three tube samples without the chopped leaves (blank) were prepared using the same conditions described above.

The content of minerals and trace elements (Na, Mg, Al, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, Se, Mo, and Cd) was analysed by inductively coupled plasma atomic emission spectrometry (Optima 3300 DV, Perkin Elmer, USA). The analysis was carried out under the following conditions: 1300 W of RF power, 15 mL.min⁻¹ of plasma argon flow rate, 0.7 L.min⁻¹ of auxiliary argon flow rate, 0.5 L.min⁻¹ of nebulizer argon flow rate and 1.5 mL.min⁻¹ of injection rate. The following analytical wavelengths were employed: Na at 589 nm, Mg at 285 nm, Al at 405 nm, Ca at 405 nm, Cr at 268 nm, Mn at 259 nm, Fe at 260 nm, Ni at 232 nm, Cu at 225 nm, Zn at 214 nm, Se at 196 nm, Mo at 202 nm, and Cd at 214 nm.

The limits of detection (LOD) and quantification (LOQ) were determined as proposed by Catharino et al. (2006) (Supplementary Material). The analytical curves (R² > 0.982) used for quantifying the components were constructed with standard multi-element solutions. The result of minerals was expressed in milligrams per hundred grams of fresh sample (mg.100 g⁻¹).

2.7. Experimental design and data analysis

All chemical analyses were performed in three repetitions. Means and standard deviations were performed for each parameter. From the peak areas and the concentrations of the analytical standards for carotenoids, vitamins and minerals linear regression analysis were prepared and the determination coefficient (R²) was calculated. The SPSS software Version 23.0 was used to perform to descriptive analysis.

3. Results and discussion

3.1. Morphological characterization

The T. officinale leaves exhibited rosular phyllotaxis in the shape of a basal rosette, with simple division of the limbus and a pinapartite shape, with the limbus irregularly cut, in addition to the presence of laticiferous channels in the leaf mesophyll (presence of latex). The T. officinale leaves had a serrated edge (Figure 1) a milky sap was found inside. The physical characteristics of the leaves were compatible with those observed by other authors (Fatima et al., 2018; Kinupp and Lorenzi, 2014; Sáid et al., 2018).

3.2. Proximate composition

Several noncommunicable diseases (such as cancer, obesity, cardiovascular, cognitive, skin, eyes, lung, and bone diseases) can be prevented by regular consumption of vegetables, based on the inverse relationship between their consumption and the risk of developing the disease (Yahia et al., 2019). This fact demonstrates the importance of knowing about the nutrients and bioactive compounds in unconventional edible plants, to better inform people about the possible health benefits that come with including these plants in a balanced diet.
Despite the potential for its insertion into the dietary habits of people, there is a considerable lack of information about the proximate composition of T. officinale grown in Brazil, being that much of the available data are from samples collected in Europe and Asia. This limitation of knowledge highlights the need for more scientific advances regarding the Brazilian specimens of T. officinale, especially since the chemical composition of plants is affected by the region of their cultivation.

Water was the main constituent of the T. officinale leaf (84.9%) (Table 1), remaining within the range observed in other studies (79.12% – 81.94%) (Dias et al., 2014; Murtaza et al., 2022). Due to the high-water activity and, consequently, high perishability, the consumption or reduce the acceptance of the product (Barbosa et al., 2021). Another factor that may contribute to the lower insertion of NCEP into the dietary habits of the general population is the belief that they may have fewer advantages regarding the consumer-related factors that can affect the composition of Brazilian T. officinale and conventional plants that corroborated this popular belief were not found.

