UTILIZATION OF BEAN LEAVES AS A CHEAP SOURCE OF VITAMIN A, IRON AND ZINC IN THE DIET

PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN FOOD NUTRITION AND DIETETICS OF THE UNIVERSITY OF NAIROBI

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This Project report has been submitted for examination with my approval as the University supervisor.

Dr. George Ooko Abong' (PhD)

Department Of Food Science, Nutrition and Technology.

Signature. _____________________________ Date. __________________________

DEDICATION

I would like to dedicate this work to my mother Beatrice Lyaka Matifary for seeing me through school and instrumental in shaping my life.

ACKNOWLEDGEMENT

This work was made possible by the efforts and contributions of many people.

I express my heart-felt gratitude to, first of all, the Almighty God, Who has given me His unlimited grace to do all that I have done this far.

Secondly, I thank my supervisor: Dr. George Abong' for his continued guidance and support throughout the period I was undertaking this project. Special thanks to Prof. P.M Kimani for providing me with the bean varieties for analysis and his guidance through-out the project.

I would also like to thank the staff in DFSNT for their unequaled input during my laboratory analysis.

Finally, to my parents for their financial and moral support during the period of this research.

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ABBREVIATIONS AND ACRONYMS

WHO – World Health Organization

RDA – Recommended Dietary Allowance

ANOVA – Analysis Of Varriance

RDA – Recommended Daily Allowances

AAS – Atomic Absoption spectrophotometry

DMB – Dry Matter Basis

ABSTRACT

Introduction

Varieties of legumes are recognized as an important source of protein and dietary minerals by a number of ethnic groups in East, South and Central Africa. Among the legume that is preferred by most Africans are the bean varieties. Beans are consumed in many forms: the young leaves, green pods, and fresh bean grains are used as vegetables Apart from alleviating food insecurity, the bean leaves, green bean pods and fresh bean grains are good sources of micronutrients especially vitamin A iron and zinc.(Mamiro et al 2012).

Methodology

Vitamin A was analyzed as beta carotene . The carotenoids were extracted using acetone, the acetone was evaporated and the residue mixed with petroleum ether to dissolve beta carotene. This was then passed through an activated silica gel column to separate the beta carotene from the other carotenoids. The absorbance was read and then vitamin a content calculated using a constant from the standard curve.

Zinc and Iron were determined by digesting ash from dry samples of bean leaves with 20% hydrochloric acid. The resulting solution was filtered into a volumetric flask made to the mark with distilled water. The values were read from this solution using the AAS machine.

Key findings

The following results were obtained from analysis of the raw samples.

	Samples No.	**Dry matter (%)**	**Vitamin A(IU) DMB/100g**	**Iron(mg) DMB/100g**	**Zinc(mg) DMB/100g**
BCB bean varieties	8	15.043	54915	127.40	20.069
Bio-fortified bean varieties	8	14.941	69277	224.41	15.941
KCB bean varieties	8	13.369	59253	234.40	14.405
Comparison Within genotypes	24	P value <0.001	P value <0.001	P value 0.4583	p. value <0.001
Within varieties	24	P value <0.0002	P value <0.001	P value 0.3488	P value <0.001
Effect of cooking on Vit. A	12		p. value 0.7011		

Table 1:summary of results

The bean varieties chosen in this study contain significant amounts of vitamin A, Zinc and Iron.

There are significant differences within the genotypes and varieties in terms of vitamin A given by a P value of < 0.001. Thus different bean varieties contain different amounts of vitamin A.

There were significant difference in the amounts of zinc within the genotypes and varieties different bean varieties have different amounts of zinc.

There were no significant differences within the genotypes indicated by a p value of 0.4583 and among the varieties indicated by a p. value of 0.3488. This means that one will obtain nearly the same amount of Iron irrespective of the genotype or variety consumed.

On the effect of cooking on vitamin A, There were no significant losses due to cooking shown by the p. value 0.7011.

Conclusion

Bean leaves contain significant amounts vitamin A zinc and iron that are important within the diet.

Different genotypes and varieties contain different amounts of vitamin A and zinc. However they contain nearly equal amounts of iron so whichever variety consumed will deliver significant amounts.

There are no significant loses in the content of vitamin A in the bean leaves due to cooking.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND INFORMATION

Varieties of legumes are recognized as an important source of protein and dietary minerals by a number of ethnic groups in East, South and Central Africa. Among the legume that is preferred by most Africans are the bean varieties. Beans are consumed in many forms: the young leaves, green pods, and fresh bean grains are used as vegetables; dry bean grains are used in various food preparations, and both are used as relish or side dishes together with the staple food. Apart from alleviating food insecurity, the bean leaves, green bean pods and fresh bean grains are good sources of micronutrients especially iron and zinc.

Although legumes are often used as a complement to cereals in terms of amino acid content, they also make a particular important contribution to micronutrient nutrition. . The common bean (Phaseolus vulgaris L.) is the most important grain legume for direct human consumption, being especially important in Eastern Africa and Latin America. (Mamiro et al 2012)

Vitamins are organic compounds that are required in the diet in very small quantities but perform very important function. Vitamin A is such a compound and has the following important functions in the human body: It enables the eye to adjust to changes in light, helps in the maintenance of skin and mucus membranes as well as the cornea of the eye. It also plays a role in the development of healthy teeth and bones.it pays a major role in the reproductive processes, the manufacture of red blood cells and the Immune system.

Rich sources of vitamin A include: liver, eggs, carrots, sweet potatoes, pumpkins and dark green leafy vegetables. (Peggy and Hui 2009)

Iron is an essential trace element and plays numerous biochemical roles in the body. More than 2 billion people worldwide suffer from iron deficiency making it the most common deficiency syndrome in the world. Iron has a role in the regulation of energy production and immune function. It is also an important component in enzymes that manufacture blood.

Iron sources in the diet are divided into two: Haem iron sources (red meat, chicken, and fish) and Non haem iron sources (cereals, vegetables, beans, fruits, pulses etc.). (Paul sharp .2005)

Zinc is an essential micronutrient in the human body. It has major roles to play in the body. However its deficiency symptoms do not show easily. Zinc plays a major function in metabolism as a co factor for over 100 enzymes and thus it is key in all enzyme co-ordinated systems in the body.

Rich sources of zinc include: meat (red and white), fish and dark green leafy vegetables. (Paul Sharp 2005).

This study wishes to establish the amounts of vitamin A, zinc and iron in cooked and uncooked bean leaves and compare them to the recommended daily allowances for the nutrients. This will provide a scientific basis for the utilization of bean leaves as a vegetable to provide these micronutrients in the diet.

