

COMPOSITIONAL ANALYSIS OF PAKISTANI GREEN AND RED CABBAGE

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Nowadays, vegetables are gaining attention amongst the masses to mitigate lifestyle related dysfunctions owing to their safe nature and functional properties. Considering health benefits and cost-effectiveness of cabbage, the current research was designed to investigate the proximate composition and mineral profile of locally grown green and red cabbage. Comparative compositional characterization of green and red cabbage indicated significantly higher amounts of crude protein, crude fat, crude fiber and ash content in red cabbage as compared to green cabbage due to non-momentously lower content of moisture in red cabbage. However, on fresh weight basis, moisture was the major constituent differing from 89.84±4.04 to 91.29±4.29 g/100g F.W. trailed by nitrogen free extract, crude fiber, crude protein, ash and crude fat. Moreover, most of the minerals like potassium, calcium, sodium, iron, copper, cobalt and manganese were on higher side in red cabbage except magnesium, zinc and copper. However, potassium was the most abundant mineral in both cabbage samples varying between 53.42±1.87 to 96.44±3.38 mg/100g F.W. followed by magnesium and calcium, ranged from 20.61±0.99 to 22.60±0.81 and 19.88±1.29 to 20.56±1.11 mg/100g F.W., respectively. In the nutshell, red cabbage has shown better nutritional value, thus this knowledge need to be disseminated among the masses to change their dietary preference. As a response, vegetable growers in Pakistan should focus on the production of red cabbage over green equivalent.

Keywords: *Brassica oleracea* L., vegetables, free radicals, antioxidants, dietary fiber.

INTRODUCTION

Earlier surveys have inversely associated the sufficient intakes of vegetables and legumes with diseases owing to the presence of biologically active ingredients including dietary fiber, phytoceutics and minerals that aid in preventing uncontrolled free radicals (Hussein, 2012; Assad *et al.*, 2014; Ji *et al.*, 2015; Ashraf *et al.*, 2016; Raza *et al.*, 2017). Previously, these dietary approaches have also shown their defensive potential against oncogenic events. Amongst various vegetables, brassica vegetables like cabbage, cauliflower, broccoli, brussels, *etc.* contribute positively towards nutrition and health perspectives (Oerlemans *et al.*, 2006; Singh *et al.*, 2007; Bacchetti *et al.*, 2014).

Cabbage (*Brassica oleracea* L.) is an important crop, belongs to family Cruciferae or Brassicaceae containing abundant proportions of fiber, vitamins, minerals and health boosting compounds. Pakistan is an agricultural economy, cultivating various types of fruits and vegetables. Recently, approx. 77233 tons of cabbage was cultivated on an area of 4983 hectares in Pakistan (GOP, 2016). The most familiar varieties of cabbage include green, red, Chinese and savoy (Khan *et al.*, 2014). Due to the difference in soil conditions, red cabbage is sometimes having purple color hence also named as purple cabbage. It is a fall/winter crop *i.e.* native to southern Europe where it is being employed in numerous cuisines. It possesses crunchiness along with sweet and peppery taste; however, for optimum organoleptic features, it

is cultivated in cold environments (Draghici *et al.*, 2013; Assad *et al.*, 2014).

Recently, crucifers have gained renewed interest with special reference to ample amount of minerals such as K, Fe, Mg and Mn; involve in cardiac health and co-factor of Mn-SOD *i.e.* an endogenous antioxidant enzyme. Besides, these vegetables are also considered as a rich source of dietary fiber, phytoceutics and antioxidant vitamins (Vallejo *et al.*, 2004; Podsędek *et al.*, 2006; Jeffery and Araya, 2009; Amnah, 2013; Al-Dosari, 2014; Park *et al.*, 2014; Abbas *et al.*, 2017). Furthermore, previous researchers disclosed the mineral profile of raw and cooked common cabbage that reflected higher amounts of potassium followed by calcium, magnesium and sodium, whereas trace amounts of iron, manganese, copper and zinc were also detected. Interestingly, it is documented that calcium absorption from cabbage is higher owing to the existence of organic acids like malic and citric acids (Kawashima and Soares, 2003). Besides, cabbage juice is considered as a rich source of potassium that could fulfill 17% of the daily requirement hence maintains body's fluid balance especially for those who consume higher amounts of sodium in their diet or facing nutrient malabsorption. Apart from this, calcium fulfills 19% of 1000 mg of daily suggested intake, contributing structure to bones and teeth. Furthermore, the presence of selenium in cabbage is attributed to enhance immune responses. Considering Fe, the shredded green and red cabbage could supply 2 and 3% of the daily value, maintaining red blood cells function *i.e.*

carrying oxygen to all the cells ultimately protecting from anemia (Priya, 2012). Such an indication of minerals should need to be assessed in Pakistani cultivars because large variations exist from country to country, on the basis of genome or environment (Gaafar *et al.*, 2014).