Expectedly, dietary fibers are found in leafy vegetables, and this fact was also true for the T. officinale, being the second largest component in the specimens collected from family farming in Governador Valadares (3.7 g.100 g⁻¹). The total dietary fiber in these plants was similar to the amount found in conventional vegetables like Erechtites valerianifolia (3.7 g.100 g⁻¹) (Barreira et al., 2019), Sonchus species (3–6 g.100 g⁻¹) (Garcia-Herrera et al., 2014; Al-Essa, 2003; Panfili et al., 2020), and A. oleracea (≥3 g.100 g⁻¹) (Aguiar et al., 2014; Neves et al., 2019). It is noteworthy that dietary fibers are food compounds capable of reducing the risk of developing obesity, diabetes, cancer, and intestinal disease (Cronin et al., 2021; O’Grady et al., 2019). In recent years, with the advancements in research, some other functions of dietary fibers have been discovered, including reducing heavy metal toxicity, the risk of developing cardiovascular diseases, improving allergic symptoms such as rhinitis, and even reducing the risk of developing certain health conditions which afflict women (He et al., 2022).

The Brazilian T. officinale analysed in this study had a lower content of proteins and carbohydrates, but more lipids than that observed in leaves from India (Gani et al., 2018; Murtaza et al., 2022). Likewise, the carbohydrate content (1.97 g.100 g⁻¹) was lower and lipid content (1.2 g.100 g⁻¹) higher than that of the conventional vegetable Lactuca sativa (U.S. Department of Agriculture (USDA), 2019). Furthermore, the leaf exhibited a protein content similar to that of conventional vegetables like E. valerianifolius (1.3 g.100 g⁻¹) (Barreira et al., 2019), Sonchus species (3–6 g.100 g⁻¹) (Garcia-Herrera et al., 2014; Al-Essa, 2003; Panfili et al., 2020), and A. oleracea (≥3 g.100 g⁻¹) (Aguiar et al., 2014; Neves et al., 2019).

Due to the low content of macronutrients, the T. officinale in this study had a low energy value (27.84 kcal.g⁻¹), lower than that observed in leaves from India (Gani et al., 2018; Murtaza et al., 2022).

### Table 1. Proximate composition and total energy value in dandelion (Taraxacum officinale) from family farming in Governador Valadares (Minas Gerais, Brazil).

| Parameters          | Content¹ᵇ |
|---------------------|------------|
| Moisture (g.100 g⁻¹) | 89.4 ± 0.45 |
| Protein (g.100 g⁻¹) | 2.3 ± 0.01  |
| Lipids (g.100 g⁻¹) | 1.2 ± 0.03  |
| Ash (g.100 g⁻¹)     | 1.43 ± 0.02 |
| Total dietary fiber (g.100 g⁻¹) | 3.7 ± 0.09  |
| Available carbohydrates (g.100 g⁻¹) | 1.97 ± 0.04  |
| Total energy value (kcal.100 g⁻¹) | 27.88 ± 0.02 |

¹ Values are expressed in fresh matter.
ᵇ Average of three repetitions ± standard deviation.

### 3.3. Carotenoids and vitamins

#### 3.3.1. Qualitative composition

Among the carotenoids analysed in this study, β-carotene and β-cryptoxanthin were the only ones identified in the T. officinale specimens, with no presence of α-carotene and lycopene (Figure 2a). However, the presence of β-carotene and α-carotene in T. officinale has been demonstrated by other authors (Gomez et al., 2018; Sircelj et al., 2018; Znidarcic et al., 2011).

No vitamin C was detected in the samples of T. officinale obtained from the family farming site in Governador Valadares, Brazil, which corroborates with what was observed in T. officinale collected in the Southern USA (Gomez et al., 2018). However, other studies carried out so far differ as to the presence of vitamin C in T. officinale. The presence of this compound was confirmed in T. officinale collected in the Northeast of the USA, India, Poland, and in Romania (Biel et al., 2017; Gomez et al., 2018; Murtaza et al., 2022; Pădureț et al., 2016).

This was the first study to assess the presence of α, β, γ, and δ-tocotrienols in T. officinale (Figure 2b). The scarcity of this information highlights the importance of further studies about the vitamin E composition in this plant. Of the eight isomers of vitamin E, six were identified in the present work (α, β, γ, δ-tocopherols, and tocotrienols). However, α, β and γ-tocopherols were found in T. officinale from Portugal (Dias et al., 2014), while α-tocopherol was identified in samples from Romania (Sircelj et al., 2018).
The high variability in the profile of carotenoids, vitamin C, and vitamin E observed in this study, especially when considering the compositions reported in the literature, suggests an influence of the place of cultivation, which can affect the nutrient profile of the plants (Isah, 2019; Li et al., 2020; Saini and Keum, 2018).