1.2 PROBLEM STATEMENT

Vitamin A zinc, and iron deficiencies have been reported worldwide. Globally approximately 21% of all children suffer from vitamin A deficiency with about 28% -30% of them being in Africa. 1.6% of deaths worldwide are attributable to zinc deficiency it is responsible for approximately 16% of lower respiratory tract infections, 18% of malaria and 10% of diarrheal disease globally. On the other hand 1.5% deaths worldwide are attributable to iron deficiencies. (World health report 2002).i

This is further compounded by expensive vitamin A supplements and poor food choices among the people. In Kenya, government supplementation programs for these nutrients are not enough to mitigate the deficiencies. This study seeks to contribute towards mitigating these deficiencies by providing a cheap vegetable alternative in the diet.

1.3 JUSTIFICATION.

Kenya’s main staple food is maize which is grown in most areas in Kenya seasonally. For this crop to thrive it is usually intercropped with beans to provide the maize plant with nitrogen in the soil. For every maize plant planted at least two bean crops are planted. This makes bean crops to be in abundance. In Kenya beans are commonly grown for their grains. It is one of the widely consumed legumes in Kenya.

In most scenarios the bean leaves are usually by products of the grains. This is because of the economic and nutritional importance attached to the grains. Consumption of bean leaves creates a cheap vegetable alternative that can be as nutritious as the grains and this will further enhance the nutritional importance of the bean plant. When compared to other green leafy vegetables that have to be bought, bean leaves are easily available and don’t have to be bought because they are in abundance.

A study carried out in Tanzania on the “Contribution of minerals from fresh kidney bean leaves and grains in meals consumed in east, south and central Africa” by Peter Mamiro et al 2012 reveals that The iron and zinc levels in bean leaves and fresh bean grains have shown to be significantly higher than the levels in dry bean grains.

Vitamin A includes both pro-vitamin A carotenoids, retinol and its active metabolites. Pro-vitamin A carotenoids are those that can be oxidized to retino-aldehyde, an active form of vitamin A. These carotenoids are found in dark green yellow, red and orange fruits and vegetables. (David A bender 2005) this illustrates the fact that green bean leaves contain

Vitamin A.

1.4 AIM

To reduce micronutrient deficiencies in the world through innovative solutions to the problems.

1.5 PURPOSE

To purpose of this study is to provide a cheap dietary alternative that will contribute in the mitigation of iron, vitamin A and zinc deficiencies.

1.6 GENERAL OBJECTIVE

To provide scientific basis for the utilization of bean leaves as a cheap source of vitamin A, Zinc and Iron in the diet.

1.7 SPECIFIC OBJECTIVES

- To determine the amounts of vitamin A, Zinc and Iron in leaves of different bean varieties.
- To determine the effects of cooking on the amounts of vitamin A, the leaves of different bean varieties.

1.8 HYPOTHESIS

Bean leaves contain enough vitamin A, Zinc and Iron to meet their recommended daily allowances in the diet.

CHAPTER 2: LITERATURE REVIEW

Globally approximately 21% of all children suffer from vitamin A deficiency with about 28% - 30% of them being in Africa. 1.6% of deaths worldwide are attributable to zinc deficiency it is responsible for approximately 16% of lower respiratory tract infections, 18% of malaria and 10% of diarrheal disease globally. On the other hand 1.5% deaths worldwide are attributable to iron deficiencies. (World health report 2002).

2.1 COMMON BEAN (phaseolus vulgaris)

It is also known as the kidney bean, bush bean, navy bean etc. there are two main types of cultivars of this bean: dwarf or bush cultivars which are early maturing with lateral and terminal influences and climbing or pole cultivars which have indeterminate growth up to three meters in height. It is believed that the common bean originated in Mexico and the first species was domesticated in Peru.

It was introduced to Europe by Portuguese merchants in the 16th century and also to tropical Africa afterwards. Currently it is mostly cultivated in East Africa, West Africa, the Caribbean, central and south America.

Immature pods are usually harvested 14 – 21 days after flowering. A delay in harvesting is likely to reduce the pod quality. For the dried bean harvesting /picking is delayed until lower pods are at the point of shattering.

Young pods and mature seeds are normally used as a cooked vegetable. The young leaves are also used as a vegetable particularly in East Africa. The nutritional value of fresh bean pods and dried beans are given in the table below:

Plant part	Water(ml)	Calories	Proteins(g)	Fat(g)	Carbs(g)	Fiber(mg)	Iron (mg)	β carotene (μg)	Ascorbic acid
Seeds	12	336	21.7	1.5	60	4.4	8.2	10	1
Pods	88	36	2.5	0.2	7	1.8	1.4	750	27

Table 2: nutritional value of fresh bean pods and dried beans (H.D. Tindall 1983)

Varieties of legumes are recognized as an important source of protein and dietary minerals by a number of ethnic groups in East, South and Central Africa. Among the legume that is preferred by most Africans are the bean varieties. Beans are consumed in many forms: the young leaves, green pods, and fresh bean grains are used as vegetables; dry bean grains are used in various food preparations, and both are used as relish or side dishes together with the staple food. Apart from alleviating food insecurity, the bean leaves, green bean pods and fresh bean grains are good sources of micronutrients especially iron and zinc. (Peter Mamiro et al 2012)

2.2 VITAMIN A, The bioconversion to of its precursors to active vitamin A in the body.

Vitamin A is an essential micronutrient for all vertebrates. It is required for normal vision, reproduction and embryonic development, cell and tissue differentiation and immune function. The main sources for vitamin A include: liver, eggs, carrots, sweet potatoes, pumpkins and dark green leafy vegetables. Dietary vitamin A is ingested in two main forms: preformed vitamin A and pro vitamin A carotenoids. These precursors serve as substrates for the biosynthesis of two essential metabolites of vitamin A: retinal – required for vision and Trans retinoic acid required for cell differentiation and regulation of gene transcription.

Vitamin A is a generic term used to refer to compounds with the biological activity of retinol. These include pro-vitamin carotenoids, principally beta carotene, alpha carotene and beta cryphtoxanthin which are provided in the diet by green, yellow or orange vegetables. Carotenoids are synthesized by photosynthetic plants in the leaves.

Beta carotene, alpha carotene and beta cryphtoxanthin are pro vitamin A carotenoids that possess significant vitamin A activity. To be active as Vitamin A, a carotenoid must have an un-substituted beta ionone ring and an unsaturated hydrocarbon chain. These three carotenoids meet the above conditions and that’s why they have vitamin A activity. (Catherine Ross and Earl Harrison 2007)

2.3 IRON, bioavailability and anti-nutrient factors.

Although non haem iron is the most prevalent source of dietary iron, it is much less bioavailable than haem iron. Only 1-10% of dietary non haem iron is absorbed due to profound influence on dietary components that enhance or inhibit iron availability. The most potent enhancer is ascorbic acid (vitamin c) that acts by reducing the ferric iron to the more soluble and absorbable form. Other small organic acids such as citric acid and alcohol promote the absorption of non haem iron.

