

NUTRITIONAL QUALITY EVALUATION OF ORGANICALLY VIS-A-VIS CONVENTIONALLY GROWN BROCCOLI (*BRASSICA OLERACEA*)

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ABSTRACT

A study on effect of organically and conventionally grown broccoli on physical characteristics, proximate composition, dietary fibre, carbohydrate contents and chemical constituents was conducted. The results of the study revealed that the average weight of ten heads of organically and conventionally grown broccoli was 39.66 ± 1.82 and 37.83 ± 1.93 g respectively. The dry matter, crude protein, crude fat, ash and total carbohydrate content in organically and conventionally grown broccoli were analysed as 13.11 and 11.15 per cent, 4.28 and 3.23 per cent, 0.23 and 0.19 per cent, 2.25 and 1.88 per cent and 6.25 and 5.81 per cent respectively. The NDF, ADF and hemicellulose contents of organically grown broccoli were higher (15.10, 13.36 and 1.75 per cent, respectively) in comparison to conventionally grown counterparts. The total sugars, reducing sugar and ascorbic acid contents of organically and conventionally grown broccoli were 2.04, 1.95 per cent, 90.00 mg/100g and 1.96, 1.87 per cent, 85.20 mg/100g respectively. The sodium and potassium contents in organically and conventionally grown broccoli were recorded as 254.84 and 1150.00mg/ 100g and 212.90 and 1150.00mg/ 100g respectively. Broccoli is low in calorific values and rich in vitamin-c and minerals and if grown with organic inputs have even better content of these nutrients.

INTRODUCTION

Broccoli (*Brassica oleraceae* L.) belongs to the family Brassicaceae and is closely related to the cabbage, cauliflower and brussels sprouts. Broccoli is one of the most important of vegetables grown under temperate to tropical climate conditions. It is a crop plant that is easily grown on a wide range of soil types and is adaptable to many different climatic conditions (Erdem *et al.*, 2010).

Broccoli is known to be highly nutritious vegetable which contains vitamins, minerals, as well as various phytochemicals like phenolics, glucosinolates and others which have antioxidant and chemo protective effects. Diets high in broccoli and other cruciferous vegetables have been associated with many health benefits, such as lowering cancer risk, heart disease, and other chronic illnesses. The low fat and high protein content of broccoli is highly suitable for cardiovascular diseases (Aldrich *et al.*, 2011).

In order to achieve a higher yield and maximum value of growth, generally, excessive amounts of inorganic fertilizers are applied to vegetables (Stewart *et al.*, 2005). The use of inorganic fertilizers alone may cause problems for both human health as well as the environment. On the contrary, the organic manures by enhancing mineralization and solubilization process, make the soil healthy by making unavailable form of soil nutrients to available form (Vanilarasu and Balakrishnamurthy, 2014).

Awareness of role of organically produced fruits and

vegetables in healthy diet is increasing day by day among the masses. Organic foods have become one of the fastest growing food categories with sales increasing nearly 20 per cent each year since 1990 (Winter and Davis, 2006). Studies assessing consumer perceptions of organic produce have concluded opinions that organic produce is safer, more nutritious and better in taste than conventionally grown produce (Yiridoe *et al.*, 2005). Hence, there is a need to evaluate the nutritional quality of organically and conventionally grown produce. With the aforesaid background in mind, a comparative study for nutritional evaluation of organically and conventionally grown broccoli was carried out.

MATERIALS AND METHODS

Fresh and optimally mature organically grown samples of broccoli (var. *Palam Samridhi*) were procured from the Department of Organic Agriculture, College of Agriculture, CSK Himachal Pradesh Agriculture University, Palampur whereas; the same variety of broccoli was grown using inorganic inputs in other farm of the department. The optimally mature samples were selected and after sorting and proper washing, the samples were evaluated for various physical and chemical characteristics. 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 the organic crop as compared to the conventional crop and was calculated as per the following formulae (Worthington, 2001).

