



The Effect of Boiling on the Proximate Analysis and Mineral composition of Okra

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ABSTRACT

Okra fruits are one of the most commonly consumed vegetables worldwide for good health as well as nutritional benefits. The present work seeks to determine the effect of boiling on the proximate and mineral composition okra purchased from Wurukum market, Makurdi. Benue State. The samples were washed with distilled water to remove sandy particles. It was then sliced in to uniform thickness using stainless steel knife, oven dried and pounded into powder form and were analysed for proximate and mineral contents using standard methods. Results of proximate composition of both raw and boiled okra is as follows: moisture content (12.20 and 12.82), Ash content (8.45 and 7.80). Crude fibre (17.65 and 15.58), Crude protein (16.44 and 14.89),Crude fat (2.40 and 2.15). The results revealed that boiling have effect on the proximate parameters. The results obtained from mineral analysis of both raw and boiled okra revealed the presence of Ca (50.00 and 46.67 ppm), Fe(0.49 and 0.22ppm), Na(11.83 and 10.12 ppm), Mg(7.45 and 6.93 ppm) and Zn (0.09 and 0.04 ppm). The results of the mineral elements were within WHO standard for food consumption. Generally the results both the proximate and mineral analysis showed that okra were healthy for human consumption.

INTRODUCTION

Okra vegetable (*Abelmoschus esculentus*) initially belonged to the genus *Hibiscus* but was later labeled *Abelmoschus*, which is distinguished from the genus *Hibiscus* (Aladele *et al.*, 2008). A proposal was subsequently made to raise *Abelmoschus* to the rank of distinct genus by Medikus in 1787 (Benchasri, 2012). Okra is a multi-purpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds (Habtamu *et al.*, 2014). It ranks one of the topmost in India in terms of its consumption but its original home is Ethiopia and Sudan, the north-eastern African countries (Kumar *et al.*, 2013). It is a semi-woody, fibrous, herbaceous annual vegetable with an indeterminate growth habit; it grows to a height of 3 to 6 ft (0.9 to 1.8 m). The plant is known to form a deeply penetrating taproot with dense, shallow feeder roots in the upper 18 inches (46 cm) of the soil with large, alternate, palmate leaves with small stipules (Lamont & Wall, 1999). Okra, also known as "lady's fingers" and is one of the vegetable crops grown in Southwestern Nigeria (Okoh *et al.*, 2018).

Okra (*Abelmoschus esculentus*) is an important vegetable crop (Oyelade *et al.*, 2003) originated in Ethiopia (Dandena 2010). This crop is one of the most widely known and utilized species of the family Malvaceae (Naveed *et al.*, 2009). Okra is known by many local names in different parts of the world (Nzikou *et al.*, 2006). In Nigeria local languages, in Tiv it is called Atuu, in Iggede it is called Ugbody, in Idoma it is called Ikpho, and in Yoruba it is called Ila, It is called lady's finger in England, gumbo in the United States of America, guinogombo in Spanish, guibeiro in Portuguese, and bhindi in India (Ndunguru & Rajabu, 2004; Sorapong Benchasr, 2012). In its origin of Ethiopia it is also called Kenkase (Berta), Andeha (Gumuz), Bamia (Oromica/Amharic) (Gemede *et al.*, 2015). The name Okra probably derives from one of Niger-Congo group of languages (the name for okra in the Twi language is nkuruma) (Benjawan *et al.*, 2007). The term okra was in the use of English by the late 18th century (Arapitsas 2008).

Therefore, promoting the consumption of Okra pods could provide cheap sources of nutrients that can improve the nutritional status and reducing the prevalence of malnutrition especially among resource-constrained households and can also used as a means of dietary diversification. On the other hand, the presence of anti-nutritional factors is one of the major drawbacks limiting the nutritional qualities of the food (Kathirvel & Kumudha, 2011).