The best known dietary inhibitors of iron are phytates which are salts of inositol hexaphosphate found in cereal products. Phenolic compounds found in plant food sources are also potent inhibitors of non haem iron absorption. The major inhibitors are tannins found in tea and red wine. Both the phytates and phenolic compounds are thought to form insoluble iron chelates in the intestinal lumen rendering the iron in a non-absorbable form. (Paul Sharp 2005)

2.4 ZINC bioavailability and anti – nutrient factors.

Zinc is variably absorbed from different food groups. The major inhibitor is phytic acid present in large quantities in cereals, legumes and other vegetables. Phytic acid is negatively charged on the food pH table and readily forms insoluble complexes with positively charged ions such as zinc thereby limiting their bioavailability.

2.5 OVERCOMING ANTI-NUTRIENT FACTORS

The inhibitory effect can be partly overcome by food preparation techniques. Examples include:

Addition of yeast during bread making increases phytase activity (an enzyme that breaks down phytates) reducing phytates level.

Animal protein is thought to have antiphytic activity and enhances bioavailability of zinc. It is believed that small peptides and amino acids released during digestion improve the solubility of zinc and iron and protect against formation of insoluble phytate complexes. (Paul Sharp 2005)

2.6 GAP IN KNOWLEDGE

Little analysis has been done on bean leaves to determine their nutrient composition. This is because beans are always grown for the seeds and sometimes the pods. Consumption of bean leaves is on a lower scale because people don't understand their composition and through this research people will have the knowledge. This will enable them to use this vegetable since it is highly abundant.

CHAPTER 3: METHODOLOGY

3.1 STUDY DESIGN

Experimental design was employed in this study.

3.2 STUDY SETTING

The study was based in the University of Nairobi, college of agriculture and veterinary sciences. It is located off Kapenguria road 14 kilometers to the northwest of Nairobi. It has two major faculties, the Faculty of Agriculture and that of Veterinary Medicine.

3.3 SAMPLING PROCEDURE

Purposive sampling was used to choose three major bean varieties that is, BCB , KCB and Bio-fortified bean varieties. Among the three large categories, four genotypes were picked and planted in sterilized soil. This formed the sample size for analysis of vitamin A, zinc iron in raw bean leaves. The sample size was calculated as follows:

In the second experiment, two varieties with the highest levels of vitamin A in each of the categories were chosen and analyzed for vitamin A while in raw form and in cooked form

3.4 SAMPLE SIZE DETERMINATION.

3 categories were chosen and 4 genotypes picked from each category. 2 replicates were planted for each genotype and analyzed.

3x4x2 = 24 samples

In the effect of cooking on vitamin A experiment, two varieties were picked from each category. Two replicates were analyzed for each category.

6 x2 = 12

3.5 DATA COLLECTION METHODS

Data shall be collected using the following methods:

- **Laboratory analysis**
  - Laboratory determination of beta carotene(Vitamin A) Method number 44 of international Federation of Fruit Juice Producers adopted in 1972.

    Two grams of the wet sample was crushed and the carotenoids extracted using acetone. The extract is filtered using glass wool into a ground neck flask. The acetone was then evaporated in a rotary evaporator. After evaporation to dryness the residue was mixed with petroleum ether and passed through an activated silica gel column to separate beta carotene from the carotenoids. The beta carotene was collected in 25 ml volumetric flasks and the absorbance read. This was then converted to .vitamin A using the standard curve.
  - **Determination of zinc and iron by wet digestion of ash by hydrochloric acid.**

    4 grams of the dry powdery sample heated in a muffle furnace at 500^0C. The ash is then digested with 20% hydrochloric acid and then heated till boiling. This solution was then filtered into a 50 ml volumetric flask and filled to the mark with distilled water. The resulting solution was then taken for reading using an Atomic Absorption Spectroscopy Machine (AAS Machine)
- USDA Recommended daily allowance tables

3.6 DATA QUALITY CONTROL

- Utilization of 2 replicates for each variety for high quality results
- Soil sterilization to cater for the effect of soil iron on the bean leaves.

3.7 DATA ANALYSIS

Data analysis was done using GENSTAT statistics software and presented in terms of ANOVA tables and charts

GENOTYPE	VITAMIN A (IU/100G)	IRON (MG/100G)	ZINC (MG/100G)	%DRY MATTER
BCB 11-132	84133.53 ± 7048.67	145.45±0.49	50.135±0.13	13.505± 1.08
BCB 11-144	58428.065±5460.17	163.87±3.75	11.12±1.51	13.71± 0.65
BCB 11-204	21781.685±2399.23	89.06±0.27	6.485±0.26	18.96± 0.14
BCB 11-245	55315.11±4085.22	111.23±4.51	12.535±0.22	13.995± 0.64
KCB 13-01	49343.92±3595.98	211.49±0.16	25.64±50.04	14.45± 0.17
KCB 13-04	75097.635±5492.28	466.915±539.46	6.595±0.43	14.58± 0.72
KCB 13-06	51966.04±2699.58	113.295±0.59	9.79±0.07	15.12± 0.27
KCB 13-08	60605.11±2407.59	145.895±9.26	15.59±0.49	15.615± 0.21
KENYA AFYA	56697.48±4071.87	184.975±4.12	21.7±0.27	13.125± 0.62
KENYA ALMASI	114906.185±1343.34	156.88±5.47	20.97±0.18	14.015± 0.02
KENYA MAJANO	33474.52±2801.94	380.86±8.73	8.145±0.16	14.58± 1.06
ROSECOCO MADINI	72029.235±2990.62	380.86±1.82	12.95±0.62	11.755± 0.35

Table 3: Values of vitamin A, iron and Zinc in bean leaves of the different genotypes within the three varieties chosen for this study on dry matter basis.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 OBJECTIVE ONE

To determine the amounts of vitamin A, zinc and iron in the leaves of different bean varieties.

2 grams of leaves were picked from each replicate in each genotype and analyzed in the Laboratory for vitamin A, zinc and iron.

