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Effect of lemon juice treatment and sun drying on vitamin C retention in three steam and water blanched indigenous vegetables over six weeks storage period

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Vitamin C is very important for human nutrition and any method that reduces its degradation in foods like vegetables needs to be advocated and utilized. In this current study, the effect of using lemon juice and sun drying on vitamin C retention of steam and water blanched *Amaranthus hybridus, Bidens pilosa* and *Cleome gynandra* indigenous vegetables stored for a period of six weeks was investigated. Results showed that the amount of vitamin C retained in lemon juice treated samples was higher than in untreated samples and steam blanching was found to be better in retaining vitamin C than water blanching. The mean vitamin C retention percentages soon after blanching were 80 and 40%, respectively for the lemon juice steam and water blanched vegetables in all the vegetables while for control steam blanched vegetables, vitamin C retention ranged from 60-67.8% as compared to a mean retention of 20% for the control water blanched vegetables. Furthermore, results showed that when vitamin C retention after six weeks storage period was compared for each individual indigenous vegetable, the values were higher in lemon juice treated blanched vegetables regardless of blanching type as compared to the control samples. The use of lemon juice in vegetable preservation is strongly encouraged.

Key words: Vitamin C, lemon juice, steam blanching, water blanching, indigenous vegetables.

INTRODUCTION

There is now a growing consensus that indigenous vegetables are extremely important especially to the low resource communities globally. Despite receiving limited research attention in the past, there is now growing interest as evidenced by a number of research findings which has demonstrated that indigenous vegetables are nutritionally rich in essential nutrients and can significantly improve food security of the less privileged communities in developing countries.

A number of studies on nutritional value of indigenous vegetables have shown that they contain essential nutrients for good nutrition. Five African indigenous vegetables namely *Amaranthus cruentus*, *Solanum scarbrum*, *Solanum aethiopicum*, *Corchorus olitorious* and

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Abelmoschus callei were reported to be an important sources of some vital nutrients such as calcium, magnesium, potassium, phosphorus, zinc, iron, proteins and carotenoids and can reduce nutrition-related disorders in Africa (Kamga et al., 2013). Seasonality and perishability of these vegetables explain the necessity of applying preservation technologies, such as freezing in order to extend their shelf life (Martinez et al., 2013). However, it is common knowledge in most instances that traditionally preserved vegetables are characterized by poor quality in both appearance as well as in nutritional value mainly due to uncontrolled blanching, uncontrolled drying conditions, inappropriate storage conditions, limited or lack of food processing additives and in general limited knowledge in appropriate processing technologies.

All preservation and processing methods have been known to cause some significant reduction in most essential nutrients in vegetables and vitamin C has been one of the most affected vitamins. The losses of nutrients in vegetables have also been exacerbated by loss of mixed leaves ripening, inefficient packaging system and inefficient transport system due to poor road network which subject leaves to static and dynamic stress (Seidu et al., 2012). Preservation of foodstuffs through dehydration is an ancient practice. Among the various drying methods available, open sun drying is the most common preservation methods followed where solar radiation is high (Verma and Gupta, 2004). It is a common practice even under traditional preservation method that vegetables are first blanched before being dried and a study on the effects of boiling and sun drying on oxalate, cyanide, nitrate, vitamin C, β-carotene, mineral elements such as iron, calcium, magnesium and potassium in *Amaranthus cruentus* showed that both methods significantly reduce oxalate, cyanide, nitrate and vitamin C contents (Ogbadoyi et al., 2011). The poor quality of traditionally preserved vegetables under open sun drying has been attributed to a number of factors such as improper blanching procedures and uncontrolled drying conditions. In recent times, most studies have shown that both controlled blanching and drying conditions significantly contributes to retention of nutrients such as vitamin C in processed foods. The citric acid and ascorbic acid in the blanching water was found to minimize the losses of some quality parameters of frozen turnip green (Martinez et al., 2013). Fruits such as lemons are known to contain considerable amounts of both citric and ascorbic acid which if properly utilized can improve the quality of traditionally processed vegetables. Considering that a majority of resource poor communities in developing countries cannot afford to access some of the available commercial food additives such as citric and ascorbic acid for use in their preservation methods, cheaper sources of these substances such as lemons which can be found within their communities would be more appropriate in vegetable preservation. The objective of the current study therefore was to investigate the effect of using lemon juice on the blanching water with subsequent sun drying on vitamin C retention of three steam and water blanched indigenous vegetables over a six weeks storage period.

