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Retention of Ascorbic Acid and Major Mineral Contents in Water Spinach and Chinese Kale after Three Different Cooking Methods

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ABSTRACT

Introduction: The water spinach (*Ipomoea aquatica*) and Chinese kale (*Brassica oleracea* L. var. alboglabra) are popular in Malaysia, relatively cheap and rich sources of vitamins, dietary fibre and minerals. A study was conducted to determine the retention of ascorbic acid (vitamin C) and major minerals (zinc, iron and copper) in water spinach and Chinese kale after boiling, stir-frying and steaming. **Methods:** Ascorbic acid was determined using potassium iodate titration method. Major mineral contents were determined using atomic absorption spectroscopy. **Results:** The results showed that stir-frying retained the highest ascorbic acid level in both water spinach (64.4%) and Chinese kale (85.9 %). Zinc showed maximum retention in boiled water spinach (103.6%) while stir-fried Chinese kale retained the highest content of zinc (88.8 %). The retention of iron level in water spinach ranged from 49.1 to 101.3% while that in Chinese kale was from 42.5 to 117.5%. The highest retention of copper was obtained in steamed water spinach (93.6%) and boiled Chinese kale (106.3%). **Conclusion:** Stir-frying is the best cooking method to retain ascorbic acid in water spinach and Chinese kale while zinc, iron, and copper retention in both vegetables varied depending on the type of cooking. These findings could be part of consumer education on methods of food preparation for optimum nutrient retention.

Key words: Boiled, stir-fried and steamed vegetables, *Brassica oleracea* L. var. alboglabra, *Ipomoea aquatica*

INTRODUCTION

Vegetables are a crucial component of a nutritionally adequate diet because it provides sufficient amounts of nutrients especially vitamins and minerals. For a balanced diet, people are advised to eat more vegetables and less meat (Saika & Deka, 2013). Furthermore, vegetables are also a cheap and rich source of vitamins, dietary fibre and minerals (Joshua, Timothy & Suleiman, 2012).

Consumption of vegetables can greatly enhance the health status of individuals by providing dietary antioxidants, which prevent free radicals formation in human body (Nilsson, Stegmark & Akesson, 2004). Ascorbic acid is an excellent antioxidant in vegetables. A strong and consistent vegetable intake can protect against the

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risk of several age-related diseases such as cancer, cardiovascular disease, cataract and macular degeneration, which have been shown in some epidemiological studies.

Minerals play an important role in human metabolism and various studies show that there is relationship between trace element status and oxidative diseases. Inadequate dietary intake and poor bioavailability of iron from food, for example, can contribute to anemia (Kumari *et al.*, 2004). Zinc on the other hand interacts with cardiovascular cells and its deficiency leads to cellular damage and atherosclerosis (Little *et al.*, 2010). Copper is also essential for iron metabolism due to its presence in many enzymes. A direct correlation between dietary zinc and copper ratio and the incidence of cardiovascular disease have been reported in various studies (Bayir *et al.*, 2013)

Vegetables are usually consumed either in raw or cooked form. Most of the nutrients are retained in the raw state. However, some nutrients might be loss during or after cooking using various techniques. Most vegetables are commonly cooked before being consumed, although they are sometime used in salads or chutney in the raw form. It is well-known that cooking induces considerable changes in nutrients content especially vitamins. Boiling, stir-frying, and steaming are three common cooking methods in vegetables preparation in Asian countries. The amount of nutrients retained in cooked vegetables depends on the methods of cooking and the pre-processing conditions.

Nutrients loss during cooking is inevitable. Nutrient loss varies depending on type of food, length of processing time and type of nutrients (Fubara, Ekpo & Ekpete, 2011). Ascorbic acid, for example, is readily affected by enzymatic oxidation as well as light and metals (Santos & Silva, 2008). Cooking loss also depends on degree of heating, leaching into the cooking medium, pH and other factors (Bernhardt & Schlich, 2006). However, the bioavailability of some minerals such as iron may be increased by cooking due to effect of cooking utensils (Kumari *et al.*, 2004)