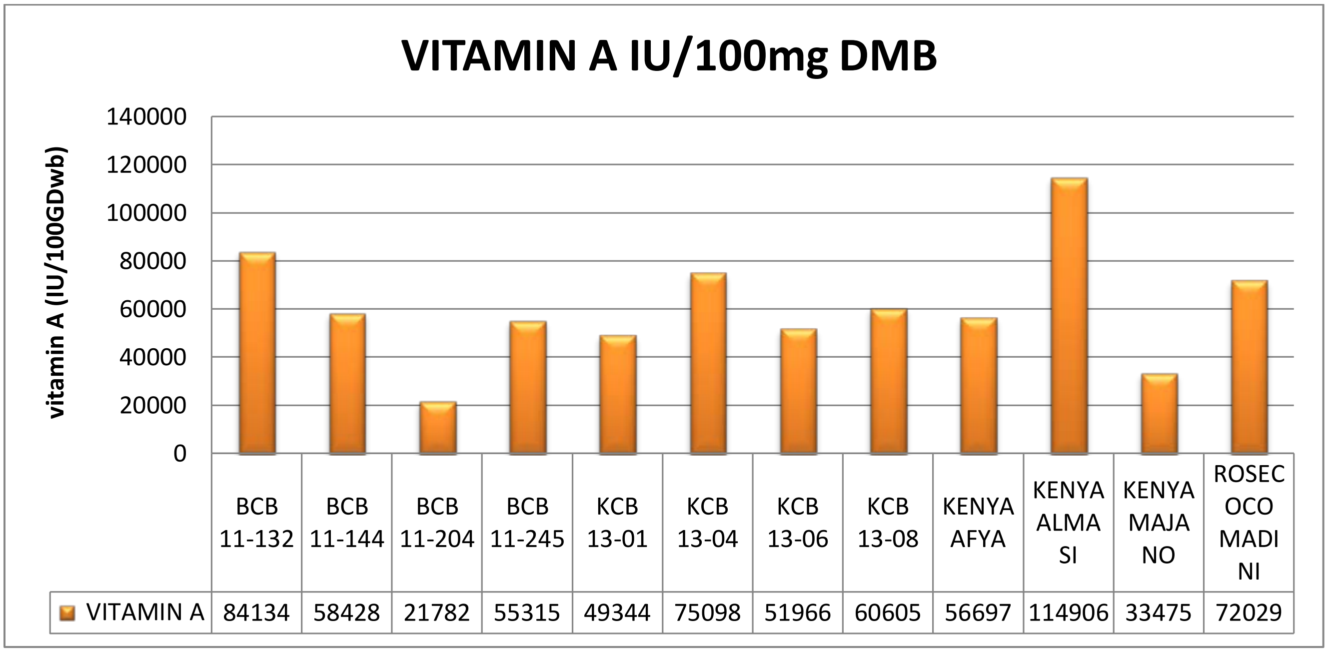


Chart 1: bar graph indicating the levels of vitamin A in the leaves of the different bean genotypes.

Kenya Almasi had the highest amount of vitamin A while BCB 11-204 had the lowest amount of vitamin A in the leaves

These results indicate that there are significant amounts of vitamin A in the leaves of the bean varieties. The vitamin A is in the form of beta carotene, a precursor of vitamin A.

Beta carotene is broken down to form retinol in the liver. This bioconversion is taken care of by a factor 0.6 in the conversion to international units.(Whitney and Rofles 2002)

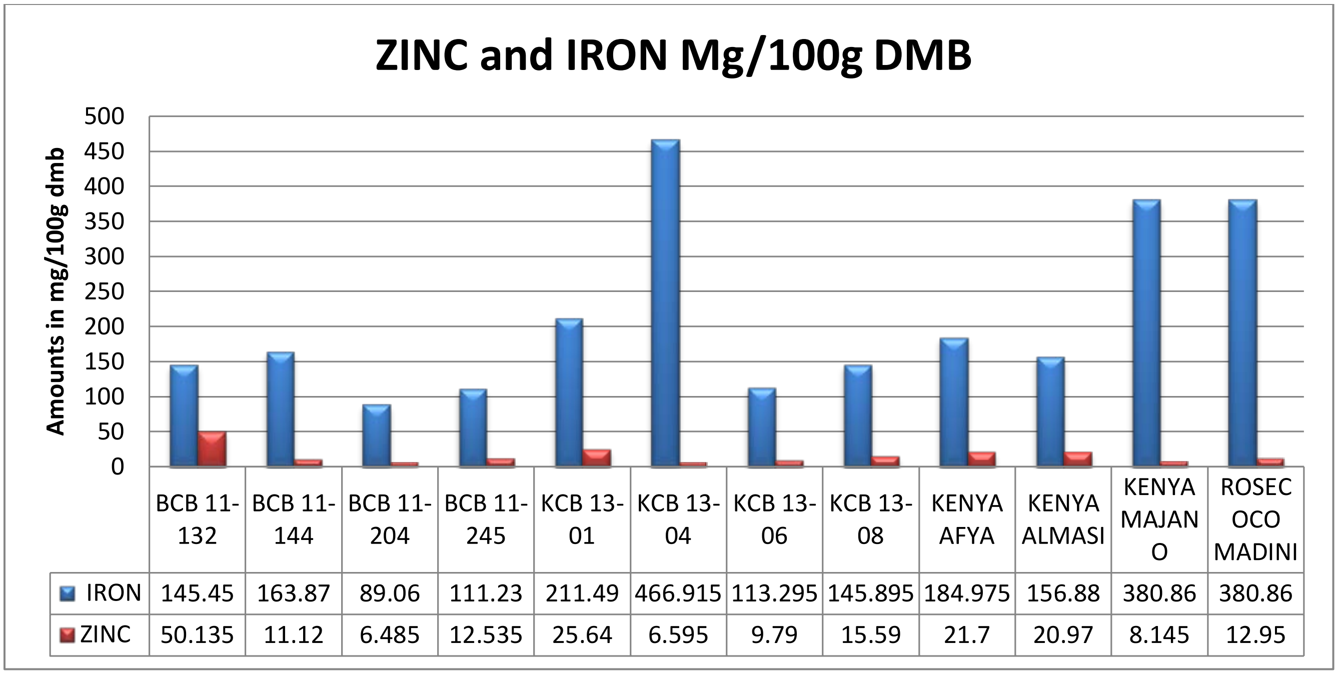


Chart 2: Combined bar graph showing the amounts of zinc and iron in the leaves of the different bean genotypes.

KCB 13-04 leaves had the highest amounts of iron while leaves from BCB11-204 have the lowest amount of iron among the genotypes.

BCB 11-132 leaves had the highest amounts of zinc while BCB 11-204 leaves had the lowest amounts of zinc.

The results above show that bean leaves contain significant amount of zinc and iron. These compare to a similar study done in Tanzania by (Mamiro et al 2012) which showed significantly high amounts of zinc, and iron in bean leaves.

