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Quality assessment of stored watercress (*Nasturtium oficinale* R.Br.) vegetable at freezing temperature

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Abstract

Watercress (*Nasturtium officinale* R. Br.) is a leafy vegetable belong to family Brassicaceae. It is used as raw and processed form in our area. But this vegetable has a short postharvest life. Keeping in views this study was deliberate to evaluate the effect of blanching and cooking with the combination of polyethylene bags on postharvest life of stored watercress vegetables at freezing temperature. The physico-chemical attributes i.e. moisture loss, crude fibre, ash content, titratable acidity (TA), pH, total sugar (TS), ascorbic acid, β-carotene and sensory characteristics like colour, texture, taste, flavour and overall acceptability were studied at an interval of 5 days (1st, 5th, 10th, 15th, 20th day) during storage. All of the treatments had shown a highly significant effect ($p<0.05$) on physcio-chemical and sensory parameters of vegetables. However, among all treatments blanching + polyethylene bag was proved most effective in the retention of crude fibre, ash content, ascorbic acid, β-carotene and sensory parameters i.e texture, taste and flavor. The treated vegetable have increased storage life up to 20 days as compared to control which was un acceptable after 7th day of the storage. The results suggested that blanching + polyethylene bags with freezing temperature might be helpful to increase the storage life of watercress vegetables for distant marketing.

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Introduction

Watercress is highly nutritious dark leafy vegetable and known by its communal terms in world i.e. biller, long tails, rib cress and brown cress etc. (James, 2009). Its annual production in United Kingdom and France is about 2500t and 10,000t whereas Africa also cultivates it on small scale (Schippers, 2004). Watercress plays an important role in diet and health because it contains good quantity of fiber, protein, vitamins, minerals and carotenoids and generally diminutive source in daily diets in remote zones (Raju *et al.*, 2007; Mosha and Gaga, 1999). It help to reduce the effect of itching on the skin, serve as a laxative and also aid to inhibit scurvy disease due to presence of nutrients (Schippers, 2004). Moreover, watercress provides color, taste and flavor (Horsfall *et al.*, 2007).

It is eaten in raw (salad) and cooked form (soups) and also used as a pungent garnish (Farida *et al.*, 2008). Quality of watercress is maintained due to presence of its natural components (Ashoor and Knox, 1984). Vegetables play vital parts in assuaging starvation and food safety by contributing majority of the nutritive constituents in the regimes of populaces where animal produces are threatened (Horsfall *et al.*, 2007). Several aspects might interfere in composition especially most common factors are varieties, environment, time and condition of cultivation, type of soil, stages of maturation, light exposure, processing and storage conditions(Rodriguez-Amaya, 2000; Amaya-Farfan, 1999; Olson, 1999). Storage of vegetables is more important because it is a seasonal vegetable. The aim of present research was to study the effect of postharvest treatments on proximate, physico-chemical and sensory attributes of watercress at freezing temperature.

Materials and methods

Dark Green, firm and fully matured watercress vegetable was directly picked from the field of farmer and transferred immediately to Food Technology laboratory in PCSIR, Peshawar. The sample was washed, cleaned and dried in the presence of fan for 5 minute. After drying samples were divided into five slots first used as Control (T_1), second fresh (T_2) and remaining samples were processed in following manners such as cooked for 5 minutes (T_3) and blanched at 100°C for 3 minute (T_4). All Samples were packed in polyethylene bags except control, stored at freezing temperature and analyzed for the following parameters.

Moisture loss percent

Moisture content was evaluated by using 5g of sample. This sample was putted into oven at 550°C for one hr. and repeated it three times to calculate its value according to AOAC (1994) method.

Crude fiber (%)

Crude fiber was assessed by using the standard method of AOAC (2000).Defatted two gram sample was neutralized by using 200 ml H_2SO_4 (0.25N) and 200ml NaOH into 500ml beaker respectively and heated up to ½ hrs by continuous stirring if fume appear put The asbestos (anti fuming agent) was used during heating. The solution was filtered and collected the residues into china dish to dry in oven, noted the values (W_1) and again put dried sample in furnace for ashing and record the reading (W_2). Calculate it by using formula $W_2 - W_1$.

Ash content (%)

About three gram dried sample was putted in muffle furnace at 550°C in order to determine the ash content by using the standard methods of AOAC (2000).

Titratable acidity (%)

Ten milliliter of juice was collected in beaker and diluted it with 100ml distill water. Diluted juice was titrated against 0.1N NaOH until final results obtained. It was repeated three times to determine the exact reading of titratable acidity according to method of AOAC (1994).

pH

pH meter was used to determine the pH value of diluted juice by dipping its electrode in 100ml conical flask (AOAC, 1994).

Total sugar

Fehling solutions were used in order evaluated the total sugar by using the standard method of AOAC (1990).