MATERIALS AND METHODS

Sample collection and preparation

The three samples used in this study namely *Amaranthus hybridus, Bidens pilosa* and *Cleome gynandra* were purchased from Lilongwe district council market in central Malawi from indigenous vegetable women sellers. Consideration in buying was based on the quality of the vegetables. The samples were immediately washed with running tap water to remove any adhering contaminants, dirt and dust. The water on vegetable surfaces was thoroughly wiped out using clean tissue papers before being dried to ensure that it does not interfere with the actual moisture content of the samples.

Moisture content determination

Moisture content was determined using the oven drying method as prescribed in AOAC (1984). Briefly, a 2 g sample for each of the vegetable used was dried at 105°C for 5 h to constant weight and was placed in a dessicator to cool to room temperature. Three replications were done for each of the samples and the percentage moisture content was calculated as shown below:

$$\text{Moisture content (w/w) (\%)} = (W1-W2)/W1 \times 100$$

Where: W1 = Initial weight of sample; W2 = weight of sample after drying.

Vitamin C determination

Before the samples were blanched prior to drying, vitamin C was determined for the raw indigenous vegetables. Vitamin C was determined using the Iodometric titration procedure. Briefly, 1 g sample in triplicates for each of the indigenous vegetable sample was crushed and weighed using an analytical balance. 100 mL of distilled water was added to the sample in volumetric flask and the mixture was then filtered to get a clear supernatant. A burette was filled with 250 mg/mL standard ascorbic acid and 25 mL of the standard ascorbic acid was pipetted into 3 flasks to which 10 drops of starch indicator was added and this was titrated with iodine solution until blue black appeared. The final volume was recorded. To determine vitamin C, 20 mL of the supernatant obtained through titration was pipetted into 100 mL volumetric flask where 10 drops of starch indicator was added. The mixture was titrated with iodine solution until a blue black colour appeared and the final volume was recorded. Vitamin C was calculated as shown below:

$$\text{Vitamin C content (mg/100g)} = \frac{(AxB)\ x100}{C}$$

Where: A= Iodine used for sample (mL); B = Standard ascorbic acid (mL); C = Iodine used to neutralize ascorbic acid (mL).

Blanching of the indigenous vegetables

The blanching of the vegetables involved two methods namely water and steam blanching. Furthermore, lemon juice was used in both methods and there was also a control. For water blanching with lemon juice, a concentration of 3 table spoons of sieved fresh

Table 1. Moisture and vitamin C contents of the raw indigenous vegetables.

Sample name	Moisture content (%)	Vitamin C content (mg/100g)
Amaranthus hybridus	85.6±0.58[a]	238.6±1.82[a]
Bidens pilosa	83.0±0.29[b]	221.1±1.97[b]
Cleome gynandra	82.5±1.61[b]	207.0±1.37[c]

Means with different superscripts in the same column are significantly different (p<0.05)

lemon juice per 500 mL of water was used. Vitamin C content of the lemon juice used in the blanching was determined and was found to be 36.5 mg/100 g. This was necessary to estimate how much vitamin C was in the blanching water and the likelihood of the vitamin C in the blanching water getting into the samples was assumed to be low and insignificant as it could have been significantly reduced by the boiling water. The cleaned partially cut vegetables ranging from 150-200 g in weight were placed in lemon juice treated boiling water for 2-3 min. The water was drained off, cooled to ambient temperature and a sample was taken for vitamin C determination. For steam water blanching, a steam blancher with the lemon juice treated water was used and the vegetables were blanched for 4-5 min and the same procedure as in water blanching was followed. Control was also performed where the blanching water contained no lemon juice.