Water spinach (*Ipomoea aquatica*), also known as kangkung in Malay, and Chinese kale (*Brassica oleracea* L. var. Alboglabra), are two favourite vegetables among the Malays and Chinese, respectively in Malaysia. Water spinach and Chinese kale are rich in vitamins and also excellent sources of minerals. The nutrient contents in water spinach and Chinese kale have been reported by Umar *et al.* (2007); Igwenyi *et al.* (2011) and Chaiwon *et al.*(2013). However, information on nutrients retention during cooking has not being studied by many researchers. Thus, this study was conducted to determine the retention of ascorbic acid and content of major minerals in water spinach and Chinese kale under three different cooking techniques. This is very important so as to provide information on how greatly these cooking methods affect nutrient loss in water spinach and Chinese kale. Minerals analysedwere iron, zinc and copper, as they are known to be high in these vegetables, according to previous studies (Emebu & Anyika, 2011; Umar *et al.*, 2007)

METHODS

Sample

Water spinach and Chinese kale were randomly purchased fresh at two local hypermarkets. Each vegetable was then pooled, visually checked for quality and sorted for similar appearance.

Sample preparation

Both vegetables were carefully washed and cut into 1 cm pieces, and subjected to three different cooking methods as described below. The cooking methods followed home cooking practice, which included using normal tap water to illustrate the actual effect of retention of nutrients based on the traditional cooking practice. An amount of 100 g of raw vegetables were also served as control.

Steaming

One litre of water was boiled up to 100 °C in a wok. Next, 100 g of each chopped vegetable was placed on a rack above the water in the wok. The wok was covered, and the heat was adjusted to maintain a medium level (85°C). The vegetable was cooked for 10 min.

Boiling

For boiled vegetable preparation, 1500 mL of water was boiled up to 100°C in a heavy pot. Next, 100 g of each chopped vegetable was added into the pot, and the heat was adjusted to maintain a steady and rolling boil. The vegetable was cooked for 5 min.

Stir frying

For stir-fried vegetable preparation, 2.5 g of cooking oil (palm oil) was preheated in a wok, until 80°C. Then, 100 g of each chopped vegetables were stir-fried in the wok for 60 sec.

Ascorbic acid determination

Ascorbic acid was determined by redox titration with iodate as described by Aziz *et al.* (2013). About 100 g of raw or cooked sample was homogenised in a blender with 50 mL of distilled water. The pulp was strained and washed with 10 mL of distilled water. Next, the extracted solution was made up to 100 mL in a volumetric flask. About 20 mL of the sample solution was pipetted into a 250 mL conical flask and added with 150 mL of distilled water, 5 mL of 0.6 mol L−1 potassium iodide, 5 mL of 1 mol L−1 hydrochloric acid and 1 mL of starch indicator solution. The sample solution was titrated with 0.002 mol L−1 potassium iodate solution. The endpoint of the titration was the first permanent trace of a dark blue-black colour due to the starch-iodine complex. The titration was repeated three times with further aliquots of sample solution until concordant results were obtained (titres agreeing within 0.1 mL).

The average volume of iodate solution used was calculated. As shown in the titration equation below, the moles of ascorbic acid reacting was determined and the concentration of ascorbic acid in the solution obtained from the vegetable was determined:

$$IO_3^- + 5\,I^- + 6\,H^+ \rightarrow 3\,I_2 + 3\,H_2O$$

Minerals analysis

About 100 g of dried samples were subjected to preparation of ash by incineration in a muffle furnace at 550°C (AOAC, 1999). A portion of 0.5 g of the ashed sample was treated with 2 mL of 65 % nitric acid in a crucible placed on a hot plate, and heated at 100 °C for 2 min. The solution was cooled to room temperature (26°C), diluted to a final volume of 10 mL with deionised water and subjected to atomic absorption spectrophotometer analysis (Perkin Elmer-Analyst 800).

Retention of nutrients

The retention percentage (ascorbic acid and minerals) was determined as follows:
% retention = cooked weight of sample (g) x mg of nutrient/kg cooked vegetable x 100 initial weight of sample (g) x mg of nutrient/kg raw vegetable

Statistical analysis

Statistical analyses were carried out using one-way ANOVA using SPSS version 21.0. Significant differences were determined using Duncan multiple range test with a 95% significant level ($P < 0.05$). All values presented are means of triplicate determination with standard deviations.