Okra are predominately produced in Benue State, they grew many varieties without knowing the nutritional values and the mineral composition, other problems are lack of adequate rain fall, lack of agriculture

tools and fertilizer. These factors has significant effect on the production of okra in the State.

Okra is a multipurpose crop due to its various uses of the pods, fresh leaves, buds, flowers, stems, and seeds. Okra immature fruits (pods), which are consumed as vegetables, can be used in salads, soups, and stews, fresh or dried, fried or boiled (Habtamu *et al.*, 2014). Despite its nutritional compositions, Okra pod is a powerhouse of valuable nutrients (Adetuyi *et al.*, 2011) and affordable source of protein, carbohydrates, minerals, vitamins, and dietary fiber when boiled (Habtamu *et al.*, 2014). Okra pods are not only have beneficial nutrients but might contain traces of antinutritional factors, which may have adverse effects on bioavailability of some minerals like calcium, iron, and zinc (minerals element). However, okra has been considered as a minor crop and there is no single information or published studies available about nutritional, anti-nutritional, and bioavailability of Okra pods grown in Ethiopia.

This study discovers the potential effect of boiling on proximate analysis and mineral composition of Okra (especially sun-dried) for nutritional benefits. This study can help researchers to uncover a critical area of nutritional profile assessment which have not been explored by other researchers.

The aim of this study is to determine the effect of boiling on the proximate and mineral composition of okra *Abelmoschus esculentus* (Okra) purchased in wurukun market, Makurdi Benue State.

MATERIALS AND METHODS.

Study Area

This study is carried out in Benue State. Benue state is located at the north central of Nigeria with 23 local government area and is divided into three senatorial zones, zone A, B and C according to the world Gazettes (2007), the state was created on February 3rd 1976, from benue plateau state, has 23 local government with 423 wards, the state shares international boundary with republic of Cameroon to south-east and inter-state boundaries with Nasarawa state to the north Taraba state to east, Enugu state and cross river state to the south and Kogi state to the west. The state capital is Makurdi, Benue state is rich in Agriculture and has a slogan 'food basket of the nation' the state is 65% agrarian and is inhabited by Tiv, Idoma, Iggede, and others including Etulo, Ufia, Jukum, Housa, Akweya, and Abaka. The predominate religion among the people is Christianity. Other forms of religion practiced in the state are Islam and traditional religion. The state has a population of 4,184,216 by 2005 census. The sample site is indicated in the Figure 1.

