Mineral Composition and Effect of Boiling Time on Vitamin C in Extract of Fresh and Dried Nigerian Vegetables with and Without Addition of Potash : Iree, Nigeria as a Case Study

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ABSTRACT

Vitamin C content of six fresh and dried Nigerian vegetable extracts [*Venonia amygadlina (ewuro), Telfaria occidentalis* (ugwu), *Indian spinach* (amunututu), *Talinum triangulare* (gbure), *Amaranthus Spp* (tete) and *Solanum notrifiolum* (gbagba)] at different cooking time with and without the addition of potash was investigated using standard methods. The study showed that *gbagba* was stable throughout with and without the addition of potash for fresh vegetables (3.99%) and *gbure* was also stable at all the cooking time with and without addition of potash (3.99%) for dried vegetables. Other vegetables such as *ewuro, ugwu and tete* were observed to be best eaten at two minutes of boiling. Calcium and sodium had their highest concentrations in *gbagba* (87.1±2.16 mg/kg and 115±2 mg/kg respectively. The highest level of potassium was obtained in *tete* with a value of 112±1 mg/kg. Two sample t-tests analysis using the Aspin-Welch unequal-variance revealed no significant difference at $p < 0.05$.

Keywords: Vitamin C, Vegetables, Cooking time, Potash, Extraction

1. Introduction

Vegetables are edible part of plants and valuable components of the daily diet contributing in form of dietary fibre, vitamins and minerals to the body. Leafy vegetables have been known to be very vulnerable to ascorbic acid loss (Favell, 1998).

There is growing interest in the role of the micronutrients (essential trace elements and vitamins) in optimizing health and in prevention or treatment of disease (Field *et al*., 2002). This arises partly from the increase in knowledge and understanding of the biochemical function that these nutrients perform (Shenkin, 2006). Micronutrients have been reported to play an important role in mounting immune response and deficiency of single micronutrients alone, or in combination with other micronutrients, which invariably increase the risk of having a poor immune response to infection (Walker, 2000; Black, 2001). They also influence adult and child productivity as well as educational achievement, child survival and maternal health (FSAU, 2005). Dietary intakes in developing countries usually consist of plant-based staple foods which are monotonous with little variation. Methods of preparation of these foods often lead to large loss of micro nutrients thus creating a deficiency risk of micro nutrient. Owing to the importance of micronutrients, efforts have been geared towards the study of the mineral composition of prepared Nigerian vegetables (Akindahunsi and Oboh, 1999; Elemo *et al*., 2010).

Vitamin C or ascorbic acid is widely found in many vegetables (Deman, 1973). It is a water soluble anti-oxidant known to be important to health and for proper functioning of the human body (Buenzie, 1999; Davey *et al*., 2000). Diets rich in fresh vegetables are also protective against chronic, degenerative diseases (Joshipura *et al*., 1999; Lampe, 1999; Cox *et al*., 2000). The seeds, pods, leaves, stem, and roots of vegetables are used as food. There are also minerals such as calcium, iron etc present in vegetables. The content of vitamin C in vegetables is not readily available due to length of boiling time used in preparing the vegetables. Vitamin C is the most easily destroyed of all the vitamins. It is oxidized by oxidase contained within the cells of vegetables, which are set free during processing (Fox and Cameron, 1980). A great percentage of it is lost to the water used for boiling vegetable because it is water soluble vitamin and heat labile. It is not stored in the body but is eliminated in the urine; therefore it is replaced on a daily basis.

Studies on the nutritional status in Nigeria have shown micronutrients (vitamins and minerals) deficiencies such as vitamin A, vitamin C, calcium, iodine and iron (Igene, 1996; Ihekoronje and Ngoddy, 1985). In developing countries such as Nigeria where milk and milk products are not easily affordable among low-income groups, frequent eating of vegetable is advisable for supplying the Daily Recommended Allowance (DRA) of calcium. Most predominant vitamins in vegetables include vitamin C. Mathews and Hall (1978) reported that 97% of total ascorbic acid is in form of *L*-ascorbic acid in green and yellow-red (ripe) vegetables.

Sodium is not known to be generally required by green plants. However, certain halophytes plants indigenous to saline soils not only tolerate the high concentration of salt in such soil but actually require sodium. Calcium is present in tissue of plants (vegetables), all natural foods contain small amount of element. Vegetables contain low amount of calcium and is very good for the body. Potassium can be found majorly in fruits and vegetables. It helps to maintain fluid and electrolyte balance in the body. Heath benefits of potassium include osteoporosis protection, reduced risk of stroke and alleviation of high blood pressure (hypertension) especially if it is not accompanied by an increase in high sodium foods.