% Difference = (Organic - conventional) / Conventional X 100

Physical characteristics

Ten whole heads of organically and conventionally grown broccoli were selected randomly from the whole lot and weighed in the weighing balance. The mean weight was reported as g/ head (Kandil and Gad, 2009). The head colour and shape were assessed by visual evaluation. The per cent edible portion was calculated by subtracting the weight of stem and inedible portion from the total weight and expressed as per cent edible portion (Verma et al., 2012)

Proximate composition and chemical constituents

The proximate constituents viz. moisture, crude protein, crude fat, crude fibre and ash were determined according to AOAC methods (AOAC, 1990). Conversion factor of 6.25 was used to convert nitrogen into protein. The total carbohydrates, available or digestible carbohydrates, unavailable or indigestible carbohydrates and total and available energy were determined by difference method. The ADF, NDF and hemicellulose were analyzed by the method of Van (1963). Sugars were estimated by Shaffer-Somogyi (1945) method as reported by Ranganna (2007). The TSS, acidity and ascorbic acid were determined by method as reported by Ranganna (2007).

Mineral composition

The dried samples were wet digested in 25 ml of diacid mixture (nitric acid and perchloric acid; 5:1) as per method given by Ranganna (2007). The digested samples were analyzed for sodium and potassium using Flame Photometer, Model Mediflame 127 and for calcium, iron, zinc, magnesium and copper, Atomic absorption spectrophotometer, Perkin Elmer Analyst 400 was used.

RESULTS AND DISCUSSION

Physical characteristics

Data in Table 1 pertains to physical characteristics of organically and conventionally grown broccoli. The average weight of organically grown broccoli ranged between 38.70 and 40.30 g per head with an average weight of 39.66 ± 1.82g per head. Whereas, the corresponding values for conventionally grown broccoli were comparatively less and ranged between 35.30 and 39.10 g with an average weight of 37.83 ± 1.93g per head. The colour of organically and conventionally grown broccoli was dark green and darker green respectively.

Data reported average on ten heads

The edible portion of organic broccoli was more (30.00 to 33.00g) than that of conventionally grown broccoli (25.00-29.00g).The improved growth in organic broccoli might be

due to better soil physical condition, prolonged availability of macro and micro nutrients (Verma et al., 2014). Similar results in broccoli have been reported by Chaudhary et al. (2012) and Magd et al. (2006).

Proximate composition

Data of proximate composition of broccoli grown with organic and conventional inputs (Table -2) revealed that the moisture content of broccoli grown with conventional inputs was more i.e. 88.89 per cent when compared with broccoli grown with organic inputs (86.89 %). On the contrary, the dry matter content of organic broccoli was 13.11 per cent and that of conventionally grown broccoli was 11.15 per cent. The crude protein, crude fat, ash and total carbohydrate contents of organically grown broccoli were more and were to the tune of 4.28, 0.23, 2.25 and 6.25 per cent, respectively. Whereas, the corresponding values for these parameter in conventionally grown broccoli were slightly lower and were 3.23, 0.19, 1.88 and 5.81 per cent, respectively. The per cent difference for dry matter, crude protein, crude fat, ash and total carbohydrates was +17.57, +32.50, +21.05, +19.68 and +7.57 respectively signifying that organic broccoli had higher values for these parameters. The increase may be attributed to the organic inputs which helps in improving soil health and ensures proper aeration in soil and improves water holding capacity. These results are in conformation with Kamdi et al., (2014) who reported that organic produce showed superiority over conventionally grown, which might be due to the high level of N and P in the plant which increases the proportion of protein and oil in the groundnut.

Similar finding depicting superiority of organic produce over the conventional counterparts have been reported by Kandil and Gad (2009), USDA (2009), Dogra and Awasthi (2010), and Aldrich et al. (2011).

