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Full Length Research Paper

Comparative analysis of vitamin C, crude protein, elemental nitrogen and mineral content of canola greens (*Brassica napus* L.) and kale (*Brassica oleracea* var. *acephala*)

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This study aims at promoting the consumption of canola greens (*Brassica napus* L.) as alternative, affordable and available dietary sources of vitamin C, minerals and protein. As one of the oldest-known forms in cabbages family, kale *(Brassica oleracea* var. *acephala* L.) greens are among the most consumed vegetable cabbages in Turkey. In this study, kale and canola greens were compared with regards to vitamin C, crude protein and mineral materials. At the end of the study, vitamin C content was found to be 68.3 mg 100 g^{-1} for canola and 80.12 mg 100 g^{-1} for kale; crude protein content was determined to be 31.1% for canola and 29.8% for kale; nitrogen (N) content was found to be 4.90% in canola and 4.70% in kale; phosphorus (P) content was 0.40 mg 100 g^{-1} in canola and 0.46 mg 100 g^{-1} in kale; potassium (K) content was 3.06 mg 100 g^{-1} in canola and 3.60 mg 100 g^{-1} in kale; calcium (Ca) content was found to be 2.65 mg 100 g^{-1} in canola and 2.51 mg 100 g^{-1} in kale; magnesium (Mg) content was 0.29 mg 100 g^{-1} in canola and 0.33 mg 100 g^{-1} in kale; manganese (Mn) content was was 16.50 mg 100 g^{-1} in canola and 5.55 mg 100 g^{-1} in kale; copper (Cu) content was found to be 0.35 mg 100 g^{-1} in canola and 0.16 mg 100 g^{-1} in kale; ıron (Fe) content was 23.96 mg 100 g^{-1} in canola and 14.01 mg 100 g^{-1} in kale; zinc (Zn) content was reported to be 2.95 mg 100 g^{-1} in canola and 2.06 mg 100 g^{-1} in kale. Finally, the study states that canola greens might be consumed like kale and that these greens might replace each other.

Key words: Canola greens, kale, vitamin C, crude protein, elemental nitrogen, mineral content.

INTRODUCTION

Many studies state that consuming vegetables of dark green leaves, especially *Brassica* vegetables with their antioxidant vitamins, mineral materials, flavonoids and glycosides content; may decrease some cancer risks, defend against cardiovascular diseases and prevent chronic illnesses (Barillari et al., 2006; Dixon, 2006; Jing et al., 2009; Kristal and Lampe, 2002; Kuhnlein, 1990; Podsedek, 2007; Van Duyn and Pivonka, 2000; Verhoeven et all., 1996).

Vegetables contain low amount of fat and calories, nevertheless they are high in fibre, vitamins and minerals (Giannaukourou and Taoukis, 2003). A report by the World Cancer Research Fund and The American Institute for Cancer Research (Steinmetz and Potter, 1996) confirms that diets rich in fruit and vegetables (more than 400 g day^{-1}) may diminish the risk of neoplasms by a minimum of 20%. A diet rich in broccoli, Brussels sprouts, cabbage and kale or *Brassica* vegetables may considerably reduce the risk of neoplasm (Kohlmeier and Su, 1997; Korus, 2010).

Many varieties of *Brassica* family are used as vegetables in many places of the world (Ahmad et al., 2007; Bhardwaj et al., 2003; Front et al., 2005; Kawashima and Soares, 2003; Thomson et al., 2007

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Nieuwhof, 1969).

The vegetable *Brassicas* are consumed for their nutritive values, that is, minerals and vitamins; additionally, kale and collards remain as very good sources of nutrients (Farnham et al., 2000; Kopsell et al., 2004; Martinez-Ballesta et al., 2010; Singh et al., 2010).

