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# NUTRITIONAL EVALUATION OF ORGANICALLY AND CONVENTIONALLY GROWN KALE (*Brassica oleraceae* L. var. *acephala*)

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## ABSTRACT

**In present study various physicochemical constituents of organically and conventionally grown kale (*Brassica oleraceae* L. var. *acephala*) were studied. The proximate constituents were determined by standard methods. The results revealed that dry matter, crude protein, crude fat, ash and total carbohydrate content in organically and conventionally grown kale were 12.15, 3.54, 0.68, 2.11 and 6.09 and 10.60, 2.66, 0.53, 1.63 and 5.78%, respectively. The total sugars, reducing sugar and ascorbic acid contents in organically grown kale were 1.95%, 1.05%, 49.0 mg 100 $g^{-1}$ as compared to 1.87%, 1.02% and 44.0 mg 100 $g^{-1}$, respectively, in conventionally grown kale. The sodium and potassium contents were high in organically grown kale. Kale grown with organic inputs was found nutritionally superior to conventionally grown kale so can be incorporated in food formulation as therapeutic agent.**

**Key words:** Conventional cultivation, kale, nutritional value, organic

## INTRODUCTION

Kale (*Brassica oleraceae* L. var. *acephala*) is an annual green leafy vegetable belonging to the cabbage family Brassicaceae and contains many health-promoting phytochemicals (Adams, 2013). Like other dark green leafy vegetables, kale is a rich source of dietary fiber or low molecular weight non-digestible carbohydrates, vitamins A, K, and C, and essential minerals (potassium, calcium and magnesium). In addition, kale provides significant quantities of carotenoids and folates (Migliozzi *et al.*, 2015). The size of kale varies with crop variety and mostly are 0.5- 1.5 m in width and 0.5-1.0 m in height. Kale prefers colder climatic conditions and the duration for crop harvest is approximately two months depending upon the temperature (Emebu and Anyika 2011). In India, the crop is commercially grown in Jammu & Kashmir, Assam and Himachal Pradesh. Phyto-chemicals found in vegetables are strong antioxidants which reduce the risk of chronic diseases by protecting against free radical damage, by modifying metabolic activation and detoxification of carcinogens, or even influencing the processes that alter the course of tumour (Agarwal *et al.*, 2017). It is one of the most nutritious vegetables, hence has gained increased attention as a source of beneficial effects (Nishi *et al.*, 2011). In order to achieve higher yield and growth, generally excessive amounts of inorganic fertilizers are applied to vegetables (Stewart *et al.*, 2005). However, the application of fertilizers not only affects the yield but also the nutritional qualities of produce.

The awareness among masses about the role of organically produced fruits and vegetables in healthy diet is increasing day by day. The growth of organic foods industry in USA has been dramatic since 1990 with estimated annual increase in organic sales nearly 20% and the consumer sales reaching US $ 13.8 billion in 2005 (Winter and Davis, 2006). The studies assessing the consumer perception about organic produce have revealed that these produces are safe, more nutritious and better in taste than conventionally grown produce. Consumer perceptions about organic food are highly subjective (Yiridoe *et al.*, 2005). Cabbage and other brassicas are at present grown extensively around the globe on an area of 2.47 million ha with a productivity of 29.05 t ha$^{-1}$. In India, kale is grown on 0.4 million ha area with a productivity of 22.59 t ha$^{-1}$ (Anonymous, 2014). Among leafy vegetables, kale is cultivated on commercial scale in temperate areas of India like Jammu & Kashmir, Himachal Pradesh, etc. and to a limited extent in North-East. Less work has been conducted on nutritional value assessment of organic and conventionally grown kale, hence a comparative nutritional evaluation was conducted with respect to organic and conventionally-grown kale.