4.1.1 COMPARISONS

The researcher compared the different genotypes in terms of vitamin A, Zinc iron and dry matter using the ANOVA table at 95% confidence interval as follows:

Dependent Variable: VITAMIN A

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	12663931723	1151266520	71.47	<.0001
Error	12	193302372	16108531		
Corrected Total	23	12857234094			

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Genotypes	11	12663931723	1151266520	71.47	<.0001
Varieties	2	868191703	434095851	26.95	<.0001

Table 4: ANOVA table for the analysis of vitamin A.

From the above ANOVA table there are significant differences in the amounts of vitamin A among the genotypes. This is shown by the P. value of <0.001. This confirms the earlier indication that Kenya Almasi contains the highest amount of vitamin A while BCB 11-204 contains the lowest amount of vitamin A.

When the different varieties of beans were compared in terms of vitamin A, it shows that at 95% confidence the categories have significant differences in the amounts of vitamin A shown by a p value of <0.001. This shows that different bean varieties contain different amounts of vitamin A in their leaves. This observation is further enhanced by plotting the vitamin A means of the different bean varieties as shown below:

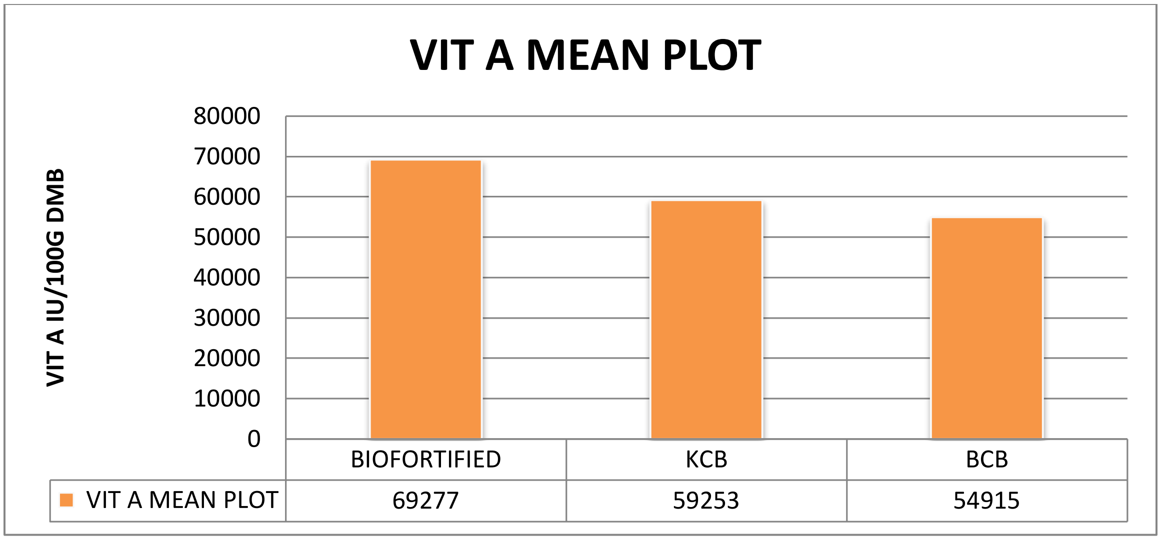


Chart 3: Vitamin A Mean plot of the different bean varieties

From the graph it shows that the leaves from the bio-fortified bean variety contain the highest amount of vitamin A while the leaves from the BCB bean variety contain the lowest amounts of vitamin A . This means that consumers who consume leaves from bio-fortified bean varieties obtain more vitamin A in the diet as compared to the other two varieties

Dependent Variable: IRON

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	282921.8199	25720.1654	1.06	0.4583
Error	12	291263.0054	24271.9171		
Corrected Total	23	574184.8253			

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Genotypes	11	282921.8199	25720.1654	1.06	0.4583
Categories	2	55887.4002	27943.7001	1.15	0.3488

Table 5: ANOVA table for the analysis of Iron.

When the iron levels in the leaves of the different genotypes is compared, it is shown that there are no significant differences in the amounts among the genotypes. This is shown by a p – value of 0.4583 which is above 0.05. This means that it does not matter which genotype one consumes since everyone will obtain nearly the same amounts of iron from the different genotypes.

There are no significant differences in the amounts of iron among the three major bean varieties that were chosen for analysis in this study. This is shown by the p- value of 0.3488 which is above 0.005. A mean plot was done for the different varieties as shown below:

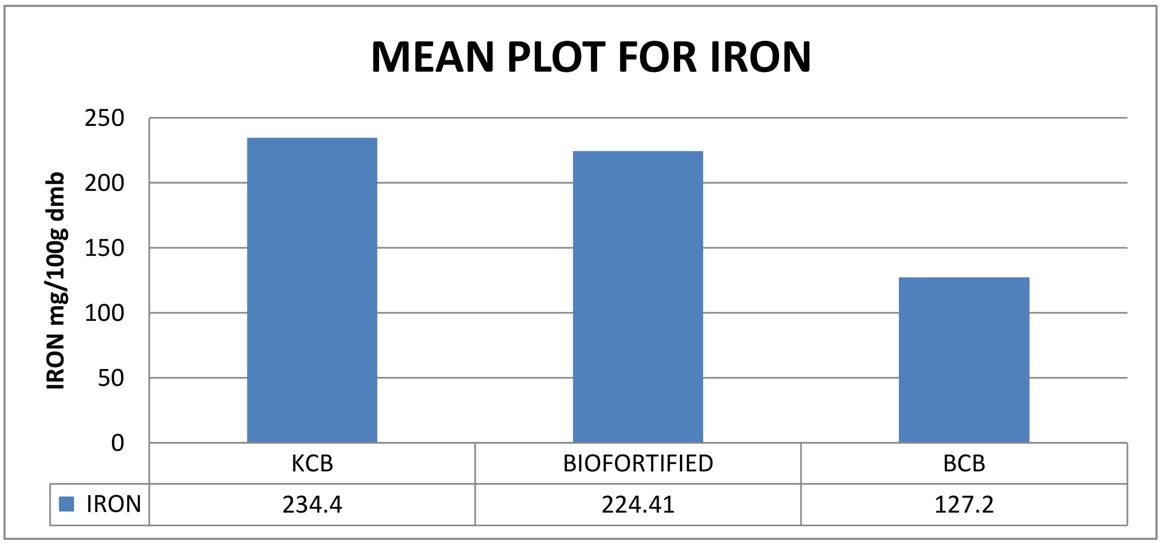


Chart 4: mean plot for iron

From the mean plot leaves from the KCB bean variety contain the highest amounts of iron though the differences are not significant. This means that despite the variety one consumes, one will get nearly the same amount of iron.

