Journal of Food and Nutritional Sciences Research 2019, 1(1), 51-63.

Quantitative Changes of Ascorbic acid and Beta carotene in African nightshade (*Solanum nigrum*) and Spider plant (*Cleome gynandra*) due to traditional cooking methods used in western Kenya

https://doi.org/10.37512/600

*Anne A. Musotsi[1], Anselimo Makokha[2], Mary O. Abukutsa-Onyango[3], and Sheila M. Kilonzi[4]

1-Masinde Muliro University of Science and Technology, P.O Box 190-50100, Kakamega-Kenya; E-mail: aswanianne@gmail.com
2-Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000-00200, City Square, Nairobi; E-mail: anmakokha@gmail.com
3-Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000-00200, City Square, Nairobi; E-mail: abukutsa.mary@gmail.com
4-Karatina University, P.O Box 1957-10101, Karatina; E-mail: skilonzi@gmail.com

ABSTRACT

African nightshade *(Solanum nigrum)* and Spider plant (C*leome gynandra*) are among African leafy vegetables (ALVs) that are consumed in Kenya. Studies were conducted to establish the traditional cooking methods for ALVs and to determine quantitative changes in ascorbic acid and beta carotene on cooking the two ALVs. Results revealed that the cooking methods had distinct steps. The amount of time and water for cooking were unspecified. Ascorbic acid decreased from 28.2mg/100g to 1.8mg/100g in Spider plant (93.6% loss) and from 19.5mg/100g to 5.8mg/100g in African nightshade (70% loss). Beta carotene decreased from 2.1mg/100g to 0.1mg/100g in Spider plant (94.4% loss) and from 1.8mg/100g to 0.9mg/100g (50.6% loss) in African nightshade. All results were significant ($P< 0.001$). The study concludes that there are existing methods of cooking ALVs. For the two ALVs, cooking led to drastic losses of ascorbic acid and beta carotene. Losses from the African nightshade were generally lower than from the Spider plant for the same nutrient, under similar processing conditions. The study recommends procedural changes in processing methods so as to conserve the two nutrients.

KEYWORDS: ALVs, cooking, Beta carotene, Vitamin C

INTRODUCTION

Cooking is one of the ways in which food is made tender, palatable and safe for consumption. Moreover, cooking enhances digestion and preserves body energy since it takes place outside the body using outside sources of energy (Pollan, 2013). Most of the foods we eat are cooked prior to consumption. This makes it imperative to study cooking, which is both an art and a science. Teherani-Kroenner (2017) argues that in most cases, we do not eat raw food materials. Studies that have been conducted on cooking have removed the foods from the kitchen context and have not taken in to account the methods that are used by the local consumers.

African nightshade (Solanum nigrum) and Spider plant (Cleome gynandra) are among African leafy vegetables (ALVs) that are commonly consumed in Kakamega County, western Kenya. Some of the

benefits of these ALVs are enhancing food security, nutrition and health and being part of the meal culture of the local people (Abukutsa-Onyango, 2010; Brückner, & Aswani, 2017). Despite these benefits, the preparation and cooking of the ALVs in a nutritious way has remained a challenge. Most recently, preparation and cooking of the ALVs has been described by modern consumers as a tedious process (Musotsi et. al., 2018). This has been attributed to the time consuming requirements of plucking (de-stalking) of the leaves from the stem and boiling them, prior to frying and fermenting. Research on documentation of recipes in western Kenya revealed that most ALVs are cooked by boiling and steaming in unspecified amount of water, or some form of wet heating (Musotsi et. al., 2005; Musotsi et. al., 2017). Recipes developed using Spider plant and African nightshade boil them for 40-45 minutes. It is argued that the long duration of cooking helps to reduce the bitter taste associated with the two varieties of vegetables (Musotsi et. al., 2005). Cooking, therefore, contributes to making a palatable meal for a majority of people. However, nutrient values of vegetables are affected by cooking methods, among other factors (Shackleton et. al., 2009). This presents a very delicate situation where balance has to be made during cooking to retain vitamins and minerals and to eliminate some phytochemicals that cause bitterness in ALVs.

According to Miglio et. al. (2008) both positive and negative effects of cooking vegetables have been reported. These effects depend upon differences in processing conditions, and morphological and nutritional characteristics of vegetables. Physical properties of vegetables are also greatly affected by heat treatments. Texture and color are important parameters in the cooking of vegetables and they may strongly influence consumer purchases of these food items. Changes in texture are often dramatic because of the membrane disruption and the associated loss of turgor. In addition, cooked vegetables exhibit poor color quality in comparison with fresh ones. Yuan et al. (2009) established that all cooking treatments, except steaming, caused a dramatic loss of vitamin C in broccoli. Steaming did not cause any significant loss of vitamin C, compared with the raw sample (Yuan et al., 2009). Further, Rodrigues-Amaya and Kimura (2004) reported that home preparation of vegetables generally increases losses in the following order: microwaving, steaming, boiling, and sautéing. Deep frying, prolonged cooking, combination of several preparation and cooking methods, baking and pickling all result in substantial loss of carotenoids. Whatever the preparation method, carotenoid retention decreases with longer processing time, higher processing temperature, and cutting or pureeing the food.

