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Basic Composition, Antioxidative Properties, and Selected Mineral Content of the Young Shoots of Nigella (*Nigella sativa* L.), Safflower (*Carthamus tinctorius* L.), and Camelina (*Camelina sativa* L.) at Different Stages of Vegetation

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Abstract: Young shoots are a completely new and rapidly growing group of foodstuffs. Also known as "vegetable confetti", they are a useful addition to commonly consumed meals and often serve a decorative purpose, especially when paired with traditional dishes. Most users are unaware of their invaluable properties as a source of bioactive compounds and add them simply as a dish garnish. Hence, the aim of this study is to evaluate and compare selected health quality parameters of the young shoots of rare oilseed plants (*Nigella sativa* L., *Carthamus tinctorius* L., and *Camelina sativa* L.), which have not been studied in the literature. They are examined for proximate composition (dry matter, total protein, crude fat, ash, digestible carbohydrates, dietary fiber), antioxidative properties (vitamin C, total carotenoids, and total polyphenol content), the content of sixteen selected minerals (calcium, potassium, magnesium, sodium, phosphorus, sulphur, selenium, barium, iron, lithium, beryllium, nickel, gallium, indium, bismuth, silver) as well as antioxidant activity at two harvest dates. The ready-to-eat young shoots in the phase of intensive growth are characterized by a very high content of the examined components and antioxidant properties, which differ depending on the harvest date and plant species. Significantly higher contents of protein, fat, and some minerals have been found in the young shoots from the first harvest compared to those from the second harvest. The antioxidant properties of the young shoots generally increase with maturity. It was not possible, however, to conclusively assess which species of young shoots show the highest health quality.

Keywords: young shoots; safflower; camelina; nigella; major essential minerals; trace elements; basic composition

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1. Introduction

There is no information in the available literature on the nutritional and non-nutritional value of the young shoots of rare oilseed plants, whose seeds, which are better studied, are a source of many substances with a very broad spectrum of health-promoting benefits, including valuable phytosterols, phytoestrogens (polyphenols), and vitamin E [1,2]. Young shoots are a completely new food group which is rapidly developing. In sprouted seeds, physiological processes, including enzymatic processes, happen swiftly, and the content of valuable bioactive, health-promoting components increases by several times, e.g., free amino acids, dipeptides, tripeptides (which are important antioxidants), vitamins, and polyphenols [1,2].

Microgreens, also known as microleaves, are the young shoots of popular vegetables, herbs, grains, flowers, and ornamental species (including wild edible species), harvested at the leaf development stage, often before the formation of the first pair of leaves (after sprouting, before the pre-young leaf phase); these microgreens have the potential to promote human health and the sustainable diversification the global food system [3]. Harvesting typically takes place up to 2–3 weeks after germination, above the ground level, so that—unlike for sprouts—the seeds and roots are not eaten, which reduces the potential transmission of pathogens. Young shoots are gaining popularity as a culinary ingredient and as a dish garnish, especially in gastronomy [4–6]. In some exclusive restaurants employing very creative chefs, microgreens are served for exotic flavors, colors, and creative presentations. They are added to salads, sandwiches, soups, desserts, and drinks [5,6]. From a gastronomic point of view, the aspect that makes microgreens particularly interesting is the possibility of using individual species and cultivars characterized by a wide range of shapes, colors (green, yellow, red, purple), tastes (sweet, neutral, slightly sour, spicy), and consistencies (delicate, crunchy, juicy). The scent of microgreens can be intense, as of many aromatic herbs [6]. Young shoots have been recognized as a potential therapeutic functional food used to improve overall health through dietary supplementation. These shoots have a delicate texture and distinctive flavor as well as an extraordinary amount of various nutrients, offering greater nutraceutical benefits compared to their mature counterparts [7].

The growing popularity of young shoots is not only due to their nutritional importance, but also to their fascinating organoleptic characteristics. A number of factors, such as the rapid reduction of land sources, changes in lifestyle and eating habits, as well as the need for sustainable food production, have increased the interest in micro-scale vegetable production for the ready-to-eat meal market [8,9]. In the United States and European countries, microgreens have begun to appear in some grocery stores, mainly large supermarkets. They are usually sold cut and packaged, but for some time now, they have been available in the form of living plantlets in containers with a cultivation medium. This form allows for longer commercial life and high quality because the consumer independently cuts the plant just before its use [7]. Young shoots can be effective and beneficial in alleviating nutritional gap challenges, making them a successful food for the future [6,10]. While for large-scale production they can be grown in fields, they are mostly cultivated in greenhouses and controlled environments or, most often, in soilless (hydroponics) systems under artificial lighting, resulting in better crop growth, yield, quality, and accumulation of bioactive compounds without being limited by lighting conditions. Moreover, their consumption does not require any culinary treatment [11,12].

Nigella sativa L. belongs to the *Ranunculaceae* family and is probably one of the most important medicinal plants in history [13]. It is an annual flowering plant, characterized by pale blue and white petals and fruits containing numerous black seeds. Alternative names for this plant include Black Cumin, Kalonji, Habbatul Barakah, which in Arabic means “seed of blessing”, as well as Black Seed. For centuries, *Nigella sativa* L. has been an important part of the culture, cuisine, and traditional medical practices in South Asia, the Middle East, Europe, and the Mediterranean [14,15]. According to the literature, nigella (*Nigella sativa*) has antioxidant, anti-inflammatory, analgesic, antiviral, anti-asthmatic, antidiabetic, hypotensive, hypolipidemic, diuretic, cholagogic, antifungal, antiparasitic, immunomodulatory, hepatoprotective, neuroprotective, nephroprotective, and even anticancer effects [13,16]. *Nigella sativa* L. seeds have a bitter taste and aroma. They are used as a flavoring additive to bread and pickles, and they are also added to tea, coffee, casseroles, etc. Ground *Nigella sativa* L. seeds are usually sprinkled on salads or mixed with honey [17].

Camelina (*Camelina sativa* L.) is an oilseed plant that belongs to the *Brassicaceae* family and is an annual plant with a short life cycle of 85–100 days. It produces small yellow flowers with four petals, which are arranged in a cluster. Camelina attracts attention due to its value for the food and energy industries (mainly grown for oil) and its potential for other applications [18]. Camelina oil obtained from *Camelina sativa* L. (also called false flax) contains a large amount of polyunsaturated fatty acids. The interest in camelina and its oil has increased in recent years due to its agronomic advantages, such as low demand for fertilizer or water, good adaptability to adverse environmental conditions, and resistance to pests. Camelina is often grown as a non-food oilseed plant, avoiding competition with other crops meant for food production (e.g., in the USA as a low-input biofuel crop) [19,20]. Camelina oil shows antioxidant and cardioprotective properties and has many beneficial effects, e.g., on lipid profile and diabetes [21].