RESULTS

Figure 1 shows the ascorbic acid and mineral (zinc, iron, and copper) contents in raw water spinach and Chinese kale. Chinese kale contained higher levels of ascorbic acid (13.7 mg/kg) than water spinach (1.8 mg/kg). However, the content of all three minerals in water spinach was

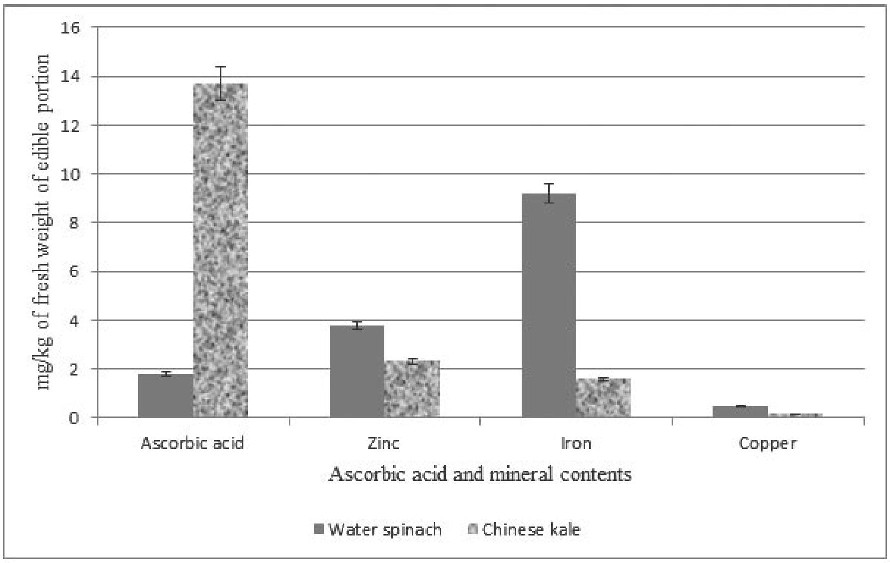

Figure 1. Ascorbic acid and mineral contents in raw water spinach and Chinese kale

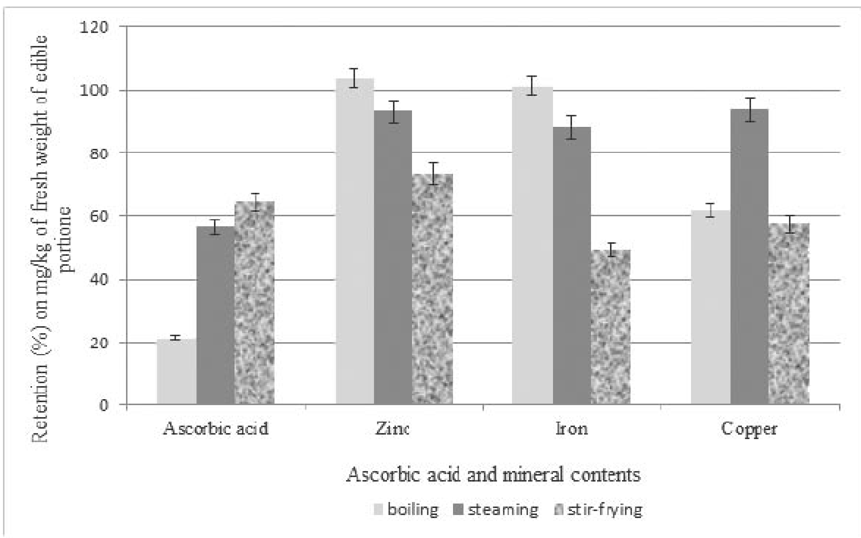

Figure 2. Retention of ascorbic acid and minerals in water spinach

higher than in Chinese kale. The amount of zinc, iron, and copper in water spinach was 3.8, 9.2 and 0.5 mg/kg respectively. On the contrary, the amount of zinc, iron and copper in Chinese kale was 2.3, 1.6 and 0.2 mg/kg respectively.

Figures 2 and 3 show the retention of ascorbic acid and major minerals in water spinach and Chinese kale cooked using different techniques. The highest retention of ascorbic acid was found in stir-fried water spinach (64.4%), followed