Nitrogen is essential for protein production, for proper growth of leaves and has many critical functions such as photosynthesis in plant. In the plant, N is converted to amino acids as building blocks for proteins. These amino acids are then utilized in forming protoplasm. Similarly, phosphorus is necessary for plant growth and it has significant roles in photosynthesis, respiration, energy storage and transfer. A crucial plant nutrient, potassium is irreplaceable by any other nutrients and is essential for plant growth as well. Potassium has a key role in stomatal functioning and makes the plant use water more efficiently by promoting turgidity to conserve internal pressure of the plant. Magnesium is an indispensable constituent of chlorophyll. Moreover, iron is necessary for the formation of chlorophyll and other enzyme reactions (Tirasoglu et al., 2005).

Humans require vitamin C as an essential component of any given diet. Since vitamin C exists in all green plants, it is easy to take an adequate amount for humans in their daily diet. It is needed to have a minimum intake of 60 mg day^{-1} for adult diets (Kim and Ishii, 2007). Generally recognized as safe (GRAS) status was granted to canola in 1985 (Shanidi, 1990).

Canola is consumed as a vegetable in some of the African countries (Miller-Cebert et al., 2009a); however, it is just produced for its oil in Turkey.

As a leafy greenery, canola greens may also offer nutritional benefits similar to those of some traditional leafy greens (Bhardwaj et al., 2003; Miller-Cebert et al., (2009a).

Mainly for use as a green vegetable in Turkey, kale is commonly cultivated and is one of the most important *Brassica* crops. Farmers generally make use of the tender leaves for human consumption and the mature ones for forage (Balkaya, 2003; Balkaya and Yanmaz, 2005). Kale may be prepared in the same way with spinach and small amounts can be put into salads as an excellent component (Podsedek, 2007).

It has local names such as “kara lahana” (black cabbage), "laz lahanasi" and "azman lahana" in Turkey (Balkaya et al., 2003; Balkaya and Yanmaz, 2005). When grown under cover, certain valuable varieties of kale are available from autumn to spring. It is preferred cooked or raw in salads (Larkcom, 2002).

Some studies are conducted on the usability of canola greens (Bhardwaj et al., 2003; Miller-Cebert et al., 2009a). The fresh greenery of canola, which is produced for alternative vegetable oil in our country, is considered to be used as salad greens in this study. Moreover, the comparison was performed on vitamin C and mineral material content of kale for which fresh consumption exist in our country and in the world. Thus the aim of this study was to show that canola greens can be used instead of kale and it can be substituted.

MATERIALS AND METHODS

Experimental design and location

The experiment was carried out during successive crop seasons: late autumn-early winter in UV consisting of PE unheated greenhouse in Corlu, Turkey (41°11' N, 27°49' E) in 2010-2011. The experiment was conducted according to random blocks experimental design with three repetitions.

Canola seeds of cv. ES Hydromel (Euralis, Semences) and kales seeds of cv. Karadere 077 (Istanbul Tohumculuk Co.) were sown in November in late autumn-early winter growing period in multipot filled with peat (Klasmann-Deilmann, potground H, Germany).

Seedlings were transplanted to greenhouse soil at the 2 to 3 true leaf stage with 25 cm intervals, 25 cm interrow and with border plant on their sides. Chemical characteristics of the soil used in the experiment are given in Table 1 and climate data in unheated greenhouse during the experiments are given in Table 2.

Data collection and analytical methods

At the conclusion of the experiment, the following characteristics were studied: Ascorbic acid (vitamin C) in samples (mg 100 g^{-1}), crude protein (%) and mineral content (%, ppm). Collected samples were washed and dried in a ventilated oven at 65°C for mineral content. Ascorbic acid content of the samples was estimated with titrimetric method (Anonymous, 1983).

The samples were analyzed for crude protein content based on nitrogen analysis utilizing the Kjeldahl system according to the Association of Official Analytical Chemists International (AOAC). The crude protein was calculated using a nitrogen conversion factor of 6.25 (AOAC, 1990). Nitrogen content of the samples was determined by Kjeldahl system (Gerhadt, KB/20S), and P, K, Ca, Mg, Cu, Zn, Mn and Fe content were determined by ICP-OES spectrophotometer (Perkin Elmer, 2100DV) after wet digestion.