On the other hand, cooking processes that involve heating also make certain nutrients more available for the body to use. For example, the amount of total carotenoids content in carrots and other vegetable-based dishes was found to be higher in boiled versions (Miglio et al., 2008). Hence, we can conclude that cooking of vegetables is a delicate matter and that a suitable method of cooking should be employed in order to conserve nutrients.

Nutrient values of ALVs could be improved by selecting species and varieties high in nutrient content. In addition, nutrient losses can be minimized by improved post-harvest handling and modification of current food practices such as reduced time of thermal treatment, improved drying processes, avoiding the chopping of vegetables before washing and adding vegetables to boiling water instead of cold water for cooking. Also, rapid processing at high temperature is a good alternative than slow, prolonged cooking.

OBJECTIVES

The objectives of this study were to:

1. Establish the traditional cooking methods for African nightshade *(Solanum nigrum)* and Spider plant *(Cleome gynandra)* in Kakamega County.
2. Determine the effect of the cooking methods on levels of Ascorbic acid and Beta carotene in African nightshade *(Solanum nigrum)* and Spider plant *(Cleome gynandra).*

MATERIALS AND METHODS

The study applied both qualitative and quantitative research methods. Qualitative research was conducted using exploratory case studies. These established the cooking methods for African nightshade *(Solanum nigrum)* and Spider plant *(Cleome gynandra)* in Kakamega County. Participatory observation, focus group discussions and key informants were used to generate data. The sample size for case studies applied the methodological principle of "saturation". Saturation refers to the criterion for judging when to stop sampling the different groups pertinent to a category. It means that no additional data are being found for development of a category for analysis. The sample size for this study comprised thirty three participant observation interviews, twenty two key informant interviews and fifteen focus group discussions.

Secondly, an analytical laboratory based experimental design was used. Laboratory experiments were conducted to determine the nutritive value of the two vegetables. Raw ALVs of Spider plant and African nightshade were analyzed to establish quantities of the ascorbic acid and beta carotene. Further tests were done to determine the quantity of nutrients in cooked ALVs according to the various recipes collected from Kakamega County. The nutritive values were compared with values for raw vegetables to determine the changes.

Determination of Vitamin C

Vitamin C was analyzed using a reversed-phase HPLC method by Ekinci and Kadakal (2005). To 5 g sample was added 20 ml distilled water and the mixture homogenized at medium speed for 1 minute. The homogenized samples were centrifuged for 10 min at 14 × 10 g. Vitamins were then separated using ODS C-18 size 250mm*4.6mm* 0.5 ul column. They were eluted with 10 ml methanol. The elute was concentrated by Rotary Vacuum evaporator and vitamins re-dissolved in the mobile phase and 20 ul injected into the HPLC. A HPLC (Shimadzu 20A series, Tokyo, Japan) with Photodiode array detector (PDA). Absorance readings were taken at the wavelength of 266 nm.

Determination of Beta carotene

Beta carotene content was analyzed using the method described by Rodriguez-Amaya and Kimura (2004) where column chromatography and a UV Spectrophotometer; acetone and petroleum and ether were used for extraction. Approximately 2 grams of fresh sample was weighed, chopped finely and placed in a mortar with about 10 mL of acetone. This was thoroughly ground and the acetone extract transferred into a-100 mL volumetric flask. The residue was again extracted with 10 mL acetone and the extract was added to the contents of the volumetric flask. The extraction with acetone was continued until the residue no longer gave colour. The combined extract was made to a volume of 100 mL with acetone. Exactly 25 mL of the extract was evaporated to dryness using rotary evaporator. The residue was dissolved with 10 mL petroleum ether and the solution introduced into a chromatographic column. This was eluted with petroleum ether and beta carotene collected in a flask. The Beta carotene elute was made to a volume of 25 mL with petroleum ether and the absorbance was read at 440 nm in a UV-Vis spectrophotometer (Shimadzu model UV – Vis 1800 PC, Kyoto, Japan). Beta carotene standard was prepared for the construction of a calibration curve.

All chemicals used were of analytical grade. All the measurements were done in triplicates.

RESULTS AND DISCUSSION

Traditional cooking methods for Spider plant and African nightshade in Kakamega County

Results from the qualitative studies showed that African nightshade (*Solanum nigrum*) and spider plant (*Cleome gynandra*) were the ALVs that were eaten regularly. They were eaten after cooking as accompaniments to starchy staples. There were systematic methods (recipes) for preparing and cooking the ALVs. Most of the recipes used were complemented with vegetables. African nightshade (*Solanum nigrum*) and Spider plant (*Cleome gynandra*) were each complemented with Ethiopian kale and/or amaranth. The steps in cooking were: de-stalking, washing, boiling, wet-frying and sometimes fermentation. Usually, the amount of water for cooking was unspecified. Fermentation according to the respondents, was a method of preservation where addition of fresh milk to cooked ALVs was done while re-heating on a daily basis. This method could be used to preserve ALVs for up to 7 days. Besides, fermentation was also used to enhance the taste of the ALVs. From observation, the water for boiling was often excess and had to be drained off and discarded before the cooked vegetables were fried. Further, most respondents did not specify the cooking time. Table 1 shows the typical recipes used to prepare and cook the two ALVs.