It has been proven that safflower (*Carthamus tinctorius* L.) extracts, due to their antioxidant, anti-inflammatory properties, and effects on the process of apoptosis, can beneficially effect both the cardiovascular system (anticoagulant, cardio- and vasoprotective, hypotensive effects) and other tissues and organs (neuro- and hepatoprotective and antidiabetic activities) [22]. However, this oily plant is not widely consumed in Poland. Extensive studies have proved that safflower extracts are significantly valuable products. Not only do they provide essential food components, including polyunsaturated fats, but also many bioactive substances which are beneficial to the body. Due to this, the studies on young shoots of rarely cultivated and lesser-known oilseed crops can not only lead to the promotion of a new, valuable food products, but also open the way for producers and growers to broaden the range of products on offer.

The aim of the study is to compare the proximate composition (dry matter, total protein, crude fat, ash, digestible carbohydrates, dietary fiber), antioxidative properties (vitamin C, total carotenoids, total polyphenol content, and antioxidant activity) as well as sixteen major essential minerals and trace elements (calcium, potassium, magnesium, sodium, phosphorus, sulphur, selenium, barium, iron, lithium, beryllium, nickel, gallium, indium, bismuth, silver) in the young shoots of rare oily plants (safflower, camelina, and nigella) at two harvest dates (first harvest: plants had cotyledons and the first true leaf; second harvest: plants had one to two true leaves each).

The measurable effect of this study will be to gain knowledge about the health-promoting properties of the aforementioned oilseeds at this stage of their vegetation. The high potential nutritional value of these young shoots of rare oilseed plants, and the lack of the available literature in this area, are strong reasons for undertaking this study. An outstanding outcome of the research will be to gain, for the first time, knowledge of the health-promoting properties of these—so far—unexplored plants at their immature stage.

2. Materials and Methods

2.1. Plant Material

The tested materials were cultivated in the greenhouse of the Faculty of Biotechnology and Horticulture of the Agricultural University of Krakow. The seeds of three uncommon oilseed plants, nigella (*Nigella sativa* L.), safflower (*Carthamus tinctorius* L.), and camelina (*Camelina sativa* L.), were collected from a horticultural industry. The seeds were sown thickly into seed boxes filled with ready-to-use, standard substrate TS 2, with universal use. TS2 growing medium is made of light peat and water-soluble fertilizer containing basic plant nutrients: 19% sulphur (SO_3); 16% phosphorus (P_2O_5); 18% potassium (K_2O); 14% nitrogen (which includes 5.5% $N\text{-}NO_3$ and 8.5% $N\text{-}NH_4$); 0.8% magnesium (MgO); 0.03% boron (B); 0.12% copper; 0.09% iron (Fe); 0.16% manganese (Mn); 0.20% molybdenum (Mo); and 0.04% zinc (Zn). The growing medium had a pH level of 6. Temperature and humidity conditions in the greenhouse were 21 °C and 50–63% during the day and 18 °C and 78–88% at night.

The plants of each species were collected at two harvesting periods. The first harvest was carried out when the plants had cotyledons and the first true leaf (BBCH (Biologische Bundesanstalt, Bundessortenamt, und CHemische Industrie) 11). Camelina and safflower were characterized by a similar development and reached subsequent phases at the same time. Nigella developed more slowly and entered the development phases approximately 12 days later. For safflower and camelina, the subsequent phases were reached after 11 days from sowing; for nigella, the subsequent phases were reached after 24 days. The second harvest took place when plants had 1–2 true leaves each (BBCH 12); for safflower and camelina, this was after 18 days from sowing; for nigella, this was after 30 days. The BBCH scale was calculated, as defined by Huck et al. [23]. Photographs of young shoots are included in the Supplementary Materials. The above-ground parts of the young plants were cut by sterile scissors, washed under tap water, cut into very small pieces (1–2 cm wide), and combined to prepare the representative samples (at least four samples for each analysis carried out on fresh material). The other parts of the raw material were rinsed, dehydrated with filter paper, mechanically crushed, frozen at −22 °C, and finally lyophilized (Christ Alpha 1-4, Osterode am Harz, Germany). The material was then ground (Knifetec 1095 Sample Mill, Tecator, Höganäs, Sweden) to obtain a homogeneous sample with particles of the lowest diameter. The freeze-dried material was then analyzed for the basic composition and mineral content. The analyses were performed in triplicate.

2.2. Analytical Methods

Dry matter content was determined as mass loss upon heating to 105 °C under normal pressure conditions according to PN-EN-12145:2001 [24]. The chemical composition and fiber content of the freeze-dried samples of the young shoots were determined according to AOAC methods [25]: total protein content (AOAC 950.36) was determined using Tecator Kjeltec 2200 (Tecator, Höganäs, Sweden); crude fat content (AOAC 935.38) was determined using Tecator Soxtec Avanti 2050 (Tecator, Höganäs, Sweden); ash content (AOAC 930.05) was determined using dry mineralization at 525 °C in a Muflon oven; dietary fiber (AOAC 930.05) was determined with a commercial Total Dietary Fiber Assay Kit (K-TDFR-100A, Megazyme International Ireland, Wicklow, Ireland) using the Tecator Fibretec System E (Tecator, Höganäs, Sweden). In short, freeze-dried samples of the young shoots were gelatinized using thermostable α-amylase (E-BLAAM, Megazyme International Ireland, Wicklow, Ireland). Protein and starch were removed with the addition of high purity protease (from *Bacillus licheniformis*) (E-BSPRT, Megazyme International Ireland, Wicklow, Ireland) and amyloglucosidase (from *Aspergillus niger*) (E-AMGDF, Megazyme International Ireland, Wicklow, Ireland). A precipitate was formed after the addition of ethanol; the precipitate was filtered, washed in ethanol and acetone, dried, and weighed. The residue was collected and weighed. The protein content was then determined in one portion and mineralized in the other. Total dietary fiber was calculated as follows: weight of sediment minus weight of protein and ash. The digestible carbohydrate content was calculated using the following equation: digestible carbohydrate = 100 − (protein + crude fat + ash + fiber).

Vitamin C content was measured and calculated as the sum of ascorbic acid and dehydroascorbic acid using the 2,6-dichlorophenoloindophenol method (PN-A-04019:1998) [26]. At first, methanol extracts were prepared. In short, 5 g of raw vegetables were taken from an average representative sample, mixed with 80 mL of 70% methanol solution, and shaken in a water bath (Elpan 357, Lubawa, Poland) for 2 h at an ambient temperature. Next, the extracts were centrifuged (MPW-340, Warszawa, Poland), filtered, and stored at −22 °C [27]. On the day of the analyses, the samples were mixed with an oxalic acid solution in order to preserve the ascorbic acid against degradation, and the vitamin C content was determined using the titration of the samples with the use of 2,6-dichlorophenoloindophenol in at least three repetitions.

At the same time, 70% methanol extracts were used for the determination of total polyphenols according to Folin–Ciocalteu method (Sigma-Aldrich, St. Louis, MO, USA) [28]; this method was also used to test the antioxidant activity based on the $ABTS^{\bullet+}$ free radical scavenging ability [29]. The total polyphenol content in the extracts was measured spectrophotometrically at 760 nm (RayLeigh UV-1800 spectrophotometer, Beijing, China) and was expressed as a chlorogenic acid equivalent (CGA) (Sigma-Aldrich, St. Louis, MO, USA) in milligrams per 100 g of fresh weight on the basis of a standard curve.

