Original Research Article

Effect of Different Cooking Methods on the Concentration of Vitamin C in *Vigna unguiculata*

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ABSTRACT

Background: Vitamin C is a water-soluble vitamin widely distributed in nature, mostly rich in fresh fruits and green leafy vegetables. The amount of Vitamin C in a given food depends on soil condition, climate in their area of growth, storage condition after harvest, and methods of preparation. Much amount of Vitamin C in vegetables is lost during cooking. It is upon this background that this study aimed to determine the concentration of Vitamin C in *Vigna ungiuculata* when cooked using different cooking methods.

Methodology: Vitamin C concentration in a solution of *Vigna unguiculata* cooked by different methods was determined by a redox titration using iodine in the presence of starch indicator. This was conducted at Busitema University, Faculty of Science and Education, Biology Laboratory in Uganda.

Results: The study revealed that cooking *Vigna unguiculata* using microwave yields the highest concentration of vitamin C (154.8 mg/L), followed by steaming (142.9 mg/L) and boiling yielding the least concentration of vitamin C (130.4 mg/L).

Conclusion: The concentration of vitamin C obtained by the three methods of cooking *Vigna unguiculata* has shown that microwaving method of cooking yields the highest concentration of vitamin C followed by steaming method and finally boiling. Further studies should be done to explain the variation of vitamin C concentration in *Vigna unguiculata* when cooked using the above cooking methods. Similar studies should be conducted on other leafy vegetables which are potential sources of Vitamin C.

Keywords: Vigna unguiculata; cooking methods; boiling; steaming; microwaving; vitamin C concentrations.

1. INTRODUCTION

Vitamin C, also known as ascorbic acid, is a water-soluble vitamin required for several functions in human bodies [1]. Its chemical formula is $C_6H_8O_6$ [2]. Vitamin C plays an important role in forming collagen, a protein that gives structure to bones, muscles, and blood vessels; in blocking the formation of nitrosamines, potentially cancer-causing compounds; in increasing the absorption of iron; in stimulating the excretion of lead; and in promoting resistance to infection [3]. Also, it is a highly effective antioxidant, acting to lessen oxidative stress [4]. The clinical importance of vitamin C relates principally to its role as a cofactor in a number of enzymes reactions involved in collagen synthesis, dysfunction of

which disrupts connective tissue integrity, resulting in impaired wound healing and capillary bleeding [5]. Previous studies from meta-analysis shows that each 0.2 serving per day increase in green leafy vegetable intake was associated with a 13% lower risk of type 2 diabetes [6]. However, human bodies cannot synthesize vitamin C and it must be obtained either from diet or dietary supplements [7]. Vitamin C is widely distributed in nature, mostly rich in fresh fruits and green leafy vegetables such as guava, mango, tomato, cabbage, green paper, *Vigan spp.,* among others [8]. The amount of vitamin C in food of plant origin depends on the variety of the plant, soil condition, climate in which they grow, of time after the harvest, fruit storage conditions and methods of preparation [9]. Study have shown that vitamin C is also lost when cooking depending on the degree of heating, surface area exposed to water, oxygen, pH and the presence of transitional metal [10]. This raise a lot of questions on what method of cooking vegetables preserves good quantity of vitamin C since most vegetables are commonly cooked before being consumed. This study therefore thought to investigate the effects of three different cooking methods (i.e., steaming, microwaving, and boiling) on the vitamin C content of *Vigna unguiculata* vegetable.

2. METHODOLOGY

2.1 Preparation of starch indicator

0.5g of soluble starch was weighed and 50ml of nearly boiling water added in a 100ml conical flask, stirred to dissolve, and then cooled before usage.

2.2 Preparation of Iodine solution the standard solution

0.85g of potassium iodide (KI) and 0.5g of iodine crystal were dissolved in 50ml of distilled water in a 250ml beaker. The solution was then made to the final volume of 250ml with distilled water resulting into 0.005 molar iodine solutions.

