January 2013 IJPSS Volume 3, Issue 1 ISSN: 2249-5894

ANALYSIS OF LEVELS OF BORON IN THREE VARIETIES OF WATERMELONS FROM GITHURAI AND MWEA MARKETS IN KENYA

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ABSTRACT

The paper represents a study carried on concentration of silicon in parts of three varieties of watermelons namely the Charleston grey (sugar F1), Crimson sweet (Zebra) and the Sugar baby. Watermelons were obtained from Githurai and Mwea markets in Kenya from different vendors for a period of 12 months. AAS instrument technique was used for qualitative and quantitative analysis of silicon in different parts of a watermelon. A one way ANOVA and the student t-test were used to determine the variation in levels of silicon in different parts and varieties of watermelon and variation between the levels of silicon in the two markets respectively. The mean levels obtained in this study in the four parts of the three varieties were 0.66±0.04-0.81±0.06 mg/g Si.

Keywords: Boron, Watermelon, Concentration mean levels, Kenya

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Introduction

Watermelon (Citrullus lunatus) belongs to cucurbitaceous family. It is related to cantaloupe, squash and pumpkin and other plants that grow on vines on the ground. The flesh may be red, pink, orange, yellow or white; the seeds can be brown, white green, or yellow and a few varieties are actually seedless[1]. No matter what ones age might be or how healthy one feel at the moment anti aging diet plays an important role in keeping the body looking great and feeling good. Anti aging diets have become very popular as one of the best ways a person can really beat the aging process. Watermelon from inside out is extremely healthy and is definitely included in the ant aging foods category. This is because it is known to contain necessary essentials such as healthy fats, vitamin E, Zn, vitamin A, B and C[2]. Watermelon is a good source of pure water- about 93%, it is a thirst quencher that may also quench the inflammation that contributes to conditions like asthma, atherosclerosis, diabetes, colon cancer and arthritis and an excellent diuretic. Because it has high water content and low calorie content it delivers more nutrients per calorie which is an outstanding health benefits[1]. Studies have shown that one can enjoy an increased lifespan with a longer period of mental acuity, learning ability becoming sharper and more alert by diet which significantly reduce calorie, which can also decrease the chance of heart disease and cancer, along with decreased loss of bone mass, which can help improve the chances of fighting osteoporosis[1].

Boron is a trace mineral that is essential to plant growth and in turn finds its way into the human diet. Boron is present in plant foods such as fruits (especially plums, grapes, and avocados), vegetables, nuts, and legumes. Despite its availability in nature, ingesting adequate amounts of boron can be difficult. For one thing, boron levels in plant foods are rather low (Harvey, 2006). Moreover, modern dietary habits almost ensure boron deficiency, as many people do not eat nearly enough fruits and vegetables. In the United States, estimated daily boron intake ranges from 0.5 mg to 3 mg, with 1 mg being average (Harvey, 2006).

Ensuring optimal boron intake becomes increasingly important as we age, especially in light of boron's critical role in safeguarding bone health. Calcium fructoborate is a plant form of boron which is a complex of calcium, fructose, and boron found naturally in fruits, vegetables and other foods (Harvey, 2006). This innovative form of boron is not only safe and well tolerated, but has been shown to be much more bioavailable than other commercial forms of

boron (Harvey, 2006). Ensuring healthy bones is fundamental to any anti-aging program, since weak bones can lead to disabling and even life-threatening bone fractures. Boron plays an integral part in bone metabolism, as it supports the functions of calcium, magnesium, and vitamin D, all of which are crucial to promoting dense, healthy bone tissue (Schaafsma, 2001). Boron has important applications in helping women preserve bone mass and prevent osteoporosis following menopause. Boron may likewise help to alleviate the detrimental effects of vitamin D deficiency on calcium metabolism. Vitamin D is Crucial to bone health because it helps to support calcium absorption (Hegsted et al., 1991).