Ascorbic acid (mg/ 100ml of vegetable juice)

Dye 2.6-dichlorophenol indo-phenol was used to titer the 10ml solution to determine ascorbic acid according to method of AOAC (2000). Following formula was applied to calculate it value:

Ascorbic acid per 100ml juice = dye equivalent × titer × dilution

β-carotene (µg/100g)

Five gram of watercress sample was took and crushed by using 10-15ml acetone; add a few crystal of anhydrous sodium sulphate. Extracted sample was put in to separating funnel with addition of 10-15ml petroleum ether. This mixture was shaken and stands for one hr until its two layers was separated. Upper layer was used to determine the β-carotene according to method of AOAC (1990) at 452 nm. It can be calculated by following formula:

$$\beta\text{-carotene } (\mu g/100\,g) = O.D \times 13.9 \times 10.4 \times 10 / \text{Wt. of sample} \times 560 \times 1000$$

Sensory evaluation

Five judges were selected from department of Food Science and Technology to check the colour, flavour, texture, taste and overall acceptability of stored samples. A nine point hedonic scale was used for sensory evaluation as described by Larmond (1977).

Statistical analysis

The obtained data was statistically analyzed on the basis of two-factor factorial in complete randomized design as designated by Steel *et al.* (1997) using MSTAT-C software (Michigan State University, 1991, United States of America).

Results and discussion

Moisture loss (%)

Fig. (1a) showed that moisture percentage of watercress leaves was significantly decreased with the advancement of period. Mean values of treated sample depicted gradual reduction of moisture content as compared to control at low temperature. This trend was also observed by Bushway *et al.* (1985) that moisture content in vegetables decreased during processing and storage. Similar result was indicated by Farida *et al.* (2008) detected that mean values of MC in stored vegetables at low temperature change slowly.

The fresh + polyethene (FP) and cooked + polyethylene (CP) was showed insignificant difference and higher retention of moisture content in blanched + polyethylene (BP) was observed as compared to control (*C*) These consequences displays that greater retaining of moisture in preserved sample was due to the providing modified atmosphere condition which should be prove helpful in reduction of evaporation rate and maintain the moisture loss. These results are in line with the study of Purvis (1984) who examined that loss was significantly decreased due to seal packaging with low density polyethylene film. Because, polyethylene bags packaging was played an important role to control loss of plants (Kawada and Albrig, 1979). Present results are also agreed with the previous study of Artemio *et al.* (2002) who confirmed that minimum degradation occurred in packed vegetables at low temperatures.

Crude fiber (%)

Fiber content of watercress vegetable was evaluated during storage. The result displays in Fig. 1b shown decreasing trends in fiber content of stored sample from 1st day to 20th day at low temperature. Reduction of fiber content in present research correlated with previous study of Bushway *et al.* (1985). It can be due to thermal-powered enthusiasts of carbohydrates in the cell wall Rickman *et al.* (2007).

The highest value of fiber content was noted in BP and CP followed by FP as compared to control. The present work on quality attributes of processed and stored fruits and vegetables are stable throughout storage period is also agreed with Shahnaz *et al.* (2003) and Rickman *et al.* (2007).

