ISSN 1023-1072

Pak. J. Agri., Agril. Engg., Vet. Sci., 2018, 34 (1): 31-39

EFFECT OF PROCESSING TREATMENTS ON THE NUTRITIVE COMPOSITION AND CONSUMER ACCEPTANCE OF RED AND WHITE TURNIP VEGETABLES WITH GREEN TOPS

S. A. Sheikh[1], A. S. Shar[1], A. A. Panhwar[1], S. M. Nizamani[2] and N. S. Memon[2]

[1]Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam, Pakistan
[2]National Center of Excellence in Analytical Chemistry, University of Sindh, Jamshoro, Pakistan

ABSTRACT

The study was carried out to evaluate the effect of processing treatments on the nutritive composition and consumer acceptance of red and white turnip vegetables during 2016. Fresh turnip samples (red and white) were collected from vegetable markets of Hyderabad and Tandojam. The processed samples were subjected to the sensory analysis and after that packed with proper labelling and preserved into deep freezer at -20± 5°C for further analysis of essential nutrients, proximate composition and vitamin C contents. The results of the present study revealed that proximate levels of crude protein and crude fiber were significantly high in curry (pulp with green tops) of red turnip. Crude protein (1.01%) was high in fresh red turnip, crude fiber (3.27%) and crude fat (17.77%) was high in curry (pulp) of white turnip. Total carbohydrate (10.29%) was significantly high in curry (pulp) of white turnip. The results of the selected minerals (sodium, potassium, iron, calcium, copper, zinc, manganese and magnesium) showed that potassium content was (6164.00 mg/kg) high in curry (pulp) of red turnip and iron content was (539.00 mg/kg) high in curry (pulp with green tops) of white turnip. Therefore, it can be concluded that, turnip (red and white) might be cooked in such a way to ensure minimal loss of nutrients.

Keywords: mineral and vitamin C, red turnip, proximate, white turnip

INTRODUCTION

Vegetables are a vital component of human diet (Hussain *et al*., 2010). In Pakistan, vegetables are grown in the area of about 411 thousand hectares with production of 6623.7 thousand tons (GoP, 2011-12). In Sindh, the total area under vegetable cultivation was 38,700 hectares along with a total production of 265.8 thousand tons (GoP, 2011-12). The area and production of turnip vegetable in Pakistan was noted as 15.7 000 hectares and 275,700 tons, respectively in the year 2011-12 (GoP, 2011-12). However, in Sindh province the production of turnip was calculated as 6,700 tons (GoP, 2011-12). Turnip (*Brassica rapa*) is one of the oldest cultivated vegetable and consumed since

Corresponding author: sasheikhsau@gmail.com

prehistoric times for its leaves and roots in all America, Asia and Europe throughout the year (Liang *et al*., 2006). Besides roots and leaves, the buds of flowers are also consumed along with other vegetables. The edible parts of the turnip are used in the preparation of stews and soups. Its juice is also highly cherished (Haliloglu *et al*., 2012). This plant grows well during winter in Sindh, Pakistan and it can be stored for long time after harvesting without much loss. Thus, turnip vegetable is a unique supply along with other crops. Brassica family is also famous for having many organic acids (phenolic and malic acids) with strong antioxidant capacity, phytochemicals and aromatic compounds which enhance the immune system of the human body (Haliloglu *et al*., 2012). This species has also been studied for volatile constituents (Wallbank and Wheatley, 1976), allozymes (Persson *et al*., 2001) of the leaves, tuberization ability of the epicotyl (Nishijima *et al*., 2005), phenylpropanoids (Liang *et al*., 2006), fatty acid composition of seed oil (Velasco *et al*., 1998) and glucosinolates of the flower buds (Rosa, 1997). Turnip vegetable has great quantity of anti-oxidants and vitamin C which may help to control the destructive oxidation reactions and free radicals. It is helpful in lowering the obesity risk, cancers of the lung, bladder, pancreas, stomach and high blood pressure apart from diabetes (Haliloglu *et al*., 2012). There is paucity of information regarding nutritive composition of turnip. Our study reported proximate composition, vitamin C levels and mineral composition during preparation of various recipes of curry making of red and white turnip followed by sensory evaluation. Thus the present study may help to identify the most effective means of commercialization and policy frame works to promote the use of turnip and maximize underutilized plant species of potentially economic and nutritive value.