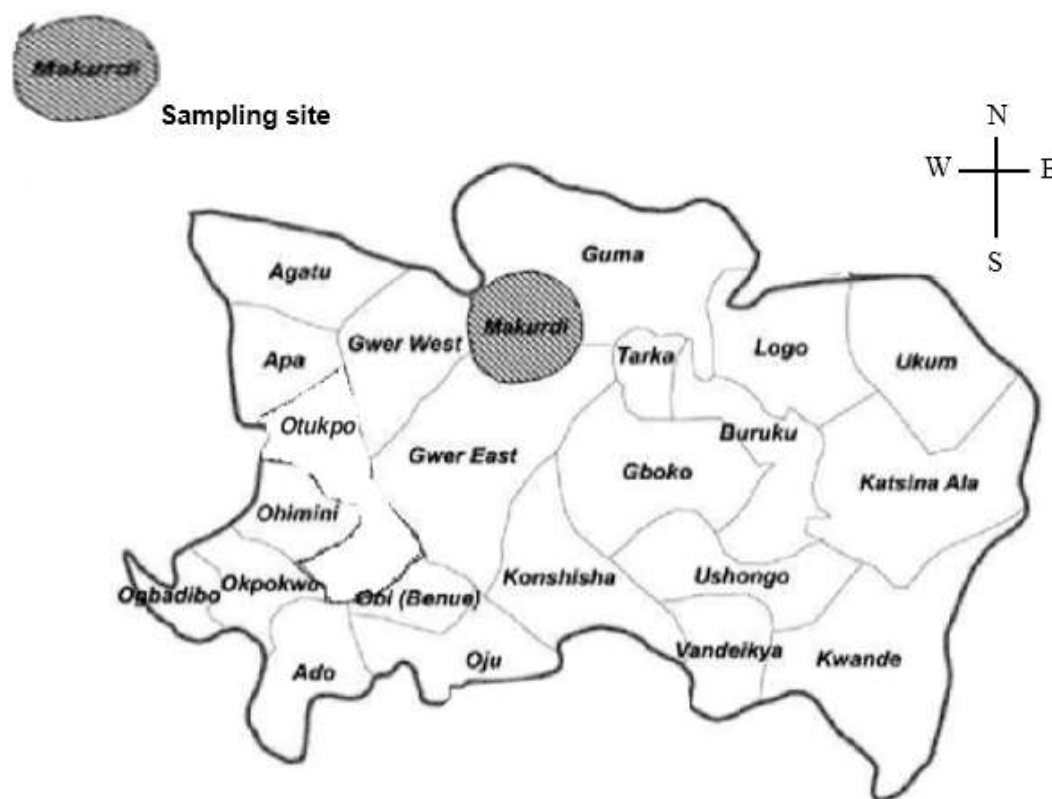


Fig. 1 Map of Benue state showing Makurdi, the sampling site

Source: <https://www.semanticscholar.org>

Sample Collection

Samples of okra (*Abelmoschus esculentus*) were bought from Wurukun Market, Makurdi at 10 am. Each of the collected okra pod were coded, packed in polyethylene bags, kept in an ice box (to prevent moisture loss), and transported to chemistry Research laboratory of Joseph Sarwuan Tarka University Benue State Makurdi.

Sample Preparation

The samples were washed with distilled water to remove sandy particles. the samples were sliced using a stainless steel knife. The moisture content each of the Okra was determined immediately after sliced to uniform thickness. It was then oven dried and ponded to powder form.

Digestion of Samples

The digestion of the samples was carried out by the process described by Adedolu & Adewuyi (2013). Exactly 1.0g dried and sieved samples was weighed into 25.0 mL conical flask. 12.0 mL of freshly prepared and aqua-regia (3ml HNO₃ + 9 ml Hcl) was added. The flask was covered with a filter paper to enable the digestion to take place under constant volume. The constant was heated for 1hr on the medium heat of a hot plate. The mixture was allowed to cool and filtered through a filter

paper into 50 mL standard volumetric flask. The filtrate was diluted to 50 mL with distilled water and then transferred to plastic sample bottle and covered prior to analysis.

Method of Analysis

Proximate Analysis

Determination of Moisture

The moisture content was determined by an air oven method as described by (AOAC, 2000) Two grams of test sample were weighed in duplicate into already weighed and cooled petri-dishes the sample were transform into air oven at 105°C for 3 hours. At the end of 3 hours the sample were allowed to cool in desiccator. It was taken to the oven to dry and be reweighed until a constant was obtain. It is calculated as:

Moisture constant
Weight of sample (g)
Weight of dry matter (x)
Loss in weight (g-x)

$$\% \text{ moisture content } \left(\frac{g-x}{g} \times \frac{100}{1} \right)$$

Determination of crude protein

Protein determination was determined by the method described by AOAC (2000). Two-tenth gram of the sample was weighed into a Kjeldhal digestive flask. Eight-tenth of catalyst moisture was placed in a conical flask with few boiling chips. 10ml of concentrated H₂SO₄ acid was added and the mixture was heat on a heating mantle. Initially gently until foaming cease and content become completely liquefied.

It was the heat vigorously until the liquid was clear and free from black colour. The flask wa cool and the constant diluted with twenty-five ml distilled water. Distillation apparatus was connected, 5ml of boric acid solution was measured into a 500 conical flask and a few drops of methylene red indicator were added. The flask was placed on the receiver so that the end of the delivery tube tips just below the level of the boric acid.