Dependent Variable: ZINC

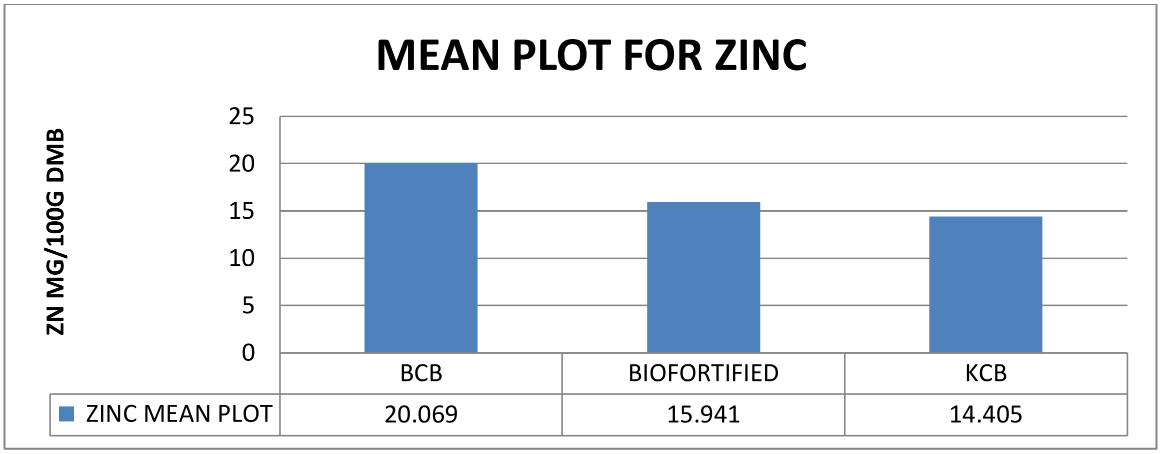
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	3264.368900	296.760809	1053.18	<.0001
Error	12	3.381300	0.281775		
Corrected Total	23	3267.750200			

R-Square	Coeff Var	Root MSE	ZN Mean
0.998965	3.158732	0.530825	16.80500

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Genotypes	11	3264.368900	296.760809	1053.18	<.0001
Categories	2	137.265025	68.632513	243.57	<.0001

Table 6: ANOVA table for the analysis of zinc

From the ANOVA table, there are significant differences in the amounts of zinc in the leaves of the different genotypes shown by a p-value of <0.0001 which is below 0.005. BCB 11- 132 contains the highest amount of zinc in the genotypes. This significant differences are also seen among the three major varieties chosen for this analysis with a P value of <0.001 . A mean plot of the varieties was done as shown below:



Chat 5: mean plot for zinc

From the mean plot above leaves from BCB bean varieties contain a significantly high amount of zinc. Thus for consumers in need of zinc I would recommend consumption of the BCB variety.

Dependent Variable: Dry Matter

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	66.07108333	6.00646212	16.70	<.0001
Error	12	4.31490000	0.35957500		
Corrected Total	23	70.38598333			

R-Square	Coeff Var	Root MSE	dm Mean
0.938697	4.149558	0.599646	14.45083

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Genotypes	11	66.07108333	6.00646212	16.70	<.0001
Categories	2	14.09185833	7.04592917	19.60	0.0002

Table 7 ANOVA table for analysis of dry matter.

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The ANOVA tables shows that there are significant differences in dry matter levels among the genotypes with a p value of <0.001 this means that different genotypes contain different amounts of dry matter. When the varieties were compared, they gave a p value 0.0002. Showing that the varieties vary in the amount of dry matter.

4.2 OBJECTIVE TWO

The cooking effect on vitamin A amounts in the leaves of the different bean genotypes.

Vitamin A amount was determined in the leaves both cooked and raw and the amounts compared as shown below. The leaves were boiled in boiling water for 15 minutes.

The results are as shown below:

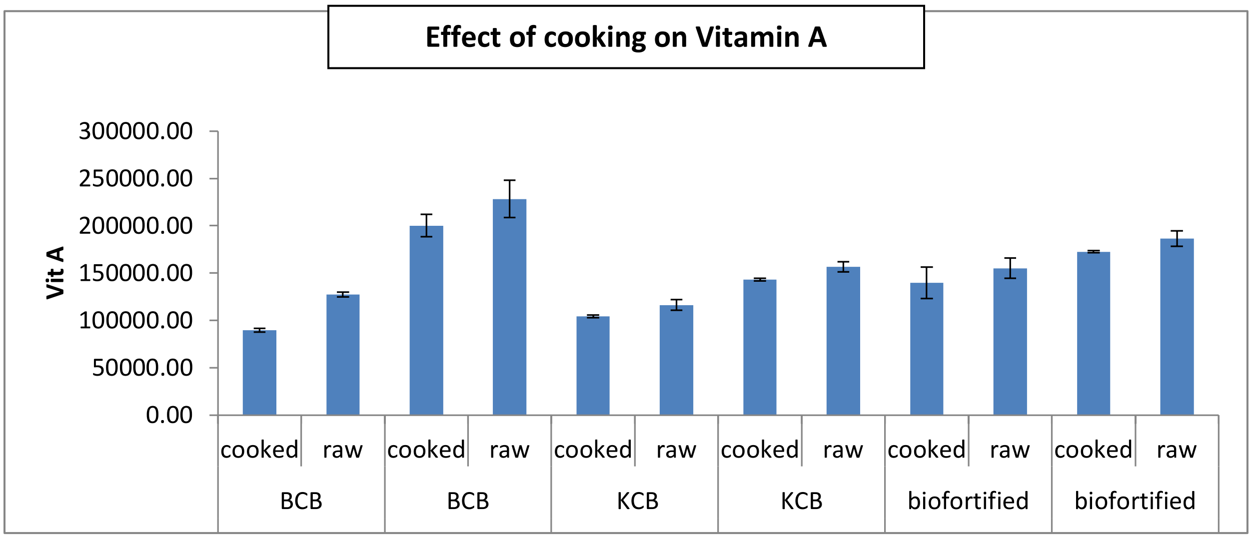


Chart 6: effect of cooking on vitamin A

The chart above shows some differences in the amounts of vitamin A between the cooked and raw. These differences were checked using the Anova table to test their significance as shown below:

Dependent Variable: VIT A

Sum of

Source	DF	Squares	Mean Square	F Value	Pr > F
Model	11	37562337782	3414757980	2.65	0.0540
Error	12	15438523209	1286543601		
Corrected Total	23	53000860991			