Antioxidant activity was measured at 734 nm (RayLeigh UV-1800 spectrophotometer) by the determination of the colored solution resulting from the reduction of $ABTS^{\bullet+}$ free radicals (2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) by the antioxidants presented in the examined product. The values obtained for each sample, after their comparison to the concentration–response curve of the standard Trolox solution, were expressed as μM Trolox eq/1 g fresh weight (TEAC).

The total carotenoid content was determined spectrophotometrically, according to the Polish Standard with modifications (PN-90/A-75101/12) under dark conditions to protect carotenoids from light degradation [30]. The samples were homogenized with an extraction solvent (acetone-hexane mixture, 4:6 *v*/*v*); then, the optical density of the supernatant at a wavelength of 450 nm was measured using a RayLeigh UV-1800 (China) spectrophotometer and compared with a standard curve (standard range of 0–30 milligrams).

Micronutrients and trace elements were measured as follows: 0.5 g of the air-dried samples were placed into 55-mL TFM dishes and mineralized in 10 mL of HNO_3 (65% super pure, Merck no. 100443.2500) with the Mars 5 Xpress (CEM, East Norwalk, CT, USA) microwave mineralization system, at first for 15 min, in order to achieve a temperature of 200 °C, and then for another 20 min, to maintain the temperature. Afterwards, the samples were cooled down and quantitatively transferred into 25 mL volumetric flasks with redistilled water. The amounts of magnesium (Mg), calcium (Ca), sulphur (S), potassium (K), phosphorus (P), sodium (Na), and iron (Fe) were quantified using an optical emission spectrometer with high-dispersion inductively coupled plasma (ICP-OES by Prodigy Teledyne Leeman Labs, Lafayette, USA) [31]. Because selenium (Se), lithium (Li), barium (Ba), beryllium (Be), nickel (Ni), gallium (Gal), indium (In), bismuth (Bi), and silver (Ag) are all of lower densities, their analysis was performed using inductively coupled plasma mass spectrometry with a triple quadruple spectrometer (iCAP TQ ICP-MS by ThermoFisher Scientific, Bremen, Germany).

2.3. Statistical Analysis

All measurements were carried out in at least three repetitions ($3 \leq n \leq 6$) and the results were presented as means ± standard deviations (SD). The data were subjected to a two-factorial (3 × 2) analysis of variance, including three species of the young shoots of rare oilseed plants and two dates of harvest. The differences between the means were evaluated using the post hoc Duncan test, with the significance level established at $\alpha \leq 0.05$ (Statistica software v. 13.1 PL, Dell Inc., Tulsa, OK, USA).

3. Results

3.1. Basic Composition

As for the dry matter content in the young shoots of rare oilseeds, the differences observed were statistically significant ($p \leq 0.05$) depending on the harvest date (Table 1).

Table 1. Dry matter content (g 100 g^{-1} FW) and the chemical composition (g 100 g^{-1} DW) in young shoots at different stages of vegetation.

Compounds	Young Shoots of Nigella (*Nigella sativa* L.)		Young Shoots of Safflower (*Carthamus tinctorius* L.)		Young Shoots of Camelina (*Camelina sativa* L.)	
	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **
Dry matter	5.25 ± 0.21 ^{c}	6.50 ± 0.57 ^{d}	2.35 ± 0.49 ^{a,b}	3.15 ± 0.21 ^{b}	1.65 ± 0.21 ^{a}	1.75 ± 0.07 ^{a}
Total protein	30.03 ± 0.84 ^{b}	24.86 ± 0.86 ^{d}	34.69 ± 0.70 ^{a,c}	31.78 ± 1.37 ^{b,c}	37.91 ± 2.65 ^{a}	37.49 ± 0.86 ^{a}
Crude fat	3.72 ± 0.08 ^{c}	9.49 ± 0.21 ^{e}	4.21 ± 0.00 ^{d}	3.49 ± 0.0 ^{b}	3.36 ± 0.01 ^{b}	2.45 ± 0.01 ^{a}
Ash	19.76 ± 0.44 ^{c}	15.71 ± 0.38 ^{a}	16.19 ± 0.40 ^{a}	15.65 ± 0.01 ^{a}	18.15 ± 0.13 ^{b}	19.99 ± 0.03 ^{b}
Dietary fiber	22.24 ± 0.93 ^{a}	26.53 ± 2.03 ^{b,c,d}	23.18 ± 1.42 ^{a,b}	25.67 ± 1.30 ^{b,c}	29.33 ± 0.83 ^{d}	27.92 ± 1.15 ^{c,d}
Digestible carbohydrates	26.74 ± 0.00 ^{a}	25.91 ± 1.20 ^{a}	24.98 ± 1.65 ^{a}	26.02 ± 0.01 ^{a}	13.88 ± 1.77 ^{b}	14.67 ± 0.65 ^{b}

The values of compounds are expressed as mean ± standard deviation. Values within lines with different superscript letters (a–d) are significantly different at $p \leq 0.05$). * Stage of vegetation—plants had cotyledons and the first leaf proper. ** Stage of vegetation—plants had 1–2 leaves proper each.

Dry matter values were lower after the first harvest than after the second harvest (Table 1). A significantly higher ($p \leq 0.05$) dry matter content was observed in nigella, compared to camelina and safflower. The average dry matter content of nigella was approximately twice as high as that of safflower and 3.4 times higher than that of camelina. In turn, the dry matter content was the highest in nigella (average of two harvests—5.9 g per 100 g of fresh weight—FW) and the lowest in safflower (1.7 g/100 g FW). All the young shoots of the examined rare oilseeds differed in a statistically significant way ($p \leq 0.05$) in the dry matter content.

The ash content of the analyzed young shoots ranged from 15.65 to 19.99 g per 100 g dry weight—DW. The average ash content in the young nigella shoots was 17.73 g/100 g DW. There was no statistically significant ($p > 0.05$) difference in the ash content depending on the harvest date in the young safflower shoots; however, such a difference in this parameter was observed in the young shoots of nigella and camelina. In the young nigella shoots, a higher ash content (by 20.5%) was noted after the first harvest than after the second harvest.

A statistically significant difference ($p \leq 0.05$) was observed in the total protein content with respect to the harvest date of the nigella young shoots (Table 1). In this case, the protein content was significantly higher ($p \leq 0.05$) after the first harvest (by 17.22%) than after the second harvest. Of the examined plants, camelina had the highest protein content (37.91 g/100 g DW) and nigella had the lowest (24.86 g/100 g DW).

The fat content of the young shoots of nigella, safflower, and camelina differed in a statistically significant way ($p \leq 0.05$) depending on the harvest date (Table 1). After the first harvest, the young shoots of camelina and safflower had a higher fat content, contrary to the young shoots of nigella, which had a lower fat content. The lowest fat content was exhibited in camelina shoots (2.9 g/100 g DW), whereas the highest fat content was exhibited in safflower shoots (6.6 g/100 g DW). The fat content of nigella after the second harvest was increased by 2.5 times compared to the first harvest. For the other young shoots, the fat content after the second harvest decreased by 17% (safflower) and 27% (camelina), respectively. All of the examined young shoots of rare oilseeds differed in a statistically significant way ($p \leq 0.05$) in terms of fat content.