MATERIALS AND METHODS

Fresh turnip (red and white) samples were collected from vegetable markets of Hyderabad and Tandojam during 2016. The vegetable samples were packed with proper labelling in ice chest box and brought to the laboratory of Institute of Food Sciences and Technology, Sindh Agriculture University Tandojam for processing and cooking.

Sample preparation of red and white turnip

Fresh turnip samples were washed thoroughly to remove dirt and other extraneous materials. The roots and tops (greens) were separated, followed by removal of non-edible parts which constituted about 18% of roots and 23% of green tops. Edible portions (pulp of roots and destalked tender leaves) were then chopped separately for curry preparation.

Recipe used in cooking curry of red and white turnip with and without green tops

Chopped roots and green tops were boiled separately for about five minutes. The water used for boiling was discarded and the boiled samples were used for cooking as per recipe used in cooking of vegetable samples (Table 1). The pan was placed on medium flame and cooking oil was added. The sliced onions were fried till golden brown color appeared. Chopped garlic and tomatoes with all other ingredients added and stirred for 30 seconds. The boiled samples were then added, stirred for 5 minutes and then left till water evaporated under low flame. The vegetable was stirred again and then taken out into pre-washed bowl. The curry samples were then subjected to the sensory analysis and after that packed with proper labelling and preserved into deep freezer at -20 ± 5°C for further analysis of essential nutrients according to the standard methods.

Table 1. Recipe for cooking curry of red turnip pulp, red turnip pulp with green tops, white turnip pulp and white turnip pulp with green tops

Ingredients	**Weight (g)**			
	Red turnip pulp (g)	**Red turnip pulp with green tops (75:25)**	**White turnip Pulp (g)**	**White turnip pulp with green tops (75:25)**
Total vegetable	500	500 (375 g root and 125 g green tops)	500	500 (375 g root and 125 g green tops)
Salt	2	3	2	3
Red chili powder	2	3	2	3
Turmeric powder	0.5	0.8	0.5	0.8
Onion (chopped)	20	10	20	10
Tomato	20	10	20	10
Garlic	3	5	3	5
Chili green	5	10	5	10
Oil	20 ml	30 ml	20 ml	30 ml
Final product (Curry)	565	570	578	598
No of servings	5 persons	5 persons	5 persons	5 persons

Sensory evaluation

Sensory analysis was performed by the panel of staff members of Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam. The panel comprised of females and males of age between 22-36 years. A five point scales as described by Larmond (1977) was used, where 5= like very much, 4= like moderately, 3= neither like nor dislike, 2= dislike moderately and 1= dislike very much. The four samples were served in identical plates, coded with numbers and presented to panellists in one session. The sensory attributes of interest were appearance, taste, texture or mouth feel, aroma, overall acceptability and purchase. Necessary precautions were taken to reduce crossover effects by selecting greater number of interested panellists rather than motivating panellists and using small number and repeating preparations.

Bio-chemical analysis

The AOAC (2005) method was used for moisture, protein, fat, fiber, carbohydrates and titratable acidity (citric acid mg/kg). The pH and TSS values were measured using pH meter and digital refractometer. Determination of carbohydrates was carried out by difference method (James, 1995). Ascorbic acid content was measured by titration method (Rangamma, 1977). Selected mineral contents including sodium (Na), potassium (K), calcium (Ca), zinc (Zn), copper (Cu), iron (Fe), manganese (Mn) and magnesium (Mg) were analyzed by atomic absorption spectrophotometer (Kazi *et al*., 2010).

Statistical analysis

The data were analyzed for simple means, standard deviations, and percentages using analysis of variance (ANOVA) as per method of Steel *et al.* (1997). The means were compared using DMRT (P< 0.05).

RESULTS AND DISCUSSION

Proximate composition

The proximate levels (moisture (%), pH, titratable acidity (%), TSS (°Brix), carbohydrates (%), crude fiber (%), lipid (%), protein (%) and ash (%) of fresh, boiled pulp, boiled pulp with green tops, curry pulp and curry pulp with green tops after processing of each variety of turnip are shown in Table 2 and 3. Proximate levels of protein and crude fiber were significantly high (P<0.05) in curry pulp with green tops of red turnip. Crude fiber (3.27%) was high in curry pulp with green tops of red turnip while protein (1.00%) and crude fat (17.77%) was high in fresh and curry (pulp) of white turnip. Total carbohydrate (10.29%) was significantly high in curry pulp of white turnip.