Cultivation and irrigation practices

Neither fertilization nor pesticide application of any kind was carried out during the experiment. Pests and disease incidences were not observed and weeding was carried out when need arose during the growing period.

Statistical analysis

All data were analyzed statistically with SPSS software program (v.16.0 for Windows OS) and the differences between practices were compared by using least significant difference (LSD) test at ($p<0.05$) probability.

RESULTS AND DISCUSSION

Vitamin C

Significant differences were observed ($p<0.05$) for vitamin C among the canola greens and kale in this study (Table 3 and Figure 1). According to these results, vitamin C content was found to be 68.3 mg 100 g^{-1} for canola and 80.12 mg 100 g^{-1} for kale.

Table 1. Chemical characteristics of the soil (0 to 20 cm).

Parameter	Value	Unit
pH	7.26	%
EC	0.17	%
$CaCO_3$	1.24	%
Organic Matter	5.62	%
Total N	0.28	%
Ca	0.54	%
P	167.46	ppm
K	265.47	ppm
Mg	713.67	ppm
Mn	6.98	ppm
Cu	1.51	ppm
Fe	6.03	ppm
Zn	5.23	ppm

Table 2. Average climate data in unheated greenhouse during the months of the experiment.

Month	Average temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Average humidity (%)
November	9.1	19.0	4.9	86
December	8.2	17.1	3.9	90
January	9.9	18.2	4.1	89
February	10.0	21.0	4.0	87
March	10.0	22.1	4.1	90
April	12.9	23.7	6.5	84.7

Table 3. Amount of vitamin C and crude protein of canola greens and kale greens.

Parameter	Vitamin C (mg 100 g^{-1})	Crude protein (%)
Canola greens	68.3b	31.1a
Kale greens	80.12a	29.8b
Mean	74.21	30.45
LSD*	7.21	2.95

*LSD: $p<0.05$.

Cruciferous vegetables are relatively good sources of abundant antioxidants (such as vitamin C), and there is a substantial and significant variation both within and between the subspecies and also differences in genotype for the antioxidant phytochemicals. Vitamin C content is influenced by seasonal factors such as sowing time and harvesting date (Kim and Ishii, 2007; Podsedek, 2007; Singh et al., 2007). According to Kurilich et al. (1999), kale gave higher levels in vitamins (a-carotene, b-carotene, a-tocopherol, c-tocopherol and ascorbate) than did cabbage.

According to Singh et al. (2004), maximum vitamin C content was found in kale (82.14 mg 100 g^{-1}). According to Alibas (2009), ascorbic acid (vitamin C) content of the fresh product was 94.18 mg 100 g^{-1}; according to Sikora (2008), kale is a good source of vitamin C (107 mg 100 g^{-1}); according to Korus (2010), vitamin C levels in the kale ranged from 77 to 133 mg 100 g^{-1}; and all of the above results are in line with this study. This range of vitamin C content was similar to those seen in other studies.