The content of dietary fiber in young sprouts of nigella, safflower, and camelina varied significantly ($p \leq 0.05$) depending on the harvest date (Table 1). In the young shoots of safflower and camelina, the fiber content was lower after the first harvest and increased after the second harvest. Contrarily, in the young nigella shoots, this value was higher after the first harvest and decreased with time. There were statistically significant differences ($p \leq 0.05$) in the. fiber content between the young shoots of camelina, safflower, and nigella. The dietary fiber content of the nigella after the second harvest was statistically significantly ($p \leq 0.05$) increased by 16% compared to the first harvest. The highest value was determined in the young camelina shoots (28.6 g/100 g DW), while an average content was determined in nigella and safflower shoots (24.4 g/100 g DW).

In all the examined young shoots, the content of digestible carbohydrates did not differ significantly ($p > 0.05$) depending on the harvest date (Table 1). The highest value was found in young sprouts of nigella (26.74 g/100 g DW), while the lowest was in young sprouts of camelina (13.8 g/100 g DW). The young shoots of camelina had a statistically significant ($p \leq 0.05$) lower content of digestible carbohydrates, compared to nigella and safflower, by an average of 46% and 44%, respectively.

3.2. Antioxidative Properties

The vitamin C content of the examined young shoots of the rare oilseed plants varied in a wide range between 5.27 and 47.37 mg per 100 g FW. The highest statistically significant content ($p \leq 0.05$) was found in the young nigella shoots after the second harvest, while the lowest was found in the young safflower shoots, regardless of the harvest date (Table 2).

Table 2. Vitamin C, total carotenoids, total polyphenol content (mg 100 g^{-1} FW), and antioxidant activity (µmol Trolox 1 g^{-1} FW) in young shoots at different stages of vegetation.

Compounds	Young Shoots of Nigella (*Nigella sativa* L.)		Young Shoots of Safflower (*Carthamus tinctorius* L.)		Young Shoots of Camelina (*Camelina sativa* L.)	
	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **
Vitamin C	29.59 ± 1.68^{c}	47.37 ± 0.16^{a}	5.28 ± 0.09^{e}	5.32 ± 0.15^{e}	18.75 ± 0.95^{d}	38.99 ± 0.53^{b}
Total carotenoids	13.60 ± 0.71^{b}	18.73 ± 2.22^{c}	8.40 ± 0.00^{a}	18.66 ± 1.27^{c}	13.09 ± 2.24^{b}	22.07 ± 2.70^{c}
Total polyphenols [mg CGE/100 g FW]	45.40 ± 0.99^{a}	69.95 ± 0.00^{c}	59.17 ± 1.53^{b}	65.22 ± 1.52^{c}	58.70 ± 3.01^{b}	64.95 ± 1.14^{c}
Antioxidant activity [µmol Trolox/1 g FW]	1.25 ± 0.00^{f}	1.42 ± 0.01^{e}	4.32 ± 0.06^{b}	4.43 ± 0.06^{a}	3.86 ± 0.01^{d}	4.10 ± 0.01^{c}

The values of compounds are expressed as mean ± standard deviation. Values within lines with different superscript letters (a–f) are significantly different at $p \leq 0.05$). * Stage of vegetation—plants had cotyledons and the first leaf proper. ** Stage of vegetation—plants had 1–2 leaves proper each.

The young shoots of nigella and camelina showed a statistically significant ($p \leq 0.05$) increase in vitamin C content after the second harvest, compared to the first harvest. The highest increase, by 62%, was observed for the young nigella shoots (Table 2).

It was observed that all species of the young shoots from the second harvest had a significantly higher ($p \leq 0.05$) content of total carotenoids compared to the first harvest (Table 2). The highest increase, by 125%, was found in the young safflower shoots, while the lowest, by 38%, was found in the case of the young nigella shoots. The content of the compounds investigated ranged from 8.40 to 22.07 mg per 100 g FW. The lowest statistically significant carotenoid content was recorded in the young safflower shoots from the first harvest, compared to the remaining young shoots from the first harvest, for which similar results were observed. There were no statistically significant differences ($p > 0.05$) in the content of the discussed compounds for the young shoots after the second harvest.

The content of total polyphenols ranged from 45.40 to 68.95 mg/100 g FW (expressed as chlorogenic acid) (Table 2). As with total carotenoids, the harvest date had a significant effect ($p \leq 0.05$) on the content of total polyphenols. All species of the examined young shoots from the first harvest contained considerably less of these compounds compared to the second harvest. The increase in the total polyphenol content reached 62% for the young nigella shoots, while for the remaining shoots it was approximately 11% on average.

The antioxidant activity of the young shoots varied in a statistically significant way ($p \leq 0.05$), depending on the time of the harvest and the species of the young shoots, ranging widely from 1.25 to 4.43 µmol Trolox per 1 g FW (Table 2). The young nigella shoots were characterized by the lowest antioxidant activity, followed by camelina and safflower shoots. The young shoots of safflower showed the strongest antioxidant activity compared to the remaining examined species, regardless of the harvest date. The antioxidant activity of the young nigella shoots was three times lower than the average antioxidant activity of the young camelina shoots. Further, the antioxidant activity of the young nigella shoots was 3.3 times lower than that of the young shoots of safflower.

3.3. Selected Minerals

Of all 16 elements examined, potassium was the macronutrient whose content in all the species of the young shoots of rare oilseed plants was the highest and ranged widely from 6780.41 to 11,221.57 mg per 100 g DW (Table 3). The highest statistically significant ($p \leq 0.05$) potassium content was in the young nigella shoots from the first harvest, and the lowest was in the safflower shoots from the first harvest, compared to the other examined plants. The Potassium content in the young shoots of camelina at both harvest dates and in nigella at the second harvest date were similar.

Table 3. Selected mineral content in young shoots at different stages of vegetation (mg 100 g^{-1} DW).