Table 1: Typical recipes of Spider plant and African nightshade in Kakamega County

Type of ALV	Requirements	Preparation method	Changes observed	Duration
Spider plant	250-300 g spider plant 75-100 g amaranth Cooking oil Tomatoes Onions Salt to taste Fresh Milk or cream	Pluck the vegetables Wash vegetables several times with plenty of water Place vegetables in a pan. Add ab. ½ litre of water Cover with banana leaves and a plate Boil for 1 hour Fry onion in the oil until brown, add tomatoes. Add salt Fry the tomatoes until they become very soft. Add the vegetables and mix well. Add milk or cream and cook for 10 minutes. Vegetables are ready to serve	The color of washing water turned green, and this intensified with each wash. As vegetables began to boil, there was a characteristic smell. This changed to a savory smell. The color also changed from bright green of the raw leaf to brown color after cooking	Plucking- ab. 30 minutes depending on amount Washing- ab.15 minutes Boiling-1½- 2 hours Simmering- 10 -15 minutes Total duration of preparation and cooking- 2½- 2¾ hours
African night-shade	250-300 g night-shade 75-100 g amaranthus Cooking oil Tomatoes Onions Salt to taste Fresh Milk or cream	Pluck the vegetables Wash vegetables several times with plenty of water Place vegetables in a pan. Add ab. ½ litre of water Cover with banana leaves and a plate Boil for about 1 hour Fry onion in the oil until brown Add tomatoes. Add salt Fry the tomatoes until they become very soft. Add the vegetables and mix well. Add milk or cream and cook for 10 minutes. Vegetables are ready to serve	As above, except that the washing water had more color intensity	Plucking- ab. 30 minutes Washing- ab. 15 minutes Boiling- ab. 1 hour Simmering-10 minutes Total duration of preparation and cooking- approx. 2 hours

By outlining the steps and explaining reasons for each step, the respondents demonstrated that they had knowledge on cooking of the ALVs. The study also found that this knowledge was passed from mothers to their children by word of mouth. This reveals that the cooking of Spider plant and the African nightshade in Kakamega County still employs indigenous knowledge. It reveals the importance of such knowledge in ensuring food and nutrition security for the local communities. On the other hand, knowledge on the preparation and cooking of ALVs is also evolving. From the study, there were modifications to the traditional recipes by modern consumers. Frying is one such modification. Because of frying, addition of milk is now optional as opposed to the past when it was almost the only additive. Although the modification of frying may not be perceived as adding value for some consumers whose impression of cooking oil was negative, it is the common practice today. This trend suggests that there is room for change in the traditional recipes, a positive thing that could support the adoption of new recipes based on laboratory analyses.

The time taken to accomplish the steps in preparation, cooking and fermentation is significant with regard to the amount of nutrients retained. De-stalking took up to 30 minutes to accomplish, meaning long exposure times of the ALVs to oxidation. There is rapid loss of ascorbic acid when vegetables are exposed to air and light. Moraes et. al. (2010) also showed that there are significant losses of vitamin C during improper storage, preparation and transportation. Other nutrients that may be lost considerably include beta carotene, total antioxidants and minerals: calcium, iron and zinc. This reveals that to minimize losses in the preparation of ALVs, the processes need to be done fast.

Washing of ALVs is important as it enhances food safety and palatability. Washing several times is a way of ensuring that the food is safe for consumption by removing soil and sometimes microorganisms such *Escherichia coli*, which are often found on the surface of the vegetables (Mahan & Raymond, 2017). In the process of washing, it was noted that the water turned color to green as the number of washings increased. The green color is a symbol of chlorophyll which is evidence that some materials, which may include nutrients and phytochemicals, are dissolved or leached into the water. Chlorophyll contains vitamins A, C, E and K as well as beta carotene. It is also rich in antioxidants and minerals such as iron and calcium (Masfuzal *et. al*., 1997; Ifemeje 2015; Maseko *et. al*., 2017). When these are leached during washing it further reduces the quality of the ALVs and makes then less nutritive. This is in agreement with Kirigia *et. al*. (2017) who showed that post-harvest processing of ALVs can also lead to damage through leaf tearing, crushing and other physical damage. This eventually leads to loss of nutrients through oxidation, leaching and senescence. The duration of washing is also significant. The more the time spent on washing, the longer the exposure of the ALVs to oxidation. This could lead to loss of sensitive nutrients (Kirigia *et. al*., 2017).

The time spent on boiling/steaming was between 1-2 hours. Further, the water added for cooking was estimated to about two litres of water for cooking approximately two Kilogrammes of vegetables. This water was left in the ALVs after cooking and was discarded during frying. While boiling and steaming are considered safe methods of cooking that allow softening of food, for vegetables the vitamin losses are higher due to the high temperatures used. Traore *et. al.* (2017) found that boiling of the African nightshade for 30 minutes reduced the amount of beta carotene significantly, from 16.40mg/100g to 5.37mg/100g. A study done by Agbmalfe *et. al.* (2012) also showed that with increased boiling time, there was drastic loss of beta carotene and vitamin C in green vegetables consumed in Ghana. The losses were attributed to oxidation and isomerization (Traore *et. al.* 2017). While vegetables are generally an important source of vitamins and minerals, a considerable amount of them is lost when vegetables are cooked in water. Therefore, vegetables are best cooking using rapid methods such as stir frying and perhaps steaming for those that need moist method.