Table 2. Effect of different processing methods on proximate composition of white turnip

Treatments	Moisture (%)	pH	TA (%)	*TSS (°Brix)	*CHO (%)	*CF (%)	Fat (%)	*CP (%)	Ash (%)
Fresh	88.51± 0.19^{c}	5.38± 0.001^{a}	0.66± 0.02^{c}	2.43± 0.07^{a}	8.55± 0.17^{ab}	1.65± 0.25^{b}	0.13± 0.05^{a}	1.00± 0.10^{a}	0.15± 0.003^{a}
Boiled pulp	87.27± 1.91^{c}	6.74± 0.01^{a}	0.52± 0.03^{b}	3.88± 0.09^{c}	9.94± 1.38^{bc}	1.10± 0.40^{a}	0.23± 0.15^{a}	0.80± 0.15^{a}	0.62± 0.06^{c}
Boiled pulp with green tops	88.42± 0.22^{c}	4.98± 3.44^{a}	0.38± 0.07^{a}	3.27± 0.35^{b}	8.08± 0.21^{a}	1.07± 0.02^{a}	0.60± 0.10^{a}	0.80± 0.10^{a}	1.02± 0.02^{d}
Curry pulp	69.62± 0.80^{a}	5.38± 0.0001^{a}	0.90± 0.07^{d}	4.67± 0.05^{d}	10.29± 0.58^{c}	2.02± 0.07^{c}	17.77± 1.90^{c}	0.90± 0.10^{a}	0.44± 0.08^{b}
Curry pulp with green tops	71.69± 0.29^{b}	5.71± 0.45^{a}	0.90± 0.03^{d}	4.32± 0.31^{d}	9.27± 0.70^{ab}	2.15± 0.05^{c}	14.29± 0.72^{b}	0.89± 0.12^{a}	1.66± 0.04^{e}

Values are expressed as mean ± standard deviation (n=3); Mean values followed by the same letter down the column were not significantly different at P<0.05 DMRT; *TA= Titratable acidity; *TSS= Total soluble solids; *CHO= Carbohydrate; *CF= Crude fiber; *CP= Crude protein

The values of moisture, ash, protein and fiber in fresh white and yellow turnip were in line as those reported by Saeed *et al.* (2012), while the results of carbohydrates in present study were slightly higher. Such slight difference is expected to vary from variety to variety and region to region. Satter *et al*. (2016), reported the moisture content of the wild vegetables Dhekishak, Helencha, Kalmishak, Patshak and Shapla were 90.37, 87.60, 90.12, 86.81 and 94.36%, respectively. Hassan and Umar (2006), reported the highest values of protein content in Momordica foecide (4.6%) fresh and dried plant extracts of B. pilosa (19.1%) consumed in Swaziland and Nigeria. In present study, the proximate values of all the samples had slight variation after cooking but in curry samples the fat content was observed high due to addition of extra cooking oil. Dietary fiber helps to prevent constipation, bowel problems (Asaolu *et al.,* 2012). The crude fiber contains indigestible cellulose which may absorb water and provide roughage for better functioning of the alimentary system. The pH is dependent on the maturity and stage of ripeness (Aye, 2012). The results of the present study were considerably higher than the reported values when compared to some wild edible plants (3%) of Pakistan and commonly consumed vegetables (29.40-32.80%) in Nigeria (Khan *et al.,* 2013).

Table 3. Effect of different processing methods on proximate composition of red turnip