Compounds	Young Shoots of Nigella (*Nigella sativa* L.)		Young Shoots of Safflower (*Carthamus tinctorius* L.)		Young Shoots of Camelina (*Camelina sativa* L.)	
	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **	First Harvest *	Second Harvest **
Calcium (Ca)	1566.88 ± 51.34 [d]	1715.68 ± 17.94 [e]	1804.53 ± 90.21 [e]	2979.04 ± 54.78 [b]	2764.19 ± 54.61 [c]	3834.06 ± 50.92 [a]
Potassium (K)	11,221.57 ± 340.01 [a]	7832.96 ± 119.54 [d]	6780.41 ± 364.18 [b]	5478.21 ± 104.32 [c]	7935.72 ± 586.64 [d]	8174.47 ± 227.49 [d]
Magnesium (Mg)	414.80 ± 4.06 [d]	347.72 ± 4.16 [e]	546.13 ± 24.65 [b]	719.54 ± 13.50 [a]	415.37 ± 25.44 [d]	472.43 ± 5.13 [c]
Sodium (Na)	115.10 ± 27.33 [d]	159.54 ± 23.17 [b]	130.82 ± 41.18 [c]	275.13 ± 47.32 [a]	87.10 ± 23.04 [e]	82.39 ± 32.12 [e]
Phosphorus (P)	1157.23 ± 27.23 [c]	738.61 ± 17.94 [b]	834.55 ± 34.50 [d]	827.00 ± 11.38 [d]	1255.54 ± 31.90 [a]	1126.73 ± 12.45 [c]
Sulphur (S)	533.23 ± 10.39 [c]	462.95 ± 7.65 [d]	362.00 ± 14.39 [e]	386.19 ± 5.09 [e]	1034.31 ± 25.19 [a]	866.10 ± 12.54 [b]
Selenium (Se)	0.00219 ± 0.000 [d]	0.00257 ± 0.000 [d]	0.04752 ± 0.003 [a]	0.02792 ± 0.002 [b]	0.01161 ± 0.002 [c]	0.00356 ± 0.000 [d]
Barium (Ba)	0.34 ± 0.00 [e]	0.81 ± 0.01 [c]	0.56 ± 0.12 [d]	0.60 ± 0.02 [d]	0.91 ± 0.03 [b]	1.12± 0.02 [a]
Iron (Fe)	34.28 ± 0.97 [a]	22.93 ± 0.34 [d]	29.54 ± 1.49 [b]	35.68 ± 0.31 [a]	27.33 ± 2.22 [c]	21.84 ± 0.39 [d]
Lithium (Li)	3.086 ± 0.08 [a]	2.565 ± 0.06 [b]	0.076 ± 0.01 [d]	0.132 ± 0.01 [c,d]	0.086 ± 0.01 [d]	0.170 ± 0.00 [c]
Beryllium (Be)	5.97 ± 0.13 [b]	4.96 ± 0.08 [c]	2.80 ± 0.08 [f]	3.89 ± 0.16 [e]	4.48 ± 0.33 [d]	6.43 ± 0.004 [a]
Nickel (Ni)	0.297 ± 0.01 [d]	0.272 ± 0.01 [d,e]	0.244 ± 0.01 [e]	0.211 ± 0.10 [b]	1.234 ± 0.02 [a]	0.149 ± 0.04 [c]
Gallium (Ga)	0.00093 ± 0.000 [c]	0.00363 ± 0.000 [a]	0.00068 ± 0.000 [c]	0.00031 ± 0.000 [c]	0.00269 ± 0.001 [b]	0.00094 ± 0.000 [c]
Indium (In)	nd	nd	nd	nd	nd	nd
Bismuth (Bi)	nd	nd	nd	nd	nd	nd
Silver (Ag)	nd	nd	nd	nd	nd	nd

The values of compounds are expressed as mean ± standard deviation. Values within lines with different superscript letters (a–f) are significantly different at $p \leq 0.05$). * Stage of vegetation—plants had cotyledons and the first leaf proper. ** Stage of vegetation—plants had 1–2 leaves proper each.

Calcium, magnesium, and phosphorus were generally present in the lowest statistically significant ($p \leq 0.05$) amounts in the young nigella shoots, regardless of the harvest date (Table 3). Calcium contents in the examined plants were between 1566.88 to 3834.06 mg/100 g DW. The highest calcium content was found in the young camelina shoots from the second harvest and these amounts were almost 2.5 times higher compared to that determined in the nigella shoots from the first harvest. Magnesium in the examined young shoots was in the range from 347.72 to 719.54 mg/100 g DW. The lowest content was found in nigella, regardless of the harvest date; the second lowest content was found in camelina; and the highest content was found in safflower. In comparison with the other plants examined, the highest magnesium content was determined in the young safflower shoots from the second harvest. The magnesium content of safflower from the second harvest was as much as two times higher than that of the young nigella shoots from the second harvest.

As for phosphorus, its content in the examined plants was between 738.61 and 1255.54 mg/100 g DW. The young camelina shoots from the first harvest contained 70% more of this macronutrient, compared to the nigella shoots from the second harvest. No effect of the harvest date ($p > 0.05$) was observed on the phosphorus content of the examined young shoots. The content of sodium ranged widely from 82.39 to 275.13 mg/100 g DW. The highest statistically significant amounts ($p \leq 0.05$) of this element were found in safflower from the second harvest and were about 3.3 times higher than the amounts detected in camelina from the second harvest. When compared to the other examined plants, the young camelina shoots contained the lowest statistically significant amounts ($p \leq 0.05$) of this element, regardless of the harvest date. An opposite relation was observed for the next macronutrient discussed, i.e., sulphur, whose content was within the range between 362.00 and 1034.31 mg/100 g DW. It was found that the camelina shoots had the highest content of this element, and the lowest content of this element was found in the safflower shoots, regardless of the harvest date. The absolute difference between the highest content in camelina from the first harvest and the lowest in safflower from the first harvest was 672 mg/100 g DW.

Selenium is an important micronutrient that has antioxidant properties. It was found in the highest statistically significant amounts ($p \leq 0.05$) in safflower, followed by camelina, and then nigella, regardless of harvest dates (Table 3). The amounts of selenium were within a very wide range of 0.002 to 0.047 mg/100 g DW. The amount of selenium determined in safflower from the first harvest was as much as 25 times higher compared to the young nigella shoots from the first harvest. Interestingly, the opposite relationships were observed for the content of another micronutrient, i.e., lithium. Its amount in the young nigella shoots from the first harvest was even 41 times higher (3.085 mg/100 g DW) compared to that found in safflower from the first harvest (0.076 mg/100 g DW). In the case of gallium, however, its amount in the young nigella shoots from the second harvest was twelve times higher than its amount in safflower from the second harvest and four times higher, compared to its content in camelina from the second harvest. With regard to the other micronutrients, i.e., barium and beryllium, their highest amounts were recorded in camelina from the second harvest, compared to the remaining shoots. The lowest statistically significant ($p \leq 0.05$) content of these micronutrients was in nigella from the first harvest (barium) and in safflower, also from the first harvest, compared to the examined young shoots. The nickel content ranged broadly from 0.149 to 1.234 mg per 100 g DW. Its highest amounts were marked in camelina from the first harvest, while the lowest were in camelina from the second harvest. The values within this species varied by more than eight times, depending on the harvest date. The iron content determined in the young shoots ranged between 21.84 and 35.68 mg/100 g DW; the highest amounts of iron were in the young nigella shoots from the first harvest and the safflower shoots from the second harvest; the lowest amounts were determined in camelina and nigella from the second harvest. The young shoots were also examined for the contents of three other trace elements, i.e., silver, bismuth, and indium, which were not detected in the samples investigated.

4. Discussion

4.1. Basic Composition

While germination occurs in young shoots (microgreens), fats are degraded to free fatty acids, proteins to oligopeptides, and free amino acids and polysaccharides to oligosaccharides and monosaccharides. These processes boost biochemical mechanisms in the human body. For this reason, germination can be viewed as one of the kinds of pre-digestion that helps to decompose materials of high molecular compositions into their constituent elements [11]. At present, there are many vegetables and herbs grown as young shoots. The popular taxonomic families cultivated include *Fabaceae* (e.g., alfalfa, fenugreek, sweet pea), *Apiaceae* (e.g., parsley, carrot, celery), *Amaranthaceae*, *Asteraceae*, *Brassicaceae* (broccoli, cabbages, mizuna, etc.), and several others. It is also well established that the chemical composition of microgreens varies significantly from that of more mature crops [32].