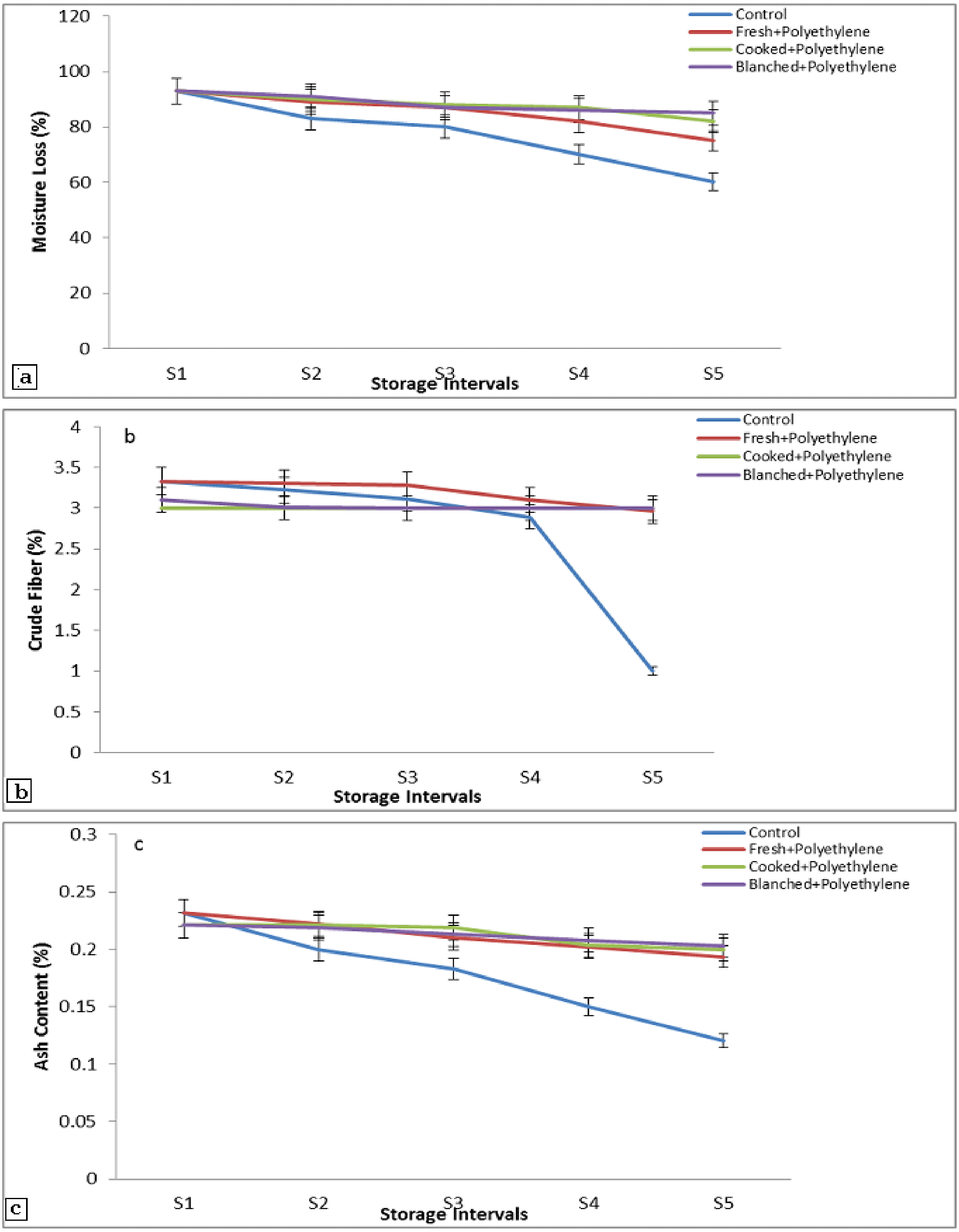

Fig. 1 (a,b,c,). Effect of treatments on proximate composition of watercress during storage.

Ash content (%)

The ash content is an amount of the essential minerals found in the food (Lewu *et al.* 2009). Data relating to the ash (Fig. 1c) revealed overall tendency of ash in stored sample. Reduction in ash content was perceived in all treated watercress sample with the advancement of period. Highest quantity of ash was detected at 1st day and decreased values were depicted at last day of storage. This decline may be due to increase of storage time or might be water preoccupation during dispensation causing to enfeeblement and these results in line with (Lewu *et* al., 2009; Eugene et al. (2003). Maximum ash value was noted in BP followed by CP, FP as compared to control. Higher retention of ash content may be due to the slow variation in mineral contents in present research are in line with Shahnaz et al. (2003).

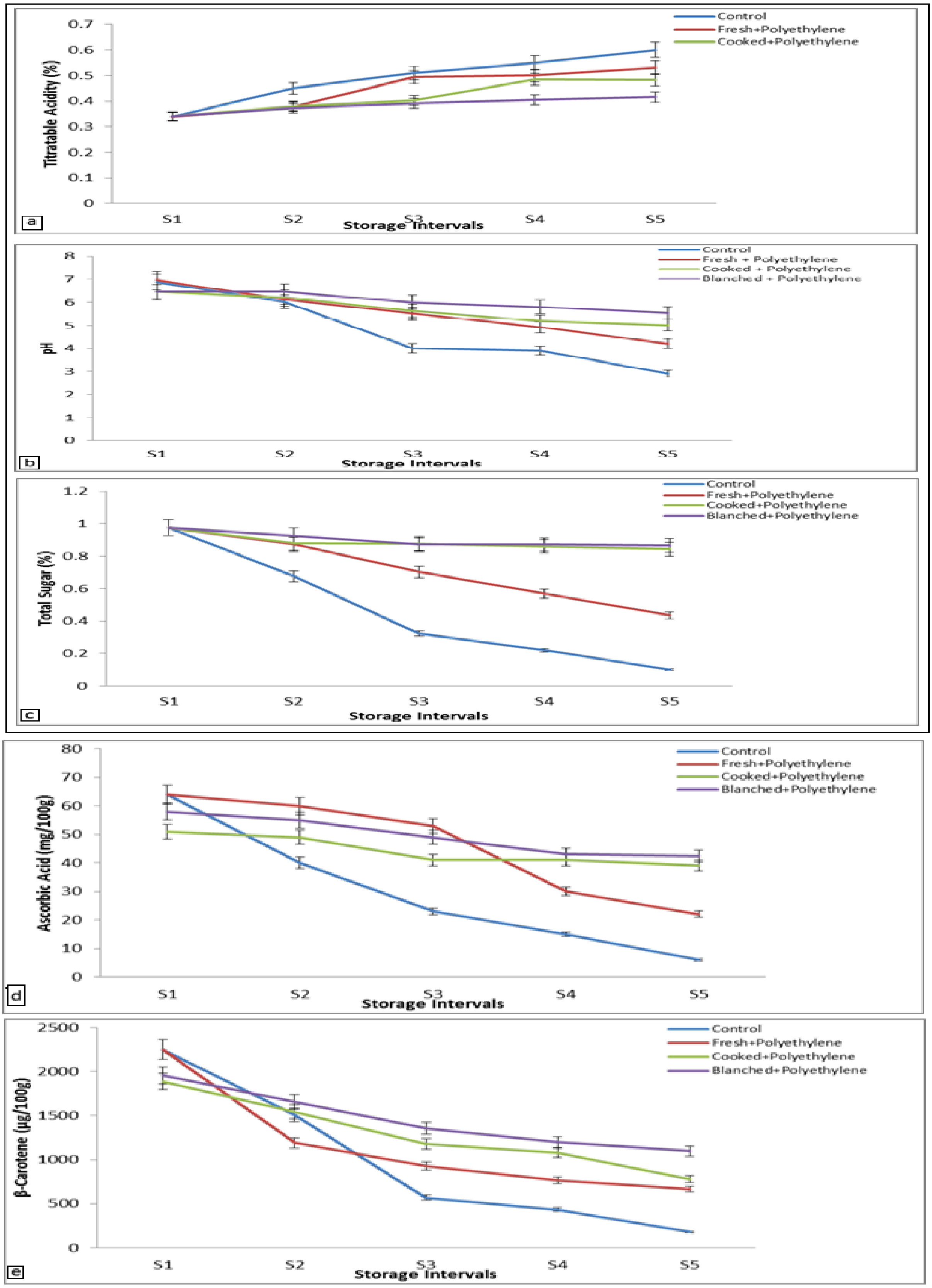

Fig. 2 (a,b,c,d,e). Effect of treatments on physico-chemical composition of watercress during storage.