## MATERIALS AND METHODS

***Procurement of raw materials***

Fresh and optimally mature organically grown samples of kale (var. *DSK-1*) were procured from the Department of Organic Agriculture, CSKHPKV, Palampur (India). The area is situated between 30° 22′ 44″ and 33° 12′ 40″ N latitude, and 75° 45′ 55″ to 79° 04′ 20″ E longitude. Himachal Pradesh is a hilly state with a general increase in elevation from west to east and south to north ranging from 240 to 7000 m. Agro-climatically the location represents Zone II (mid hill sub humid) wherein mean annual temperature lies between 14 to 22ºC and rainfall in Dharmshala and Palampur is as high as about 3000 mm while in the remaining areas it is about 1500 mm.

Farmyard manure and vermicompost application @′ 1.0 and 0.5 kg m$^{-2}$ were incorporated in the soil 15 days before transplantation in organic kale field. Whereas same variety of kale was grown in field conventionally where fertilizers were applied @ 10:10:5 (N:P:K) g m$^{-2}$ and mixed thoroughly in soil. Half N and full dose of P and K was applied as basal dose and remaining 50% N applied in two split doses at an interval of 15 days.

The optimally mature fresh whole leaves were selected and after sorting, washed under running water and trimmed. The prepared samples were evaluated for proximate constituents, dietary fiber and minerals compositions. The data for chemical analysis of different parameters is reported as average of duplicate determinations. The per cent difference indicated the per cent more or less of a nutrient found in organic crop as compared to the conventional crop and was calculated as per the formulae suggested by Worthington (2001).

$$\% \text{ Difference} = (\text{Organic-conventional}) / \text{Conventional} \times 100$$

***Physical characteristics***

Ten whole leaves of organically and conventionally grown kale was selected randomly from the whole lot and weighed in a weighing balance. The leaf colour and shape were assessed by visual evaluation. The per cent edible portion was calculated by subtracting the weight of inedible portion from the total weight and expressed as per cent edible portion (Kandil and Gad, 2009).

***Proximate composition and chemical constituents***

The proximate analysis for moisture, crude protein, crude fat, crude fibre and ash was determined by standard methods (AOAC, 1990). Conversion factor of 6.25 was used to convert nitrogen into protein. Total carbohydrates were determined by difference method i.e. by subtracting the sum of moisture, protein, fat and ash from 100. The acid detergent fibre (ADF), neutral detergent fibre (NDF) and hemicellulose were assessed as per Van Soest (1963). The available or digestible carbohydrates were determined by subtracting NDF from total carbohydrates. The unavailable carbohydrates were determined by subtracting available carbohydrates from total carbohydrates. Total energy was calculated by multiplying the protein, fats and total carbohydrates contents by 4.0, 9.0 and 4.0, respectively, and summing up the values, whereas the available energy was calculated by multiplying the per cent protein, fat and available carbohydrates by 4.0, 9.0 and 4.0, respectively, and summing up the values. The values were expressed as kcal 100 $g^{-1}$ on dry matter basis. Hemicellulose was calculated by difference method {hemicellulose (%) = NDF-ADF}. Sugars were estimated as per Shaffer-Somogyi method (Ranganna, 2007). The TSS, acidity and ascorbic acid contents were determined as per Ranganna (2007).

***Mineral composition***

The dried samples were wet digested in 25 mL diacid mixture (nitric acid and perchloric acid; 5:1) (Ranganna, 2007). The digested samples were analyzed for sodium and potassium using a flame photometer (model Mediflame 127) and for calcium, iron, zinc, magnesium and copper atomic absorption spectrophotometer (Perkin Elmer Analyst 400) was used.

***Statistical analysis***

Data was subjected to statistical analysis for analysis of variance (ANOVA) in a completely randomized design and the data was compared at 5 % level of significance.

## RESULTS AND DISCUSSION

***Physical characteristics***

The single leaf weight of kale grown organically was 6.0 to 7.0 g which was more than that of conventionally grown kale leaf (5.8 to 6.9 g). The colour of kale grown organically was light dark green whereas the conventionally grown kale leaves were dark green. The shape of organic and conventionally grown kale leaves showed no change, both were curly. The average edible portions of kale grown organically and conventionally were 4.5 and 4.3 g $leaf^{-1}$, respectively. The variations in above parameters in organic and conventionally grown kale could be due to the balanced carbon: nitrogen ratio, more organic matter build up, enhanced microbial activity, improved soil properties, better root proliferation, and more availability and accelerated transport of plant nutrients. This process may have accelerated metabolic activities so leading to better photosynthesis and efficient translocation of photosynthates from sink to sources and resulting in improvement in leaf yield and its related attributes (Qureshi, 2013).