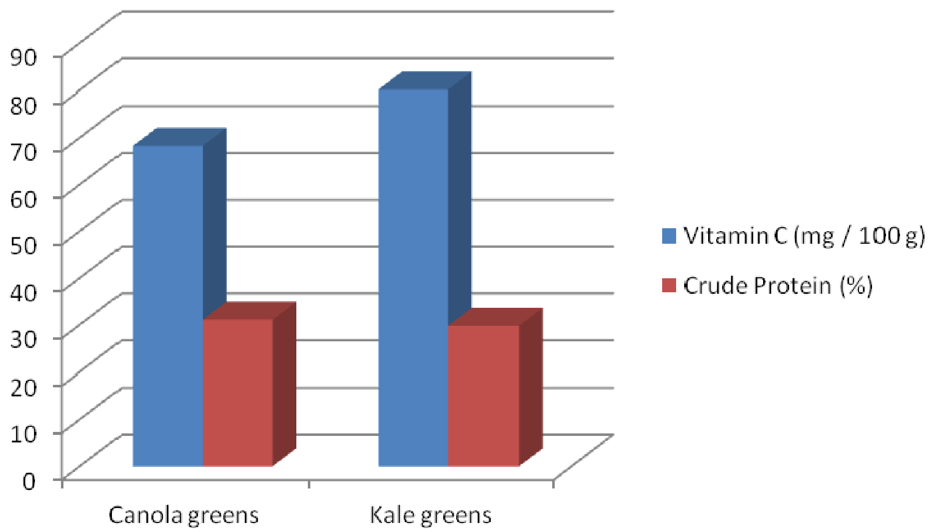

Figure 1. Amount of vitamin C and crude protein of canola greens and kale greens.

Table 4. Mineral contents in canola greens and kale greens.

Parameter	N (%)	mg 100 g^{-1}							
		P	K	Ca	Mg	Mn	Cu	Fe	Zn
Canola greens	4.90^{a}	0.40^{b}	3.06^{b}	2.65^{a}	0.29^{b}	16.50^{a}	0.35^{a}	23.96^{a}	2.95^{a}
Kale greens	4.70^{b}	0.46^{a}	3.60^{a}	2.51^{b}	0.33^{a}	5.55^{b}	0.16^{b}	14.01^{b}	2.06^{b}
Mean	4.8	0.43	3.33	2.58	0.31	11.025	0.175	18.98	2.505
LSD*	0.321	0.036	1.079	0.453	0.025	5.702	0.040	1.259	0.447

*LSD: p<0.05.

Crude protein

Significant differences were observed ($p<0.05$) for crude protein among the canola greens and kale (Table 3 and Figure 1). According to these results, crude protein content was found to be 31.1% for canola and 29.8% for kale.

Crucifers are a good source of protein which has all the essential amino acids, particularly sulfur containing amino acids (Salunkhe and Kadam, 1998). Fresh kale leaves can be a valuable source of amino acids. Nitrogen compounds in which amino acids predominate are about one third of the dry matter of kale (Lisiewska et al., 2008). It can be also valid for canola greens.

Bhardwaj et al. (2003) reported that canola greens contained 30.6% protein; according to Singh et al. (2004), protein content of kale was 3.45 g 100 g^{-1}; Rosa and Heaney (1996) showed the highest crude protein concentration to be 267 g kg^{-1} in summer/winter seasons; Heimler (2006) showed 1.44 to 2.82 g 100 g^{-1} content of protein in kale; and these are all concurrent with the results of this study.

According to Miller-Cebert et al. (2009b), the amount of protein content among *Brassica* species ranked as kale>canola>collard>cabbage and protein content for kale was 24.85% and it ranged from 19.34 to 25.65% for canola.

Mineral content

Significant differences were observed ($p<0.05$) for elemental nitrogen and mineral contents among the canola greens and kale, and N, P, K, Ca, Mg, Mn, Cu, Fe and Zn contents in canola and kale greens grown are given in Table 4; Figures 2 and 3.

N content was found to be 4.90% in canola, 4.70% in kale; P content was found to be 0.40 mg 100 g^{-1} in canola and 0.46 mg 100 g^{-1} in kale; K content was determined to be 3.06 mg 100 g^{-1} in canola and 3.60 mg 100 g^{-1} in kale; Ca content was found to be 2.65 mg 100 g^{-1} in canola and 2.51 mg 100 g^{-1} in kale; Mg content was 0.29 mg 100 g^{-1} in canola, 0.33 mg 100 g^{-1} in kale; Mn content was 16.50 mg 100 g^{-1} in canola, 5.55 mg 100 g^{-1} in kale; Cu content was 0.35 mg 100 g^{-1} in canola and 0.16 mg 100 g^{-1} in kale; Fe content was 23.96 mg 100 g^{-1} in canola, 14.01 mg 1 00 g^{-1} in kale; Zn content was determined to be 2.95 mg 100 g^{-1} in canola and