In this context, Pakistani green and red cabbages were scrutinized to highlight the nutritive value of these vegetables.

MATERIALS AND METHODS

The present research was carried out at the Faculty of Food, Nutrition & Home Sciences, University of Agriculture, Faisalabad (UAF), Pakistan. In the current investigation, locally grown green and red cabbages were procured to assess their compositional and antioxidant status.

Procurement and preparation of raw materials: The green cabbage (variety: Ever Green F1) and red cabbage (variety: Red Globe), Botanical name: *Brassica oleracea var. capitata* were procured from Ayub Agriculture Research Institute (AARI), Faisalabad, Pakistan. The cabbage samples were randomly selected on the basis of quality attributes; color, head size and free from any visual defects and washed to remove foreign matters and other impurities followed by refrigeration prior to experimentation. The reagents and standards were acquired from different companies whose details and catalogue numbers are given.

Compositional analysis: The cabbage samples were analyzed for proximate composition and their brief descriptions are given below:

Moisture content: The percentage moisture in cabbage samples was measured using Method No. 934-01 (AOAC, 2006). Accordingly, 5 g fresh cabbage sample was dried at 105±5°C in Air Forced Draft Oven (Model: DO-1-30/02, PCSIR, Pakistan) till weight became constant. Afterwards, moisture content in cabbage samples was calculated by following expression;

$$\text{Moisture (\%)} = \frac{\text{Fresh cabbage weight (g)} - \text{Dried cabbage weight (g)}}{\text{Fresh cabbage weight (g)}} \times 100$$

Crude protein: The crude protein in cabbage samples was quantified using Method No. 984-13 via Kjeltch Apparatus; Model: D-40599, Behr Labor Technik, GmbH-Germany (AOAC, 2006). Purposely, dried cabbage sample was digested through conc. H₂SO₄ (Sigma-Aldrich, Japan Cat # 339741) plus digestion tablets from AppliChem, Germany Cat # A7734 (K₂SO₄:FeSO₄:CuSO₄ 100:5:10; to prevent from splashing) till light greenish color, achieved after three to four hours. After digestion, the material was diluted up to 250 mL. For distillation, the digested diluted material (10 mL) was treated with 10 mL of 40% NaOH (Sigma-Aldrich, Japan Cat # 221465) via distillation assembly. The released NH₃ was trapped in 4% boric acid solution containing methyl red (indicator), forming ammonium borate that expresses nitrogen content. Finally, the distillate was titrated against 0.1 N H₂SO₄ till light golden color and volume was noted. The

crude protein (%) in the sample was estimated by multiplying percent nitrogen (N%) with correction factor (5.65) using following formula;

$$\text{N (\%)} = \frac{\text{H}_2\text{SO}_4 \text{ volume used} \times 0.0014 \times 250 \text{ mL (dilution volume)}}{\text{Initial sample weight} \times \text{Diluted sample volume taken}} \times 100$$

$$\text{Crude protein (\%)} = \text{N (\%)} \times 5.65$$

Crude fat: The crude fat in dried samples was determined using Method No. 920-39 via Soxhlet System; Model: H-2 1045 Extraction Unit, Hoganas, Sweden (AOAC, 2006). For maximum fat extraction, dried cabbage powder (5 g) was given five to six siphoning washes, continuously using n-hexane (MP Biomedicals, USA Cat # 02195220) by regulating flow rate; 3-4 drops/second followed by sample drying at 105±5°C. The crude fat measured was expressed as loss in sample weight.

$$\text{Crude fat (\%)} = \frac{\text{Dried cabbage weight (g)} - \text{Dried \& defatted cabbage weight (g)}}{\text{Dried cabbage sample weight (g)}} \times 100$$