***Proximate composition***

The moisture content of organic kale was less (87.85%) as compared to conventionally grown kale (89.4) {Table 1}. The organic kale had more dry matter (+14.62%) as compared to conventionally raised kale. Further, the organic kale showed an improvement in protein, crude fat, ash and total carbohydrates with an increase of +33.08, +28.30, +29.44 and +5.36%, respectively, over conventionally grown kale. The increase may be attributed to the organic inputs which helps in improving the soil health and ensures proper soil aeration and water holding capacity. Qureshi *et al.*

**Table 1: Proximate composition of kale as affected by organic or conventional methods of cultivation**

| Constituents (%) | Organic | Conventional | % Difference | $CD_{0.05}$ |
|---|---|---|---|---|
| Dry matter | 12.15 | 10.60 | +14.62 | 0.26 |
| Moisture | 87.85 | 89.40 | +1.73 | 0.29 |
| Crude protein | 3.54 | 2.66 | +33.08 | 0.27 |
| Crude fat | 0.68 | 0.53 | +28.30 | NA |
| Ash | 2.11 | 1.63 | +29.44 | 0.28 |
| Total carbohydrates | 6.09 | 5.78 | +5.36 | 0.24 |

The values expressed as per cent on dry weight basis

**Table 2: Carbohydrate and energy contents of kale as affected by organic and conventional methods of cultivation**

| Constituents | Organic | Conventional | Difference (%) | $CD_{0.05}$ |
|---|---|---|---|---|
| NDF (%) | 16.30 | 15.06 | +8.23 | 1.23 |
| ADF (%) | 10.85 | 10.35 | +4.83 | NA |
| Hemicellulose (%) | 5.47 | 4.71 | +16.13 | 0.42 |
| Crude fiber (%) | 10.01 | 7.01 | +42.79 | 0.44 |
| Digestible carbohydrates (%) | 10.21 | 9.28 | +10.02 | 0.41 |
| Indigestible carbohydrates (%) | 4.12 | 3.50 | +17.71 | 0.45 |
| Total energy (k cal 100 $g^{-1}$)$^{-}$ | 44.64 | 38.53 | +15.85 | 0.43 |
| Available energy (k cal 100 $g^{-1}$) | 61.12 | 51.65 | +18.33 | 0.43 |

The values expressed as per cent on dry weight basis

(2013) reported increased protein content in organically produced kale and assigned it to the supplementation of soil reservoirs on mineralization of organic nitrogen and phosphorus of FYM as well as to the enhanced activity of ammonifiers and phosphate solubilizing bacteria in rhizosphere. The results are in agreement with those of Kahlon *et al.* (2008), Embu and Anyika (2011), Sikora and Bodziarczyk (2012), Baloch *et al.* (2015) and Agarwal *et al.* (2017).

***Fiber carbohydrate, non-fiber carbohydrate and energy contents***

The organically grown kale contained slightly more NDF (16.30%) and ADF (10.85%) contents as compared to the conventionally grown kale (15.06 and 10.35%, respectively) [Table 2]. The organic kale had more NDF and ADF contents (+8.23 and +4.83%) as compared to the conventionally raised kale. Further, organic kale showed improvement in crude fiber, hemicelluloses, digestible and indigestible carbohydrates with an increase of +42.79, +10.02, +15.85 and +18.33%, respectively, over conventionally grown kale. The increased dietary fiber content in organic produce might be attributed to the reason that organic manure activates many species of living organisms, which release phyto-hormones and stimulate plant growth and absorption of nutrients. The results are in accordance with those of USDA (2009) and Silva *et al.* (2014).