Treatments	**Moisture (%)**	**pH**	**TA (%)**	***TSS (°Brix)**	***CHO (%)**	***CF (%)**	**Fat (%)**	***CP (%)**	**Ash (%)**
Fresh	88.20± 0.20^{b}	6.46± 0.01^{c}	0.67± 0.04^{b}	1.67± 0.30^{a}	8.07± 0.52^{ab}	1.77± 0.07^{b}	0.20± 0.10^{a}	0.90± 0.10^{a}	0.85± 0.03^{a}
Boiled pulp	90.76± 0.14^{c}	7.07± 0.001^{d}	0.50± 0.03^{a}	4.06± 0.03^{c}	6.56± 0.15^{a}	0.77± 0.02^{a}	0.20± 0.10^{a}	0.97± 0.17^{a}	0.74± 0.02^{a}
Boiled pulp with green tops	89.11± 2.15^{bc}	7.41± 0.02^{e}	0.48± 0.06^{a}	3.94± 0.05^{c}	6.91± 1.80^{a}	0.77± 0.32^{a}	0.26± 0.15^{a}	0.90± 0.10^{a}	1.04± 0.06^{ab}
Curry pulp	68.78± 0.38^{a}	5.43± 0.001^{a}	0.69± 0.03^{b}	3.28± 0.17^{b}	10.07± 0.56^{b}	2.72± 0.02^{c}	16.67± 1.50^{c}	0.87± 0.20^{a}	1.01± 0.79^{ab}
Curry pulp with green tops	70.72± 1.26^{a}	5.53± 0.001^{b}	0.65± 0.02^{b}	3.50± 0.30^{b}	9.20± 1.38^{b}	3.27± 0.25^{d}	14.92± 0.90^{b}	1.00± 0.10^{a}	1.62± 0.02^{b}

Values are expressed as mean ± standard deviation (n=3); Mean values followed by the same letter down the column were not significantly different at P<0.05 DMRT; *TA= Titratable acidity; *TSS= Total soluble solids; *CHO= Carbohydrate; *CF= Crude fiber; *CP= Crude protein

Table 4. Effect of different processing methods on vitamin C (%) of red and white turnip

Treatment	**White turnip**	**Red turnip**
Fresh	9.40± 0.99^{b}	9.40± 0.37^{b}
Boiled pulp	4.88± 0.37^{a}	4.76 ± 0.78^{a}
Boiled pulp with green tops	4.63± 0.57^{a}	4.76± 0.57^{a}
Curry pulp	10.27± 1.32^{b}	9.52± 0.57^{b}
Curry pulp with green tops	9.90± 0.57^{b}	10.27± 0.57^{b}

Values are expressed as mean ± standard deviation (n=3); Values with different superscripts down the column are significantly different from each other at P<0.05 DMRT

Table 5. Effect of different processing methods on mineral composition (mg/kg) of white turnip

Treatments	**Sodium**	**Potassium**	**Iron**	**Calcium**	**Copper**	**Zinc**	**Manganese**	**Magnesium**
Fresh	2721.00± 1940.98^{a}	5205.00± 164.01^{a}	445.33± 45.65^{b}	1145.67± 454.09^{a}	71.33± 1.52^{b}	24.00± 4.35^{a}	67.00± 2.64^{b}	1438.67± 1344.15^{a}
Boiled pulp	4758.67± 527.43^{b}	4829.67± 645.50^{a}	412.00± 5.00^{c}	2936.67± 35.21^{c}	81.00± 4.35^{b}	28.33± 9.29^{a}	54.67± 7.37^{a}	4368.00± 423.24^{b}
Boiled pulp with green tops	1261.67± 141.52^{a}	4692.00± 504.26^{a}	302.33± 11.84^{b}	1963.67± 679.25^{a}	61.67± 1.52^{a}	29.00± 1.00^{a}	56.67± 2.51^{a}	2475.00± 376.26^{a}
Curry pulp	5880.00± 703.03^{b}	5642.67± 55.01^{a}	529.33± 25.54^{c}	2076.67± 44.83^{b}	84.67± 2.51^{c}	34.00± 6.24^{a}	71.67± 2.08^{b}	4100.00± 93.82^{b}
Curry pulp with green tops	4720.67± 467.00^{b}	5894.00± 758.65^{b}	539.00± 25.06^{c}	2047.33± 466.84^{b}	80.33± 5.50^{c}	37.33± 3.78^{b}	82.67± 3.51^{c}	2555.00± 845.24^{a}

Values are expressed as mean ± SD (n=3); Values with different superscripts down the column are significantly different from each other at P<0.05 DMRT

Table 6. Effect of different processing methods on mineral composition (mg/kg) of red turnip