### 3.3.2. Quantitative composition

The total carotenoid content (11.95 mg.100 g⁻¹) in Brazilian *T. of ficinale* was approximately twice as low as that found in *T. of ficinale* from Romania (23.39 mg.100 g⁻¹) (Sircean et al., 2018), but superior to that found in plants from Slovenia (6.34 mg.100 g⁻¹) (Znidaric et al., 2011). The total carotenoids were higher than that of conventional leafy vegetables like *L. sativa* (9.74 mg.100 g⁻¹) (Cruz et al., 2012), *E. valerianifolius* (4.8 mg.100 g⁻¹) (Barreira et al., 2019), and Sonchus species (5.58 mg.100 g⁻¹) (de Paula Filho et al., 2022).

It is important to note that the carotenoid levels depend on several factors, including species, variety, cultivar, production practice, maturity, as well as environmental conditions regarding light, temperature, and soil properties (Saini and Keum, 2018). This may justify the divergences between the contents observed in the study and the other studies mentioned. The total carotenoid content of *T. officinale* may be explained by the temperature at which the plant grew since low temperatures stimulate the production of carotenoids (Saini and Keum, 2018). In plants collected in Brazil and Slovenia, where temperatures reach 35 °C, the total carotenoid content was lower than those collected at lower temperatures, like the ones in Romania (16 °C).

In addition, the fact that β-carotene was the most abundant carotenoid detected in this plant suggests that *T. officinale* is a potential source of pro-vitamin carotenoids capable of supplying human daily needs of vitamin A. Importantly, the β-carotene content (11.86 mg.100 g⁻¹) in the samples analysed in this study was much greater than that found in the leafy vegetables which are most widely consumed by the Brazilian population, like *L. sativa* (3.33 g.100 g⁻¹) (Cruz et al., 2012), *E. valerianifolius* (4.3 g.100 g⁻¹) (Barreira et al., 2019), and Sonchus species (4.97 mg.100 g⁻¹) (de Paula Filho et al., 2022).

Studies on the total vitamin E content of Brazilian dandelions are scarce and data on tocotrienols in this plant are not available. The content of vitamin E found in the Brazilian *T. officinale* (43.67 μg.100 g⁻¹) was similar to that observed in the *T. officinale* leaves from Northeastern Portugal (44.76 μg.100 g⁻¹) (Dias et al., 2014). In our case, α-tocopherol, γ-tocopherol, and δ-tocotrienol were major components in *T. officinale*, making up 14.5%, 7.4%, and 21.4%, respectively, of the total vitamin E content. Vitamin E is naturally found in several plants and has an important antioxidant function for the human body, where it modulates free radicals (Lis and Olas, 2019). It is of great relevance to know the potential of *T. officinale* in relation to its vitamin E profile, as it can be better used both nutritionally and therapeutically.

### 3.4. Minerals

Edible plant species comprise an essential and nutritious portion of the human diet, as they contain an abundance of beneficial minerals,
which contribute to the maintenance of good health (Manwani et al., 2022; Moura et al., 2021). Therefore, with the growing popularity of NCEP consumption, determining the inorganic components found in these plants is of great interest to public health (Manwani et al., 2022). The T. officinale samples collected from the family farming area presented a high content of iron and manganese (Table 2). The ingestion of 100 g of fresh leaves from this plant can supply from 10% to 20% of the recommended daily values for these nutrients considering a male adult aged between 19 and 30 years (Institute of Medicine (IOM), 1997, 2001, 2005). Furthermore, the leaves presented moderate content of selenium, copper, molybdenum and zinc, being able to provide between 5 and 10% of the recommended daily values for these nutrients.