In Nigeria, the different length of time used in cooking these vegetables leads to variation in the quality in terms of nutrients. Also, the addition of potash to bring about easiness of softness of the vegetable and to reduce the time of boiling may have effect on the nutritional parameters especially vitamins C that are easily susceptible to destruction. Therefore, this work was carried out to evaluate the effect of cooking time and additive on the Vitamin C content of six species of fresh and dried Nigerian Vegetables.

2. Materials and Methods

2.1 Study Area: The study area is Iree, Osun State, southwestern Nigeria and is located on latitude 7o56.878'N and longitude 4o44.652'E with a topographical height of 454 m above the sea level. Generally, the lithology is composed of medium to coarse grained sandy horizon interbedded with thin band of clay and silt which oocur in minor proportions. The major occupation of the people is farming and is surrounded by rocks. More than forty percent of the inhabitants are students of the famous Osun State Polytechnic, Iree.

2.2 Source of Sample: Matured vegetables of *ewuro* (*Vernonia amygadlina*), *ugwu* (*Telfaria occidentalis*), *tete* (*Amaranthus Spp*), *amunututu* (*Indian spinach*), *gbure* (*Talinum triangulare*) and *gbagaba* (*Solanum notrifiolum*) used for the study were purchased from Iree market near the Polytechnic junction.

2.3 Processing: The leaves and stems of six varieties of vegetables were picked. 50g of both fresh and dried vegetables of each species were weighed into four 1L Pyrex beakers containing 500 mL of hot water. 0.5g of potash was added to two beakers containing fresh and dried vegetables and the other two beakers were boiled without the addition of potash. The extraction time was varied (from 2, 4, 6 and 8 minutes respectively) with a constant temperature of 100^{o}C. At the end of each extraction, the extract was filtered using a clean muslin cloth and cooled. This extract was stored in glass bottle and kept for further analysis. Leaves of vegetable samples collected were also air-dried, ground, sieved and kept for metal analysis.

2.4 Chemical Analysis: Ascorbic acid was determined by redox titration.

$$\text{Ascorbic acid} + I_2 \longrightarrow 2I^- + \text{dehydroascorbic acid}$$

10ml of the extract was measured and titrated against standardized iodine. The titration was done three times for each sample and average volume of iodine used calculated. The percentage vitamin C was calculated.

The determination of the mineral content of the vegetables (Ca, Na and K) were carried out using the method as described by A. O. A. C (1995). 5.0 g of theair-dried, sieved vegetable sample was weighed into a crucible and then placed in a furnace at 500 ^{o}C. 2.0g of the ash obtained was weighed and 50 mL of 2M HNO_3 added and digested at low heat on a hot plate. This was allowed to dry. 5 mL of 2M HNO_3 was then added and re-heated. The mixture was then diluted to 50 mL mark with distilled water. Calibration was carried out by preparing 1000 ppm stock solutions of each metal. Working standard solutions were prepared from this and then used for calibration using atomic absorption spectrophotometer (BUCK Scientific, 200A). Blank sample was also prepared. Blank reading was subtracted from sample reading and the result read from the calibration graph. The amount of Ca, Na and K in vegetable sample was extrapolated from the calibration graph and recorded as mg/kg.

2.5 Statistical Analyses: All the analyses in this study were carried out in triplicates. For each, a mean value and standard deviation were calculated. Statistical analysis used involved the use of Aspin-Welch unequal variance two sample t-tests, Pearson correlation and box plots using number cruncher statistical system (NCSS 18335841).

3. Results and Discussion

3.1 Vitamin C in Extracts of Vegetables

The results obtained for the vitamin C level in all the vegetables analyzed are as shown in Figures 1 to 4. Figure 1 shows the vitamin C content of fresh vegetables with respect to time. It shows that high percentage of vitamin C was lost during extraction at 8 minute of boiling with the addition of potash for *ewuro* but with low vitamin C in the extract at 2 minutes. This implies that *ewuro* is best consumed at 2 minute when potash is added. The essence of adding potash is to reduce boiling time for the softness of the leaves. Averagely, Figure 1 shows that for most of the vegetables, low vitamin C was lost at 2 minutes. This invariably means that the vegetables are best consumed after two minutes of boiling when potash is added because very little vitamin C will be lost to the extract and higher percentage will be in the boiled leaves left for consumption. Loss as a result of boiling is justified since vitamin C is water-soluble and heat labile (Egerg *et al*., 1977). *Tete* and *gbagba* had low vitamin C content irrespective of the time used in boiling.