Wet frying and addition of tomatoes and onions is expected to improve taste and palatability of the ALVs. Adding oil can also protect and enhance absorption of the fat soluble vitamins (Mahan & Raymond, 2017). On the other hand, oil has been associated with increased energy density and excessive consumption of oil is known to result in increased risk to lifestyle diseases and poor health. In

addition, simmering after frying increases the cooking time for the ALVs thus exposing the heat sensitive nutrients to further loss.

Fermentation could have both positive and negative effects in the recipes. Since there is addition of fresh milk on a daily basis, fermentation could enhance availability of proteins, zinc and calcium. The preservative role can enhance food security in the household since the vegetables were said to last up to one week when fermented. Enhancement of taste and flavor can also help to increase intake as consumers will be encouraged to eat more of the ALVs. On the other hand, the prolonged methods of reheating every morning may lead to loss of heat sensitive nutrients.

These results reveal the importance of time in preparation and cooking methods for Spider plant and the African nightshade. There have been some arguments about cooking of Spider plant and the African nightshade. Some consumers argue that they need to be cooked for long to reduce bitterness (associated with high levels of phytochemicals) while others prefer to cook them for a short time to preserve vitamins that are susceptible to leaching and breakdown due to prolonged cooking and the use of large amounts of water. The balance between the two arguments is what many studies have failed to capture, with most of them shying away from recommending the optimal cooking time for the two ALVs. Thus, the above recipes were subjected to laboratory analyses in order to determine the levels of ascorbic acid and beta carotene.

Retention of Vitamin C and Beta carotene after cooking ALVs using traditional recipes

Vitamin C

Results showed a decrease in the amount of Ascorbic acid after cooking as compared to the raw leaf. There was a decrease of the Ascorbic acid (A.A) in Spider plant from 28.2 mg/100g in the raw leaf to 5.6 mg/100g in the boiled leaf, representing 80% loss. In the fried recipe, Ascorbic acid reduced to 3.0 mg/100g (89% loss), while in the fermented recipe, Ascorbic acid content reduced to 1.8 mg/100g (93.6% loss). In the African nightshade, the change was from 19.5 mg/100g of raw leaf to 10.2 mg/100g in the boiled leaf, representing a 47.6% loss. The fried recipe contained 8.0 mg/100g of Ascorbic acid, which was equivalent to 58.9% loss. The fermented and reheated product contained 5.8 mg/100g of Ascorbic acid (70% loss). The losses were statistically significant at $p<0.001$. These losses are mainly attributed to repeated washing in plenty of water and the prolonged duration of cooking.

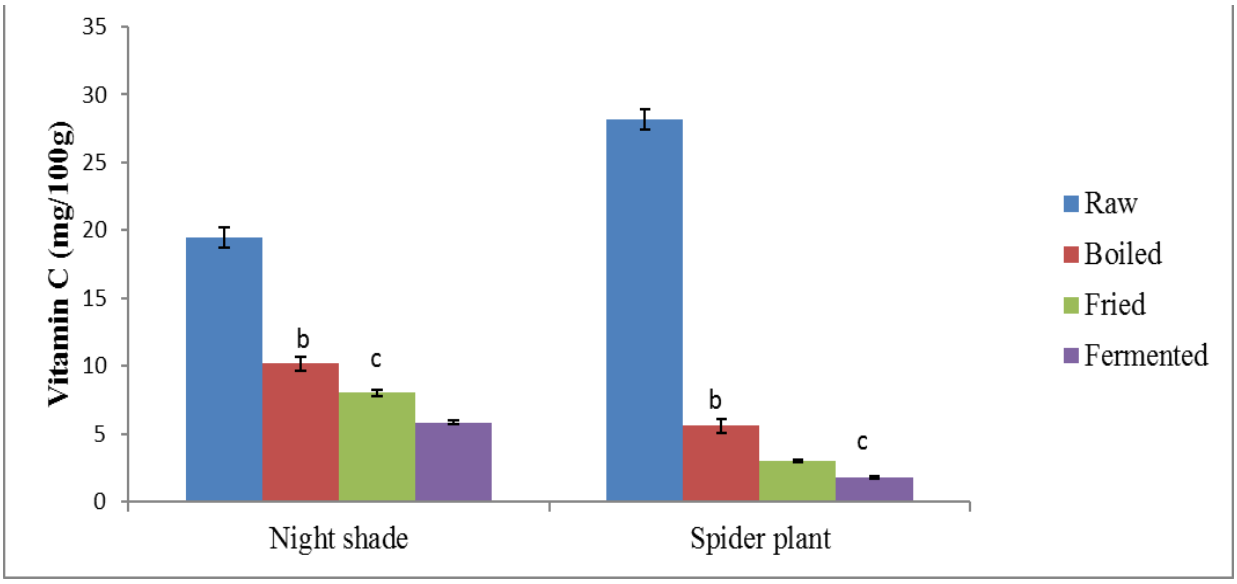

Figure 1: Amount of Vitamin C in raw and processed Spider plant and African nightshade
Data are means ± standard deviations of replicates of the sample

The results of Vitamin C analysis revealed that preparation, cooking, and cooking the fermented vegetables led to drastic losses of vitamin C in both vegetaables. Vitamin C is abundant in most green leafy vegetables but it is easily lost during cooking and processing due to its unstable nature in the presence of oxygen, heat and water. The results were consistent with the findings by Nwozo *et. al*. (2015), Agbemafle *et. al*. (2012), and Muthiani (2004), who, in their studies, found that there were significant reductions in Ascorbic acid of African green leafy vegetables during processing. Hossain *et. al.* (2017) and Singh (2016) also found similar results when investigating Vitamin C content of different Asian leafy vegetables subjected to different processes. In the studies for both African and Asian vegetables, it was found that boiling, as a method of cooking contributed to the greatest loss of Ascorbic acid. Thus, boiling may not be a suitable method of cooking leafy vegetables when there is need to conserve Vitamin C.