5 ml of digested samples was pipette into distribution unit 7 ml of 50%, NaOH solution was added. The unit was close and the liberated ammonia was streamed distilled into boric acid the unit was titrated with 0.1m HCL acid until the green colour changed to purple.

The percentage of nitrogen in the sample was calculated with the formula

Crude protein
Weight of sample (g)
Titre value (T)

$$\% N = \frac{T \times m \times 0.014 \times Df \times 100}{g}$$

$$\% \text{ protein} = \% N \times 6.25$$

Determination of crude fibre

The method described as outline in AOAC (2000) modified was used in determining the crude fibre content of sample, two grams of sample was weighed into a 500 ml beaker and boiled into 200 ml HCL (1%) for 30 mins. The suspension was filtered using a white filter paper and rinsed with hot water to obtain filtrate. The residue obtained was transferred into a crucible and placed in an oven for 30mins. The dried residue was cooled in a desiccator and weighed. Percentage of crude fiber was calculated as

crude fiber
Weight of sample (g)
Weight of dry matter (x)
weight of residue (y)

$$\% \text{ fibre} = \left(\frac{x-y}{g} \times \frac{100}{1} \right)$$

Crude fat

Crude fat was determined using AOAC (2000) method 5 g of sample were weighed into thimble and a loose plug of fat free cotton wool was fitted into top thimble with its content was inserted into the bottom extractor of the Soxhlet apparatus. A 250 ml round bottom flask of known weight contain 150-200 ml of petroleum ether and fat extracted under reflux for about 3hrs. At end of the extraction the solvent was recovered. The mixture of extracted oil solvent was transfer to an air oven 100°C for 5 mins, to move radiant moisture. The flask with the oil was then cooled in a desiccators and weighed.

crude fat
Weight of sample (g)
Weight of fat (x)

$$\% \text{ fat} = \left(\frac{x}{g} \times \frac{100}{1} \right)$$

Determination of ash

The ash of food stiff is the inorganic residue remaining after the organic matter has been burnt away. The ash obtain is not necessarily of the same composition of the mineral losses due to volatilization of some interaction between components.

Procedure:

A crucible was first ignited in a finance of 550 °C for about 15 min. cooled in a desiccator and weighed, 2 grams of sample was weighed into the cruible and the temperature was increased gradually until smoking ceased and the sample with charred sample was placed in a muffle furnace, temperature of the furnace to 550 °C and maintained for 4-5 hrs until whitish grey ash was obtained.

The crucible was cool in desiccators to room temperature and then weighed.

The percentage as was calculated as
Weight of sample (g)
Weight of Ash (x)

$$\% \text{ ash} = \left(\frac{x}{g} \times \frac{100}{1} \right)$$

Determination of carbohydrate

The procedure outlined in AOAC (2005) was used in the determination of carbohydrate content.

This was calculated by difference sum total of the moisture, fat, protein ash content were subtracted from 100 as below.

$$\% \text{ carbohydrate content} = 100 - (\% \text{ protein} + \% \text{ moisture} + \% \text{ fat} + \% \text{ ash} + \% \text{ crude fibre}).$$

Mineral Element Analysis

2.0 cm³ of the samples were each weighed and digested with concentrated HNO₃. After completed digestion. The volume was made up with deionized water in a volumetric flask. The samples were analyzed for mineral element using (AAS 989 Model).