Figure 2 explains time variation of vitamin C in fresh vegetables without the addition of potash. From the figure, *gbagba* and *uwgu* showed almost the same content in their vitamin C (3.99%) extract throughout the studied time and this is in accordance with what was obtained for *uwgu* by boiling as discussed by Babalola *et al*. (2010) in their studies. It implies that even without the addition of potash the vitamin C level is not time dependent. However, *ewuro* showed high vitamin C in its extract at 8 minutes (95.7%). It implies a very low vitamin C will be left in the leafy vegetables of *ewuro* for consumption. Nagy and Smoot (1977) explained in their study that as time of boiling increases vegetables are subjected to denaturation, further heating may tend to bring the level to zero.

Figure 3 shows that for all the dried vegetables studied with addition of potash, *gbure* seems to be stable irrespective of the cooking time (3.99%). At 8 minutes, extract from ewuro gave the highest vitamin C (47.8%) implying lower vitamin C level left in the leafy vegetable for consumption. Dried *amunututu* proved to be the best so far because at 2 minutes of cooking time, only 1.04% vitamin C was extracted implying a higher vitamin C left in the dried leafy vegetables.

The level of vitamin C in dried vegetables without the addition of potash is as shown in Figure 4. *Gbure* was observed to be stable irrespective of the cooking time implying that the leaves are best consumed at any cooking time without the addition of potash. At two minutes, gbure *and amunututu* showed higher preference (3.99% and 7.47% respectively). At four and six minutes, *gbure* and *amunututu* were also observed to be the best (3.99% and 12.0% respectively). At eight minutes, *gbure* and *amunututu* were also observed to be the best (3.99% and 16.0% respectively). The figure shows that the best cooking time for dried vegetables is two minutes because at this time the leafy vegetables still contain more vitamin C to be consumed. The results obtained are in accordance with what was obtained by Davey *et al*. (2000).

3.2 Metals in Extracts of Vegetables

The results of mineral contents of both fresh and dried vegetables are as shown in Tables 1 to 3 below.

3.2.1 Distribution of calcium in fresh vegetables

The levels of calcium in the six vegetables are as shown in Table 1. The highest calcium content was obtained in *tete (41.9*±0.46 mg/kg). *Gbagba* had a calcium level of 34.4±0.51 mg/kg which was higher compared to what was obtained in *ewuro (*10.0±0.09 mg/kg), *uwgu* (2.07±0.10 mg/kg) and *amunututu (*12.6±0.02 mg/kg).

3.2.2 Distribution of Calcium in Dried Vegetables

Table 1 explains the distribution of calcium in all the types of dried vegetables analysed. *Gbagba* had the highest calcium level (87.1±2.16 mg/kg) and then *tete* (71.5±1.31 mg/kg). *Ugwu* had the lowest calcium level here (3.85±0.33 mg/kg). It is not advisable for someone with high calcium level in his or her body mass to consume *gbagba* because of its high calcium content.

3.2.3 Distribution of Sodium in Fresh Vegetables

The level of sodium in the six types of vegetables studied is as shown in Table 2. The table explains the highest level of sodium in the leaves of *gbagba* (113±1 mg/kg) and also *tete* (103±5mg/kg). *Uwgu* of all the vegetables studied had the least sodium content (79.3±0.03 mg/kg). This implies that someone with high level of salt is not advisable to take *gbagba* because of its high sodium content, but can go for *ugwu* with low sodium level as observed in this study.

3.2.4 Distribution of Sodium in Dried Vegetables

Levels of sodium in all the dried vegetables studied are as shown in Table 2. It explains sodium to be very high in *gbagba* (115±2 mg/kg) and very low in *Ugwu* leaves (78.5±0.01 mg/kg). This supports the intake of *ugwu* for people with high sodium level in their body mass (both fresh and dried *ugwu* are preferable).