2.3 Procedure for determining Vitamin C concentration in *Vigan Unguiculata*

Fifty (50)g of *Vigna Unguiculata* leaves were cut into smaller pieces and cooked by the three different methods under investigation: boiling, steaming, and microwaving for a period of 0, 5, 10, 15, 20, 25 and 30 minutes. The juice extracts were obtained by blending different cooked samples with 200ml of distilled water using a blending machine for a period of two minutes. The blended samples were filtered using a sieve and the filtrate put in different 250ml beakers for each cooking method each containing 200 mL of the extract. Twenty-five (25) mL of the sample were pipetted in a clean 250 mL conical flask and 20 drops of 1% starch indicator was added. The sample was titrated with 0.005 molar iodine solutions until the endpoint was reached (i.e., the point at which the stable traces of blue-black color is formed due to the formation of iodine-starch complex) and the volume of the iodine solution (standard solution) used in the titration was recorded.

2.4 Determination of vitamin C concentration in *Vigan unguiculata*

Iodine solution was used as the standard solution to determine the unknown concentrations of vitamin C in the different cooking method using the reaction equation and the formular below.

$$Ascorbic\ acid + I_2 \rightarrow 2I^- + Dehydroascorbic\ acid$$

$$[C_6H_8O_6] = \frac{[I_2] \text{ x Av. Vol of } I_2}{Vol\ of\ C_6H_8O_6}$$

2.3. Data analysis

One-way ANOVA was used to determine significance of the statistical differences in the concentrations of vitamin C between the three different methods cooking: boiling, steaming, and microwaving and significance was accepted at P≤0.05. The Pearson's product moment correlation coefficient (*r*) was used to determine the relationship between time and concentrations of Vitamin C in *Vigan unguiculata* for the three methods of cooking. The influence of time as a factor of determination of the concentration of vitamin C for the three methods of cooking were predicted using coefficient of determination (r^2).

3. RESULTS

3.1 Effects of cooking methods on the concentrations of Vitamin C in *Vigna Unguiculata*

The results obtained showed that there is variation in the concentration of Vitamin C *Vigna unguiculata* when subjected to the three different cooking methods. The highest concentration of Vitamin C is found to be in microwaving method of cooking (154.8 mg/L), followed by steaming (142.9 mg/L) and boiling (130.4 mg/L), (Figure 1 A, $F(7) = 5.85$, $p = .011$). The concentration of vitamin C in the control (un-cooked) was higher (163 mg/L) compared to those of the cooking methods because the extract used in the control experiment was obtained from a fresh sample of *Vigna unguiculata* without subjecting to cooking. Gradual decrease in the concentration of vitamin C were observed in all the three methods of cooking over a period of 30 minutes (Figure 1 B).