Titratable acidity

Data given in Fig. 2a was exhibit titratable acidity (TA) of watercress. TA was increased during storage may be due to the variation of organic acids (salt and ester form) are agreed with Shakir *et al.* (2008).Organic acid have a better taste influence than inorganic acids at the same pH (DeMan, 1999). Organic acids are available in most vegetables which are required to carry out the metabolic process Wills *et al.* (1989). The greater mean value was detected in FB and least in control might be due to less oxidation process of vegetables or slow degradation of ethylene carbon dioxide and water are in line with studies of Agar *et al.* (1995) and Wills *et al.* (1981).

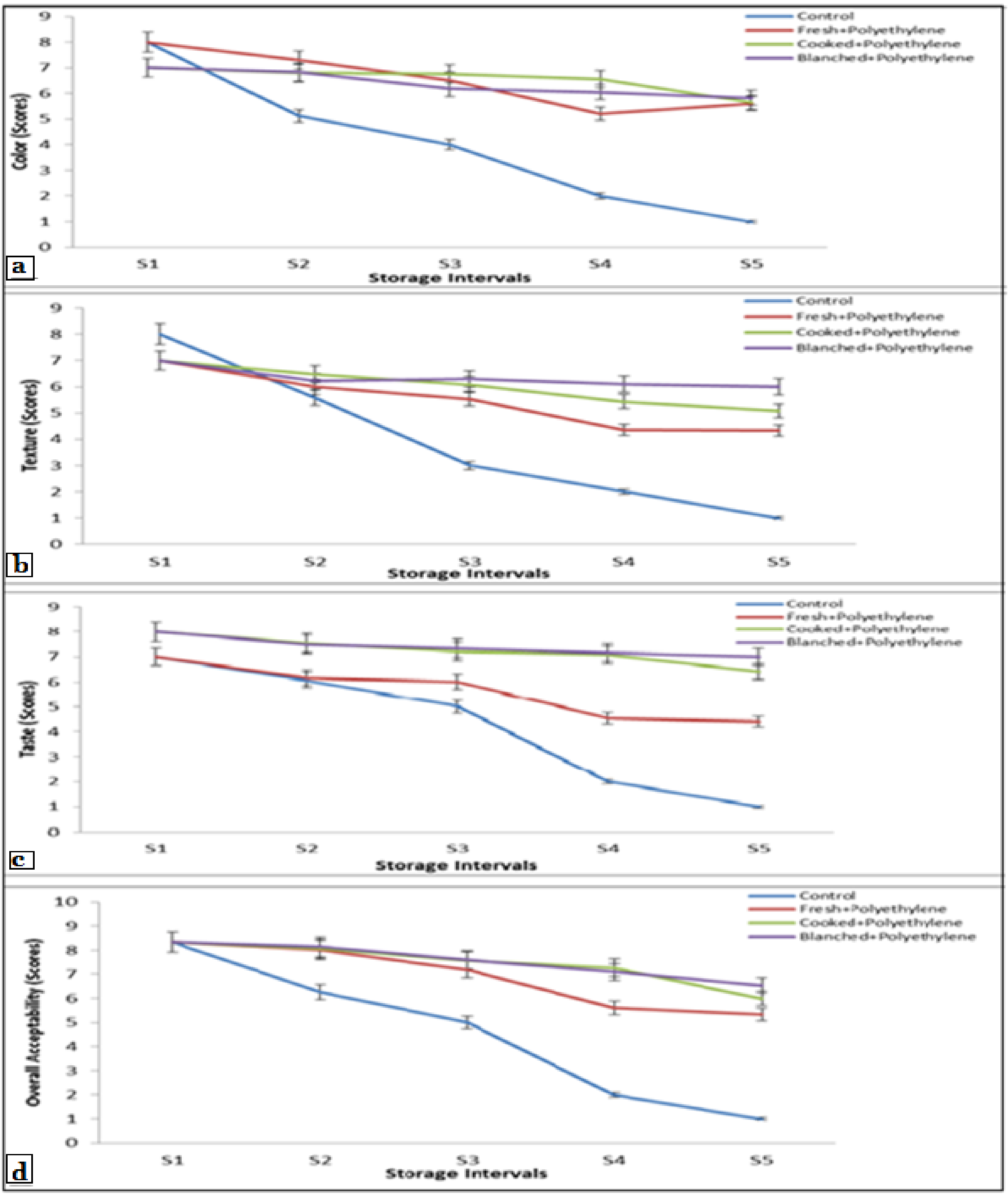

Fig. 3 (a,b,c,d). Effect of treatments on sensory evaluation of watercress during storage.

pH

Data concerning pH presented in Fig. 2b show decreasing trend during storage. This trend may be due to metabolic process which is responsible to increase the organic acid indirectly it's a measurement of pH. Similar results were observed by the investigation of Shakir *et al.* (2008). Fig. 2b depicted maximum retention in BP, CP and FP respectively. These treatments showed a significant difference statistically. Several aspects influence on the infection development rate in vegetables. So, low temperature helped to control the postharvest decay which is responsible to increase pH of processing fruits and vegetables. Mean value of pH aid in regulation of microbial growth and also minimum pH has good effect on the nature of processing which is required to increase shelf life of vegetable. These consequences are in line with Ehsan *et al.* (2003).