Vitamin C is essential for growth and repair of body tissues and enhances absorption of iron from food, among several other functions in the human body. Further, its powerful anti-oxidative ability makes it useful in protecting body tissues from oxidation (Mahan & Raymond 2017). The human body cannot make vitamin C, and, therefore, food (especially fruits, vegetables and organ meat) is the main source of the vitamin. Considerable amounts of the vitamin are required in the diet on a daily basis because it cannot be stored by the body. The requirement for daily intake of Vitamin C is 60 mg/ day for non-smoking men and women (Mahan & Raymond 2017). The results above attest to losses where 93.6% occurred in fermented and reheated Spider plant and 70% occurred in fermented and reheated African nightshade. This implies that people consuming 100 g of fermented Spider plant dish would obtain less than 10 mg of Vitamin C, while those consuming fermented African nightshade would obtain much less than one third of what is contained in the raw leaf. Thus, the amount of vitamin C available in Spider plant and African nightshade cooked using the traditional methods in western Kenya may not meet the RDA if they consume a serving of 100 g. These ALVs, hence require cooking methods that are more preservative to vitamin C such as steaming and stir-frying. Additionally, extreme care, including protection from extreme light and air, minimizing cooking time and water need to be taken to conserve this vitamin during preparation and cooking to prevent the dramatic losses.

Beta Carotene

The study revealed a decrease in the level of Beta carotene in the cooked Spider plant and African nightshade as compared to the raw ones. The level of the nutrient also decreased in the fermented vegetable but was higher than in the cooked vegetable. In Spider plant, the amount of beta carotene dropped from 2.1 mg/100g in raw leaf to 0.3 mg/100g in boiled ones, which was an 87.6% loss. In the fried recipe, Beta carotene declined to 0.1 mg/100g representing 94.4% loss. In the fermented recipes, the amount of Beta carotene was 1.0 mg/100g which was a 52% loss compared to the content in the raw leaf. In the African nightshade, the values were 1.8 mg/100g in raw leaf, which then dropped to 0.6 mg/100g in the boiled leaf (65% loss). After frying, the amount of Beta carotene was 0.1 mg/100g, which was a 93% loss and but was higher in fermented vegetable at 0.9 mg/100g. This represented a 50.6% loss compared to the raw leaf. These changes are represented in Figure 2. Losses in both Spider plant and African nightshade were statistically significant at $p<0.001$.

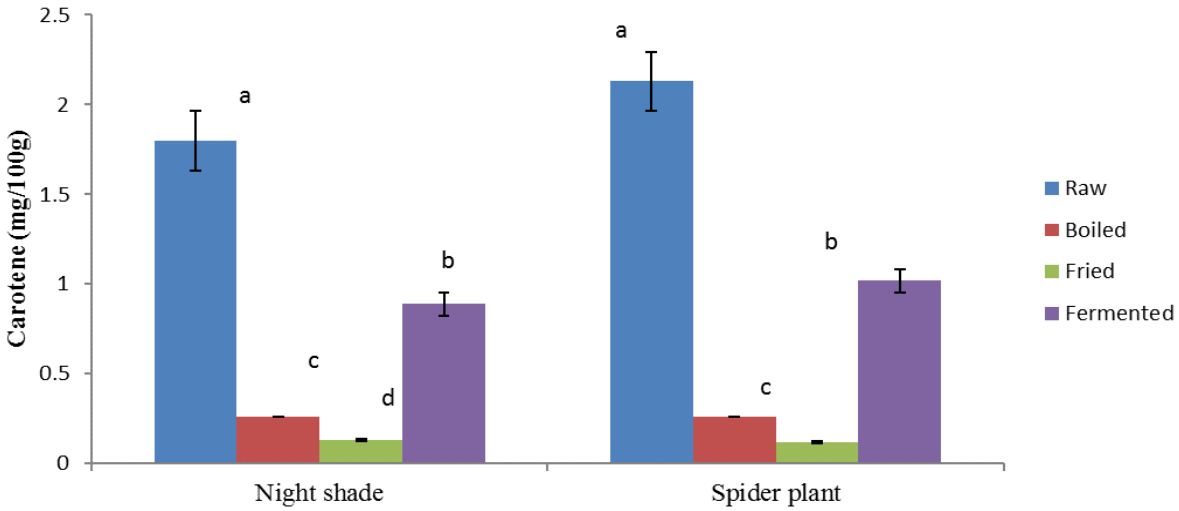

Figure 2: amount of Beta carotene in raw and processed Spider plant and African nightshade Data are means ± standard deviations of replicates of the sample.