Crude fiber: The crude fiber was measured using Method No. 978-10 (AOAC, 2006). Accordingly, dried and defatted cabbage sample (2 g) was digested with boiling 1.25% H₂SO₄ (200 mL) for 30 min in Labconco Fibertech apparatus (Labconco Corporation Kansas, USA). After draining the acid, digested sample was filtered followed by washing with boiling distilled water to make it acid free. Later, the resultant sample was treated with 1.25% 200 mL of boiling NaOH solution for 30 min to remove all base solubilized fractions. Again filtration and washing procedure was repeated, remaining residues (containing crude fiber and ash) were dried at 130°C for 2 hr followed by weighing (W₁) and ignition in Muffle Furnace ((MF-1/02, PCSIR, Pakistan; 550±15°C) till whitish grey ash. After cooling, reweighed the ash achieved (W₂). The percent crude fiber was calculated using formula given below;

$$\text{Crude fiber (\%)} = \frac{\text{Dried sample weight after digestion } W_1 \text{ (g)} - \text{Ash weight } W_2 \text{ (g)}}{\text{Dried \& defatted sample weight (g)}} \times 100$$

Ash content: The inorganic residues in cabbage samples were estimated Method No. 942-05 (AOAC, 2006). Purposely, 5 g cabbage powder was charred on flame in crucible until fumeless trailed by ignition in muffle furnace (550±15°C) till whitish grey residues were attained (5-6 hr).

$$\text{Ash (\%)} = \frac{\text{Weight of whitish grey residues after ignition (g)}}{\text{Initial weight of dried cabbage (g)}} \times 100$$

Nitrogen free extract (NFE): The nitrogen-free extract in cabbage samples was calculated by using equation as under; NFE (%) = 100 – (moisture + crude protein + crude fat + crude fiber + ash)%

Mineral profile: Minerals like Ca (Sigma-Aldrich, Japan Cat # 21049), K (AppliChem, Germany Cat # 313190) and Na (AppliChem, Germany Cat # 313192) were detected via Flame Photometer-410; Sherwood Scientific Ltd., Cambridge, UK using Method no 956.01 while Mg (AppliChem, Germany Cat # 313184), Fe (AppliChem, Germany Cat # 313182), Zn (AppliChem, Germany Cat #

313193), Mn (Merck, Germany Cat # 119789), Co (AppliChem, Germany Cat # 313177) and Cu (AppliChem, Germany Cat # 313178) through Atomic Absorption Spectrophotometer; Hitachi Polarized Zeeman AAS, Z-8200, Japan using Method no 975.03 (b) and 991.11 (AOAC, 2006). In this context, dried cabbage (0.5 g) was wet digested using di-acid system; nitric acid: perchloric acid (7:3) from Sigma-Aldrich, Japan Cat # 438073 & 311421, respectively on hot plate till 1 to 2 mL of solution left. Afterwards, dilution up to 100 mL was made followed by characterization using their respective system.

Statistical analysis: The resultant data from each parameter were subjected to statistical modeling through completely randomized design (CRD) using Statistix 8.1. Furthermore, level of significance was also estimated ($p < 0.05$ & $p < 0.01$) by using analysis of variance (ANOVA) technique followed by Tukey's HSD multiple comparison tests for means separation (Mason *et al.*, 2003).

RESULTS

The compositional analysis is an imperative tool to assess the nutritive value of food commodities. According to Table 1 the moisture content was found slightly higher in green cabbage 91.29 ± 4.29 g/100g F.W. than red cabbage 89.84 ± 4.04 g/100g F.W. Resultantly, other components including crude protein, crude fat, crude fiber, ash and NFE were found significantly higher in red cabbage as compared to green counterpart, ranging from 0.92 ± 0.03 to 1.21 ± 0.05 , 0.02 ± 0.01 to 0.04 ± 0.00 , 2.95 ± 0.11 to 3.49 ± 0.17 , 0.69 ± 0.01 to 0.87 ± 0.03 and 4.13 ± 0.14 to 4.55 ± 0.17 g/100g F.W. correspondingly.

Table 1. Compositional profiling of cabbage.

Proximate composition (g/100g F.W.)	Green cabbage	Red cabbage
Moisture	91.29 ± 4.29	89.84 ± 4.04
Crude protein	0.92 ± 0.03^b	1.21 ± 0.05^a
Crude fat	0.02 ± 0.01^b	0.04 ± 0.00^a
Crude fiber	2.95 ± 0.11^b	3.49 ± 0.17^a
Ash	0.69 ± 0.01^b	0.87 ± 0.03^a
Nitrogen free extract	4.13 ± 0.14^b	4.55 ± 0.17^a

Data values represent mean \pm SD ($n = 3$); Means carrying same letters do not differ significantly.