Osteoarthritis is the most common form of joint disease, a source of daily pain, stiffness, and decreased range of motion. In addition to preserving bone health, boron may help relieve the debilitating symptoms of osteoarthritis (Gaby, 1999). Examining the relationship between boron intake and osteoarthritis prevalence around the world, researchers have uncovered epidemiological evidence demonstrating that in areas where boron intake is 1 mg or less per day, the estimated incidence of arthritis ranges from 20% to 70%. Conversely, in areas of the world where boron intake is usually 3-10 mg per day, the estimated incidence of arthritis is dramatically lower, ranging from zero to just 10%. This remarkable finding is compelling evidence that abundant intake of dietary boron may confer powerful protection against the development of osteoarthritis (Balch, 2006).

Boron may play an underappreciated role in protecting men against prostate cancer. As men grow older, their risk for prostate cancer skyrockets. Fortunately, growing research indicates that boron may help prevent prostate cancer. Studies have revealed that prostate cancer risk can be reduced simply by consuming a greater amount of boron-rich foods (Zhang et al., 2001). Boron compounds inhibit the activity of many serine protease enzymes, including prostate-specific antigen (PSA). Elevated PSA may promote prostate cancer via its degradation effects on the extra-cellular protein matrix (the protein surrounding the cell) within the prostate gland. Breaking down these cellular barriers may enable prostate cancer cells to more readily invade healthy tissue and spread (metastasize) beyond the prostate gland (Faloon and Strum, 2005).

Oral administration of various concentration of a boron-containing solution may help to shrink prostate tumors and decrease levels of PSA, an important prostate cancer marker.

Recent discoveries have shown that PSA itself may contribute to prostate cancer promotion. Ensuring adequate boron intake should thus be considered a critical component of any strategy to prevent prostate cancer and maintain optimal PSA levels (Gallardo et al., 2004).

Boron is necessary to allow the brain to function properly. Boron increases mental alertness, low boron intake by humans caused decreased brain activity. People on low boron diet have lower brain performance on attention and short term memory tests (MII, 2011). This essential mineral may also have important applications in helping aging adults preserve one of their most treasured assets: cognitive function (Penland, 1998). Calcium fructoborate decreases the production of intracellular reactive oxygen species, this antioxidant activity has clinical significance in protecting skin cells from oxidation-induced injury (Scorei et al., 2005).

Boron affects the metabolism and utilization of numerous other substances involved in life processes including macro minerals, energy substances such as triglycerides and glucose, nitrogen containing substances such as amino acids and proteins, reactive oxygen species and estrogen. Through this effect boron can affect several body systems including brain, skeleton and immune system (Heiner et al., 2002). Substituted carboranes and polyhedral hydroborate salts are potent anti-neoplastic agents inhibiting the growth of human leukemia, uterine carcinoma, colon adenocarcinoma, lung brochogenic tumor and gliomas (Hall et al., 1998).

Food and drinks of plant origin, especially non-citrus fruits, leafy vegetables, nuts, pulses, legumes and beer are sources of boron (Michael, 2005). Levels of boron in pumpkins, squash, cucumbers and cantaloupe have not been reported (WHF, 2010). The WHO established an acceptable safe range of population mean intakes for boron of 1-13 mg/day.

Materials and Methods

Research design

The experimental design which was used involved the determination of levels of the selected metals in four parts of watermelon namely; the peel, the rind, the flesh and seeds of three varieties of watermelons. The three varieties of watermelon; Charleston Gray (SugarF1), Crimson Sweet (zebra) and Sugarbaby were obtained from Mwea and Githurai market in Kenya. Sampling was done at equal intervals of time to avoid bias as a result of seasonal variations.

Sampling sites and sampling design

Purposive non probability strategy was used to select the sampling sites. The sampling sites were Mwea and Githurai markets; the main criterion for selection of sampling sites was the availability of the three varieties of watermelons. Mwea market was particularly considered because the watermelons are grown in the region and neighboring regions throughout the year by irrigation while Githurai being a market in Nairobi the capital city of Kenya, the watermelons are also available throughout the year from all over the country

The collected watermelon samples were packed and transported to laboratory, then separated into four parts namely the peel, rind, flesh and seeds, oven dried, wet digested and analysed under similar conditions in replicates under the same conditions using the atomic absorption spectroscopy (AAS).