Although a wide range of microgreens are currently being cultivated, scientific data about uncommon oilseed young shoots such as nigella, safflower, or camelina are generally not available. The results of the dry matter content analysis obtained in this study (1.65–6.56 g/100 g FW) differ from those given by Drozdowska et al. [33], who examined the 14-day-old young shoots of red cabbage (7.33 g/100 g FW); the results also differ from the findings reported by Kapusta-Duch et al. [34] for 21-day-old young shoots of white cabbage (7.36 g/100 g) and red cabbage (8.20 g/100 g). Sadowska et al. [35] similarly showed that the dry matter content of mustard increases with the extension of the plant's growing season. However, Šamec et al. [36] also noted significantly higher results for the sprouts of white cabbage in comparison to the levels obtained in this study. Most of the results in the published literature concern plants at the fully mature stage. The results reported above vary, but they can be explained by different weather conditions during the plant vegetation period, varying cultivation treatments, and different dates of harvest, as well as by the variation of biological materials between the species and the cultivar.

In this study, the results demonstrated that the young shoots of uncommon oilseed plants are characterized by a high total protein amount (24.86–37.91 g/100 g of DW), which is compatible with the findings of Drozdowska et al. [33] for the 14-day-old shoots, and with the findings of Kapusta-Duch et al. [34] for the 21-day-old selected *Brassica* shoots. Intriguingly, the amounts of total protein found by Drozdowska et al. [32] in the mature crops were nearly two times lower. According to Hotton et al. [20], the protein in mature camelina is characterized by the following amino acid composition: glutamine, asparagine, arginine, leucine, lysine, glycine, valine, serine, and proline in a ratio similar to soy or rapeseed. Readily consumable young shoots are a better source of total protein, perhaps due to the fact that shoots are in an intensive growth phase. Šamec et al. [36] examined five different *Brassica* species of young shoots and found that arugula, broccoli, and kale, contain 28–42% more total protein (43.88–46.24 mg/g DW) than Chinese and white cabbage (26.57 and 33.34 mg/g DW, respectively). The findings are very comparable to the results of the present study for the young shoots of nigella, safflower, and camelina. Vale et al. [37] reported that sprouts (which were produced under a light cycle) harvested after reaching about seven centimeters in length, were characterized by a lower amount of protein, 26.95 and 29.95 g/100 g DW, accordingly. The results obtained by Vale et al. [37] are also concordant with our findings.

As per the findings of Drozdowska et al. [33], the crude fat amount of the 14-day-old shoots of red headed cabbage was 2.5 g/100 g DW, which is in agreement with the findings of this study, wherein the value was 2.45 g/100 g DW for the young camelina shoots from the second harvest. The authors also discovered that crude fat levels in the young shoots of red cabbage were almost three times higher than those found in the vegetable at full maturity. In the case of the nigella shoots from the second harvest, the results obtained in this study also are in line with the findings of Vale et al. [37]. According to these authors, the mean value of crude fat in the 7-centimeter red cabbage shoots is much higher, amounting to as much as 8.81 g/100 g DW. The results of Kapusta-Duch et al. [34] for the young shoots of 21-day-old selected *Brassica* plants are also congruent with the findings of this study.

In the present study, the amount of dietary fiber determined in the young shoots of uncommon oilseed plants was within the range of 22.24–29.33 g/100 g DW. The amount of dietary fiber determined by Kapusta-Duch et al. [34] in the selected *Brassica* young shoots tended to be higher, amounting to 37.4 and 33.5 g/100 g DW, depending on the species. The values noted by Drozdowska et al. [33] for the 14-day-old young sprouts of red cabbage were very similar to those given by Kapusta-Duch et al. [34] (30.2 g/100 g DW). A study performed in south Korea on 30 diverse varieties of sprouts revealed that the amount of dietary fiber was between 18 and 33 g/100 g DW, and the mean content was 25 g/100 g DW [38]. Lee et al. [38] also reported that the mean fiber content of the sprouts was 1.6 times greater than in the seeds on their own before germination.

The content of ash in the shoots of uncommon oilseed plants ranged from 15.71 to 19.99 g/100 g DM. However, Drozdowska et al. [33] and Kapusta-Duch et al. [34] report a slightly lower ash content in the shoots of selected *Brassica* species in comparison to the mean levels achieved in that study. The content of digestible carbohydrates in the young shoots of three rare oilseed species, calculated from the formula, ranged widely from 13.88 to 26.02 g/100 g DW. Drozdowska et al. [33] found that the content of digestible carbohydrates in red cabbage at full maturity (about 71.6%) was significantly higher than in the 14-day-old shoots (12.69 g/100 g DM), which only slightly differs from the lowest amount acquired in this study. In turn, the results obtained for the 21-day-old shoots of certain *Brassica* species by Kapusta-Duch et al. [34] was almost twice as high as the highest result obtained in this study.

4.2. Antioxidative Properties

Vitamin C is a necessary dietary ingredient for the human body, operating as an antioxidant. Yadav et al. [39] studied microgreens and their counterparts in nine plants and showed that the concentration of ascorbic acid ranged from 10 to 199.99 mg/100 g FW in mature vegetables, whereas in microgreens, it ranged from 6 to 52.31 mg per 100 g FW. These authors concluded that the human body can fully access the ascorbic acid present in microgreens as they are generally consumed fresh, so the amounts are not so important. Ghoora et al. [4] examined ten young culinary seedlings such as spinach, onion, fennel, carrot, sunflower, radish, mustard, roselle, and French basil. According to the author, vitamin C ranged from 41.6 to 139.8 mg/100 g [4]. A comparable content in terms of total ascorbic acid was determined in 25 species of microgreens (20.4–147.0 mg/100 g FW) [40] and in another study on 30 varieties of *Brassica* seedlings (32.9–120 mg/100 g FW) [37]. The study of Xiao et al. [41] confirmed a higher level (six times greater than its mature counterpart) of vitamin C in the young shoots of broccoli and cauliflower. In a prior study, Xiao et al. [40] reported that the microgreens of red cabbage and garnet amaranth contained the highest vitamin C level, followed by China rose radish, opal basil, and opal radish. These authors also showed that the shoots of red cabbage had six times more vitamin C in comparison to their mature counterparts, and additionally, the shoots of garnet amaranth had a significantly higher vitamin C content than its mature counterpart. However, de la Fuente et al. [42] found that the shoots of kale and mustard were characterized by a lower vitamin C content in comparison to their full-grown stages. Marchioni et al. [43], in turn, showed that mustard shoots have a higher vitamin C content (606.87 µg/g f.w.) than the young shoots of daikon, broccoli, and watercress (124.1–137.52 µg/g FW), and rocket shoots (which contained only 29.67 µg/g FW of this vitamin). Dhaka et al. [44] studied the nutritional profiles and the growth conditions (under the light with a 16 h light/8 h dark cycle) for mung bean, pearl-millet, mustard, lentil, red radish, and red cabbage microgreens. The content of ascorbic acid in 100 grams of fresh mass was between 16.34 mg in mung bean and 140.22 in red cabbage.