Dietary fiber, carbohydrate and energy content

The data pertaining to the carbohydrate and energy contents of broccoli is represented in Table-3. The values for NDF, ADF and hemicellulose of organically grown broccoli were more i.e. 15.10, 13.36 and 1.75 per cent, respectively. The corresponding values for these parameters for conventionally grown broccoli were slightly lower and were 13.11, 12.38 and 1.73 per cent, respectively.

The organic broccoli had 12.98 per cent crude fiber whereas; the conventional broccoli had slightly less i.e. 11.87 per cent crude fiber. The values of digestible and indigestible carbohydrates of organic broccoli were more and were to the tune of 8.85 and 2.60 per cent when compared with conventionally grown broccoli where the corresponding values were 7.30 and 1.49 per cent, respectively. The total and available energy contents of organically grown broccoli

Table 1: Physical characteristics of broccoli

Physical characteristics	Organic Range	Mean	Conventional Range	Mean
Weight (g)	38.70-40.30	39.66 ± 1.82	35.30-39.10	37.83 ± 1.93
Colour	Dark green	-	Darker green	-
Shape	Dome	-	Dome	-
Edible portion (g)	30.00-33.00	31.66 ± 1.52	25.00-29.00	27.00 ± 1.93

Table 2: Proximate compositions (on dry weight basis) of broccoli

Constituents (%)	Organic	Conventional	% Difference*
Dry matter	13.11	11.15	+ 17.57
Moisture	86.89	88.89	-2.24
Crude protein	4.28	3.23	+ 32.50
Crude fat	0.23	0.19	+ 21.05
Ash	2.25	1.88	+ 19.68
Total carbohydrates	6.25	5.81	+ 7.57

*The plus and minus signs refer to conventional crops as baseline for comparison

Table 3: Dietary fiber, carbohydrate and energy content

Constituents	Organic	Conventional	% Difference*
NDF (%)	15.1	13.11	+ 15.17
ADF (%)	13.36	12.38	+ 7.91
Hemi-Cellulose (%)	1.75	1.73	+ 1.15
Crude fiber (%)	12.98	11.87	+ 9.35
Digestible Carbohydrates (%)	8.85	7.30	+ 21.23
Indigestible Carbohydrates (%)	2.60	1.49	+ 74.49
Total energy (Kcal/100g)	44.19	37.87	+ 16.68
Available energy (Kcal/100g)	54.59	43.83	+ 24.54

*The plus and minus signs refer to conventional crops as baseline for comparison

Table 4: Nutritional composition (fresh weight basis except for sugars) of broccoli

Constituents	Organic	Conventional	% Difference*
TSS (°Brix)	13.60	12.40	+ 9.67
Acidity (%)	0.41	0.29	+ 41.37
pH	6.25	6.17	+ 1.29
Total sugar (%)	2.04	1.96	+ 4.08
Reducing sugar (%)	1.37	1.33	+ 3.00
Non-reducing sugar (%)	0.64	0.60	+ 6.66

*The plus and minus signs refer to conventional crops as baseline for comparison

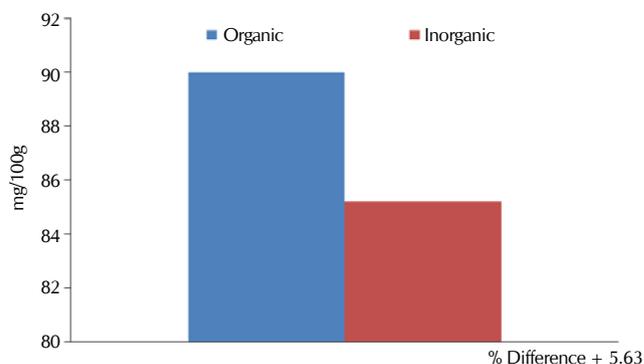
Table 5: Mineral content (mg/100g on dry weight basis) of broccoli