Statistical Analysis

The results obtained were subjected to statistical analysis. Data obtained were evaluated using mean, (SD) and coefficient of variation percentage (CV) all determinations were in triplicated

RESULTS AND DISCUSSION

Results

Table 1: Proximate Composition of Raw and boiled Okra

Parameters	Raw okra	Boiled okra	Mean	SD	CV%	WHO Stdrd Yr 2011
%Moisture	12.20	12.82	12.51	0.45	3.40	89.5
%Ash content	8.45	7.80	8.13	0.46	5.66	4.1
%Crude fibre	17.65	15.58	16.62	1.46	8.78	1.8
%Crude protein	16.44	14.89	15.67	1.09	6.96	0.61
%Crude fat	2.40	2.15	2.78	0.73	26.26	0.14

Table 2: Mineral element of raw and boiled okra

Metals	Raw okra	Boiled okra	mean	SD	CV	WHO Stdrd Yr 2011
Ca	50.00	46.67	48.33	2.36	11.49	24.00
Fe	0.49	0.22	0.36	0.18	9.53	0.10
Na	11.83	10.12	10.97	1.21	13.29	3.00
Mg	7.45	6.93	7.19	0.37	1.91	10.00
Zn	0.09	0.04	0.06	0.05	3.28	0.14

DISCUSSION

Moisture content

Moisture content determination is an integral part of the proximate composition analysis of food. The result of Moisture content of raw and boiled Okra is presented in Table 4.1.

The moisture content of raw okra 12.20 % was less than that of boiled okra 12.82 %, the total mean of raw and boiled okra is 12.51 %. Though moisture content are not lost due to heat, they are usually leached if boiled in boiling water. The high moisture content in okra is in agreement with the finding of Adetuyi *et al.*, (2011). Also this is in accordance with the finding of Gopalan *et al.*, (2007) (89 %) and (Nwachukwu *et al.*, 2014) (88.47 %). Moisture content of any food is an index of its water activity and is used as a measure of

stability and susceptibility to microbial contamination (Uyoh *et al.*, 2013). The high moisture content in vegetables makes them vulnerable to microbial attack, hence spoilage (Nwofia *et al.*, 2012). This high moisture content also implies that dehydration would increase the relative concentrations of other food nutrient and therefore improve the shelf-life and preservation of the fruits (Aruah *et al.*, 2012). There is also need to store the fruit in cool condition if they are to be kept for a long period without spoilage especially in the urban areas where wastage of vegetable crops is estimated to be around 50 % due to high moisture content (Nwofia, 2012). The mean value of the moisture content in these study is 12.51% and it is far below what WHO standard 2011 reported (89.5 %).

The effect of boiling in the moisture content of okra is shown in figure 4.1: below