3.2.5 Distribution of Potassium in Fresh Vegetables

Table 3 illustrates the amount of potassium obtained in each vegetable type in this study. Highest potassium content was obtained in *tete* (110±1 mg/kg). The level of potassium in *gbure and tete* were 85.8±0.34 mg/kg and 110±1 mg/kg respectively. In terms of nutrition, someone with high salt level is not advisable to take *tete*, *ugwu* and *amunututu* because of the high potassium level. The person can go for *ewuro* with low potassium content (80.3±0.12 mg/kg) as shown in table 3.

3.2.6 Distribution of Potassium in Dried Vegetables

The levels of potassium in dried vegetables are illustrated in Table 3. *Tete* had the highest potassium level (112±1 mg/kg), but lowest in *gbagba* (80.0±1.89 mg/kg). For a person with high potassium in its body mass, it is advisable to take *gbagba* as vegetables because of its low potassium content. Someone with low potassium level in its body mass can go for *tete* since it had the highest potassium level in dried vegetable in this study.

3.3 Statistical Analysis

Two sample t-tests analysis using the Aspin-Welch unequal- variance reveals no significant difference between the means of vitamin C obtained at the various time intervals studied at $p< 0.05$ for both fresh and dried vegetables. The t-values and p values obtained are as shown in Table 5. The box plots obtained are as shown in Figures 5 to 12.

The pattern of the quantitative data is as displayed in the box plots in Figures 5 to 12. Figures 5 to 8 show distributions are skewed right for fresh vegetables with and without potash. Figures 9 to 12 explains that dried vegetables with and without potash are all skewed left (except dried vegetables extracted at 8 minutes when potash was added which show a symmetrical distribution). The box plot further supports the evidence that no significant difference exist in means of the extracted vitamin C at the various time used for the study.

Paired t-test results shows significant difference in the means obtained for metals between fresh and dried vegetables except for Ca in *ugwu* with p value 0.3441 and t value, -1.1206 at $p= 0.05$

4. Conclusion

Vegetables are good sources of vitamin C. The vitamins are however lost during boiling since the vitamin is a water soluble vitamin. As the time of boiling increases, the level of vitamin C lost to the extract increases thereby leaving a lower vitamin C in the leaves left for consumption. For those that are vitamin C deficient, the extract of the vegetables with higher vitamin C can be taken such as *ewuro* when boiled for longer period, eight minutes in this case without even consuming the vegetables. These days, consumers at home don't want to add potash to vegetables while boiling, but this study reveals that for most of the vegetables studied, those vegetable samples that potash where added to their water had the least vitamin C in their extract. It invariably implies that more vitamins are left for consumption in the leafy vegetables. *Gbagba* and *tete* showed high metal content in terms of sodium and potassium and are recommended for those with low sodium and potassium in their body mass. Since processing of most vegetables is especially by boiling and tends to reduce the vitamin C content of the vegetable, it is therefore advisable to add fruits to ones daily meal alongside vegetables to meet up with the US daily reference intake of 75 mg and 90 mg/day of vitamin C for women and men respectively (Szeto *et al*., 2002). The level of metals in vegetables should also be ascertained before consumption so as not to take more than the daily requirement.

5. Acknowledgement

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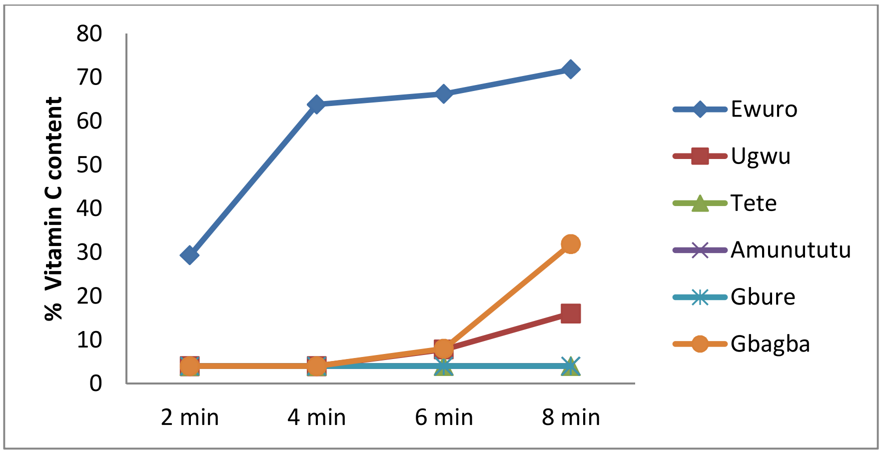

Figure 1: Variation of Vitamin C Content of Fresh Vegetables with Addition of Potash with Respect To Time