Carotenoids are secondary plant metabolites and lipid-soluble (from yellow to red) pigments. While all the 25 young shoots examined in the study of Xiao et al. [40] contained lutein and zeaxanthin, cilantro had the highest levels of lutein and zeaxanthin (10.1 mg/100 g FW), followed by the young shoots of red sorrel, red cabbage, and garnet amaranth (8.8, 8.6, and 8.4 mg/100 g FW, respectively). The lowest concentration of lutein and zeaxanthin was found in popcorn shoots (1.3 mg/100 g FW). The young shoots of red cabbage had an average level of these substances, which was measured at 11.5 mg/100 FW. Xiao et al. [40] also reported that almost all the 25 microgreens examined, except the popcorn shoots and golden pea tendrils, can be named as the best source of β-carotene. As was demonstrated by Marchioni et al. [43], the total carotenoid content was significantly lower in watercress (96.9 µg/g FW) in comparison to other *Brassica* species, which showed similar values (from 175 to 217 µg/g FW). Bulgari et al. [45] observed that the concentration of carotenoids varies between species, since the lowest levels were monitored in the young shoots of red basil. In contrast, the other two species (green basil and rocket) exhibited similar values.

In the study of Yadav et al. [39], nine summer season microgreens were evaluated, and the results showed that the total phenolic content varied from 25 to 152.10 mg GAE/100 g FW. The highest phenolic content was observed in the jute and water spinach microgreens. According to the study by Ghoora et al. [4], the highest total polyphenol content was found in roselle microgreens (73.6 mg GAE/100 g FW) while the lowest was in spinach microgreens (14.6 mg GAE/100 g FW). These values were comparable with those obtained by Samuolienė et al. [46] in basil (95 mg/100 g FW) and parsley (62 mg/100 g FW). In another study on 13 microgreens species, the total polyphenol content varied from 691 µg/g DW (2.8 mg/100 g FW) to 5920 µg/g DW (35.4 mg/100 g FW) [47]. There are many factors that affect how much phenol there is, such as what kind of plant it is, how it grows, when it is ready to be harvested, and how it was prepared [48]. Other young shoots with a specifically superior total polyphenol content were, according to Ghoora et al. [4], fennel (63.5 mg/100 g), radish (61.8 mg/100 g), and mustard (49.3 mg/100 g). The authors also noticed a remarkable differentiation in the total polyphenol content of all six chosen microgreens. The highest content of total polyphenols was found in pearl millet microgreens, while the lowest was found in mustard microgreens, depending on the time of harvesting [4]. Agarwal et al. [48] also found a greater total polyphenol concentration in the microgreens of fenugreek, radish, and roselle, in comparison with the red cabbage, radish, broccoli, and purple radish microgreens. Phenolic compounds exhibit antioxidant capabilities and are advantageous for human health in many ways. Their potent antioxidant capacity stems from their ability to scavenge free radicals, provide electrons to oxidizing species, and indirectly mitigate the accumulation of reactive oxygen species (ROS) [44,49]. Karamać et al. [50] analyzed the polyphenol profile and antioxidant activity of the camelina plant (*Camelina sativa* L.), collected at five morphological phases, i.e., from the vegetative stage to the stage of mature seed pods. The total content of polyphenols in the camelina extracts ranged from 49.2 to 59.1 mg GAE/g FW and the discrepancies were not statistically meaningful for the several growth stages examined. Karamać et al. [50] observed the presence of chlorogenic acid and quercetin glycosides in the aerial parts of *Camelina sativa* L., which was its principal phenolic components. The contents varied in different ways during the growth cycle, although the chlorogenic acid content and the sum of the flavonoids both reached the maximum levels in the plant extracts at the bud phase. The overall values of polyphenol content of the plant extracts at all growth phases were greater in comparison to the amounts reported by Matthäus [51] for the defatted seed extracts prepared using several types of diluents (3.2–21.8 mg GAE/g of FW). The total polyphenol content determined by Karamać et al. [50] in the fresh matter of camelina at the ripe seed pod phase was quite comparable to the total polyphenol content examined in the *Camelina sativa* L. seed meal [52] and in seeds and defatted meal [53]. Yadav et al. [39] concluded that the increased concentrations of phenolic antioxidants in mature phases might be due to the synthesis of these compounds, as plant defense molecules increase via the activation of the phenylpropanoid pathway.

The antioxidant activity of the shoots of rare oilseed plants ranged from 1.25 (nigella from the first harvest) to 4.43 (safflower from the first harvest) µmol Trolox/1 g FW. As reported by Drozdowska et al. [54], the red cabbage young shoots exhibited higher and more statistically significant antioxidant activity compared to red-headed cabbage, and the antioxidant activity of the young shoots dated using ABTS, DPPH, and FRAP assays was 700.1, 186.7, and 324.9 mmol Trolox/g DW, respectively. The amounts reported by Baenas et al. [55] for the red cabbage sprouts were similar to those found by Drozdowska et al. [54]. In the study of Yadav et al. [39], the results showed that the antioxidant activity of microgreens ranged from 2.15 to 17.77 µmol TE/g and in the four assays assessed, mature vegetables had a significantly higher antioxidant potential than their microgreens. The authors concluded that the higher antioxidant activity of mature vegetables might be due to the greater concentrations of polyphenols. The same conclusions were reached by Sharma et al. [56] and Ebert et al. [57] in the case of the comparison between buckwheat and amaranthus at different stages of vegetation. The antioxidant potential of *Nigella sativa* L. plant parts (roots, seeds, and shoots) was assessed using the ORAC assay by Bourgou et al. [58]. The authors obtained results which confirmed the important antioxidant activity of these extracts. The extract from the shoots was found to be the most active (with an ORAC value of 4.07 mmol of TE/mg), followed by the extract from the roots (with an ORAC value of 2.57 mmol of TE/mg). The extracts from the Tunisian components of the *Nigella sativa* plants show broad activity. Through in vitro and ex vivo examinations, the methanol extracts from the roots, shoots, and seeds were found to have a high antioxidant potential, which implies that they can be used as a source of readily available natural antioxidants and as a possible dietary supplement to control organoleptic degradation caused by free radicals [58]. The differences which exist between the number of bioactive components and the variability in the antioxidant activity of the vegetable samples tested in this study and in studies by other authors may be due to a multitude of reasons. The variation between the vitamin C, carotenoid, and polyphenol content may be due to the natural variability of the material tested, growing and environmental conditions, the date of harvest, maturity status, as well as post-harvest storage conditions [59]. Kyriacou et al. [47] showed that popular commercially available microgreen types such as *Apiaceae*, *Lamiaceae*, *Brassicaceae*, and *Malvaceae* revealed very strong antioxidant activity ranging widely from 303.3 (jute) to 878.3 mmol/kg (cress). The *Brassicaceae* species had the highest antioxidant potential, which was followed by the *Lamiaceae* family. Additionally, Karamać et al. [50] proved that the plant extracts at the bud and flowering phases generally had the highest antioxidant activity in the polar systems (FRAP, DPPH, and TEAC tests). In these conditions, they showed the greatest antioxidant activity (when the amounts were calculated per fresh matter) at the ripe-pod phase. The camelina extracts at the flowering and ripe seed-pod phases exhibited the greatest antioxidant activity in the lipid emulsion system [50]. It is also worth noting that despite the existence of a number of methods for assessing antioxidant properties, there is a lack of standardization of the results obtained. Frequently, many variants of a given method are known, which differ in the measurement conditions to such an extent that a comparison of results is unavailable.