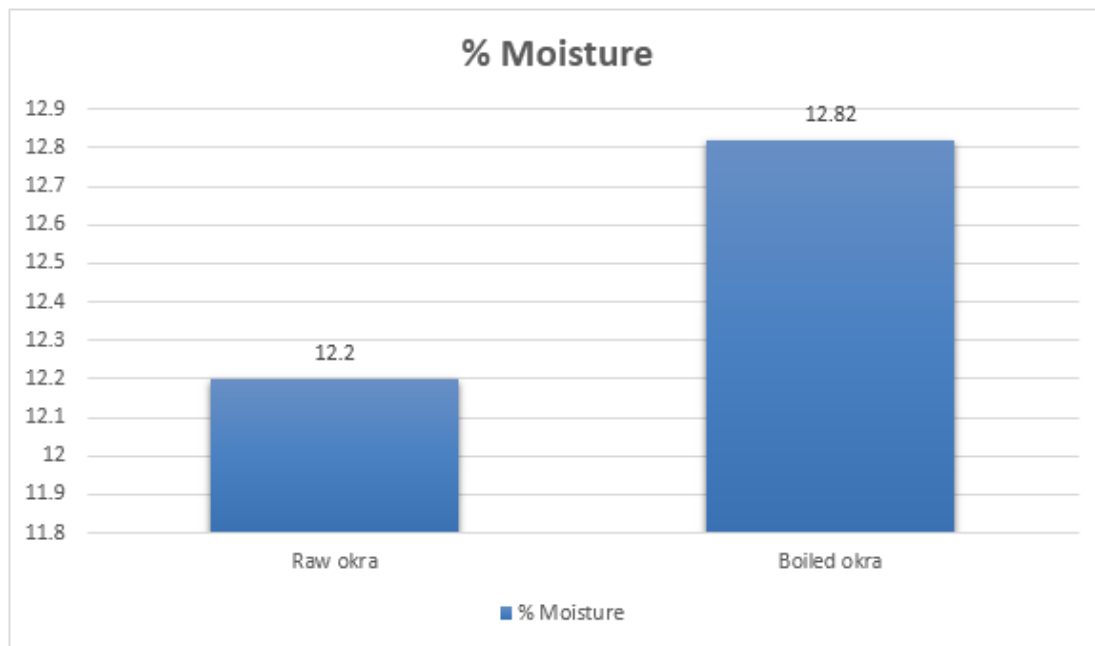


Figure 1: % moisture content in raw and boiled okra

Ash content

The ash content is a measure/reflection of the nutritionally important mineral contents present in the food material (Omotosho 2005; Nnamani *et al.*, 2009). Table 4.1 shows the crude ash contents of raw and boiled used in this study. The level of ash content was ranged from 8.45 % (raw okra) to 7.80 % (boiled okra) with a mean of 8.13 %. The ash content was significantly higher in “raw okra” (8.45 %), whereas the boiled okra had a lower ash content (7.80 %). The results showed

that the samples contains high ash content which indicates that the okra pods would provide essential valuable and useful minerals needed for body development. The mean of ash content in this result agrees with the findings of Adetuya *et al.*, (2011) (7.19–9.63 %). And it is high above the reported WHO standard 2011 (4.1 %).

The difference between the ash content in raw and boiled okra is shown in figure 4.2.

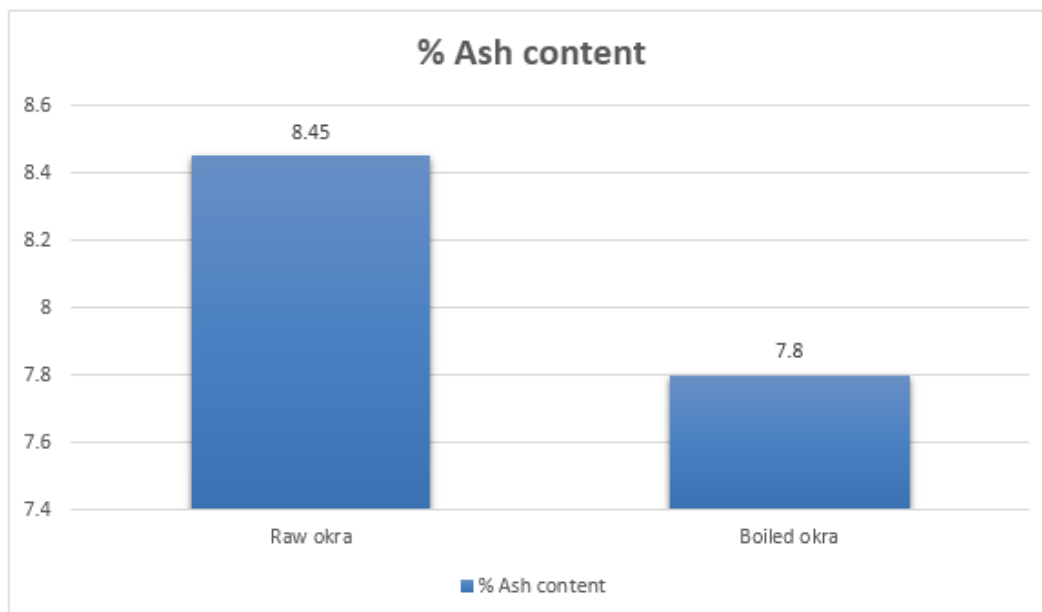


Figure 2: % % ash content in raw and boiled okra

Crude Fibre

Crude fibre provides bulk to the gut which stimulates peristalsis and result in shorter passage time and more frequent defecation. The proximate crude fibre content presents in this study was (17.65 % and 15.58 %) for the raw and boiled samples and the mean value was (16.62 %). According to Eromosele (2013), Fibre helps in the maintenance of human health and has been known to reduce cholesterol level in the body. High fibre foods