Moreover, statistical inference indicated that minerals including potassium, sodium, iron, cobalt and manganese differed momentarily in both cabbages however, on higher side in red cabbage 96.44 ± 3.38 , 12.33 ± 0.55 , 1.11 ± 0.04 , 0.20 ± 0.01 & 0.18 ± 0.01 mg/100g F.W. than green cabbage 53.42 ± 1.87 , 9.87 ± 0.39 , 0.75 ± 0.03 , 0.14 ± 0.00 & 0.12 ± 0.01 mg/100g F.W., respectively. Furthermore, calcium, magnesium, zinc and copper explicated non-significant variations with respect to both cabbages though, calcium was detected more in red cabbage 20.56 ± 1.11 mg/100g F.W. than

green equivalent 19.88 ± 1.29 mg/100g F.W., whereas magnesium, zinc and copper were quantified relatively more in green cabbage 22.6 ± 0.81 , 0.31 ± 0.01 & 0.05 ± 0.00 mg/100g F.W. as compared to red cabbage 20.56 ± 0.99 , 0.29 ± 0.01 and 0.04 ± 0.00 mg/100g F.W., accordingly (Table 2).

Table 2. Mineral content of cabbage.

Minerals (mg/100g F.W.)	Green cabbage	Red cabbage
Potassium (K)	53.42 ± 1.87^b	96.44 ± 3.38^a
Calcium (Ca)	19.88 ± 1.29	20.56 ± 1.11
Magnesium (Mg)	22.60 ± 0.81	20.61 ± 0.99
Sodium (Na)	9.87 ± 0.39^b	12.33 ± 0.55^a
Iron (Fe)	0.75 ± 0.03^b	1.11 ± 0.04^a
Zinc (Zn)	0.31 ± 0.01	0.29 ± 0.01
Copper (Cu)	0.05 ± 0.00	0.04 ± 0.00
Cobalt (Co)	0.14 ± 0.00^b	0.20 ± 0.01^a
Manganese (Mn)	0.12 ± 0.01^b	0.18 ± 0.01^a

Data values represent mean \pm SD ($n = 3$); Means carrying same letters do not differ significantly

DISCUSSION

The current results are in close harmony with the work of previous researchers, who measured crude fiber, carbohydrate, fat, protein, ash and NFE in white, green or common cabbage, varying between 21.64-33.31, 62-71.26, 0.52-4.4, 14.3-30.09, 5.82-10.5 and 35.12% D.W., whereas in red cabbage, the said traits were reported as 14.61-44.87, 64.54, 0.85, 13.99-26.67, 9.77 and 17.84% on dry weight basis, respectively. The total dietary fiber in dried cabbage was found to be varying from 27.3 to 29.9%; however, the moisture content in fresh red cabbage was varying from 91.0 to 91.7% (Wu *et al.*, 2006; Kahlon *et al.*, 2007; Kahlon *et al.*, 2008; PeñAs *et al.*, 2010; Hussein, 2012; Amnah, 2013; Mohammed and Luka, 2013). Previously, the compositional profile of outer leaves of cabbage portrayed protein $18.43 \pm 0.60\%$, lipid $1.02 \pm 0.11\%$, ash $9.02 \pm 0.90\%$, carbohydrate $30.46 \pm 0.99\%$ and total dietary fiber $40.89 \pm 2.25\%$; soluble dietary fiber $7.35 \pm 0.81\%$ and insoluble dietary fiber; $33.54 \pm 1.44\%$ on dry mass basis (Tanongkankit *et al.*, 2012). Earlier scrutiny documented that cabbage possesses approx. 4.6 g carbohydrate, 1.8 g protein, 0.1 g fat, 0.6 g minerals and 36.6 mg vitamin C, 98 IU vitamin A & 76 µg vitamin K per 100 g F.W. (Tiwari *et al.*, 2003; Park *et al.*, 2014). The ranges of almost all attributes in the aforementioned studies are covering the data obtained in the current investigation.