Minerals	Organic	Conventional	% Difference*
Calcium	3.42	2.57	+ 33.07
Magnesium	2.43	1.68	+ 44.64
Copper	0.03	0.01	+ 200.00
Zinc	0.35	0.35	0
Iron	1.75	0.95	+ 84.21
Cobalt	0.01	0.001	0
Manganese	0.02	0.01	+ 100
Sodium	254.84	212.90	+ 19.69
Potassium	2880.10	2266.50	+ 27.07

*The plus and minus signs refer to conventional crops as baseline for comparison

were 44.19 and 54.59 Kcal /100g and were slightly more than those of conventionally grown counterparts where the values were 37.87 and 43.83 Kcal /100g, with a per cent difference of + 16.68 and + 24.54 respectively.

The increased values in organic produce might be due to the reason that organic manure activates many species of living organisms, which release phytohormones and may stimulate the plant growth and absorption of nutrients. Madhu and Kochhar, (2014) reported 4.5 ± 0.57 and 5.6 ± 0.04 g of neutral detergent fiber, 11.65 ± 0.31 and 12.80 ± 0.44 g of acid detergent fiber, 7.15 ± 0.28 and 7.2 ± 0.14 g of hemicelluloses and 2.2 ± 0.28 and 2.0 ± 0.23 g of cellulose in broccoli (*Brassica oleracea L. var. italica* plenck) floret and leaf powder respectively.

**Figure 1: Ascorbic acid content in broccoli**

Chemical constituents

The ascorbic acid content of organic broccoli was 90.00mg/100g which was comparatively higher than that of conventionally grown broccoli where the value for ascorbic acid content was 85.20 mg/100g with per cent difference of +5.63 (Fig.1). Negi *et al.* (2017) while evaluating the effect of organic manures and biofertilizers on quality of broccoli also reported that combined application of different bio-fertilizers and vermicompost played a significant role for higher ascorbic acid accumulation in the broccoli heads.

The TSS, acidity and pH contents of organically and conventionally grown broccoli were 13.60°B, 0.41 per cent, 6.25 and 12.40°B, 0.29 per cent and 6.17, respectively. The per cent difference for these parameters was +9.67, +41.37 and +1.29 respectively signifying higher values in organic broccoli. The values for total, reducing and non-reducing sugars of organic broccoli were slightly higher i.e. 2.04, 1.37 and 0.64 per cent, respectively when compared with conventional broccoli where the corresponding values were 1.96, 1.33 and 0.60 per cent, respectively with per cent difference of +4.08, +3.00 and +6.66 respectively (Table 4). The TSS content increased with the increase in the nutrient level in the soil. Application of organic manures influenced broccoli longevity due to the increased nutrient uptake by the plants and greater development of water conducting tissue (Negi *et al.*, 2017). The findings are in agreement with those reported by Kandil and Gad (2009), USDA (2009) Dogra and Awasthi (2010) and Mishra *et al.* (2014).

Mineral contents

The mineral profile of organically and conventionally grown broccoli is presented in Table 5. Scrutiny of data revealed that irrespective of the growing inputs, the broccoli is good source of mineral especially sodium and potassium. The calcium, magnesium, copper, zinc and iron content of organically and conventionally grown broccoli were 3.42, 2.43, 0.03, 0.35, 1.75 and 2.57, 1.68, 0.01, 0.35, 0.95 mg/100 g, respectively. Scrutiny of the data revealed that in general the samples grown with organic inputs contained more minerals when compared with conventionally grown counterparts. The per cent difference for calcium, magnesium, copper, iron, manganese, sodium and potassium was +33.07, +44.64, +200, +84.21, +100, +19.69 and +27.07 respectively. Kandil and Gad (2009) concluded that use of organic manure with mineral fertilizers achieved the best figures either on macronutrients or micronutrients. These results are in agreement with those reported by El-Shakry (2005) who found that organic manure enhances nutrients absorption by sweet fennel plants. Similar results have been reported by Dogra and Awasthi (2009) and USDA (2009).

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