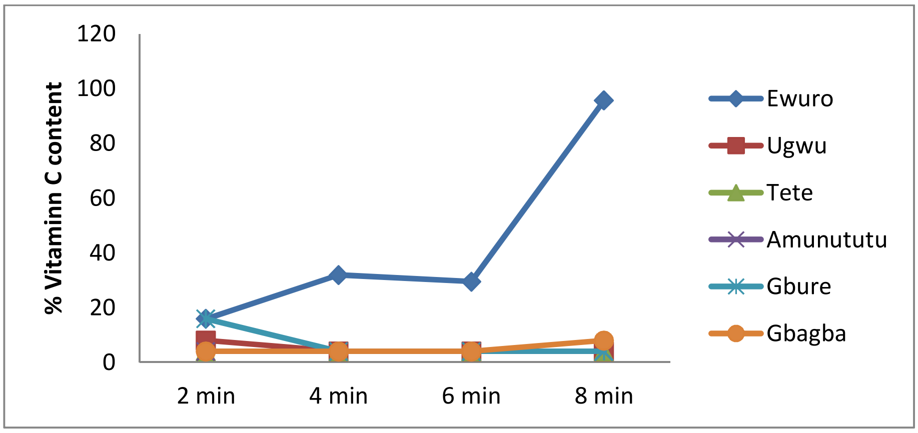

Figure 2: Variation of Vitamin C Content of Fresh Vegetables Without Addition of Potash with Respect to Time

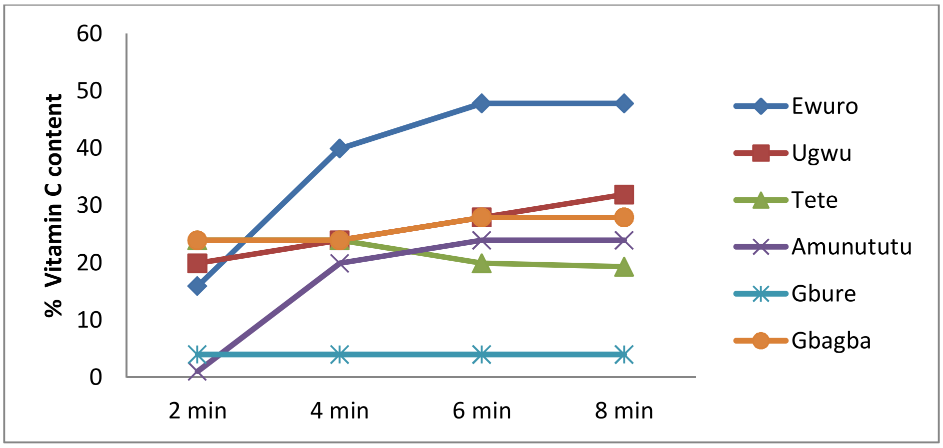

Figure 3: Variation of Vitamin C Content of Dried Vegetables with Addition of Potash with Respect to Time

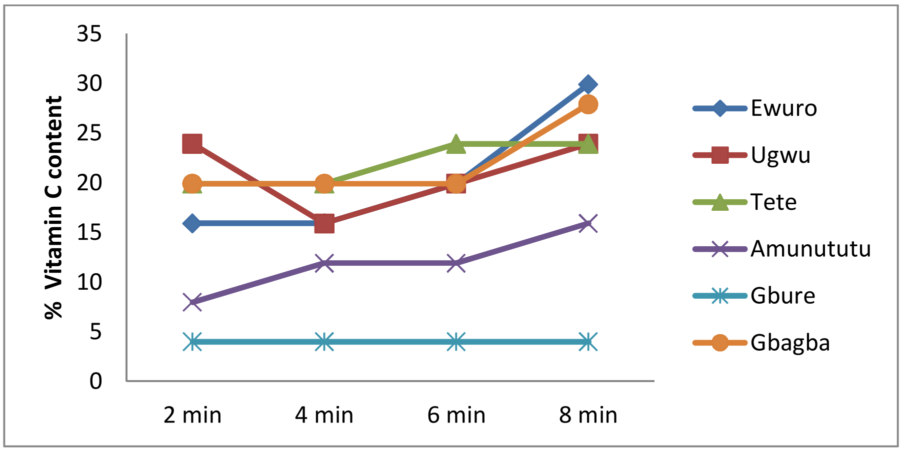

Figure 4: Variation of Vitamin C Content of Dried Vegetables Without Addition of Potash with Respect to Time.