The losses could be attributed to prolonged boiling (over 30 minutes) during cooking. While Beta carotene is known to be stable to heat, prolonged cooking could destroy it due to degradation and polymerization. The increase after fermentation may be as a result of addition of milk. According to Ullah *et. al.* (2017) and *Strunsinka et. al.* (2010), cow milk is a good source of Beta carotene. This is dependent partly on the cows' feed. The natural yellow color of cow's milk comes mainly from Beta carotene. FAO/Government of Kenya (2018) showed that the amount of Beta carotene found in milk is 153 mcg/100g (0.153mg/100g). When added to ALVs on a daily basis as in the case of fermented product, the level of Beta carotene could be increased.

The findings on cooking and fermentation of Beta carotene agree with Agbemafle *et. al*. (2012) and Muthiani (2004), who in their studies found reduction in Beta carotene in cooked green vegetables as compared to their raw counterparts. However, some studies have shown that Beta carotene is stable during heating. Mosha *et. al.* (1997) and Mduma (2010) showed that carotenoids were retained at higher levels as compared to the raw leaf when green vegetables including cowpea leaves and amaranth are cooked for a shorter time (10-15minutes). This could be attributed to the breakdown of cell walls of plants during cooking, making carotenoids more available. Also, Chang *et. al*. (2013) found similar results although these were not related to green leafy vegetables but other vegetables such as cabbage and red and white spinach. This shows that Beta carotene may be affected depending on the type of vegetables cooked or processed and the cooking time.

Beta carotene, a member of the carotenoids, is a pro-vitamin A carotenoid which is absorbed and converted into vitamin A (retinol) in the body. The vitamin A activity of Beta carotene is calculated as 6 µg (0.006mg) being equivalent to 1 µg (0.001mg) of retinol (Webster-Gandy *et.al,* 2006). It is abundantly found in fruits and vegetables and some studies have shown that it is also found in milk (Ullah *et. al*, 2017, Strusinka *et, al*. 2010, Swensson & Lindmark-Mansson 2007). Among the major functions of Beta carotene are promoting cognitive functions, maintaining skin health, promoting visual health and preventing cancer. The recommended daily intake of vitamin A (RDA) for men and women is 1 mg and 0.8 mg retinol, respectively (Mahan & Raymond, 2017). From the data above, a person consuming 100 g of cooked S0pider plant and African nightshade would not meet their RDA since it would provide a maximum of 1mg and 0.9 mg respectively of Beta carotene, whereas the contribution towards meeting the RDA would be 6 mg for men and 5.4 mg for women, when 100 g of the two ALVs are consumed.

Lack of vitamin A is an issue of public health concern in Kenya. Consequently, the Government of Kenya, has put in place public health interventions that make it a requirement that all children under five

years be supplemented with vitamin A. Spider plant and African nightshade are rich sources of Beta carotene. However, most of it is lost during cooking and processing as seen from the above results and people eating these vegetables may not meet their RDA. In order to prevent vitamin A deficiency (VAD), we not only need to eat a diversity of foods rich in Beta carotene, but also ensure the foods are cooked using nutrient-sensitive methods in order to retain Beta carotene.

Loss of Ascorbic acid and Beta carotene by leaching during cooking

The water drained after boiling of Spider plant and African nightshade were analyzed to determine the presence of the two vitamins. This water is usually discarded in traditional recipes. Results showed that Ascorbic acid and Beta carotene were not detected. The lowest detection level of UV/vis for beta carotene was 0.01 µg/ml while that of HPLC Shimadzu 20 series used for vitamin C was 0.001 µg/ml, according to the manufacturers.

Kirigia *et. al*. (2017) reported that leaching can be occasioned by damage to the plant cells during processing. Washing after destalking and cooking of ALVs are processes that can lead to leaching. Washing and cooking are especially significant to leaching because nutrients and bioactive compounds are released into the water.

Overall, results on cooking water revealed the importance of taking into account the amount of water used in preparation and cooking Spider plant and African nightshade. If too much water is used, leaching of bioactive compounds occurs. This has negative effects on the nutritional quality and health benefits of the ALVs in most cases. There is need to balance the amount of water used versus the bioactive compounds desired to be retained.

Modified recipes for Spider plant and African nightshade for conservation of bioactive compounds

Based on the findings, the researchers suggested modified recipes as shown in table 2.

Table 2: Modified recipes for retention of bioactive compounds in Spider plant and the African nightshade

TYPE OF ALV	REQUIREMENTS	PREPARATION METHOD	DURATION
Spider plant	250-300g Spider plant 75-100g amaranth Cooking oil Tomatoes Onions Fresh Milk or cream	Wash vegetables 2-3 times Pluck the vegetables Place vegetables in a pan/pot. Add about 200-250ml of water Cover with a lid Steam Fry onion in the oil until brown, add tomatoes. Fry the tomatoes until they become very soft. Add the vegetables and mix well. Add milk or cream and cook for 10 minutes. Vegetables are ready to serve	5 minutes 15-20 minutes (depending on quantity) Steaming-15 minutes Simmering-5minutes Total duration of preparation and cooking- 40-45 minutes
African nightshade	50-300g African nightshade 75-100g amaranth Cooking oil Tomatoes Onions Fresh Milk or cream	Wash vegetables three times Pluck the vegetables Place vegetables in a pan. Add 200-250ml of water Cover with a lid Steam Fry onion in the oil until brown Add tomatoes. Fry the tomatoes until they become very soft. Add the vegetables and mix well. Add milk or cream and simmer Vegetables are ready to serve	5 minutes 15-20 minutes (depending on quantity) Steaming-15 minutes Simmering 5 minutes Total duration of preparation and cooking- 40-45 minutes