Treatments	Sodium	Potassium	Iron	Calcium	Copper	Zinc	Manganese	Magnesium
Fresh	1199.33± 333.12[a]	4409.00± 3301.63[a]	312.67± 120.01[a]	1151.00± 279.78[a]	44.00± 6.08[a]	34.00± 8.71[c]	69.00± 9.16[ab]	1393.67± 149.25[a]
Boiled pulp	3462.00± 246.53[b]	4428.00± 494.53[a]	407.33± 4.50[a]	1666.33± 124.16[a]	52.33± 4.16[a]	28.33± 5.03[b]	71.00± 2.00[ab]	2268.00± 123.86[a]
Boiled pulp with green tops	3849.33± 1980.92[b]	4.7200.00± 58221.69[a]	419.33± 2.51[b]	1739.67± 421.11[a]	78.67± 3.78[c]	19.67± 3.78[a]	54.33± 5.13[a]	2656.67± 1762.06[abc]
Curry pulp	6035.00± 519.10[c]	6164.00± 158.76[a]	514.00± 3.60[c]	1696.00± 261.00[a]	56.00± 7.00[b]	17.33± 2.08[a]	77.67± 12.66[b]	4235.33± 90.36[c]
Curry pulp with green tops	6229.67± 563.01[c]	1.8300.00± 1266.91[a]	522.33± 23.15[c]	1708.33± 419.64[a]	81.67± 2.08[c]	18.00± 3.60[a]	85.00± 16.70[b]	3769.67± 582.90[c]

Values are expressed as mean ± SD (n=3); Values with different superscripts down the column are significantly different from each other at *P*<0.05 DMRT

Table 7. Sensory evaluation of cooked red and white turnip

Parameters	White turnip		Red turnip	
	Curry pulp	Curry pulp with green tops	Curry pulp	Curry pulp with green tops
Appearance	4.33± 0.91[b]	2.50± 0.83[a]	3.83± 0.75[a]	3.16± 0.40[a]
Taste/ flavor	3.31± 0.31[a]	3.33± 0.51[a]	3.58± 0.54[a]	3.36± 0.41[a]
Texture rating	3.66± 0.71[a]	3.00± 0.63[a]	3.43± 0.34[a]	3.53± 0.54[a]
Aroma	3.93± 0.85[a]	3.09± 0.89[a]	3.67± 0.81[a]	3.18± 0.45[a]
Overall acceptability	3.83± 0.75[b]	3.16± 0.40[a]	3.31± 0.11[a]	3.51± 0.54[b]
Purchase	3.00± 0.63[a]	2.66± 0.51[a]	3.83± 0.91[a]	2.66± 0.81[a]

Values are expressed as mean (n=6); Values with different superscripts down the rows are significantly different from each other at *P*<0.05 DMRT

Vitamin C content

The vitamin C content of fresh, boiled pulp, boiled pulp with green tops, curry pulp and curry pulp with green tops of each variety after different processing methods are shown in Table 4. There was a significant difference (*P*<0.05) for vitamin C content in turnip varieties. Vitamin C content was high (10.27%) in curry pulp of white turnip, while it was also high (10.27%) in curry pulp with green tops of red turnip.

Vitamin C was reduced (about 40 to 60%) during cooking at high temperatures as compared to fresh product value (Lee and Kader, 2000; Oboh, 2005). Bello and Fowoyo (2014) reported that vitamin C of fruits and vegetables is affected by heat (50 and 70°C). If more the heat is applied to the samples, the less vitamin C will be retained in the final product. Similarly Babalola *et al.* (2010) also stated that vitamin C is dependent on the temperature. Adefegha and Oboh (2011) also attributed that the loss of vitamin C content during the different cooking methods. The loss of vitamin C was observed in the present study when the vegetables were subjected to boiling because during boiling vegetable slices became soft and vitamin C leached to boiled water. Since boiling of vegetables is inevitable, preventive measures should be taken to avoid nutrient losses like boiling only for a very short time (Diengdoh *et al*., 2015).

Mineral composition of turnip varieties

The results of minerals contents (mg/kg) of varieties of turnip are presented in Table 5 and 6. The results showed that potassium content was high (4720.67 mg/kg) in boiled pulp with green tops of red turnip, iron content was high (539.00 mg/kg) in curry pulp with green tops of white turnip. The sodium content was high (6229.67 mg/kg) in curry pulp with green tops of red turnip, calcium content was high (2936.67 mg/kg) in boiled pulp of white turnip, copper content was high (84.67 mg/kg) in curry pulp of white turnip. Zinc was significantly high (P<0.05) in curry pulp with green tops of white turnip. The supply of minerals is not sufficient to meet the requirements of increasing population in many developing countries, because body itself cannot synthesize the minerals (Anjorin *et al*., 2010). Plasma volume, muscle and nerve movements and acid-base balance is regulated by sodium (Akpanyung, 2005). Its deficiency may lead to iron deficiency anemia which has affected billions of people throughout the globe (Trowbridge and Martorell, 2002). Zinc is required by the body for normal immune function and human growth (Black, 2003). About 20% of the population in the world is reported at the risk of zinc deficiency (Hotz and Brown, 2009). The study further reveals that the turnip is rich in essential minerals therefore intake of various turnip products may help in reducing the mineral deficiency in common citizens who cannot afford expensive mineral supplements.