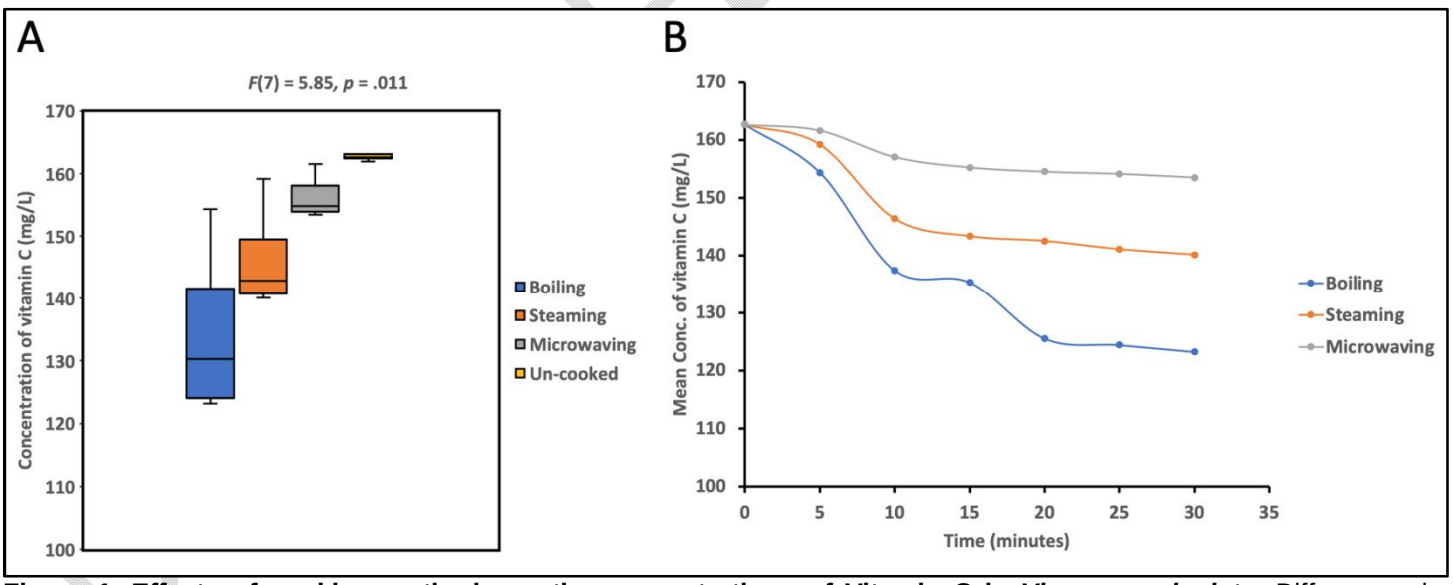

Figure 1. Effects of cooking methods on the concentrations of Vitamin C in *Vigna unguiculata*: Differences in concentrations of vitamin C after boiling, steaming, and microwaving the vegetable after 30 minutes (A), Effect of boiling, steaming and microwaving methods on the vitamin C concentration during the 30 minutes (B), The statistical significance of the differences between the methods of cooking was determined using One-way ANOVA ($F(7) = 5.85$, $p = .011$).

3.2 Impact of cooking time on the concentration of vitamin C in *Vigna unguiculata*

There were strong negative correlations between the cooking time and concentrations of vitamin C in all the three methods of cooking: boiling, r (4) = -.92, p = .009, steaming, r (4) = -.85, p = .034, and microwaving, r (4) = -.89, p = .018, (Figure 2 A, B, and C). The cooking time significantly impacted the concentrations of vitamin C in all the three cooking methods: boiling; r^2 = .85, p = .009, steaming; r^2 = .72, p = .034; microwaving, r^2 = .79, p = .018, (Figure 2 A, B and C).