Some studies confirm the presence of calcium, iron, magnesium, and copper in T. officinale, in quantities equivalent to that observed in our study (7.3 mg.100 g⁻¹ Ca, 1.6 mg.100 g⁻¹ Fe, 2.08 mg.100 g⁻¹ Mg, and 0.05 mg.100 g⁻¹ Cu) (Khan et al., 2013). However, they also reported high levels of sodium (0.013 mg.100 g⁻¹) and zinc (0.14 mg.100 g⁻¹) (Khan et al., 2013), which was not the case for our samples. This high variability may be associated with the harvest period and other environmental conditions that may affect the chemical composition of the substrate in the place of cultivation (Issah, 2019; Li et al., 2020). It is worth mentioning that the T. officinale analysed in this study had four times more iron than the lettuce that belongs to the same family as the T. officinale, highlighting its importance to human nutrition.

It should likewise be noted that this is the first study to analyse the content of molybdenum and selenium found in T. officinale. These micronutrients have specific biochemical functions in the human body, with molybdenum being important for the function of some oxidases in addition to being involved with some aspects of the immune system. Selenium, on the other hand, is essential to the activity of antioxidant enzymes, such as glutathione peroxidase (Godswill et al., 2020; Shenkin, 2006). These micronutrients were found in low concentrations in the leaves of T. officinale obtained from the family farming area, demonstrating that the introduction of this species into the diet can be beneficial for health.

Although the consumption of vegetables is recognized as beneficial to human health, the inadvertent excess accumulation of heavy metals (As, Cd, Hg, and Pb) in vegetables and their subsequent intake by humans may affect their physiological functions and their metabolomic properties when ingested, with some cases having been associated with diseases like cancer, mental retardation, and immunosuppression (Manwani et al., 2022). It should be mentioned, therefore, that in the present study, traces of heavy metals (Cd, Al, Cr, Ni) were found, although in small amounts.

Other research carried out on T. officinale obtained from industrial and rural areas in Italy and Poland, demonstrated that the environmental impacts of such activities contribute strongly to the increase in the metal content of plants (Giacomino et al., 2016; Ligocki, 2011), with the T. officinale in those cases exhibiting a good capacity to store Cr, Cd, Ni, Ti, Fe, Zn, and Cu. Therefore, analysing the T. officinale destined for consumption, in addition to characterising the regional socio-environmental context where they were collected is of great relevance, since these conditions can affect the accumulation of heavy metals. Thus, the results of our study indicate the need for further elucidation about the possibility of soil and water contamination at the site, especially in the city of Governador Valadares, considering that the Doce River channel was hit by mud from mining waste because of the Fundão dam rupture. With this in mind, a study has shown that the Doce River presents high levels of heavy metals, which exceeds the maximum values allowed by Brazilian legislation (Carvalho et al., 2017). This leads us to ask: can the plants and animals that live in the main channel of the Doce River, and who therefore are exposed to the river or well water be accumulating heavy metals? If so, what are the implications short and long term? It is known that heavy metals have a cumulative effect and present different levels of toxicity representing potential risks to human health and food safety.

4. Conclusion

The T. officinale samples collected from the family farming field in Governador Valadares exhibited a low content of macronutrients (proteins, carbohydrates, and lipids), as well as a low total energy value. Additionally, we detected a substantial amount of total dietary fiber, a low content of vitamin E and total carotenoids, as well as no detectable amounts of vitamin C. This also study evidenced a high content of iron and manganese, with moderate quantities of selenium, copper, molybdenum and zinc in the T. officinale leaves. Lastly, minor amounts or traces