From each of the two markets, sampling was done six times for each variety (where; sample size from Githurai is $n_1 = 6$ and from Mwea $n_2 = 6$ for each part). The experimental design of the three varieties of watermelons obtained from Githurai market is explained in Figure 3.1

Reagents and Apparatus

All reagents used in this study were of analytical grade. Concentrated nitric acid, sulfuric acid, hydrogen peroxide, potassium nitrate and hydrochloric acid were sourced from Thomas Baker Chemicals ltd Mumbai India whereas sodium borate ($Na_2B_4O_7.10H_2O$), calcium carbonate decahydrate ($CaCO_3.10H_2O$), silicon dioxide (SiO_2), molybdenum (Mo) metal, vanadium metal (V) and Chromium (Cr) metal were purchased from Fluka Chemie GmbH Aldrich chemical company, inc. USA.

Cleaning of Apparatus

All plastic ware and glass ware apparatus were washed with liquid detergent and hot water then rinsed severally with tap water followed by soaking overnight in 10 % analytical grade nitric acid. Finally they were rinsed with distilled water. The glass ware were dried in an oven at 105 °C and the plastic bottles in open racks and stored in lockable drawers under lock and key.

Sample collection and pre-treatment

Samples obtained were placed in separate labeled plastic bags to maintain their freshness and then transported to laboratory. Each of the watermelons was cleaned using distilled water, cut and the four parts (seeds, flesh part, rind and the peel) separated. The four parts were dried at 105 °C in a gravity oven for at least 24 hours and ground in a blender reducing them to

powder; this was done to obtain a fine homogenous powder. To avoid contamination aluminum foil and containers were used to hold the samples in the oven. The ground samples were stored in well labeled plastic bags awaiting digestion and analysis.

Preparation of standards

Stock solutions were prepared from analar grade granulated metals and salts of high purity (99.9%). The salt was first dried at 105 $^{\circ}$C, cooled in desiccators prior to weighing and transferred into 1 litre volumetric flasks. Boron stock solution was prepared by dissolving 44.095 g of $Na_2B_4O_7.10H_2O$ in 500 ml of distilled water and then diluted to 1 litre to give 5000 µg/ml B. During serial dilution and subsequent dilution of stock solutions, the final acid concentration was maintained at about 1% to keep the metal in free ionic state. The stock solutions were stored in plastic bottles and labeled appropriately. Working standards were freshly prepared from stock solutions each time an analysis was carried out, using serial dilution equation 7.

$$C_1V_1 = C_2V_2 \quad \text{.....Eq.7}$$

Where:

C_1- original concentration

V_1 -original volume

C_2 - new concentration

V_2 - new volume

In order to account for the background effects from the acids and to correct for changes resulting from digestion procedures, six blank samples were digested following the same procedures as the samples and each of the blank samples were determined for the elements of interest (Ca, Mo, Cr, Si, B and V) by atomic absorption spectrophotometer. Their absorbance's were recorded and their means and standard deviations were calculated and used for calculating limit of detection using the Equation 8 as described by Christian (2005).

$$\text{Limit of detection} = \frac{3\text{x Standard deviation of blank readings}}{\text{Absorbance of standard} - \text{Mean absorbance of six blanks}} \quad \text{.....Eq. 8}$$

Preparation of samples for atomic absorption spectrophotometer (AAS)

Ground samples were re-dried at 105 °C in an oven for an hour then cooled in desiccators. A 0.500 g of each sample was weighed accurately using electronic balance model AAA (Adam Co limited). A 9 ml mixture of HNO_3 and H_2SO_4 in the ratio 2:1 were first added to the 0.500 g of sample in Kjeldahl flask and then gently heated on hot mantle until the dense brown fumes began to appear. Hydrogen peroxide was added drop wise to clear the brown fumes. Digestion was allowed to continue until the solution was clear and white fumes observed. The digested sample was cooled and filtered using whatman No 42 filter paper into 100ml clean dry volumetric flask and then diluted to the mark with distilled water. They were then transferred into separate plastic bottles, labeled and appropriately stored in a freezer until analysis.

Sample analysis

Analysis of boron was done in replicates using computerized Varian Atomic Absorption Spectrometer model AA-10. The samples were analyzed in replicates under the same conditions as standards and blanks. For precision, standards were measured before and after the sample solution. The calibration of the instrument using standards and blank was frequently done between samples to ensure stability of the base line. The operating conditions for the AAS were; 249.8 nm wavelength, 0.2 nm slit width, N_2O-acetylene flame, 8.4 ppm sensitivity and 2 ppm instrument detection limit

Calibration graphs established from a plot of absorbance readings of standards against their corresponding concentration were used to determine the concentration of B.