Total Sugar

Result related to total sugar showed decreasing trend in stored samples of watercress (Fig. 2c). Highest mean value depicted on first day and lowest value was observed on last day of storage. This phenomenon in total sugars in storage period due to high quantity of organic acid or slower the metabolic process. Main factor cause reduction of sugar can be heat treatment during storage as stated by Adewusi and Falade (1996). Sugars such as glucose, fructose, maltose and sucrose have a key protagonist in food biological systems and supply energy. High concentrations of sugar are responsible to reduce the growth of micro-organisms (DeMan, 1999). All treatment had significant difference from each other. Fig. 2c depicted that the CP and BP have maximum percentage of sugar followed by FP and minimum sugar was observed in control. Present results correlated with the study of Wang (2006) exhibited slow decline of sugar due to be slowly alteration in polysaccharides.

Ascorbic acid

Major component of fruit and vegetable is ascorbic acid (DeMan, 1999; Howard *et al.*, 1999) that plays an important role in human health. The data pertaining on ascorbic acid of watercress during storage had shown decreasing trend (Fig. 2d). Mean value of the ascorbic acid content decrease from first to last day of storage might be due to action of enzymes, light exposure and prolonged heating in the presence of oxygen (DeMan, 1999). Ascorbic acid is least stable and is easily destroyed in processing and storage. Especially cooking and blanching affects the nutrient retention (Shameem *et al.*, 2009) and could possibly to reduce leaching of ascorbic acid into water. In present research the ascorbic acid content was slowly decreased with the passage of time at low temperature are in agreement with the previous study of Shameem *et al.* (2009) for stored vegetables at same condition. The interactions among storage intervals, treatments and storage with treatments had significantly different from each other. These results are confirmed with the Shameem *et al.* (2009); Fafunso and Bassir (1976) and Krehl and Winters (1950). Retention in stored packed blanch sample might be due to low temperature/freezing which is responsible to slowdown the process of oxidation process in ascorbic acid agreed with the study of Martins and Silva (2004) and Summer *et al.* (1983). Similarly study were recorded by Howard *et al.* (1999) for freeze vegetable for prolong period of time with maximum retention of composition.

β-carotene

The most important and beneficial nutrient in diet is carotenoids from health point of view which act as an antioxidants (Farida *et al.*, 2008; Khalil and Saleemullah, 2004). β-carotene is significant constituent of carotenoids present in fruits and vegetables enhanced the humeral and cell-mediated immune responses (Chew *et al.*,1991). Fig. 2e depicted the mean values of β-carotene present in watercress from first to last day of storage. Whole storage period was showing decreasing trend, this may lead to oxidation by lipid peroxides, storage temperature and duration (DeMan, 1999) or as a result of heat destruction of the tissues (Howard *et al.*, 1999) or cooking cause to partial loss of nutrients and considerable changes in its sensory characteristics (Kala and Prakash, 2004). During postharvest storage, carotenoid were decreased in leafy vegetables as in line with Negi and Roy (2000) and Craft *et al.* (1988) reported β-carotene was loss due to storage. Fig. 2e had shown the maximum retention of BP as compared to control. Freezing temperature may be responsible in reduction of leaching of it into water. Present study are correlated with previous research of Howard *et al.* (1999); Klein and Perry (1982); Fennema (1975).

Sensory evaluation

Colour

Colour is an important quality factor to determine the anaesthic presentation of product. Pigments contribute the colour of plant which is flavonoids, chlorophylls, betalains and carotenoids. Most important color of plant is green which developed by chlorophyll pigment (Kays, 1991). Color reduction was reported in stored watercress (Fig. 3a) that may be due to climatic factors affect before harvesting. The color score was decreased during storage might be due to the degradation of chlorophyll by the activity of enzymes and low pH of medium is in line with the Dong *et al.* (2004) and Canjura *et al.* (1999). All treatments are significantly differing from each other except FP and BP. Maximum scores was found in FP and BP as compared to control. Freezing storage of watercress leaves helped in retention of chlorophyll similar studies were observed by Dong *et al.* (2004), Lisiewska *et al.* (2004) and Kidmose and Hansen (1999) for blanched and stored different vegetable species.

Flavour

Receptors present in mouth aid to perceived senses such as taste and smell (DeMan, 1999). Mean scores of flavor were decreased with the passage of time (Fig. 3b). Reductions of flavor scores may be due to storage life inversely affect the flavor or other possible reason is degradation of ethylene into carbon dioxide and water because CO_2 responsible to the formation of bad smelling aldehydes (Kader, 1992 and Wills *et al.* 1981). Fig. 3b shows that all the treatments are highly significantly different during storage. The maximum mean value of flavor in stored sample may be due to the high retention of soluble sweeteners and volatiles compounds that conserved flavour for a longer period are agreed with Martins and Silva, (2004).