Drying and storage of the dried vegetables

The different treated blanched vegetables were sun dried until they were well dried and doneness in the dried vegetables was confirmed when the vegetables became brittle. The drying time ranged from 1-2 days. The dried samples were kept in traditionally woven baskets in cool dry place to mimic the traditional storage conditions. The samples were stored for six weeks after which samples were also analyzed for vitamin C content.

Data analysis

All the data collected from the study were analysed using GenStat Discovery Edition 3 computer package. Differences among treatments were evaluated by least significance difference test at 5% level of significance.

RESULTS AND DISCUSSIONS

Moisture and vitamin C contents of raw indigenous vegetables

Results for the moisture and vitamin C contents of *A. hybridus*, *B. pilosa* and *C. gynandra* are presented in Table 1. Both moisture and vitamin C contents for the three indigenous vegetables with exception of moisture content for *B. pilosa* and *C. gynandra* were significantly different (p<0.05). The differences in vitamin C content in foods like fruits and vegetables have been attributed to a number of factors such as genotypic differences, preharvest climatic conditions, cultural practices, maturity and harvesting methods and postharvest handling procedures (Lee and Kader, 2000). For moisture content, our results are in contrast with those reported by Odhav et al. (2007) who reported that the moisture contents for *A. hybridus*, *B. pilosa* and *Cleome monophylla* which may be closely related to *C.gynandra* were 83, 88 and 88% respectively. However, results on moisture content for *B. pilosa* was in line with what was reported by Santos and Carvahlo (1995) who found out that the highest moisture content in *B. pilosa* was 83%. Differences have also been reported in vitamin C content and the analysis of vitamin C content for different indigenous vegetables in Tanzania revealed to range as low as 7.7 mg/100 g to as high as 266 mg/100 g (Lyimo et al.,2003). The vitamin C content for *A. hybridus* in our study was found to be higher as compared to other previous findings which reported that the average vitamin C content in Amaranthus leaves ranged from 62-209 mg/100 g (Prakash et al., 1995). The vitamin C values obtained for *B.pilosa* and *C. gynandra* in this study were very high as compared to those reported in similar related studies and reviews respectively as evidenced by the low values of 16.0 mg/100 g and 23.0 mg/100 g for *B. pilosa* (Abidemi, 2013; Uusiku et al., 2010) and 104.3 mg/100 g for *C. gynandra* (Mibei and Ojijo, 2011).

Vitamin C content of lemon juice treated and untreated steam and water blanched indigenous vegetables

Results for vitamin C content of the three indigenous vegetables subjected to different blanching treatments are presented in Table 2. Furthermore, results for the retention percentage of the vitamin C in the three indigenous vegetables which was calculated based on the mean vitamin C content against the mean value obtained soon after blanching are also presented in Table 2 and shown in brackets. Both steam and water blanching with either lemon juice or not, significantly reduced the vitamin C content although it is clear that the losses in steam blanching regardless of lemon juice treatment were lower than in water blanching. A number of authors have reported similar results in the loss of vitamin C in vegetables during blanching although the magnitude of the losses are different from the ones reported in this study. The use of the lemon juice in the blanching water have been shown to significantly reduce the loss of vitamin C (Table 2) and this could be attributed to the presence of organic acids present in the lemon juice which are known to minimize vitamin C losses and our findings are in agreement with previous

Table 2. Vitamin C content (mg/100 g) of steam and water blanched indigenous vegetables.

Treatment	*A. hybridus*		*B. pilosa*		*C. gynandra*	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Steam	190.9±1.5^{a}	161.7±0.4^{a}	176.9±1.6^{a}	156.9±0.4^{a}	165.8±0.9^{a}	124.3±0.2^{a}
Water	95.4±0.7^{b}	47.7±1.4^{b}	88.5±0.8^{b}	44.2±1.6^{b}	82.9±0.4^{b}	41.4±0.6^{b}

Means with different superscripts in the same column are significantly different ($p<0.05$); Treated = blanching water added with lemon juice (approximately 45 mL juice/500 mL water); Untreated = no lemon juice added to blanching water.