R-Square	Coeff Var	Root MSE	VITA Mean
0.708712	24.81765	35868.42	144527.9

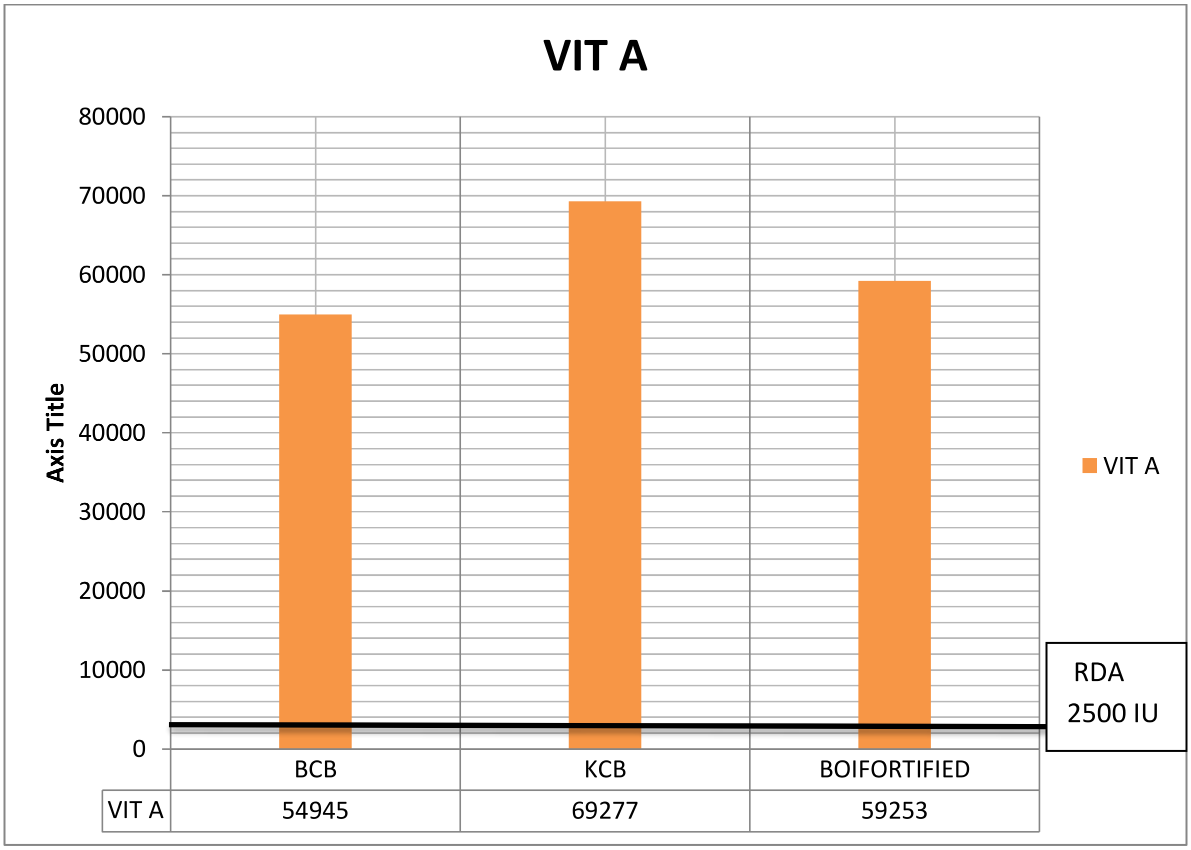
Source	DF	ANOVA SS	Mean Square	F Value	Pr > F
Genotype	5	29687997410	5937599482	4.62	0.0140
Variety	2	3960304218	1980152109	1.54	0.2541
Cooking	1	198804429	198804429	0.15	0.7011
Genotype*variety*cooking	3	3715231725	1238410575	0.96	0.4419

Table 8: Anova table for the analysis of the effect of cooking on vitamin a

When subjected to the ANOVA table, it shows that the differences shown on the chart are not significant with a P value of 0.0540 which is above 0.05. This means that there are no significant losses on vitamin A due to cooking. This may be due to the fact that vitamin A is fat soluble and the bean leaves were boiled in water. This also means that the leaves retain vitamin A more during cooking thus high amounts are still available during consumption.

4.3 COMPARISON WITH THE RECOMMENDED DIETARY ALLOWANCES (RDA'S)

4.3.1 VITAMIN A



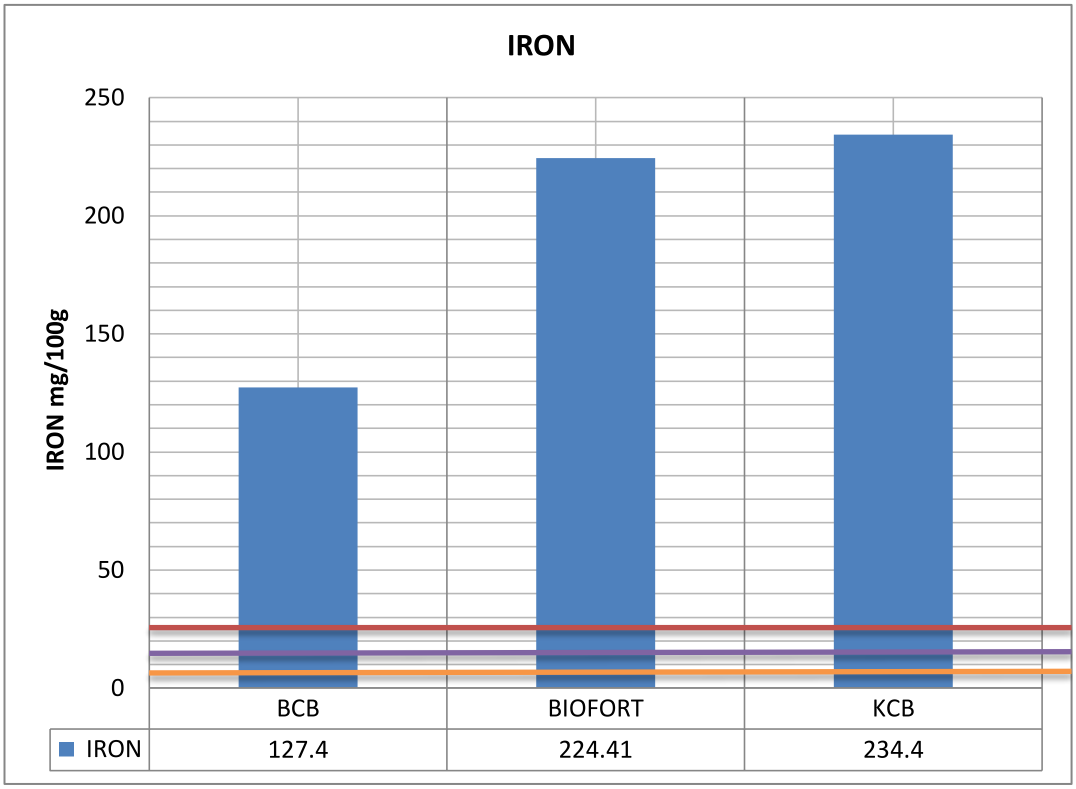
2500-3000 IU RDA for Adults

(source: Institute of Medicine (IOM) of the U.S. National Academy of Sciences. 2010)

Chart 7: Comparison of the vitamin A levels in the three varieties to the RDAS

When the vitamin A means from the three bean varieties chosen for this study are compared, it shows that they are able to comfortably provide an Adult man a with his or her daily intake. It shows that if an individual consumes 100g of dry matter which translates to 500g on wet matter basis he /she will be able to surpass the RDA for adult men and women given that this group has the highest requirements for vitamin A.