***Chemical constituents***

The organically grown kale had more total soluble solids (TSS) and acidity with 24.24 and 28.81% positive difference in organically grown kale as compared to the conventionally grown kale (Table 3). Conventionally grown kale had pH content (5.83) higher than organically grown kale (4.85). The ascorbic acid content in organically grown kale was 49.0 mg 100 $g^{-1}$ which was comparatively more than that of inorganic kale with 44.0 mg 100 $g^{-1}$ ascorbic acid. Further, organic kale showed improvement in total, reducing and non-reducing sugars with an increase of +4.27, +2.94 and +4.93%, respectively, over conventionally grown kale. These findings for organically grown produce are in concurrence with USDA (2009), Emebu and Anyika (2011), Sikora and Bodziarczyk (2012), Ogbede *et al.* (2015) and Agarwal *et al.* (2017).

**Table 3: Nutritional composition of organically and conventionally grown as affected by organic or conventional methods of cultivation**

| Constituents | Organic | Conventional | Difference (%) | $CD_{0.05}$ |
|---|---|---|---|---|
| TSS (°Brix) | 2.05 | 1.65 | +24.24 | 0.17 |
| Acidity (%) | 0.76 | 0.59 | +28.81 | 0.17 |
| pH | 4.85 | 5.83 | -16.80 | 0.15 |
| Ascorbic acid (mg/100g) | 49.00 | 44.00 | +11.36 | 0.16 |
| Total sugar (%) | 1.95 | 1.87 | +4.27 | NA |
| Reducing sugar (%) | 1.05 | 1.02 | +2.94 | NA |
| Non-reducing sugar (%) | 0.85 | 0.81 | +4.93 | NA |

The values expressed on fresh weight basis except for sugars

**Table 4: Mineral content of kale as affected by organic or conventional methods of cultivation**

| Minerals | Organic | Conventional | Difference (%) | $CD_{0.05}$ |
|---|---|---|---|---|
| Calcium | 3.26 | 3.36 | -2.97 | NA |
| Magnesium | 3.05 | 3.80 | -19.73 | 0.10 |
| Copper | 0.03 | 0.05 | -40.00 | NA |
| Zinc | 0.30 | 0.28 | +8.00 | NA |
| Iron | 1.44 | 1.37 | +5.10 | NA |
| Cobalt | 0.007 | 0.007 | 0 | NA |
| Manganese | 0.09 | 0.04 | +125.00 | NA |
| Sodium | 1150.00 | 1150.00 | 0 | NA |
| Potassium | 2398.50 | 1872.00 | +28.12 | 3.13 |

Values expressed as mg 100 $g^{-1}$ on dry weight basis

***Mineral contents***

Kale is a good source of mineral especially sodium and potassium either grown with organic inputs or conventional input (Table 4). The values for zinc, iron, manganese and potassium were found to be slightly higher in organically grown kale i.e. 3.26, 3.05, 0.03, 0.30, 1.44 mg 100 $g^{-1}$ than conventionally grown kale (i.e. 3.36, 3.80, 0.05, 0.28 and 1.37 mg 100 $g^{-1}$, respectively), and 8.0, 5.1, 125.0 and 28.1% was the positive increase in organic kale, respectively. These results are in agreement with Kandil and Gad (2009) who concluded that the use of organic manure with mineral fertilizers best values either on macronutrients or micronutrients. El-Shakry (2005) also found that organic manure enhanced nutrients absorption by sweet fennel plants. Similar findings have been reported by USDA (2009), Emebu and Anyika (2011) and Sikora and Bodziarczyk (2012) and Ogebede *et al.* (2015).

**Conclusion:** The study revealed that organically grown kale was comparatively more nutritious as compared to the conventionally grown counterparts. Although kale is lesser known vegetable, it has enormous nutritional potentials. Kale is very low in calories and fat but higher protein content in it has proved its health benefits. However, it is rich in dietary fibers, minerals and vitamins. Thus, it can be inferenced that kale is nutritionally rich and if grown with organic inputs will have better nutritional composition which could be harnessed by incorporating it in food formulation as therapeutic agent. It should be included in our food basket to provide protection against various degenerative diseases especially cancer and diabetes.

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