Table 1: Calcium Content of both Fresh and Dried Vegetables (mg/kg)

Vegetable Type	Fresh Vegetable (mg/kg)	Dried Vegetable (mg/kg)
Venonia amygadlina (Ewuro)	10.0±0.09	15.4±0.08
Telfaria occidentalis (*Ugwu*)	2.07±0.10	3.85±0.38
Indian spinach (*Amunututu*)	12.6±0.02	16.7±0.22
Talinum triangulare (*Gbure*)	0.18±0.34	10.7±0.17
Amaranthus Spp (*Tete*)	41.9±0.40	71.5±1.31
Solanum notrifiolum (*Gbagba*)	34.4±0.51	87.1±2.16

Table 2: Sodium Content of both Fresh and Dried Vegetables (mg/kg)

Vegetable Type	Fresh Vegetable (mg/kg)	Dried Vegetable (mg/kg)
Venonia amygadlina (Ewuro)	84.3±0.01	83.5±0.17
Telfaria occidentalis (*Ugwu*)	79.3±0.02	78.5±0.01
Indian spinach (*Amunututu*)	94.4±0.03	92.5±0.03
Talinum triangulare (*Gbure*)	96.9±0.01	90.7±0.01
Amaranthus Spp (*Tete)*	103±5	103±1
Solanum notrifiolum (*Gbagba)*	113±1	115±2

Table 3: Potassium Content of both Fresh and Dried Vegetables (mg/kg)

Vegetable Type	Fresh Vegetable (mg/kg)	Dried Vegetable (mg/kg)
Venonia amygadlina (Ewuro)	80.3±0.12	82.7±0.17
Telfaria occidentalis (*Ugwu*)	98.5±0.08	101±1
Indian spinach (*Amunututu*)	93.2±0.02	90.0±0.21
Talinum triangulare (*Gbure*)	85.8±0.34	81.1±0.16
Amaranthus Spp (*Tete)*	110±1	112±1
Solanum notrifiolum (*Gbagba)*	85.6±3.00	80.0±1.89

Table 4: Two Sample t-test Results of Means of Vitamin C obtained at Various Time Intervals for Fresh Vegetables with and Without Potash

Time (min)	t- value	p -value
2	- 0.086	0.0507
4	0.483	0.0706
6	0.674	0.0899
8	0.107	0.0511

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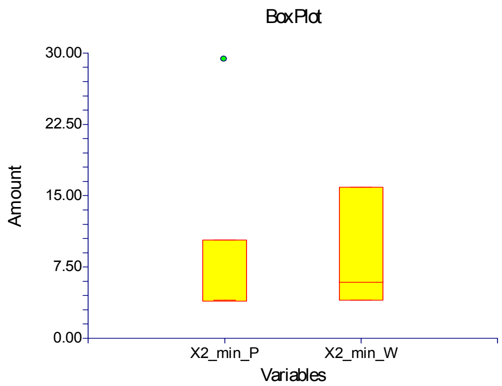

Figure 5: Box Plot of Vitamin C Content of Fresh Vegetables with/Without Potash at 2 Minutes

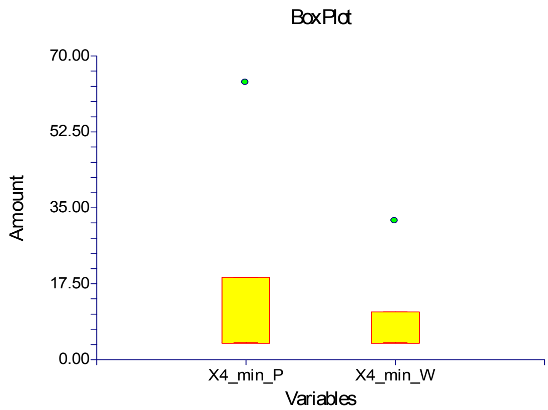

Figure 6: Box Plot of Vitamin C Content of Fresh Vegetables with/Without Potash at 4 Minutes