Table 3. Vitamin C content (mg/100 g) and retention percentage of the dried indigenous vegetables after six week storage period.

Treatment	*A. hybridus*		*B. pilosa*		*C. gynandra*	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Steam	8.1±0.02^{a} (4.2)	6.8±0.01^{a} (4.2)	9.2±0.02^{a} (5.2)	7.7±0.02^{a} (4.9)	9.3±0.02^{a} (5.6)	7.8±0.03^{a} (6.3)
Water	5.4±0.02^{b} (5.7)	4.1±0.25^{b} (8.6)	6.2±0.02^{b} (7.0)	4.6±0.02^{b} (10.4)	6.2±0.01^{b} (7.5)	4.6±0.03^{b} (11.1)

Means with different superscripts in the same column are significantly different ($p<0.05$); Treated = blanching water added with lemon juice (approximately 45 mL lemon juice/500 mL water); Untreated = no lemon juice added to blanching water. Values in brackets represent the vitamin C retention percentage of the dried vegetables after six week storage period

findings by other authors who reported that the use of acids in the blanching water minimized total soluble solids, antioxidant capacity and total phenolic losses during frozen storage of turnip green (Martinez et al., 2013). Similar results with respect to vitamin C losses during blanching for different leafy vegetables were also reported by Musa and Ogbadoyi (2012), Adetuyi et al. (2008) and Osum et al. (2013). Differences were noted in vitamin C retained in the three steam blanched vegetables regardless of whether it was treated with lemon juice with the exception of *A. hybridus* and *B. pilosa*. However, the results for the water blanched vegetables were the same for all treatments in the three vegetables implying to some extent that the effect of water blanching was uniform in all the treatments. Different processing treatments have been reported to cause different vitamin C losses as evidenced by the findings of Gao-feng Yuan et al., 2009) who reported that the greatest loss of vitamin C was observed in broccoli after stir-frying/boiling and boiling (38 and 33%, respectively) treatments followed by microwaving and stir-frying (16 and 24%, respectively) treatments. The differences in the extent of losses especially for the steam blanched vegetables could be attributed to the factors as highlighted by Gupta et al. (2008) who reported that ascorbic acid content of all greens blanched at 80°C showed a reduction but the extent of loss varied between the vegetables and further reported that the differential loss of ascorbic acid in the leafy vegetables could be attributed to different vulnerabilities due to surface area, mechanical damage, initial ascorbic acid content and enzymatic activities. In all the blanching treatments with addition of lemon juice, it was observed that vitamin C was well retained as compared to the untreated samples and similar findings were reported by other authors who concluded that the traditional methods of cooking sweet potato leaves with addition of lemon is advantageous because it reduces polyphenols while retaining higher levels of minerals, β-carotene and vitamin C (Laswai et al., 2011). Similarly, the trend in our findings agrees with what was reported by Sobowale et al. (2010) who reported that among the treatments for leafy vegetables consumed in Nigeria, cooking accounted for 64.3-67.5% loss of vitamin C while blanching and sun drying accounted for 44.8-47.1 and 36.8-39.6%, respectively. However, the extent of vitamin C losses was higher in their study as compared to our results for steam blanching while alternatively, the extent of vitamin C losses for water blanching in our study was higher than theirs which could be attributed to many factors such as differences in methodology, climatic conditions , stage of maturity and post handling procedures.