expands the inside wall of the colon, causing the passage of waste, thus making it an effective anti-constipation. Fibre also reduces the risk of various cancers, bowel diseases and improves general health and well-being of individual. The mean value of fiber in this study is higher than the result reported by World Health Organization standard (1.80). Table 1. revealed the mean value of raw and boiled samples and this was higher than 11.8% reported by Olagunju (2014) and 8.02% result reported by Alawore (2014).

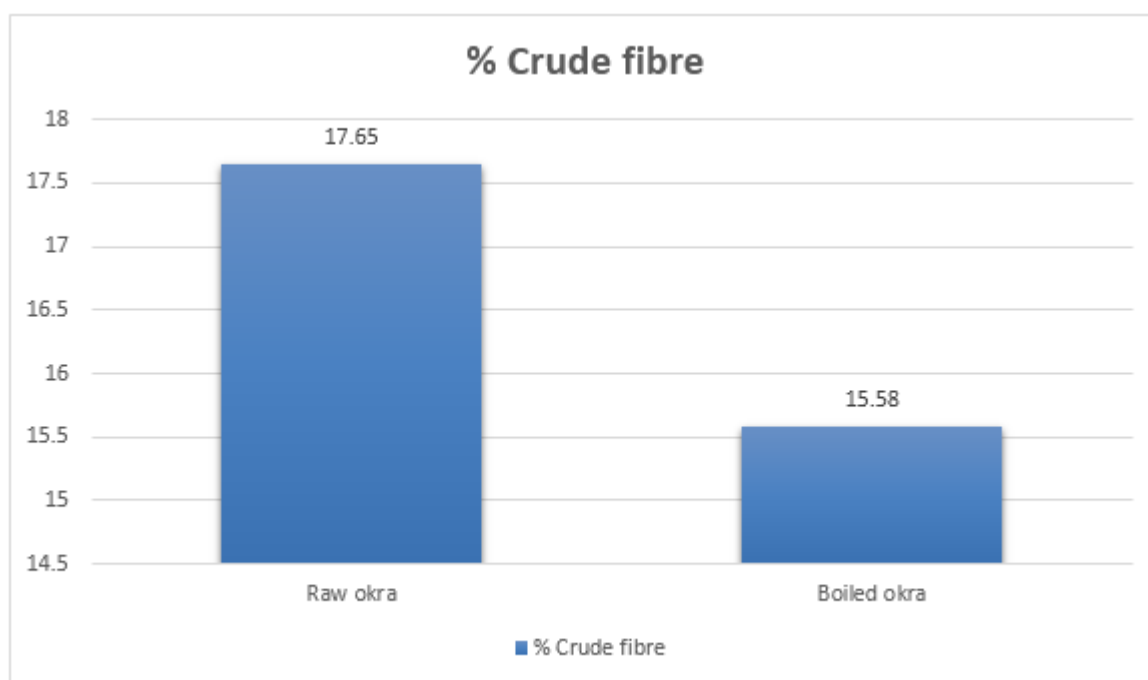


Figure 3: % crude fibre content in raw and boiled okra

Crude protein

The main functions of proteins are growth and replacement of lost tissues in the human body. Table 4.1 shows the crude protein contents of raw and boiled okra used in the study. The protein content of Okra varied significantly from 16.44 % in raw okra to 14.89 % in “boiled okra”. The mean value (15.67 %) of the accessions obtained in the study is almost comparable with the finding of Adetuya *et al.*, (2011) (13.61–16.27 g/100 g) while higher than the value reported by Nwachukwu *et al.*, (2014) (4.81 g/100 g). And this implies that Okra pod can serve as a good source of protein.