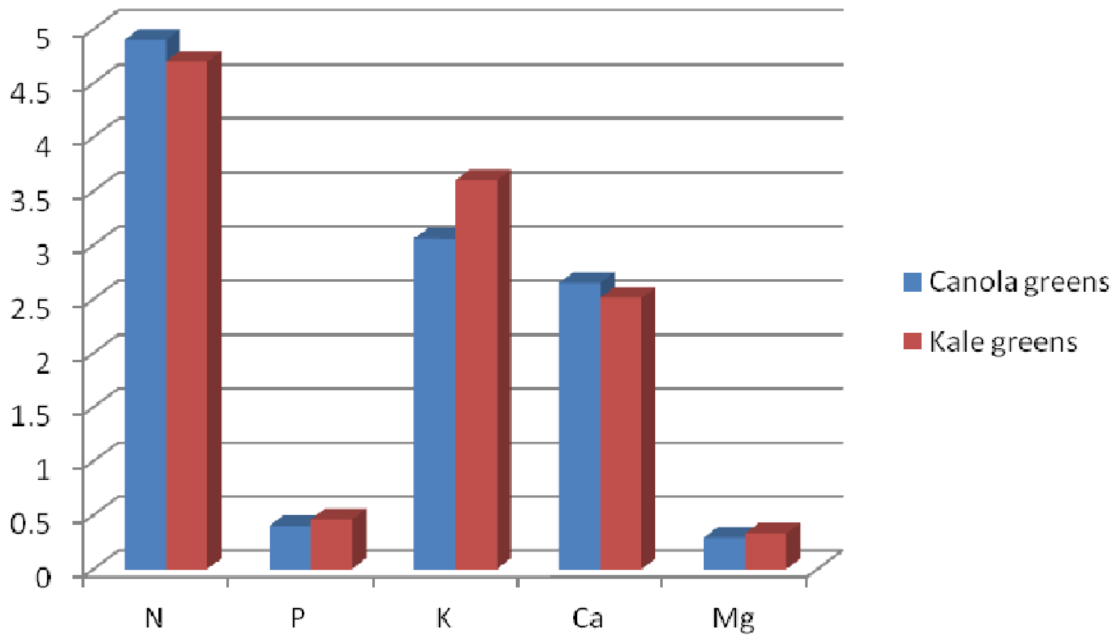

Figure 2. Macro mineral content in canola greens and kale greens (N in %; P, K, Ca, and Mg in mg 100 g^{-1}).

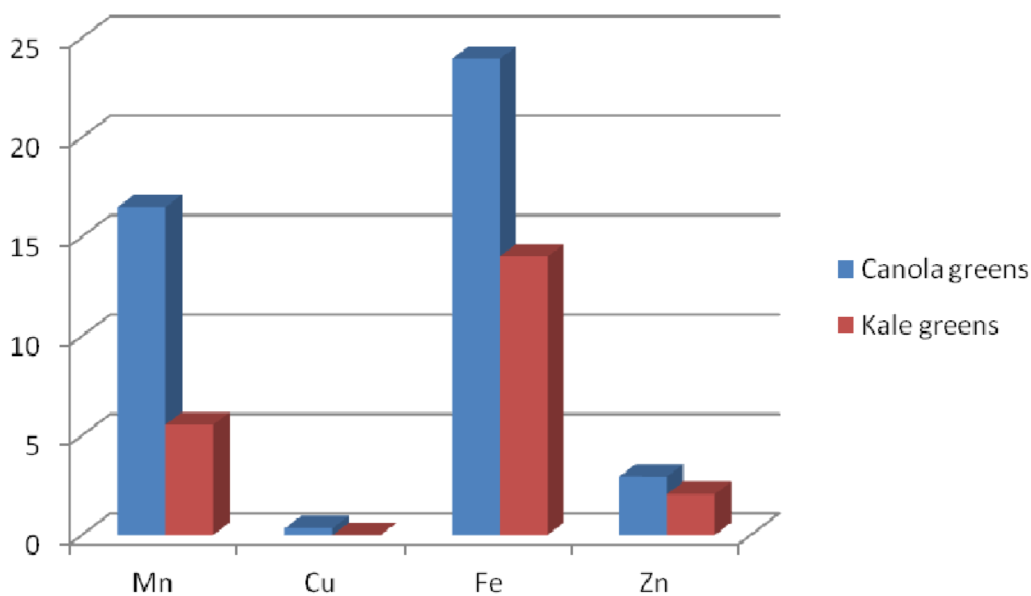

Figure 3. Micro mineral contents in canola greens and kale greens (mg 100 g^{-1}).