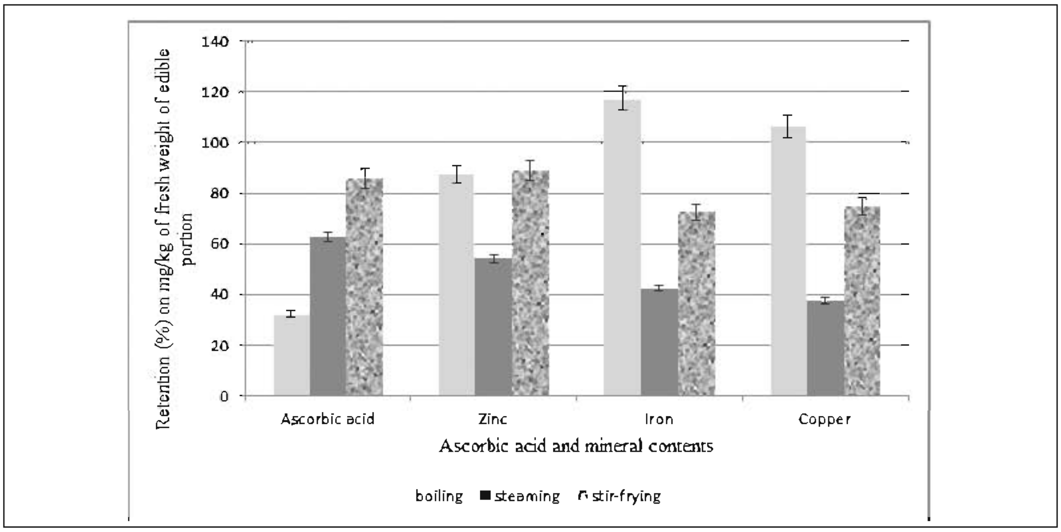

Figure 3. Retention of ascorbic acid and minerals in Chinese kale

by steamed water spinach (56.7%), and boiled water spinach (2.7%). Boiled water spinach significantly ($P < 0.05$) retained the least ascorbic acid among the three cooking methods. However, ascorbic acid retention in stir-fried Chinese kale was significantly ($P < 0.05$) higher (85.9%) than in steamed Chinese kale (62.7%). Ascorbic acid retention in boiled Chinese kale was also the least (32%) compared to stir fried and steaming methods of cooking..

In relation to zinc loss in the vegetables through cooking, our results showed that boiled water spinach was very stable to the boiling process by retaining 103.62% of zinc ($P < 0.05$). The zinc content in water spinach after steaming and stir-frying cooking accounted for 93.1% and 73.4% respectively. However, there was a significant ($P < 0.05$) reduction in retention of zinc in cooked Chinese kale in descending order: stir-frying (88.8%), boiling (87.6%) and steaming (54.1%).

Iron retention of water spinach ranged from 49.1 to 101.3%. Compared to its raw form ($P > 0.05$), there was a slight increase in retention of iron in boiled spinach (101.3%). The iron content in stir-fried water spinach was found to be the least stable since it could only retain 49.1% of iron. In boiled Chinese kale, there was a significant ($P < 0.05$) increase (117.5%) in retention of iron compared to raw Chinese kale. However, the lowest rate of iron retention ($P < 0.05$) was obtained in steamed Chinese kale (42.5%).

Cooking of water spinach using all three cooking methods resulted in copper loss. The highest copper loss was observed in stir-fried water spinach (42%) while the lowest loss was obtained in steamed water spinach (6%). However, for Chinese kale, copper content was found to be slightly increased in boiled Chinese kale (106.3%) in comparison to raw Chinese kale. Stir-fried Chinese kale retained about 75% of copper but steamed Chinese kale only retained 37.5% of the copper content.

DISCUSSION

Less ascorbic acid was retained in boiled broccoli as compared to steamed or microwaved cooking method (Warthesen *et al.*, 1984). This result is similar to the findings of the present study where boiled Chinese kale and water spinach only retained 22 – 32 % of the ascorbic acid content. Chinese kale and water spinach are leafy vegetables. Our finding is similar to a previous study which showed that the typical loss for ascorbic acid from cooking was around 40% for root vegetables and 70% for leafy vegetables (Selman, 1994).

Some of the factors that determine ascorbic acid retention in cooked vegetables are cooking method, amount of water used and cooking time (Howard *et al.*, 1999). A longer duration of boiling resulted in nutrients washing up and leading to degradation. This results in breakdown of plant cells and release of their content into the solution (Czarniecka-Skubina, 2001). In the present study, the vegetables were chopped into small pieces before cooking, which increased the surface area, hence causing a greater loss of ascorbic acid through leaching. A shorter cooking time and less cooking water favoured better preservation of ascorbic acid in vegetable. As stir frying required the least cooking time and no water was involved, it retained the highest ascorbic acid content in the present study.