Calculation of concentrations of elements in the samples

The concentration of essential elements in the samples was worked out from the obtained AAS analytical results (read out) using the Equation 2

$$\text{Actual concentration}(\mu g/g) = \frac{\text{Concentration } (\mu g/ml) \text{ x Volume digested } (ml)}{\text{Weight of dried sample taken } (g)} \quad \text{.....Eq.2}$$

In cases of dilution, the actual weight was obtained by multiplying the read out results with the dilution factor. The means of the replicate measurements were then calculated from the actual concentration obtained. The concentrations of B in the samples were worked out by calculating their means and standard error values.

In cases where the sample readings were below the optimum working range, standards of known concentrations were added to bring the sample reading to this range. The absorbances were recorded for the original sample and after the addition of the standard. Equation 3 described by Skoog et al. (1992) was used to calculate the actual weight of the sample.

$$C_x = \frac{A_1 C_s V_s}{(A_2 - A_1) V_x} \quad \text{.....Eq.3}$$

Where;

C_x - Concentration of sample

C_s - Concentration of the standard

A_1 - Absorbance of the sample before addition of standard

A_2 - Absorbance of sample after addition of standard

V_s - Volume of standard added

V_x - Volume of sample solution

Data analysis

Mean values obtained for silicon, molybdenum, boron, calcium, Cr and vanadium studied in the four parts of watermelons and the three varieties of watermelon samples were compared by One-Way ANOVA at 95% level using SPSS 18 for windows assuming that there were significant differences among them when the statistical comparison gives $p< 0.05$. The student t-test was used to compare the means in levels of the elements between the two markets. Whenever a significance difference exists, the means were compared at $p= 0.05$ significance level which accounts for errors since a sample was used to represent a population (Sawyer et al., 2007).

Results and discussions

Concentration of boron in watermelons

Levels of boron in watermelons from Githurai and Mwea markets

The results of the analysis of boron in part of various varieties of watermelon from Githurai and Mwea markets are discussed in the following subsections.

Mean levels of boron in parts of watermelons from Githurai and Mwea markets

Levels of B in the four parts of three varieties of watermelon were analyzed in triplicates using AAS instrument. The means obtained in each part were compared at α =0.05 level as shown in Table 4.28.

The result recorded in Table 4.28 indicate that in Charleston Gray from Githurai market, B mean levels recorded by the peel, rind, flesh and seeds were 1.20±0.26 mg/g, 0.73±0.05 mg/g, 0.20±0.01 mg/g and 1.21±0.20 mg/g respectively. Boron mean levels in the seeds, peel and rind did not differ significantly, however B mean levels recorded by the flesh were significantly lower than the other three parts since p (0.001) < p (0.05). Mwea market recorded mean levels of boron of 0.39±0.08 mg/g, 0.09±0.01 mg/g, 0.03±0.01 mg/g and 0.24±0.03 mg/g in the peel, rind, flesh and seeds respectively. Boron mean levels in the peel were significantly higher than those recorded by the other three parts and also mean levels recorded by the seed were significantly higher than those recorded by the rind and flesh since p (0.001) < p (0.05). B mean levels in the rind and flesh did not differ significantly. The seeds of Charleston Gray from Githurai market recorded the highest B mean levels. However, when the mean from the two markets were averaged the peel had the highest B mean levels.

In Crimson Sweet B mean levels reported from Githurai market in the peel, rind, flesh and seeds were 0.80±0.20 mg/g, 0.94±0.11 mg/g, 0.39±0.05 mg/g and 0.96±0.07 mg/g respectively. Boron mean levels in the flesh were significantly lower than those obtained from the other parts since p (0.013) < p (0.05). Boron mean levels in the seed, rind and peel did not differ significantly. Mwea market recorded B mean levels of 1.16±0.13 mg/g, 1.07±0.11 mg/g, 1.38±0.02 mg/g and 1.01±0.05 mg/g in the peel, rind, flesh and seeds respectively B mean levels in the rind, seed and peel did not differ significantly, however the mean levels recorded by the seed were significantly lower than those recorded by the flesh since p (0.037) < p (0.05).