Texture

Texture is an important quality parameter followed by flavour and colour (DeMan, 1999). Texture is identified by its characteristics i.e. hardness, viscosity and elasticity (Szczesniak and Kleyn, 1963). Eating quality of vegetables is related to the cellular structure (texture) of these materials (Reeve and Brown, 1968a, b). Data on texture of stored watercress was showing decreasing trend with the advancement of period (Fig. 3c) are in line with earlier study of Rizzo and Muratore (2009) for firmness reduction in stored samples. This decreased in texture score of sample should possibly due to change in pectic substances which are responsible for the firmness of the vegetables. During storage insoluble form of pectic substances i.e. protopectin is gradually broken to soluble form cause softening of vegetables (Wills *et al.*, 1981). Fig (3c) showed significant difference among the treatments. The texture was observed maximum in blanching + polyethylene as compared to control show minimum. Maximum score showing maximum retention which may be due to slow change of pectin substance to soluble forms (Weichmann, 1987). Present results were in agreement with the Martins and Silva (2004).

Taste

Human buds are able to identify thousands of different tastes. Basic tastes such as bitter, salty, sour and sweet have traditionally been categorized. The sweet, sour, salty and bitter taste of the vegetables due to sugars, acids, salt (sodium chloride) and great organic and inorganic compounds (DeMan, 1999). Data related to taste mean score showed significantly reduction trend during storage (Fig. 3d). The decreased in taste score might be reason to quick conversion of carbohydrate into simpler compounds or due to change of phenolic compounds. Present results are in line with the Kays (1991) who noted similar trend in stored samples. Good taste was observed in Maximum taste score 7.4 was observed in

BP and CB having bad taste during storage Slow change observed in BP and CB might be due to the slowly alteration of carbohydrates in vegetables. Organoleptic attributes are maintained at frozen temperatures are in agreement with results of Batal (2006) and Martins and Silva (2004) showed similar study.

Overall acceptability

Sensory properties such as colour, texture and flavor depicted the overall acceptability of vegetables are significant aspects of the food consumer point of view (Horsfall *et al.*, 2007). Acceptance or rejection of a specific product is depending upon the judgment of consumers (Wills *et al.*, 1981). Mean scores of overall acceptability of treated watercress at freezing temperature present in Fig. 3e indicated decreasing trend. This trend might be due to alteration of organic acid responsible to spoil the taste of stored vegetables. Present investigations are in line with the study of previous scientist Rizzo and Muratore (2009). All treatments are significantly different during storage (Fig. 3e). The treatments blanching + polyethylene and cooking + polyethylene showed highest overall acceptability as compared to control having lowest score during storage. The maximum retention of overall acceptability could be slow alteration of biochemical process during storage period. However, these treatments are proved beneficial in retention of nutritional qualities of watercress sample with the advancement of period. These results are in confirmation with the previous finding of Horsfall *et al.* (2007).

Conclusion

The effect of blanching and cooking on postharvest life of stored watercress packaged in sealed polyethylene bags was examined at freezing temperature. The quality attributes and sensory parameters were investigated to 20 days of storage period. All of the treated samples had exposed a significant effect on shelf life of watercress. Though, the treatment (blanched packed watercress in polyethylene) was proved more beneficial in respect to total soluble solids, titratable acidity, total sugar and organoleptic characteristics like colour, flavour, texture, taste and over all acceptability at freezing temperature. While, treatment (cooked sample of watercress packed in polyethylene) was observed superior as compared to other treatments.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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Reference

Adewusi SRA, Falade OS. 1996. The effects of cooking on extractable tannin, phytate, sugars and mineral solubility in some improved Nigerian legume seeds. Food Science and Technology **2,** 231- 239. https://doi.org/10.1177/108201329600200405

Agar T, Polate A. 1995. Effect of different packing materials on the storage quality of some apricot varieties. Acta Horticulturae **384,** 625- 631. https://doi.org/10.17660/ActaHortic.1995.384.98

Amaya-Farfan J. 1999. Overview of research on carotenoidesin Brasil. Perspective and Needs. Arch Latinoam. Nutrition **49,** 92- 94.

AOAC. 1990. Official Method of Analysis, Association of Analytical Chemists. Arlington Virginia, USA.

AOAC. 1994. Official Method of Analysis, Association of Analytical Chemists. Ed 16th, Arlington Virginia, USA.

AOAC. 2000. Official Method of Analysis, Association of Analytical Chemists. Ed 16th, Arlington Virginia, USA.

Arthey D, Philip RA. 2005. Fruit Processing

Nutrition, Product and Quality Management, Ed 2nd Brijbasi Art Press Limited, India 45.