2.06 mg 100 g^{-1} in kale.

Thus, it was determined that canola greens have high and valuable levels of nutrients in N, Ca, Mn, Cu, Fe and Zn; however, kale greens are rich in P, K and Mg. According to Singh et al. (2004), 1.36 total N (%), 0.61 P (%), 0.17 Na (%), 2.18 K (%), 0.011 Cu (mg g^{-1}), 0.274 Fe (mg g^{-1}), 0.070 Mg (mg g^{-1}), 0.110 Zn (mg g^{-1}) was seen in kale; according to Miller-Cebert et al. (2009a), micro mineral composition (mg 100 g^{-1}) of canola leafy greens was 20.67 Al, 24.77 Fe, 16.40 Mn, 0.30 Cu, 3.00 Zn and micro mineral composition (mg 100 g^{-1}) of kale greens was 8.62 Al, 18.58 Fe, 18.40 Mn, 0.19 Cu and 3.62 Zn; macro mineral composition (g 100 g^{-1}) of canola leafy greens was 1.59 Ca, 2.05 K, 0.42 P, 0.20 Mg and macro mineral composition (g 100 g^{-1}) of kale greens was 1.54 Ca, 1.72 K, 0.39 P, 0.29 Mg. Kopsell et al. (2004)

report for kale greens was 1.86% Ca, 0.39% Mg, 2.59% K, 72.2 mg kg^{-1} Fe, 39.65 mg.kg^{-1} Zn; however, Grace et al. (2010) report for kale greens was 2.5% Ca, 0.31% P, 0.21% Mg, 1.3% K, 160 mg kg^{-1} Fe, 40 mg kg^{-1} Mn, 4 mg kg^{-1} Cu, 38 mg kg^{-1} Zn; Bhardwaj et al. (2003) gave evidence that canola greens contained 0.52% P, 4.14% K, 0.35% Mg, and 1.59% Ca, 5.47 mg 100 g^{-1} Zn, , 28.61 mg 100 g^{-1} Fe, 0.74 mg 100 g^{-1}; according to Rosa et al. (1996), kale contains 23.8 g kg^{-1} Ca, 1.8 g kg^{-1} Mg, 5.1 g kg^{-1} P, 22.5 g kg^{-1} K, 0.137 g kg^{-1} Fe, 0.061 g kg^{-1} Mn and 0.048 g kg^{-1} Zn. These micro and macro mineral compositions are all concurrent with the results of this study.

There are many factors influencing the mineral and trace element concentrations; they include cultivation method, region of production, the species or cultivar and the specific plant organ. Trace elements appear to be more affected by the cultivar than the minerals. The cultivation method influences the minerals more than the trace element content (Hernandez-Suarez et al., 2007; Martinez-Ballesta et al., 2010).

In conclusion, the values obtained for the vitamin C, P, K and Mg contents in kale were significantly higher ($p < 0.05$) than the corresponding values in canola greens. The values obtained for crude protein and N, Ca, Mn, Cu, Fe, Zn contents in canola greens were significantly higher ($p<0.05$) than the corresponding values in kale. Canola greens can be consumed as a dietary substitute for kale with dietary supplements of minerals and vitamins. Thus, the richness in macro and micro nutrients of canola in vitamin C and crude protein and its growing possibility in fall months when kale is in the market were the main issues that this study presents. Canola greens can therefore be an acceptable substitute and an alternative for traditional kale greens in Turkey.

For consumers aiming to increase dietary intake and therefore for producers, it would be favorable to have detailed information on the concentration of micro and macro nutrients in kale and canola greens.

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