Table 4.28: Mean concentration (mg/g DW) of boron in parts of Charleston Gray, Crimson Sweet and Sugarbaby watermelons from Githurai and Mwea markets

Varieties of watermelons		Parts of a watermelons Mean ±SE				p-value
		Peel	Rind	Flesh	Seeds	
Charleston Gray	Githurai $n_1 = 6$	1.20 ± 0.26^{b}	0.73 ± 0.05^{b}	0.20 ± 0.01^{a}	1.21 ± 0.20^{b}	0.001
	Mwea $n_2 = 6$	0.39 ± 0.08^{c}	0.09 ± 0.01^{a}	0.03 ± 0.01^{a}	0.24 ± 0.03^{b}	0.001
Crimson Sweet	Githurai $n_1 = 6$	0.80 ± 0.20^{b}	0.94 ± 0.11^{b}	0.39 ± 0.05^{a}	0.96 ± 0.07^{b}	0.013
	Mwea $n_2 = 6$	1.16 ± 0.13^{ab}	1.07 ± 0.11^{ab}	1.38 ± 0.02^{b}	1.01 ± 0.05^{a}	0.037
Sugarbaby	Githurai $n_1 = 6$	0.64 ± 0.29^{a}	0.16 ± 0.07^{a}	0.34 ± 0.22^{a}	1.28 ± 0.02^{b}	0.002
	Mwea $n_2 = 6$	1.27 ± 0.06^{c}	0.38 ± 0.02^{b}	0.23 ± 0.02^{a}	1.21 ± 0.05^{c}	0.001
	Overall mean n(total)=36	0.91 ± 0.09^{b}	0.55 ± 0.07^{a}	0.43 ± 0.08^{a}	0.98 ± 0.07^{b}	0.001

*mean values with the same small letters within the same row are not significantly different at α =0.05.

In Sugarbaby, B mean levels of peel, rind, flesh and seed from Githurai market were 0.64±0.29mg/g, 0.16±0.07mg/g, 0.34±0.22mg/g and 1.28±0.02 mg/g respectively. The seeds had significantly higher B mean levels compared to the other three parts since p (0.002) < p (0.05), however B mean levels in the rind, flesh and peel did not differ significantly. Mwea market recorded B mean levels of 1.27±0.06mg/g, 0.38±0.02mg/g, 0.23±0.02mg/g and 1.21±0.05 mg/g in the peel, rind, flesh and seeds respectively. The peel recorded the highest mean level of B which did not differ significantly with that recorded by the seed. However, B mean levels in the peel and seed were significantly higher than those recorded by the rind and flesh and also B mean levels in the rind and flesh differed significantly since p (0.001) < p (0.05).

Considering average of the two markets boron mean values recorded by the peels, the rind, the flesh and the seed were 0.95±0.17 mg/g, 0.27±0.05mg/g, 0.28±0.11 mg/g and 1.24±0.03 mg/g respectively. The seeds recorded the highest mean levels of B which did not differ significantly with the mean levels in peel but were significantly higher than mean level in the rind and the flesh since p (0.001) < p (0.05). Boron mean levels in the flesh and rind did not differ significantly. Statistically it means that those who consumed the seeds or the peels the same nutritional benefits of boron, and received the highest levels of boron in the Crimson Sweet.

From the results Table 4.27, the combined levels of boron for the three varieties of watermelons in the peel, the rind, the flesh and the seeds recorded ranges of (0.01-1.93) mg/g, (0.01-1.31) mg/g, (0.01-1.46) mg/g and (0.18-2.09) mg/g respectively. The wide ranges indicate that the watermelons may have been grown in soils with varying level of boron. The mean level of B in the three varieties recorded by the peel, rind, flesh and seeds were 0.91±0.09 mg/g, 0.55±0.07 mg/g, 0.43±0.08 mg/g and 0.98±0.07 mg/g respectively. There was no significant difference in B mean level recorded by peel and seeds as well as that recorded by flesh and rind. The seeds and the peel had significantly higher mean levels of B compared to flesh and the rind since p (0.001) < p (0.05). In the three varieties of watermelons considered boron was highly accumulated in the seeds and as well as the peel and either of the two would be recommended in the diet for reducing risk of prostate cancer (Zhang et al, 2001), improving cognitive function in older people (Penland, 1998), bone density and joint health (Harvey, 2006) and reducing osteoarthritis (Balch, 2006).