In another attempt, the compositions of fresh and blanched cabbage samples were compared by Nilnakara *et al.* (2009). The study outcomes presented protein, crude fat, crude fiber, ash and carbohydrates in fresh & blanched cabbage as 19.48 ± 0.19 & 21.15 ± 0.02 , 0.97 ± 0.06 & 1.85 ± 0.05 , 19.92 ± 1.08 & 47.47 ± 3.34 , 7.82 ± 0.38 & 5.26 ± 0.18 and

51.36±1.89 & 24.61±1.11% on dry weight basis, accordingly. These findings are also in corroboration with the results of the instant study. Mostly in dieting programs, cabbage is given a major share in the diet plan being low in calories (Al-Dosari, 2014). The calories content in brassica vegetables as reported by Heimler *et al.* (2006) were approx. 24-34 kcal/100g as the protein, fat and fiber were 1.44-2.82, 0.12-0.37 and 2.5 g per 100g F.W., respectively.

Considering mineral characterization, the green cabbage consumed in southern Brazil, raw and cooked counterparts were analyzed for minerals (mg/100g F.W.) and finding disclosed higher amounts of potassium 266±87 & 275±103 followed by calcium 44±6 & 46±5, magnesium 14±2 & 15±3 and sodium 3±1 & 3±1. This study found K & Ca were on the higher side, whereas Mg and Na were quantified lesser than the outcomes of the current exploration. Furthermore, trace minerals like iron 0.14±0.03 & 0.16±0.04, manganese 0.2±0.1 & 0.2±0.1, copper 0.05±0.05 & 0.04±0.04 and zinc 0.2±0.1 & 0.2±0.1 were nearly within the ranges as noted in the present study. After cooking, the percent increase in potassium was 7% whilst, percent decrease in rest of the minerals was observed as sodium 21, calcium 2, magnesium 2, iron 1, manganese 11, copper 3 and zinc 5 (Kawashima and Soares, 2003). Recently, Malav *et al.* (2015) reported calcium content in cabbage up to 45 mg/100g F.W. that was higher than the current study result. Similarly, another researcher reported calcium content in green cabbage in the range of 45 to 106 mg/100g F.W. Furthermore, he noted higher calcium content in outer leaves of cabbage; 476 to 998 mg/100g F.W. as compared to inner yellowish leaves, varying from 26 to 53 mg/100g F.W. (Cowell, 1932).

The outcomes of the current research are also comparable to previous studies that reported Ca 29, Fe 0.8 and Na 14.1 mg/100g F.W. in common cabbage (Tiwari *et al.*, 2003; Park *et al.*, 2014). Furthermore, the current data is in agreement with the results presented by Lucarini *et al.* (2000), they determined iron and zinc in green cabbage as 0.71±0.23 and 0.53±0.12 mg/100g, respectively. In a research work, Zarembski and Hodgkinson (1962) measured the Ca, Mg and P contents in cabbage, ranging from 19.5 to 87.7, 11.6 to 2.6 and 13.9 to 97.6 mg/100g F.W., correspondingly. Moreover, Warman and Havard (1997) analyzed conventional & organic cabbage samples and found Ca 341 to 603 & 312 to 614 mg/100g D.W., whereas Mg 125 to 144 & 125 to 154 mg/100g D.W. and Cu as 19 & 42 mg/100g D.W. in the respective samples. Later, Mohammed and Luka (2013) compared the green & red cabbage for different minerals like calcium and phosphorous. They noted values for the said minerals as 1.76±0.04 & 0.96±0.09 and 0.86±0.09 & 1.89±0.19 mg/100g D.W. in green & red cabbage, respectively that were far lower than results obtained in the current study. One of their peers, Draghici *et al.* (2013) found Ca and Mg in white cabbage as 40 and 12 mg/100g F.W., respectively. Although, earlier studies highlighted the rich

nutritive value of cruciferous vegetables but differences exist based on geographical location & soil condition, types and cultivars of cabbage, use of fertilizers, etc.

Conclusions: In the nutshell, cabbage grown in Pakistan possesses splendid nutritional and health perspectives. Furthermore, their inclusion in our daily routine could suffice the basic needs of the body in terms of minerals and fiber content besides protection from various free radicals induced malfunctions. Alongside, its consumption during summer season keeps the body hydrating owing to the presence of higher water content. Thus, such nutritious, approachable and cost-effective vegetables should be encouraged by the consumers. Alongside, industrialists should need to incorporate these vegetables in the recipes of existing conventional food products to replenish their nutritional value. Domestically, such studies would go a long way in guiding the vegetable growers to cultivate red cabbage in abundance.

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