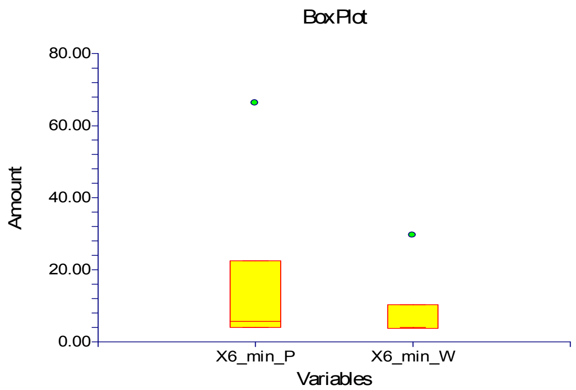

Fig. 7: Box Plot of Vitamin C Content of Fresh Vegetables with/Without Potash at 6 Minutes

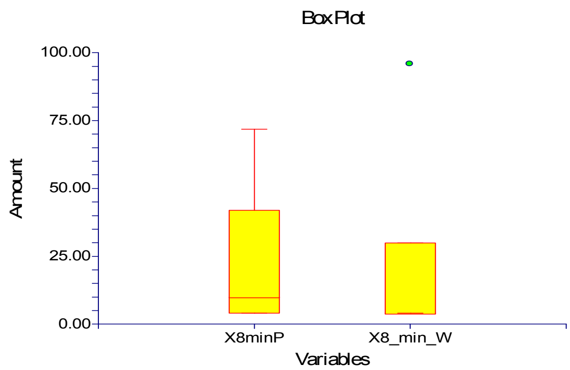

Fig. 8: Box Plot of Vitamin C Content of Fresh Vegetables with/Without Potash at 8 Minutes

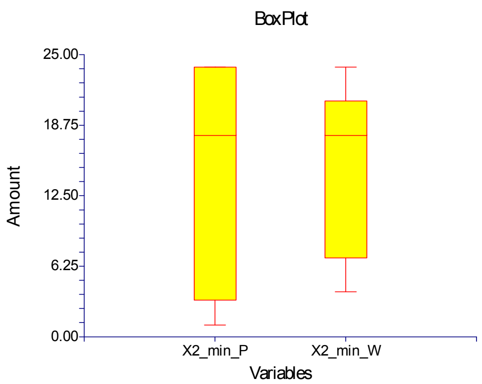

Figure 9: Box Plot of Vitamin C Content of Dried Vegetables with/Without Potash at 2 Minutes

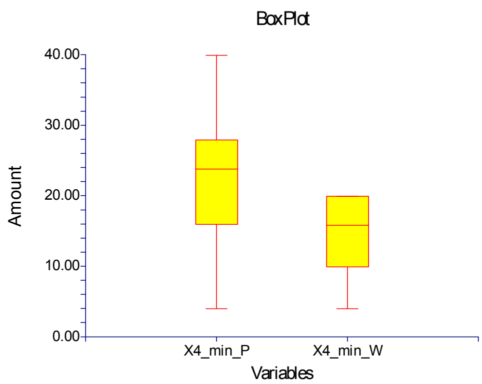

Figure 10: Box Plot of Vitamin C Content of Dried Vegetables with/Without Potash at 4 Minutes

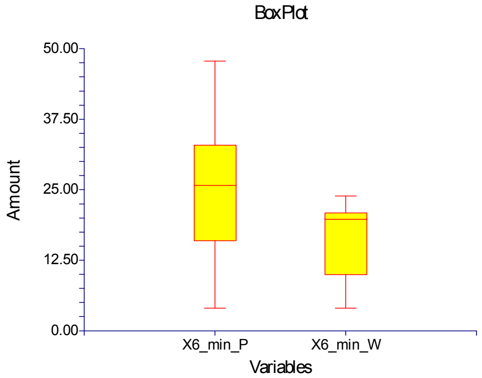

Figure 11: Box Plot of Vitamin C Content of Dried Vegetables with/Without Potash at 6 Minutes

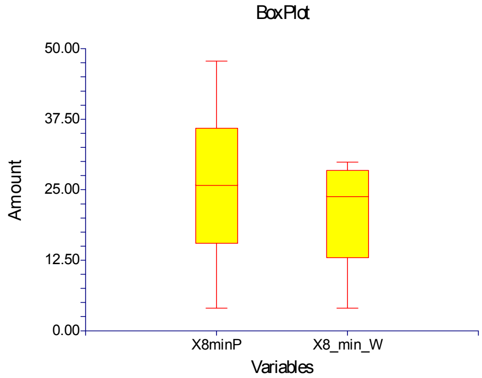

Figure 12: Box Plot of Vitamin C Content of Dried Vegetables With/Without Potash at 8 Minutes