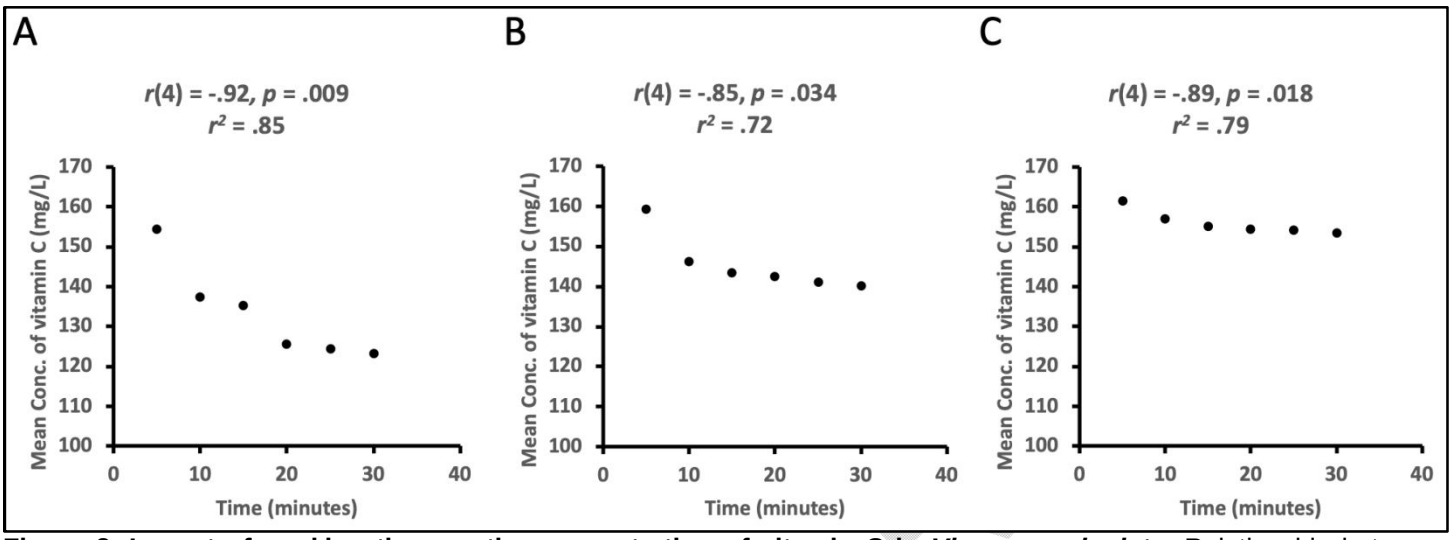

Figure 2. Impact of cooking time on the concentration of vitamin C in *Vigna unguiculata*: Relationship between boiling time (A), steaming time (B) and microwaving time (C) and the concentration of vitamin C. Correlation coefficient between the cooking time and the concentration of vitamin C was determined using Pearson's product moment correlation coefficient, (boiling, r (4) = -.92, p = .009; steaming, r (4) = -.85, p = .034; microwaving, r (4) = -.89, p = .018) and the influence of time as a factor of determination of the concentration of vitamin C for the three methods of cooking were predicted using coefficient of determination (boiling, r^2 = .85, p = .009; steaming, r^2 = .72, p = .034; microwaving, r^2 = .79, p = .018).

4. DISCUSSION

This study shows that boiling method of cooking results in the highest loss of vitamin C content in *Vigan unguiculata* vegetable compared to steaming and microwaving methods of cooking. The high loss of vitamin C content during boiling could be attributed to the fact that vitamin C is very soluble in water and not stable at high temperatures [11]. Loss of vitamin C occurs primarily by chemical degradation that involves oxidation of ascorbic acid to dehydroascorbic acid (DHAA), followed by hydrolysis to 2,3-diketogulonic acid and further polymerization to form other nutritionally inactive products [12]. Thus, the boiling temperature could have inactivated most of the vitamin C in the vegetable, while the water would also wash away the vitamin C during the boiling process [13]. Therefore, despite the fact that boiling makes leafy vegetables like *Vigan unguiculata* less toxic and more palatable, it greatly affects their vitamin C contents [13]. Hence, a balance must be made between palatability and nutritional content by either reducing the boiling time or using alternative methods of cooking like steaming or microwaving that would retain more vitamin C than boiling method.

This study also demonstrated that microwaving method of cooking has the highest retention of vitamin C in the green leafy *Vigna unguiculata* vegetable. This contradicts a finding of a similar study conducted by Zeng C. on some selected vegetables (broccoli, spinach, and lettuce) where out of the three methods of cooking, the cooking method that resulted in the least loss of vitamin C was steaming method [3]. This difference in the findings could be due to the fact that the loss of

vitamin C in vegetables also depend on the particular vegetables. In different vegetables, there are varying rates of degradation of vitamin C contents by different methods of cooking [14].

Vigna unguiculata is one of the commonest vegetables routinely consumed to provide vitamin C requirement in the diet. However, microwaving method of cooking cannot be applicable in some rural areas due to the expensive nature of the microwaving equipment and inadequate electric power supply. The local community can therefore use steaming method of cooking in order to obtain considerable quantity and quality of vitamin C.

5. CONCLUSION

The study showed that cooking methods affects the concentration of vitamin C in *Vigna unguiculata* with microwaving showing the highest retention of Vitamin C, followed by steaming and boiling showing the least retention of vitamin C. There is need for extensive studies on other factors other than cooking methods that may affect the concentration of vitamin C in leafy vegetables such as *Vigna unguiculata*. There is also need to replicate this study using other leafy vegetables which contain vitamin C.

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