4.3. Selected Minerals

Microgreens are excellent sources of minerals. Weber [60] reported that the mature broccoli had 1.15 to 2.32 times fewer selected minerals and trace elements (Mg, Mn, P, K, Zn, Fe, Cu and Ca) in comparison to the microgreens of broccoli. Waterland et al. [61] also found that the amount of minerals in the microgreens of kale were higher in the early stages compared to later phases. Drozdowska et al. [33] showed that microgreens could be a better source of certain minerals, i.e., Ca, Mg, K, Fe, Zn, and Mn in comparison to their mature counterparts. In addition, de la Fuente et al. [42] and Zhang et al. [62] concluded that the concentrations of minerals and trace minerals is higher in 90% of microgreens when compared to the mature plants. In the study of Xiao et al. [63], the mineral composition of 30 varieties of microgreens was analyzed. K was the most abundant macroelement, followed by P, Ca, Mg, and Na. Among trace elements, Fe tended to be the most abundant, followed by Zn, Mn, and Cu. The results for the macro- and micronutrients present in the highest amounts in the cited paper are in line with those obtained in this study. These authors [62] also reported that the consumption of microgreens could be a health-promoting strategy in order to cover the needs from dietary sources. Ghoora et al. [4] reported that microgreens of spinach contained significantly more Mg, whereas roselle was the best source of Zn, Se, and P. Moreover, Pinto et al. [64] also proved that the microgreens of lettuce contained more amounts of certain minerals, such as Ca, Fe, Zn, Mg, and Mn, than its mature counterpart. The results from this study are similar to the findings of Kapusta-Duch et al. [34], in which K was the main essential mineral in the analyzed microgreens of white and red cabbage. However, Drozdowska at al. [33] determined the K content in the 14-day-old young shoots at the level of 5320.48 mg/100 g DW, which is slightly lower than the lowest result obtained in this work. According to Drozdowska et al. [33], the Na amount (per 100 g DW) in adult red cabbage was 97% lower in comparison to the shoots, which reached 242.06 mg/100 g DW; this result is similar to the result achieved in this study for safflower from the second harvest. According to the literature on young shoots in selected *Brassica* vegetables, the amounts of Mg and Ca examined in the 14-day-old young shoots of red cabbage were, respectively, 398.42 and 2413.74 mg per 100 g DW, which were similar to the results of this study. In the comprehensive study of Johnson et al. [3], the mineral profiles of six microgreen species and mature counterparts were visualized using the PCA (Principal Component Analysis). The results were not conclusive and varied between the species. Therefore, the authors did not draw clear conclusions for all microgreens tested, although some results were very promising. For example, the red cabbage microgreens were higher in P (2.1-fold) and Fe (2.4-fold) in comparison to their mature counterpart. Ba concentrations were higher in broccoli (6-fold), red beet (6.1-fold), red cabbage (7.4-fold), red amaranth (6.8-fold), and arugula (4.8-fold) microgreens, compared with their mature counterparts. In turn, Kyriacou et al. [47], examined nutritional diversity across 13 microgreens of the *Brassicaceae*, *Lamiaceae*, *Malvaceae*, *Apiaceae*, and *Chenopodiaceae* species and subspecies, cultivated in a monitored environment. Kyriacou et al. [46] reported that K was the most abundant major essential mineral, followed by Ca, P, Mg, S, and Na. Kapusta-Duch et al. [34] reported that the Fe content in young shoots was 0.68 mg (white cabbage) and 0.81 mg (red cabbage) per 100 g of fresh matter. The authors observed that the achieved results were on average more than double (white cabbage) and one and a half times (red cabbage) greater when compared to those noticed in the fully adult plants. Nevertheless, Drozdowska et al. [33] examined a lower result for the Fe content in the 14-day-old shoots of red cabbage (19.7 mg/100 g DW) in comparison with the results found in this study. It is, therefore, difficult to discuss the results obtained in this study due to the lack of studies on the mineral content in the examined young shoots of oilseed plants, as well as the fact that the amounts gained in this study were determined for specific varieties of uncommon oilseed plants like nigella, safflower, and camelina. Yadav et al. [39] determined microgreens and their counterparts in nine plants and showed that the concentration of Fe ranged from 5.27 (poi) to 59.70 mg/kg FW (cucumber) in mature vegetables, whereas in the microgreens, it ranged from 1.58 (radish) to 18 mg per kg FW (amaranthus cv. *Katwa*). Corrado et al. [65] determined the macro- and microelement mineral composition of six hemp varieties grown as microgreens and found that all these young shoots are a good source of K and Ca among the macroelements, and Fe and Zn among the microelements. The results [65] highlighted that in the controlled conditions, genetic factors have a predominant role in establishing the elemental profile. The study of Kapusta-Duch et al. [34] showed that two species of young shoots (white and red cabbage) contained a high mean concentration of selected minerals, including 2954.5 mg (Ca), 337.5 mg (Mg), 3625.5 mg (K), 373.5 mg (Na), and 9.55 mg (Fe) per 100 g DW. In the study of Kapusta-Duch et al. [34], it was shown that the young shoots of red cabbage had significantly more Ca, Mg, Na, and Mn in comparison to the young shoots of white cabbage. Additionally, the red cabbage young shoots were determined to have a significantly greater amount of K, Fe, Zn, and Cu compared to the young shoots of white cabbage [34]. The presence and abundance of mineral elements in young shoots is an important criterion for the assessment of their nutritional quality and influence on human health and have great value for health professionals and consumers.

5. Conclusions

The young shoots of rare oilseed plants are young unripe green plants that are between the sprout and the pre-leaf green stage of growth. The young shoots of nigella, safflower, and camelina examined in this study were usually characterized by a greater amount of total protein, fat, and ash, as well as potassium, phosphorus, selenium, iron (except safflower), and nickel after the first harvest compared to the second harvest. In contrast, the content of vitamin C, total carotenoids, total polyphenols, and dietary fiber increased with the maturity of the young shoots. In this study, it was not possible to clearly assess which species of the young shoots had the highest content of the examined compounds. In general, the health-promoting quality of young shoots is greater (e.g., levels of proteins, carotenoids, glucosinolates, polyphenols, some vitamins, minerals, and contaminants) than their grown-up counterparts. Therefore, such young shoots of rare oilseed plants, freshly harvested and added to dishes, can provide an excellent and pure source of bioactive substances, as well as possibly a natural prophylaxis for chronic non-communicable diseases and cancer, so the harvest date in this case is of secondary importance.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app14031065/s1, Pictures of young shoots of *Nigella sativa* L., *Carthamus tinctorius L.* and *Camelina sativa L.* from the first and the second harvest.

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