Sensorial analysis

Sensory evaluations of white and red turnip curry are presented in Table 7. The results revealed that the white turnip curry with pulp was superior in term of appearance, texture, aroma/ smell and overall acceptability as compared with red turnip. However, the curry pulp of red turnip had the maximum scores in taste/ flavor and purchase. It is also revealed that, white turnip curry with pulp has a great potential to be commercialized throughout the world. The red turnip on the other hand also has chances to be commercialized due to its great taste of curry pulp.

CONCLUSION

It is therefore concluded that white and red turnip contain sufficient amount of fat, carbohydrate, protein, fiber and appreciable amounts of minerals required for normal body functions, maintenance and reproduction. The results of present study indicated that nutritive value of turnip is affected during processing. Therefore, it can be concluded that, vegetables might be cooked in such a way to ensure minimal loss of nutrients. Thus, it is observed that red and white turnip can fulfill the nutrient requirements of the man and might be used as a supplementary source of nutrients. Hence, they could be consumed to supplement the scarce or non-available sources of nutrients.

ACKNOWLEDGEMENTS

The authors are thankful to Higher Education Commission Pakistan for providing funds under project entitled “Nutritional Assessment of Selected Non-Traditional Vegetables of Sindh”. The authors are also grateful to National Centre of Excellence in Analytical Chemistry for access of laboratories for conducting part of the research work of the project.

REFERENCES

Adefegha, S. A. and G. Oboh. 2011. Cooking enhances the antioxidant properties of some tropical green leafy vegetables. African Journal of Biotechnology, 10 (4): 632-639.

Akpanyung, E. O. 2005. Proximate and mineral composition of bouillon cubes produced in Nigeria. Pakistan Journal of Nutrition, 4 (5): 327-329.

Anjorin, T. S., P. Ikokoh and S. Okolona. 2010. Mineral composition of *Moringa oleiefra* leaves, pods and seed from two regions in Abuja, Nigeria. International Journal of Agriculture and Biology, 12 (1): 431-434.

AOAC. 2005. Official methods of analysis William Horwitz 18th Ed. Gaithersburg, MD, USA.

Asaolu, S. S., O. S. Adefemi, I. G. Oyakilome, K. E. Ajibulu and M. F. Asaolu. 2012. Proximate and mineral composition of Nigerian leafy vegetables. Journal of Food Research, 1 (3): 214-218.

Aye, P. A. 2012. Effect of processing on the nutritive characteristics, anti-nutritional factors and functional properties of *Cnidoscolus aconitifolius* leaves (Iyana Ipaja). American Journal of Food and Nutrition, 2 (4): 89-95.

Babalola, O. O., O. S. Tugbobo and A. S. Daramola. 2010. Effect of processing on the vitamin C content of seven Nigerian green leafy vegetables. Advance Journal of Food Science and Technology, 2 (6): 303-305.

Bello, A. A. and P. T. Fowoyo. 2014. Effect of heat on the ascorbic acid content of dark green leafy vegetables and citrus fruits. African Journal of Food Science and Technology, 5 (4): 114-118.

Black, R. E. 2003. Zinc deficiency, infectious disease and mortality in developing world. Journal of Nutrition, 133: 1485-1489.

Diengdoh, D. F., E. R. Dkhar, T. Mukhim and C. L. Nongpiur. 2015. Effect of cooking time on the ascorbic acid content of some selected green leafy vegetables. International Journal of Science and Research, 4 (7): 35-37.

GoP. 2011-12. Agricultural Statistics of Pakistan. Pakistan Bureau of Statistics.

Haliloglu, H. I., M. Arslan, B. J. Lee and K. Dabrowski. 2012. The effects of dietary turnip (*Brassica rapa*) and biofuel algae on growth and chemical composition in rainbow trout (*Oncorhynchus mykiss*) juveniles. Turkish Journal of Fisheries and Aquatic Sciences, 12: 323-329.