Comparison of boron (mg/100 g of fresh watermelon) means levels with the RDA of 1-13 mg/day and the amount of watermelon required to meet the minimum RDA

Mean levels of boron recorded in each part of the three varieties of watermelon were converted in mg/100 g of fresh piece of watermelon as explained in section 4.3.1.4 and compared using t-test at α =0.05 level and 11 df with the RDA of 1-13 mg/day (WHO, 1996 and IPCS, 1998). In Charleston Gray, it was noted that there was no significant between the mean levels of boron and the minimum RDA of 1 mg/day in the peel, the rind and the seed since the t-calculated values of the peel, the rind, and the seed of 0.9027, 2.193 and 0.5222

respectively are less than t-Critical of 2.201 and also for the average of the four parts calculated t (1.586) < t-Critical (2.012).

For Crimson Sweet it was be noted that the calculated t values of 2.767, 4.852, 8.415 and 6.203 for the peel, rind, seed and total mean respectively were higher than t-Critical of 2.201. This means that the mean levels of B in the peel, rind and total mean were significantly above the minimum RDA of B but within the recommended safe range of 1-13 mg/day. However, the calculated t value of 1.646 for the flesh was less than critical t value of 2.201. This means that the mean levels of B in the flesh did not differ significantly with the minimum RDA of 1mg/day.

For the Sugarbaby, there was no significant difference between boron mean level in the peel and total mean with minimum RDA of 1mg/day since the calculated t of 1.904 for the peel and 0.6930 for total mean were less than Critical t of 2.201 and 2.012 respectively. The mean levels of B in the rind and flesh were significantly lower than the minimum RDA of 1mg/day of B since t calculated values of 7.437 for rind and 23.35 for the flesh were higher than t-Critical value of 2.201.The mean levels of B in parts of the varieties of watermelons studied and their corresponding amount of fresh watermelon needed to meet the minimum RDA are given in Table.4.29.

Boron mean levels (mg/100g of fresh watermelon) in parts of Charleston Gray, Crimson Sweet and Sugarbaby and amount of watermelon required to meet RDA of 1.0-13 mg /day

Part of watermelon	Charleston Gray		Crimson Sweet		Sugarbaby	
	Mean±SE n=12 (mg/100g)	Mass of fresh watermelon (g)	Mean±SE n=12 (mg/100g)	Mass of fresh watermelon (g)	Mean±SE n=12 (mg/100g)	Mass of fresh watermelon (g)
Peel	1.26±0.28	100	1.55±0.20	100	1.51±0.27	100
Rind	0.65±0.16	150	1.59±0.12	100	0.43±0.08	250
Flesh	0.18±0.04	550	1.39±0.24	100	0.45±0.17	250
Seed	1.14±0.28	100	1.55±0.07	100	1.97±0.04	100

Overall mean n = 48	0.81±0.12	100	1.52±0.08	100	1.09±0.13	100

From Table 4.29 it can be noted that the rind and flesh of in a 250 g piece of Sugarbaby watermelon or the rind in 150 g and the flesh in 550 g of Charleston Gray would be required to meet the minimum RDA of 1 mg/day. In a 100 g piece of any other part of the three varieties watermelon would provide the minimum RDA of 1mg/day of boron. On average any part in 100 g piece of a fresh watermelon is enough to meet the minimum RDA of 1 mg/day as indicated in the mean levels of B for the overall mean. Studies on boron in cucurbits have not been reported

Mean levels of boron in varieties of watermelons from Githurai and Mwea markets

Boron was detected in all parts of the three varieties of watermelon considered in this study. The overall mean for the four parts in each variety was calculated and compared with overall mean of other two varieties at $\alpha = 0.05$ level. A comparison of mean levels of boron in the three varieties of watermelons is shown in Table 4.30.