According to Czerwinska (2003), thermal treatment of leafy vegetables leads to about 70% ascorbic acid reduction. In this study, the highest ascorbic acid loss of 78% was found in boiled water spinach. The rate of ascorbic acid degradation in an intermediate moisture model food system is dependent upon oxygen availability, which in turn depends upon temperature and moisture content. It is known that the higher the water activity, the greater the loss of ascorbic acid (Masrizal, Giraud & Driskell, 1997). According to Rumm-Kreuter & Demmel (1989), the main mechanisms of ascorbic acid losses appear to be due to water solubility and mass transfer, heat sensitivity, and enzymic oxidation.

The present study found an increase in iron, zinc and copper content in boiled vegetables. The increase was observed only in the cooking method which involved addition of water into the vegetables. Thus, the increase in mineral contents was probably contributed by the water used. The water used in this study might have been relatively high in total dissolved solids which might have contributed to the increase in mineral content in the vegetables. Though the use of normal tap water introduced a confounding factor, the results reflect common practices in cooking among the general public. Variation due to water content does contribute to the actual nutrient retention values, which translates into actual nutrients being consumed. Lewu, Adebola & Afolayan (2009) and Shah *et al.* (2011) also found increased levels of iron in cooked cocoyam and pulses, respectively. The increase in iron content in cooked vegetables could also be due to the leaching out of anti-nutrients such as oxalate, which in turn improves the availability of iron (Shah *et al.*, 2011).

Except for boiling, other cooking methods showed appreciable losses in the mineral contents of water spinach and Chinese kale in the present study. Similar results were reported by Acho *et al.* (2014) and Pereira *et al.* (2014) in various vegetables. Though heat does not affect the mineral contents through cooking process, mall losses may occur due to leaching of minerals during the process of washing vegetables (Bains & Shruti, 2007). In this study, the retention of iron, zinc and copper were considerably high when water spinach was steamed, whereas Chinese kale retained most of the minerals better during stir-frying. Both methods are regarded as waterless type of cooking. Thus, significant losses of minerals can be prevented by choosing a cooking method which does not use water.

Mineral retention values were not similar for both water spinach and Chinese kale. A significant source of variation in mineral retention values was due to the type of vegetable and its interaction with the type of cooking method (Masrizal *et al.*, 1997). It appears that there is variability in the plant matrix such as interaction of enzyme and genotypic differences, which contribute to the difference in retention values of minerals in these vegetables. According to a study by Amaro-Lopez, Zurera-Cosano and Moreno-Rojas (1999), even in the same species of vegetable (asparagus), loses of mineral concentration vary, due to a difference in the level of cell development and stage of vegetative growth which involves different mobilisation of mineral elements to the tissue.

CONCLUSION

With respect to retention of ascorbic acid, the best cooking method for both water spinach and Chinese kale is stir-frying. Retention of mineral content was good in stir-fried and steamed kale and water spinach. It is recommended that efforts be extended to reduce cooking time and use a minimal quantity of water for boiling. Use of limited amounts of water in the preparation of soup or gravy may considerably increase the nutrients consumed.

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REFERENCES

Acho FC, Zoue LT, Koua GYA, Kra SAK & Niamke SL (2014). Effect of cooking on nutritive and antioxidant properties of leafy vegetables consumed in southern Cote d'voire. *Int J Res Biosci* 3: 75-78.

Amaro Lopez MA, Zurera-Cosano G & Moreno-Rojas R (1999). Nutritional evaluation of mineral content changes in fresh green asparagus as a function of the spear portions. *J Sci Food Agric* 79: 900-906.

AOAC (1999). Official Methods of Analysis of the Association of Analytical Chemist, 16th ed. Washington DC

Aziz M, Jadoon S, Parveen S, Uddin Z, Amanat H & Ayub H (2013). Evaluation of copper metal in water and determination vitamin C concentration, its reduction ability and copper metal in T*rigonella foenumgraceum* growing in Channat valley POK Kashmir. *Int J Env Biol* 3: 41-45.

Bains K & Shruti (2007). Analysis of various vegetable preparations for calcium, iron and zinc intake of Punjabi urban and rural families. *Nat Product Radiance* 6:106-110.

Bayir A, Kara H, Kiyici A, Ozturk B & Akyurek F (2013). Levels of selenium, zinc, copper and cardiac troponin I in serum patients with acute coronary syndrome. *Biol Trace Elem Res* 154: 352-356.