The purpose of washing before de-stalking is to prevent excessive leaching of water soluble nutrients during washing. Plucking injures the plant, creating points at which nutrients can escape. This can be avoided if the ALVs are washed before plucking. The time for plucking has also been reduced and this will prevent prolonged oxidation. The recipes in Table 3 have limited amount of water for cooking (200-250ml). This also is to prevent excessive leaching of water soluble nutrients. Further, the overall time for preparation and cooking has been reduced from 2-2¾ to 40-45 minutes. This is to help reduce excessive breakdown of cell structures of the ALVs during cooking, which can lead to leaching and oxidation. The preferred method of cooking is steaming and not boiling. Boiling utilizes a large amount of water and for a long duration of time. On the contrary, steaming utilizes minimal water and is done for a shorter time thus conserving bioactive compounds.

CONCLUSION

The methods of preparation and cooking of Spider plant and the African nightshade in Kakamega County have already been established. Some changes in these methods such as the addition of oil on cooking have been accommodated over time by some people in the community. Boiling the chopped vegetables and heating the fermented vegetables before consumption resulted in drastic losses of Ascorbic acid and Beta carotene.

RECOMMENDATIONS

The study recommends the following:

- That preparation of Spider plant and the African nightshade, including processes such as de-stalking and washing be done just before cooking and as fast as possible. This is so as to prevent the loss of vitamin C which is sensitive to oxidation.
- Washing of the ALVs should be done before de-stalking in order to prevent damage of cells and leaching of the nutrients into the wash-water.
- Cooking should be done with minimal amount of water in order to avoid left over water in the boiled/steamed ALVs, which is normally discarded.
- Cooking time should be reduced to at least 15 minutes of boiling/steaming and 5 minutes of simmering. Studies have shown that over this time, anti-nutrients are broken down and nutrient loss is minimized
- Sensitization should be conducted in the local community for them to accept new cooking methods in order to maximize nutrient retention from the cooking of the two ALVs

ACKNOWLEDGEMENT

We would like acknowledge the project "Horticultural Innovations and Learning for Improved Nutrition and Livelihoods in East Africa" (HORTINLEA) for funding the qualitative data collection.

REFERENCES

Abukutsa-Onyango, M. (2010). African Indigenous Vegetables in Kenya: Strategic Repositioning in the Hor ticultural Sector. Inaugural lecture, Jomo Kenyatta University of Agriculture & Technology, Nairobi. ISBN 9966-923-31-4.

Agbemalfe, R., Obodai, A. E., Adukpo, E. G., & Amprak, N. D. (2012). Effects of boiling time on the con centration of vitamin C and beta carotene in five selected green vegetables consumed in Ghana. Ad vances in Applied Science Research 3(5), 2815-2820. Found at: https:// www.pelagiaresearchlibrary.com. Accessed on 14th August, 2018.

Brückner, M. & Aswani, A. M. (2017). Promoting consumption of African Indigenous Vegetables in Kenya: The role of gendered knowledge and perception. ACTS, HORTINLEA Policy Brief 001/2017. Found at: https://www.researchgate.net. Accessed on 15th August, 2018.

Chang, S. K., Nagendra, P. K., & Amin, I. (2013). Carotenoids retention in leafy vegetables based on cooking methods. International Food Research Journal 20(1), 457-465. Found at: http:// www.ifrj.upm.edu.my. Accessed on 14th August, 2018

Ekinci R. & Kadakal Ç. (2005).Determination of seven water soluble vitamins in Tarhana, a traditional Turkish cereal food by Liquid Chromatography. ACTA Chromatographica 5. Found at: https:// www.researchgate.net. Accessed on 14th August, 2018.

FAO/Government of Kenya. (2018). Kenya Food Composition Tables, Nairobi, FAO/Government of Kenya. Found at: http://www.fao.org/3/I9120EN/i9120en.

Hossain, A., Khatun, A., Islam, M. & Huque, R. (2017). Enhancement of Antioxidant Quality of Green Leafy Vegetables upon Different Cooking Method. Preventive Nutrition and Food Science 22(3), 216-222. Found at: https://doi.org/10.3746/pnf.2017.22.3.216. Accessed on 8th September, 2018.

Kirigia, D., Kasili, R., & Mibus, H. (2017). African Leafy Vegetables Pre-harvest and Postharvest constraints and technologies for losses reduction along the field to consumer chain. African Journal of Horticultural Sciences 12, 51-60.
Found at: https://hakenya.net/ajhs/index.php/ajhs/article/view/185. Accessed on 8th September, 2018.
Mahan, L. K. & Raymond, J. L. (Eds.) (2017). The Krause's Food and The Nutrition Care Process (14th Ed.). Elsevier, St. Louis, Missouri, USA.

Mduma, I. (2010). Modified traditional cowpea leaf vegetable preparation methods for enhancing carotenoid retention and iron bioavailability (Master's thesis). Sokoine University of Agriculture, Tanzania.