Artemio ZT, Ose JK, Chachin K, Ueda Y. 2002. Effects of storage temperatures on the postharvest quality of jute leaves (Corchorusolitorius L.). Postharvest Biology and Technology **26,** 329- 338. https://doi.org/10.1016/S0925-5214(02)00065-0

Ashoor SH, Knox JM. 1984. Determination of organic acid in food by high performance liquid chromatography. Journal of Chromatography **299,** 288-292. https://doi.org/10.1016/S0021-9673(01)97843-4

Batal KM, Heaton EK, Granberry DM, Beuchat LR. 2006. Effects of n6-benzyladenine and storage temperature on shelf-life and quality of raw and cooked broccoli (Brassica oleracea L. var. italica). Journal of Food Science **47,** 1675- 1678. https://doi.org/10.1111/j.1365-2621.1982.tb05009.x

Bushway AA, Serreze DV, Mcgann DF, True RH, Work TM, Bushway RJ. 1985. Effect of processing method and storage time on the nutrient composition of fiddlehead greens. Journal of Food Science **50,** 1491- 1492. https://doi.org/10.1111/j.1365-2621.1985.tb10508.x

Canjura FL, Watkins RH, Schwartz SJ. 1999. Colour improvement and metallo-chlorophyll complexes in continuous flow aseptically processed peas. Journal of Food Science **64,** 987-990. https://doi.org/10.1111/j.1365-2621.1999.tb12265.x

Chew BP, Wong TS, Michal JJ, Standaert FE, Heirman LR. 1991. Subcellular distribution of ß-carotene, retinol and α-tocopherol in porcine lymphocytes after a single injection of ß-carotene. Journal of Animal Science **69,** 4892-4897. https://doi.org/10.2527/1991.69124892x

Craft N, Brown E, Smith J. 1988. Effects of storage and handling conditions on concentrations of individual carotenoids, retinal and tocopherol in plasma. American Association of Clinical Chemistry **7,** 15- 25.

DeMan JM. 1999. Principles of Food Chemistry. 3rd Edition.Springer (India) Science and Business Media. ISBN 81-81-8128-545-X

Dong H, Jiang Y, Liu R, Guan H. 2004. Effects of hot water immersion on storage quality of fresh broccoli heads. Food Technology and Biotechnology **42,** 135-139.

Ehsan EB, Naeem ZP, Javed A, Nazir A. 2003. Development, standardization and storage studies on grape fruit apple marmalade. Pakistan Journal of Food Science **13**, 11-15.

Eugene NO, Alexius CI, Chinyere G. 2003. Influence of heat processing on the nutrient composition of vegetable leaves consumed in Nigeria. Plant Foods for Human Nutrition **58**, 1-11. https://doi.org/10.1023/B:QUAL.0000040327.57587.db

Fafunso M, Bassir O. 1976. Effect of cooking on the vitamin C retention of fresh and wilted leaves. Journal of Agricultural and Food Chemistry **24,** 354-357. https://pubs.acs.org/doi/abs/10.1021/jf60204a054

Farida A, Khan BA, Noreen N, Masood T, Faisal S. 2008. Boiling and storage on β-carotene content of different vegetables. Pakistan Journal of Society Science **6,** 63-67.

Fennema O. 1975. Preservations of food by chilling temperatures. In Principles of Food Science: Part II. Physical Principle of Food Preservation. Marcel Dekkar Incorporation New York, 133-170.

Horsfall DM, Eboh L, Banigo DEB. 2007. Effects of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. African Journal of Food Agriculture Nutrition and Development **7**, 1684-5374.

Howard LA, Wong AD, Perry AK, Klein BP. 1999. Beta Carotene and ascorbic acid retention of fresh and processed vegetables. Journal of Food Science **64,** 929-936.
https://doi.org/10.1111/j.1365-2621.1999.tb15943.x

James MS. 2009. Horticultural Sciences Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611. Visit the EDIS Web site at.
http://edis.ifas.ufl.edu.

Kader AA. 1992. PostHarvest Technology of Horticultural Crops. University of California, Division of Agriculture and National Resource, USA Publication 3311.

Kala A, Prakash J. 2004. Nutrient composition and sensory profile of differently cooked green leafy vegetables. International Journal of Food Properties, **7,** 659-669.
https://doi.org/10.1081/JFP-200033079

Kawada K, Albrigo LG. 1979. Effect of film packaging in carton air filters and storage temperature on the keeping quality of Florida grapefruit. Proceedings of the Florida State Horticultural Society **92,** 209-212.

Kays SJ. 1991. Post Harvest Physiology of Perishable Plant Products. Published in London Van Nostrand Reinhold.

Khalil IA, Saleemullah. 2004. Book of Bio Analytical Chemistry 2nd Ed. National Book Foundation Islamabad, 26-29.

Kidmose U, Hansen M. 1999. The influence of postharvest storage, temperature and duration on quality of cooked broccoli florets. Journal of Food Quality **22,** 135-146.
https://doi.org/10.1111/j.1745-4557.1999.tb00546.x

Klein BP, Perry AK. 1982. Ascorbic acid and vitamin A activity in selected vegetables from different geographical area in United States. Journal of Food Science **47**, 941-948.
https://doi.org/10.1111/j.1365-2621.1982.tb12750.x

Krehl WA, Winters RW. 1950. Effect of cooking methods o retention of vitamins and minerals in vegetables. Journal of the American Dietitians Association **26**, 966-972.

Larmond E. 1977. Laboratory Methods for Sensory Evaluation of Foods, Canada Department of Agriculture 1637.