| Table 2. Content of carotenoids, vitamins, and minerals in dandelion (Taraxacum officinale) from family farming in Governador Valadares (Minas Gerais, Brazil). |
|-----------------------------------------------|
| Carotenoids and vitamins | Content* | Minerals | Content †(mg.100 g⁻¹) |
| Total carotenoids (mg.100 g⁻¹) | 11.95 ± 2.0 | Ca | 8.45 ± 1.4 |
| α-Carotene (mg.100 g⁻¹) | nd | Fe | 2.35 ± 0.27 |
| β-Carotene (mg.100 g⁻¹) | 11.86 ± 1.97 | Mg | 1.98 ± 0.92 |
| δ-Cryptoxanthin (mg.100 g⁻¹) | 0.09 ± 0.03 | Mn | 0.25 ± 0.00 |
| Lycopene (mg.100 g⁻¹) | nd | Se | 0.003 ± 0.00 |
| Retinol activity equivalent (µg.100 g⁻¹) | 0.991 ± 0.023 | Cu | 0.08 ± 0.01 |
| Total vitamin C (µg.100 g⁻¹) | nd | Mo | 0.004 ± 0.01 |
| Ascorbic acid (mg.100 g⁻¹) | nd | Zn | 0.6 ± 0.02 |
| Dehydroascorbic acid (mg.100 g⁻¹) | nd | Na | 1.45 ± 0.12 |
| Total vitamin E (µg.100 g⁻¹) | 43.67 ± 2.21 | K | 10.63 ± 0.69 |
| α-Tocopherol (µg.100 g⁻¹) | 10.64 ± 0.59 | Cr | Trace |
| α-Tocotrienol (µg.100 g⁻¹) | 6.31 ± 0.04 | Al | Trace |
| γ-Tocopherol (µg.100 g⁻¹) | 10.63 ± 1.66 | Cd | 0.02 ± 0.00 |
| γ-Tocotrienol (µg.100 g⁻¹) | 3.24 ± 0.13 | Ni | Trace |
| δ-Tocopherol (µg.100 g⁻¹) | 3.50 ± 0.00 | | |
| δ-Tocotrienol (µg.100 g⁻¹) | 9.35 ± 0.12 | | |
| β-Tocopherol (µg.100 g⁻¹) | nd | | |
| β-Tocotrienol (µg.100 g⁻¹) | nd | | |

* Values are expressed in fresh matter.
† Average of three repetitions ± standard deviation.
nd: not detected.
of manganese, aluminium, cadmium, molybdenum, chromium, and nickel were also found.  

*T. officinale* from the Middle Doce River region is a good alternative to diversifying daily diet and can contribute to the nutritional needs of people in communities where the plant is commonly found. To that end, deconstructing the popular notion that *T. officinale* is a weed can favour its acceptability as a food item. This rebranding of the plant's image is important given its relatively easy handling, which has almost zero cost, and could thus improve the autonomy of family farmers by providing them with an easy to grow vegetable that represents an extra source of income. Parallel to its economic and dietary value, the fact that this species has an established niche among the local flora can contribute to the development of agrobiodiversity practices, which helps communities to maintain a more harmonious relationship with the environment. Because *T. officinale* is very resistant to pollution and inhospitable regions, studies are needed to elucidate its potential to absorb and accumulate heavy metals from the soil, since the Middle Doce River region was affected by mining waste and, as was demonstrated by other authors, the presence of pollutants can interfere with the concentration of nutrients in plants, namely metals.

**Declarations**

**Author contribution statement**

Lionardo Conte de Almeida: Performed the experiments; Analysed and interpreted the data; Wrote the paper.

Maiara Rodrigues Salvador: Analysed and interpreted the data; Wrote the paper.

Helena Maria Pinheiro-Sant’Ana, Ceres Mattos Della Lucia: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Reinaldo Duque Brasil Landulfo Teixeira: Contributed reagents, materials, analysis tools or data; Analysed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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**Data availability statement**

Data included in article/support/reference in article.

**Declaration of interest’s statement**

The authors declare no conflict of interest.

**Additional information**

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**References**

Aguir, J.P.L., Yuyama, L.K.O., Souza, F.d.C.d.A., Pessoa, A., 2014. Biodeponibilidade do ferro do jambu (Sympylhes olarzuz L.): estudo em murinos. Revista Pan-Americana de Saúde 5 (1), 19–24.