Miglio, C., Chiavaro, E., Visconti, A., Fogliaono, V. & Pellerini N. (2008). Effect of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. Journal of Agricultural and Food Chemistry 56(1), 139-47. Found at: https://www.researchgate.net. Accessed on 14th August, 2018.
Mosha, T. C., Pace, R. D., Adeyeye, S., Laswai, H. S. & Mtebe, K. (1997). Effect of traditional processing practices on the content of total carotenoid, β-carotene, α-carotene and vitamin A activity of selected Tanzanian vegetables. Journal of Plant Foods for Human Nutrition 50, 189–201. Found at: https://link.springer.net. Accessed on 14th August, 2018.
Musotsi, A. A., Brückner, M., Teherani-Krönner, P. & Kingiri, A. (2018). The Gender dynamics of provisioning African Indigenous Vegetables as a meal in Kenya: A meal security perspective. Journal of Gender, Agriculture and Food Security 3(2), 36-50. Found at: https://agrigender.net. Accessed 10th January 2019.
Musotsi, A. A., Abukutsa-Onyango, M. O. & Makokha, A. (2017). Changing consumption habits: A case of African indigenous vegetables in Kakamega County, western Kenya. African Journal of Horticultural Sciences 12, 30-39. Found at: https://hakenya.net/ajhs/index.php/ajhs/article/view/183. Accessed on 8th September, 2018.
Musotsi, A. A., Sigot, A. J. & Abukutsa-Onyango, M. O. (2005). African indigenous vegetables recipe documentation and their role in food security. In Proceedings of the third workshop on Sustainable Horticultural Production in the tropics. Maseno University (MSU), Kenya.
Muthiani, F. M. (2004). Consumption patterns of traditional leafy vegetables and their contribution to recommended dietary intakes of vitamins A and C, and iron in Kalama Division, Machakos District, Kenya. (Master's thesis). University of Nairobi, Kenya.
Nwozo, S.O. Oso, B. J. & Oyinloye, B. E. (2015). Effect of Heat on Antioxidant Activity of Some Tropical Leafy Vegetables. Nigerian Journal of Basic and Applied Science 23(2), 93-101. Found at: https://dx.doi.org/10.4314/njbas.v23i2.2. Accessed on 8th September, 2018.
Pollan, M. (2013). Cooked; A natural history of transformation. New Yolk, USA: Penguin Group
Rodriguez-Amaya, B. D. & Kimura, M. (2004). HarvestPlus Handbook for Carotenoid Analysis, Washington D.C & Cali, USA, IFPRI & CIAT.
Saunders, B., Sim, J., Kingstone, T., Baker, S., Watrfield, J., Bartlam, B., Burroughs, H. & Jinxs, C. (2017). Saturation in qualitative research: exploring its conceptualization and operationalization. Quality and Quantity 52, 1893–1907. Found at: https://doi.org/10.1007/s11135-017-0574-8. Accessed on 11th August, 2018.

Shackleton, M. C., Pas.quini,V. M. & Drescher, W. A. (2009). African Indigenous Vegetables in Urban Agriculture. UK & USA, Earthsac

Shari, L. D. (2012). Sample size policy for qualitative studies using indepth interviews; editorial. Archives of Sex Behaviour 41, 1319–1320. Found at: https://doi.org/10.1007/s10508-012-0016-6. Accessed on 11th August, 2018.

Singh, R. R. & Harshal, A. (2016). Effects of Cooking on Content of Vitamin C in Green Leafy Vegetables. Scholars Journal of Agriculture and Veterinary Sciences 3(6), 416-423. Found at: https://www.researchgate.net. Accessed on 11th August, 2018.

Strusinska, D. Antoszkiewicz, Z. & Kaliniewicz J (2010). The concentrations of β-carotene, vitamin A and vitamin E in bovine milk in regard to feeding season and the share of concentrate in the feed ration. Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego 6(4), 213-220. Found at: https://www.researchgate.net. Accessed on 13th March 2019.

Swensson, C. & Lindmark-Mansson, H. (2007). The prospect of obtaining beneficial mineral and vitamin contents in cow`s milk through feed. Journal of Animal and Feed Sciences 16 (1), 21-4. Found at: Found at: https://www.researchgate.net. Accessed on 13th March 2019.

Teherani-Krönner, P. (2017). Meal Cultures-A New Concept in Food Security Debates on African Leafy Vegetables in Kenya and East Africa. Open Access Journal of Agricultural Research 2(5). 1-25. Found at: https://www.researchgate.net. Accessed on 14th August, 2018.

Ullah, R., Khan, S., Ali, H., Bilal, M. & Saleem, M. (2017). Identification of cow and buffalo milk based on Beta carotene and Vitamin-A concentration using fluorescence spectroscopy. Chamani J. (Ed.). PLoS 12(5), e0178055. Found at: https://doi:10.1371/journal.pone.0178055. Accessed on 13th March, 2019.

Webster-Gandy, J., Madden, A. & Holdsworth, M. (Editors) (2006): Oxford Handbook of Nutrition and Dietetics. Oxford University Press, New York.

Yuan, G., Sun, B., Yuan, J. & Wang, Q. (2009). Effect of different cooking methods on health-promoting compounds of Broccoli. Journal of Zhejiang University of Science B 10(880-588. Found at: https://doi:10.1631/jzus.B0920051. Accessed on 15th August, 2018.