Lewu MNl, Adebola PO, Afolayan AJl. 2009. Effect of cooking on the proximate composition of the leaves of some accessions of Colocasia esculenta (L.) Schott in Kwazulu-Natal province of South Africa. African Journal of Biotechnology **8,** 1619-1622.

Lisiewska Z, Kmiecik W, Slupski J. 2004. Contents of chlorophylls and carotenoids in frozen dill: effect of usable part and pre-treatment on the content of chlorophylls and carotenoids in frozen dill (Anethumgraveolens L.) depending on the time and temperature of storage. Food Chemistry **84,** 511-518.
https://doi.org/10.1016/S0308-8146(03)00265-6

Martins RC, Silva CLM. 2004.Frozen green beans (Phaseolus vulgaris, L.) quality profile evaluation during home storage. Journal of Food Engineering **64,** 481-488.
https://doi.org/10.1016/j.jfoodeng.2003.11.015

Mosha TC, Gaga HE. 1999. Nutritive value and effect of blanching on trypsin and chymotrypsin inhibitor activities of selected leafy vegetables. Plant Foods for Human Nutrition **54,** 271-283.

Negi P, Roy S. 2000. Effect of drying condition on quality of green leaves during long term storage. Food Research International **34,** 283-287.
https://doi.org/10.1016/S0963-9969(00)00165-4

Olson JA, Shils ME, Olson JA,Shike M, Ross AC. 1999.Modern Nutrition in Health and Disease. 9th Ed. Baltimore: Wiliams & Wilkins, 525-541.

Purvis AC. 1984. Effect of film thickness and storage temperature on water loss and interval quality of seal packaged grape fruit. Journal of the American Society for Horticultural Science **108,** 562-566.

Raju M, Varakumar S, Lakshminarayana R, Krishnakantha TP, Baskaran V. 2007. Carotenoid composition and vitamin A activity of medicinally important green leafy vegetables. Food Chemistry **101,** 598-1605.
https://doi.org/10.1016/j.foodchem.2006.04.015

Reeve RM, Brown MS. 1968a. Histological development of the bean pod as related to culinary texture. 1. Early stages of pod development. Journal of Food Science **33,** 321-326.
https://doi.org/10.1111/j.1365-2621.1968.tb01378.x

Reeve RM, Brown MS. 1968b. Histological development of the bean pod as related to culinary texture. 2. Structure and composition of edible maturity. Journal of Food Science **33,** 326-331.
https://doi.org/10.1111/j.1365-2621.1968.tb01379.x

Rickman JC, Bruhn CM, Barrett DM. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. Journal of the Science of Food and Agriculture **87,** 1185-1196.
https://doi.org/10.1002/jsfa.2824

Rizzo V, Muratore G. 2009. Effects of packaging on shelf life of fresh celery.Journal of Food Engineering **90,** 124-128.
https://doi.org/10.1016/j.jfoodeng.2008.06.011

Rodriguez DB, Raymundo LC, Lee T, Simpson KL, Chichester CO. 1976. Carotenoid pigment changes in ripening Momordica charantia fruits. Annual of Botany **40**, 615-624.
https://doi.org/10.1093/oxfordjournals.aob.a085171

Schippers RR. 2004. Nasturtium officinale R.Br. In: Grubben GJH, Denton OA, PROTA 2: Vegetables/Legumes. [CD-Rom]. PROTA, Wageningen, The Netherlands.

Shahnaz A, Khan KM, Sheikh MA, Shahid M. 2003. Effect of peeling and cooking on nutrients in vegetables. Pakistan Journal of Nutrition **2,** 189-191.

Shakir I, Durrani Y, Hussain I, Qazil M, Zeb A. 2008. Physicochemical analysis of apple and pear mixed fruit jam prepared from varieties grown in Azad Jammu and Kashmir. Pakistan Journal of Nutrition **7,** 177-180.

Shameem AB, Ahmed MF, Rahman MM. 2009. Effect of cooking temperature and storage period on preservation of water soluble vitamin C content in fruit (Citrus macroptera and Moringa oleifera lunk). Asian Journal of Food and Agro-Industry **2,** 255-261.

Steel RGD, Torrie JH, Dickey D. 1997. Principles and Procedures of Statistics.McGram Hill Book Co-oprative New York, USA, 134-145.

Summer JL, Eu SL, Dhillon AS. 1983. Ascorbic acid retention in foods. Journal of Food Nutrition **40,** 43-47.

Szczesniak AS, Kleyn DH. 1963. Consumer awareness of texture and other food attributes. Food Technology **17,** 74-77.

Wang CY. 2006. Effect of heat treatment on postharvest quality of kale, collard and brussels sprouts. International Society for Horticultural Science, Acta Horticulturae **518,** 25 International Horticultural Congress, Part 8, Quality of Horticultural Products.

Weichmann J. 1987. PostHarvest Physiology and Vegetables. Marcel Bekkar, New York, USA, 145.

Wills RHH, Graham D, McGlasson WB, Halls EG. 1981. PostHarvest: An Introduction of the

Physiology and Handling of Fruits and Vegetables.AVI Publishing Co., West port, 163.

Wills RHH, McGlasson WB, Graham D, Lee TH, Halls EG. 1989. An Introduction to the Physiology and Handling of Fruit and Vegetables. Oxford, London, Edinburgh, Boston, Melbourne. BSP Professional Books.