Bernhardt S & Schlich E (2006). Impact of different cooking methods on food quality: Retention of lipophilic vitamins in fresh and frozen vegetables. *J Food Eng* 77: 327-333.

Chaiwon F, Santasup C, Springarm K & Shutsrirung A (2013). Antioxidant activity, vitamin C content and growth of Chinese kale in response to high humus seedling media and beneficial microorganism. *CMU J Nat Sci* 12: 79-89.

Czarniecka-Skubina EGB (2001). Effect of culinary process on selected vegetables quality. *Żywn Nauka Techn Jakość* 2: 103-115.

Czerwinska D (2003). Effect heat treatment on the nutritional value of food. The shorter the better. *Przegląd Gastroenterologiczny* 3: 16-18.

Emebu PK & Anyika JU (2011). Proximate and mineral composition of kale (*Brassica oleracea*) grown in Delta State, Nigeria. *Pakistan J Nutr* 10: 190-194.

Fubara EP, Ekpo BO & Ekpete OA (2011). Evaluation of the effects of processing on the minerals contents of maize (Zea mays) and groundnut (*Arachis hypogaea*). *Libyan Agric Res Cent J Int* 2: 133-137.

Howard LA, Wong AD, Perry AK & Klein BP (1999). Beta-carotene and ascorbic acid retention in fresh and processed vegetables. *J Food Sci* 64: 929-936.

Igwenyi IO, Offor CE, Ajah DA, Nwankwo OC, Ukaomah JI & Aja PM (2011). Chemical compositions of *Ipomea aquatica* (green kangkong). I*nt J Pharma Bio Sci* 2: 593-598.

Joshua ZP, Timothy AG & Suleiman MM (2012). The effect of cooking time on the vitamin C, dietary fiber and mineral compositions of some local vegetables. *Sci World J* 7: 29-30.

Kumari M, Gupta S., Lakshmi AJ & Prakash J (2004). Iron bioavailability in green leafy vegetables cooked in different utensils. *Food Chem* 86: 217-222.

Lewu MN, Adebola PO & Afolayan AJ (2009). Effect of cooking on the mineral and the antinutrient contents of the leaves of seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa. *J Food Agric Environ* 7: 359-263.

Little PJ, Bhattacharya R, Moreyra AE & Korichneva IL (2010). Zinc and cardiovascular disease. *Nutrition* 26: 1050-1057.

Masrizal MA, Giraud DW & Driskell JA (1997). Retention of vitamin C, iron and beta-carotene in vegetables prepared using different cooking methods. *J Food Qual* 20: 403-418.

Nilsson J, Stegmark R & Akesson B (2004). Total antioxidant capacity in different pea (*Pisum sativum*) varieties after blanching and freezing. *Food Chem* 86: 501-507.

Pereira EJ, Carvalho LMJ, Dellamora-Ortiz GM, Cardoso FSN, Carvalho JLV, Viana DS, Freitas SC & Rocha MM (2014). Effect of cooking methods on the iron and zinc contents in cowpea (*Vigna unguiculata*) to combat nutritional deficiencies in Brazil. *Food Nutr Res* 58:20694-*http://dx.doi.org/10.3402/fnr.v58.20694.*

Rumm-krreuter DR & Demmel I (1989). Comparison of vitamin losses in vegetables due to various cooking methods. *J Nutr Sci Vitaminol* 36: S7-14

Saika P & Deka DC (2013). Mineral content of some wild green leafy vegetables of North-east India. *J Chem Pharma Res* 5: 117-121.

Santos PHS & Silva MA (2013). Retention of vitamin C in drying process of fruits and vegetables – a review. *Drying Tech* 26: 1421-1437.

Selman JD (1994). Vitamin retention during blanching of vegetables. *Food Chem* 49: 137-147.

Shah HU, Khan UL, Alam S, Shad AA, Iqbal Z and Parveen S (2011). Effect of home cooking on the retention of various nutrients in commonly consumed pulses in Pakistan. *Sarhad J Agric* 27: 279-284.

Umar KJ, Hassan LG, Dangonggo SM & Ladan MJ (2007). Nutritional composition of water spinach (*Ipomea aquatic* forsk) leaves. *J Appl Sci* 7: 803-809.

Warthesen J, Vickers Z, Whitney-west S & Wolf I (1984). Cookery methods for vegetables: Influence on sensory quality, nutrient retention, and energy consumption. *Home Econ Res J* 13(1): 61-79.