Vitamin C content (mg/100 g) and retention percentage of the dried indigenous vegetables after six week storage period

Results for vitamin C content as well as the percentage retention in the three dried vegetables after six weeks of storage are presented in Table 3. Vitamin C percentage retention in the dried vegetables was calculated based on the mean vitamin C content of the vegetables soon after being subjected to various treatments of blanching against the mean values obtained after the dried vegetables were stored for six weeks under ambient temperature in a cool dry place. All the results in various treatments showed that vitamin C was significantly reduced with the steam blanching regardless of treatment showing higher values than water blanching. However, when the results are compared based on percentage retention of vitamin C with respect to the values obtained soon after blanching, water blanching registered higher values than steam blanching regardless of treatments. This may not reflect the true picture as the results have shown that steam blanching accompanied by addition of lemon juice retained more vitamin C than water blanching and this might be attributed to the differences in the initial vitamin C content in sample treatments soon after blanching. A number of authors working on dried vegetables have reported similar findings and a study by Muchoki et al. (2007) reported that the retention of β-carotene and ascorbic acid at the end of three month storage period for solar dried cow pea leafy vegetables were 23-52 and 4-7%, respectively and our results fit in the range although as high as 11% retention was achieved in our study which could be attributed to a wide range of factors such as type of leafy vegetables used and storage period. Vitamin C as a quality parameter have been reported to be affected by a number of factors such as process parameters and storage length as demonstrated by findings of Gupta et al. (2012) who reported that vitamin C retention after first, second, third and fourth month for all the dried cauliflower samples were in the range of 62.15-96.09, 36.66-62.11, 27.8-59.06 and 24.0-54.14%, respectively. Similar results were also reported by Oladele and Aborisade (2009) who reported that ascorbic acid decreased by 43-48% as a result of drying but storage for twelve weeks did not result in further loss. The amount of vitamin C retained after the six weeks of storage was very low as shown by values as low as 4.1 mg/100 g in our study and with extended storage period, there would be a possibility of having no vitamin C at all in the samples and this assumption seems to agree with Penas et al., (2013) who reported that the content of vitamin C drastically decreased during the storage period and even disappeared in some dried onions and carrots following 12 months of storage.

Conclusions

In this study, the effect of using lemon juice and sun drying on vitamin C retention in three steam and water blanched indigenous vegetables namely *A. hybridus*, *B. pilosa* and *C. gynandra* over a storage period of six weeks was investigated. Results showed that the use of lemon juice in vegetable blanching considerably reduced vitamin C loss. Furthermore, both sun drying and blanching significantly reduced vitamin C content in the three vegetables. Vitamin C retention soon after blanching was 80% for lemon juice steam blanching treated vegetables and 40% for lemon juice water blanching treated vegetables demonstrating that steam blanching was better in retaining vitamin C than water blanching. The results have also shown that the amount of vitamin C in stored dried vegetables reduces with time. After six weeks of storage, vitamin C retention percentage ranged from 4.2-7.5% for lemon juice treated steam and water blanched samples and 4.2-11.1% for untreated samples although the total amounts retained in the individual dried indigenous vegetables were higher for lemon juice treated samples than untreated samples. It is recommended that the use of lemon juice in vegetable blanching should be accompanied by controlled drying conditions to minimize vitamin C losses.

Conflict of interests

The authors did not declare any conflict of interests.

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REFERENCES

Abidemi OO (2013). Proximate Composition and Vitamin Levels of Seven Medicinal Plants. Int. J. Eng. Sci. Invent. 2 (5): 47-50

Adetuyi FO, Osagie AU, Adekunle AT (2008). Antioxidant Degradation in Six indigenous okra *Abelmoschus esclulentus* (L) Moench Varieties during storage in Nigeria. J. Food Technol. 6 (5): 277-230

Gao-feng Y, Bo S, Jing Y, Qiao-mei W (2009). Effects of different cooking methods on health-promoting compounds of broccoli. J. Zhejiang Univ. Sci. B. 10 (8): 580-588

Gupta MK, Sehgal VK, Singh AK, Singh RK (2012). Effect of process parameters and storage length on quality of dried cauliflower during storage. Indian J. Tradit. Knowl. 11 (1): 177-184

Gupta S, Lakshmi J, Prakash J (2008). Effect of different blanching treatments on ascorbic acid retention in green leafy vegetables. Nat. Prod. Radiance 2 (7): 111-116