4.3.2 IRON



RDAS for different age groups

8 mg Adult male

18 mg Adult Female 19 years – 50 years

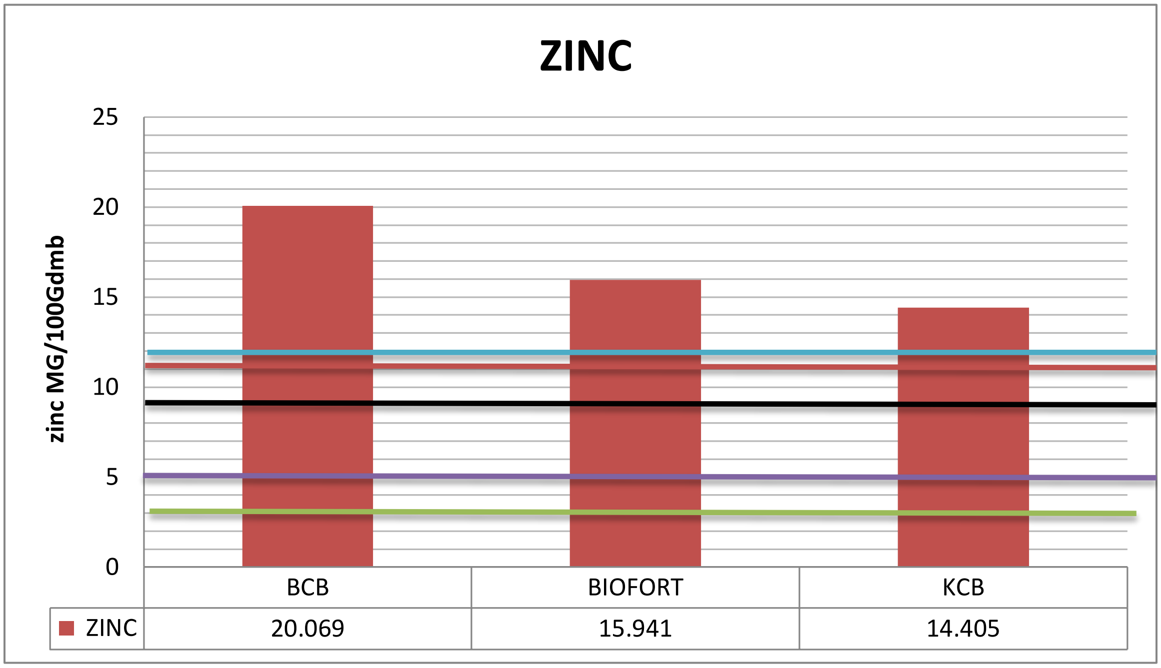
27 mg Pregnant and lactating women

(source: Institute of Medicine (IOM) of the U.S. National Academy of Sciences. 2010)

Chart8: comparison of the means of iron in the three varieties to the RDAS

The leaves contain enough amounts of iron to meet the daily requirements of adult males ,8mg, 18mg for adult females and 27mg for pregnant and lactating mothers. the iron levels in the leaves of the varieties were compared to the RDAS of adult females and pregnant and lactating mothers because of their high iron requirements due to pregnancy and menstruation. This shows that if a lady consumes bean leaves as a vegetable, the maternal iron stores will be boosted and this can help prevent iron deficiency anaemia.

4.3.3 ZINC



RDAS for different Age groups

12 mg Pregnant and lactating women

11 mg males

8 mg females

3 mg children 1-3 years

5mg children 4-8 years

(source: Institute of Medicine (IOM) of the U.S. National Academy of Sciences. 2010)

Chat 9. Comparison of the means of zinc in the three varieties to the RDAS

The above chart shows that he bean leaves from the BCB bean variety can adequately meet the RDAs for males , Females and Pregnant and lactating mothers. The other bean varieties also meet the requirements but may not be adequate to cater for loses that may occur during cooking because zinc is water soluble. However, they can meet the RDAS for children below 5 years which is a critical age where zinc is very important. This age group is particularly affected by diarrhea that can be prevented by consumption of zinc rich foods.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Bean leaves contain significant amounts of vitamin A, Zinc and Iron that can add nutritional value to the normal diet. These amounts can be instrumental in alleviating micronutrient deficiencies since bean leaves are the cheapest and easily available vegetables in the market.

Vitamin A loses due to cooking are not very significant thus most of the vitamin A contained in the bean leaves is consumed and absorbed in the body.

When compared to the recommended dietary allowances, bean leaves are able to adequately meet these daily requirements and in some cases surpass them.

5.2 RECOMMENDATIONS

1. Consumption of bean leaves as a vegetable since they contain significant amounts of vitamin A, zinc and Iron that are key nutrients the body and also the bean leaves are cheaply available
2. The breeders should consider enhancing the nutrient content of the bean leaves so as to improve both the nutritional value and economical value of the bean varieties.
3. More research should be done on the cooking effect on Iron and Zinc.

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APPENDICES

APPENDIX 1: BUDGET

ITEM	PIECES	COST	TOTAL
Planting sockets	42	5	210
Soil sterilization	3 debes	500	1500
Planting and watering			500
Laboratory analysis Vitamin A	36 samples	340	12240
Zinc and IRON	24 samples	400	9600
Printing, stationary and photocopying			1000
Miscellaneous		1000	1000
TOTALS			**26,050**

APPENDIX 2: WORK PLAN

ACTIVITY / TIME	NOV 2013	DEC 2013	JAN 2014	FEB 2014	MAR 2014	APR 2014
Proposal Development						
Proposal Presentation						
Making corrections						
Submitting Final Copy						
Planting						
Sampling and Laboratory analysis						
Data Entry and analysis						
Report writing and presentation						
Make Adjustments						
Final submission						