Table 4.30: the combined mean levels (mg/g DW) of boron in Charleston Gray, Crimson Sweet and Sugarbaby watermelons from Mwea and Githurai markets

Varieties of watermelons	Charleston Gray	Crimson Sweet	Sugarbaby	p-value
Githurai market Mean±SE(n=24)	0.83±0.12	0.76±0.08	0.60±0.12	0.307
Mwea market Mean±SE(n=24)	0.19 ± 0.04^{a}	1.15 ± 0.05^{c}	0.77 ± 0.10^{b}	0.001
Githurai and Mwea markets Mean±SE(n=48)	0.51 ± 0.08^{a}	0.96 ± 0.05^{b}	0.69 ± 0.18^{a}	0.001

*mean values with the same small letters within the same row are not significantly different at α =0.05

The results in Table 4.30 indicate that from Githurai market, B mean levels recorded by the Charleston Gray, the Crimson Sweet and the Sugarbaby watermelon were 0.83±0.12 mg/g, 0.76±0.08 mg/g and 0.60±0.12 mg/g respectively. Boron mean levels in the three varieties did not differ significantly since p (0.307) > p (0.05). Mwea market recorded B mean levels of 0.19±0.04 mg/g, 1.15±0.05 mg/g and 0.77±0.10 mg/g in the Charleston Gray, Crimson Sweet and Sugarbaby watermelon respectively. B mean levels in the three varieties differed significantly since p (0.001) < p (0.05). Considering the average of B mean levels in the two markets, the mean levels of B recorded by Charleston Gray, the Crimson Sweet and the Sugarbaby were 0.51±0.08 mg/g, 0.96±0.05 and 0.69±0.18 mg/g respectively. The mean levels of B in Charleston Gray and Sugarbaby did not differ significantly. Since p (0.001) < p (0.05) it means that Crimson Sweet recorded a significantly higher mean level of boron as compared to the other two varieties. The Crimson Sweet is therefore from the best source of boron.

Comparison of mean levels of boron in Githurai and Mwea market

Boron was detected from all the samples obtained from Githurai and Mwea market. The mean level of boron obtained in the three varieties (all parts averaged) of watermelons from the two markets were compared using t-test at α =0.05 level. The mean levels of B from Mwea and Githurai markets with their corresponding t values are recorded in Table 4.31.

Table 4.31: Mean concentration (mg/g DW) boron in Charleston Gray, Crimson Sweet and Sugarbaby watermelons from Githurai and Mwea markets

	Markets		Df	t-calculated	t-Critical (α =0.05)
	Githurai mean±SE	Mwea mean±SE			
Charleston Gray	0.83±0.12	0.19±0.04	46	5.310	2.013
Crimson Sweet	0.76±0.08	1.15±0.05	46	4.330	2.013
Sugarbaby	0.60±0.12	0.77±0.10	46	1.050	2.013

Results in Table 4.31 indicate that in the Charleston Gray B mean levels recorded by Githurai and Mwea market were 0.83±0.12 mg/g and 0.19±0.04 mg/g respectively. The calculated

(t=5.310)> Critical (t=2.013) this mean boron mean levels in Githurai market were significantly higher than those of Mwea market. This variation could have resulted from the B levels in the soils where the watermelons were grown or in the water used to grow them.

In Crimson Sweet the mean levels of boron recorded by Mwea and Githurai were 1.15±0.05 mg/g and 0.76±0.08 mg/g respectively. The boron mean level in Mwea was significantly higher than those of Githurai since t-calculated (4.330) was higher than t-Critical (2.013). The Crimson Sweet watermelons from Mwea may have been grown in soils abundant in boron as compared to the soils where Crimson Sweet watermelons were grown.

In the Sugarbaby the mean levels recorded in Table 4.30 for watermelons obtained from Githurai and Mwea markets were 0.60±0.12 mg/g and 0.77±0.10 mg/g respectively. The t-calculated (1.050) < t-Critical (2.013) meaning that there was no significant difference in the mean levels of B in Sugarbaby watermelons obtained from Githurai and Mwea markets. This indicated that the Sugarbaby watermelons may have grown in soils with similar levels of boron.

Acknowledgement

The authors wish to thank the department of chemistry Kenyatta university for supplying chemicals and providing laboratory bench and apparatus used in this study and department of geology and mines, ministry of environment and natural resources for providing analytical equipments used in this study.

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