Kamga RT, Kouame C, Atangana AR, Chagomoka T, Ndango R (2013). Nutritional evaluation of Five African Indigenous vegetables. J. Hortic. Res. 21 (1): 99-106

Laswai HS, Mwanri AW, Kogi-Makau W (2011). Nutrients and antinutrients composition of raw, cooked and sun dried sweet potato leaves. Afr. J. Food Agric. Nutr. Dev. 11 (5): 5142-5156

Lee SK, Kader AA (2000). Preharvest and post harvest factors influencing vitamin C content in horticultural crops. Post Harvest Biol. Technol. 20: 207-220

Lyimo M, Temu RP, Mngula JK (2003). Identification and nutrient composition of indigenous vegetables of Tanzania. Plant Foods Hum. Nutr. 58 (1): 85-92.

Martinez S, Perez N, Carballo J, Franco I (2013). Effect of blanching methods and frozen storage on some quality parameters of turnip green (“grelos”). LWT-Food Sci. Technol. 51 (1): 383-392

Mibei EK, Ojijo NKO (2011). Effects of processing on chemical composition of four African leafy vegetables. Electronic J. Environ. Agric. Food Chem. 10 (11): 3121-3131.

Muchoki CN, Imungi JK, Lamuka PO (2007). Changes in β-carotene, ascorbic acid and sensory properties in fermented, solar dried and stored cowpea leafy vegetables. Afr. J. Food Agric. Nutr. Dev. 7 (3): 1-20.

Musa A, Ogbadoyi EO (2012). Effect of processing methods on some micronutrients, antinutrients and toxic substances in *Hibiscus*

sabdariffa. Asian J. Biochem. 7: 63-79.
Odhav B, Beekrum S, Akula US, Baijnath H (2007). Preliminary assessment of nutritional value of traditional leafy vegetables in Kwazulu-Natal, South Africa. J. Food Compost. Anal. 20: 430-435
Ogbadoyi EO, Musa A, Oladiran JA, Ezenwa MIS, Akanya FH (2011). Effect of processing methods on some nutrients, antinutrients and toxic substances in *Amaranthus Cruentus*. Int. J. Appl. Biol. Pharm. Technol. 2 (2): 487-502.
Oladele OO, Aborisade AT (2009). Influence of different drying methods and storage on the quality of Indian spinach *(Basella rubra L*.). Am. J Food Technol. 4 :66-70.
Osum FI, Okonkwo TM, Okafor GI (2013). Effect of processing methods on the chemical composition of vitex doniana leaf and leaf products. Food Sci. Nutr. 1 (3): 241-245.
Penas E, Sidro B, Ullate M, Vidal-Valverde C, Frias J (2013). Impact of storage under ambient conditions on the vitamin content of dehydrated vegetables. Food Sci. Technol. Int. 19 (2): 133-41.
Prakash D, Joshi BD, Pal M (1995). Vitamin C in leaves and seed oil composition of the Amaranthus species. Int. J. Food Sci. Nutr. 46(1): 47-51
Seidu JM, Bobobee EYH, Kwenin WKJ, Frimpong R, Kubge SD, Trevor WJ, Mahama AA (2012). Preservation of indigenous vegetables by solar drying. ARPN J. Agric. Biol. Sci. 7 (6): 407-415
Sobowale SS, Olatidoye OP, Olorode OO, Sokeye OK (2010). Effect of preservation methods and storage on nutritional quality and sensory properties of leafy vegetables consumed in Nigeria. J. Med. Appl. Biosci. 2 : 46-56
Uusiku NP, Oelofse A, Duodu KG, Bester MJ, Faber M (2010). Nutritional value of leafy vegetables of Sub-Saharan Africa and their potential contribution to human health: A review. J. Food Compost. Anal. 23 (6): 499-509
Verma RC, Gupta A (2004). Effect of pre-treatments on quality of sola dried amla. J. Food Eng. 65 (3): 397-402