Hotz, C. and K. C. Brown. 2009. International zinc nutrition consultative group (IZINCG) technical document.

Hussain, J., R. Ullah, N. Rehman, A. L. Khan, Z. Muhammad, F. Ullah, S. T. Hussain and S. Anwar. 2010. Endogenous transitional metal and proximate analysis of selected medicinal plants from Pakistan. Journal of Medicinal Plants Research, 4 (3): 267-270.

James, C. S. 1995. Analytical chemistry of food. Seale-Hayne Faculty of Agriculture, Food and Land use, Department of Agriculture and Food studies, University of Polymouth, United Kingdom. 1: 96-97.

Kazi, T. G., G. A. Kandhro, H. I. Afridi, N. Kazi, J. A. Baig, M. B. Arain, A. Q. Shah, N. Syed, S. Kumar, N. F. Kolachi and S. Khan S. 2010. Interaction of copper with iron, iodine and thyroid hormone status in goitrous patients. Biological Trace Element Research, 134: 265-279.

Khan, N., A. Sultana, N. Tahir and N. Jamila. 2013. Nutritional composition, vitamins, minerals and toxic heavy metals analysis of *Trianthema portulacastrum* L., a wild edible plant from Peshawar, Khyber Pakhtunkhwa, Pakistan. African Journal of Biotechnology, 12 (42): 6079-6085.

Larmond, 1977. Laboratory method for sensory evaluation of food. Publication, Canada, Department of Agriculture, Ottawa.

Lee, S. K. and A. A. Kader. 2000. Preharvest and postharvest factors influencing vitamin C content of horticulture crops. Postharvest Biology and Technology, 20 (3): 207-220.

Liang, Y. S., H. K. Kim, A. W. M. Lefeber, C. Erkelens, Y. H. Choi and R. Verpoorte. 2006. Identificaion of phenylpropanoids in methyl jasmonate treated *Brassica rapa* leaves using two-dimensional nuclear magnetic resonance *spectroscopy.* Journal of Chromatography, 1112: 148-155.

Nishijima, T., H. Sugii, N. Fukino and T. Mochizuki. 2005. Aerial tubers induced in turnip (*Brassica rapa* L. var. rapa (L.) Hartm.) by gibberellin treatment. Scientia Horticulturae, 105: 423-433.

Oboh, G. 2005. Effect of blanching on the antioxidant properties of some green leafy vegetables. LWT-Food Science and Technology, 38: 513-517.

Persson, K., A. S. Falt and V. R. Bothmer. 2001. Genetic diversity of allozymes in turnip (*Brassica rapa* L. var. rapa) from the Nordic area. Hereditas, 134 (1): 43-52.

Rangamma, S. 1977. Manual of analysis of fruits and vegetable products. Tata McGraw-Hill Pub. Comp. Ltd., New Delhi.

Rosa, E. A. S. 1997. Glucosinolates from flower buds of Portuguese Brassica crops. Phytochemistry, 44: 1415-1419.

Saeed, M. K., S. Anjum, I. Ahmad, A. Nisa, S. Ali, A. Zia and S. Ali. 2012. Nutritional facts and free radical scavenging activity of turnip (*Brassica rapa*) from Pakistan. World Applied Science Journal, 19 (3): 370-375.

Satter, M. M. A., M. M. R. L. Khan, S. A. Jabin, N. Abedin, M. F. Islam and B. Shah. 2016. Nutritional quality and safety aspects of wild vegetables consumed in Bangladesh. Asian Pacific Journal of Tropical Biomedicine, 6 (2): 125-131.

Steel, R. G. D., J. H. Torrie and Q. Dickey. 1997. Principles and procedures of Statistics. A Biomaterical approach 3rd Ed. McGraw Hill Book Co. Inc. New York. USA.

Trowbridge, F. and M. Martorell. 2002. Forging effective strategies to combat iron deficiency. Summary and recommendations. Journal of Nutrition, 85: 875-880.

Velasco, L., F. D. Goffman and H. C. Becker. 1998. Variability for the fatty acid composition of the seed oil in germplasm collection of the genus Brassica. Genetic Resources and Crop Evolution, 45: 371-382.

Wallbank, B. E. and G. A. Wheatley. 1976. Volatile constituents from cauliflower and other crucifers. Phytochemistry, 15: 763-766.

(Accepted: June 19, 2018)