Nwofia *et al.*, (2012) reported that diet is nutritionally satisfactory, if it contains high caloric value and a sufficient amount of protein. It have been shown that any plant foods that provides about 12 % of their calorific value from protein are considered good source of protein (Effiong *et al.*, 2009; Ali 2010). The protein content of Okra meets these requirements and this implies that Okra pod can serve as a good source of protein. The mean value of the protein content in this study is 2.78 % which is completely high above the reported WHO standard 2011 with 0.61%.

The difference between the raw and boiled protein content is shown in figure.4.

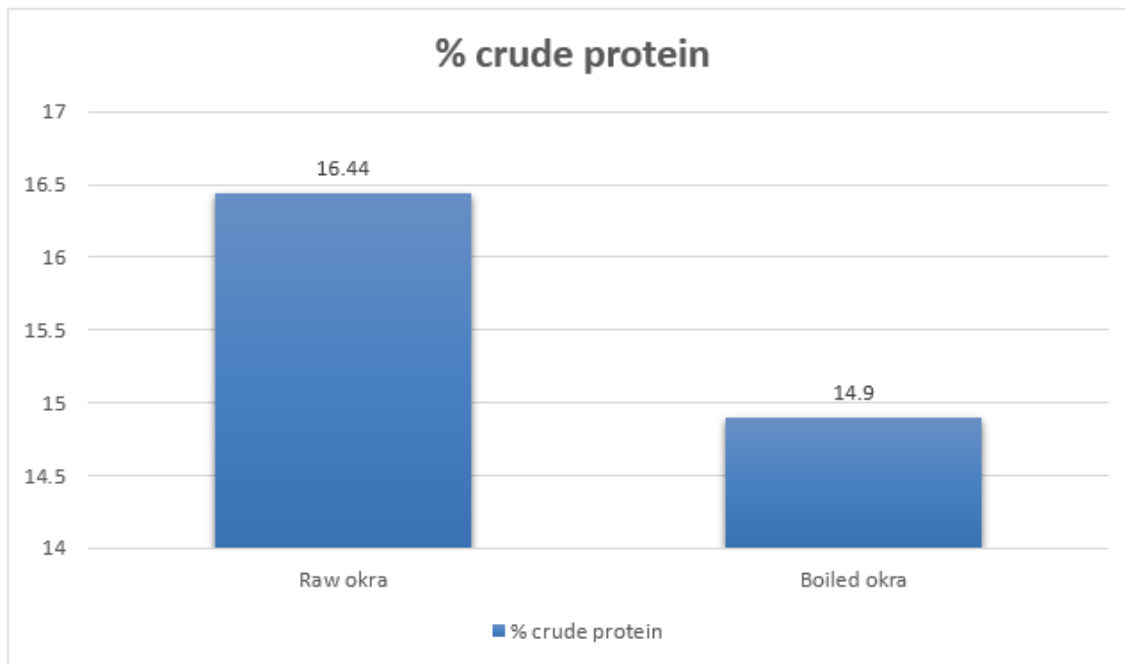


Figure 4: % crude protein content in raw and boiled okra

Crude fat

Crude fat content of raw and boiled Okra is presented in Table 4.1. The levels of crude fat varied from 2.40 % "raw okra" to 2.15 % "boiled okra". Raw okra had the highest crude fat content (2.40 %) which was significantly higher than the crude fat content of boiled okra. With the mean of (2.78%). Excess consumption of fat have been implicated in certain cardiovascular disorders such as atherosclerosis, cancer, and aging, whereas a diet

providing 1–2% of its caloric of energy as fat is said to be sufficient to human beings (Aruah *et al.*, 2011), in this regard, the consumption of Okra pod diet should be encouraged to reduce the risk of above diseases in man. The mean value of the fat content in this study is 8.13 % which is completely high above the reported WHO standard 2011 (014 %).

The effect of boiling on the fat content of okra pod is shown in figure 5.

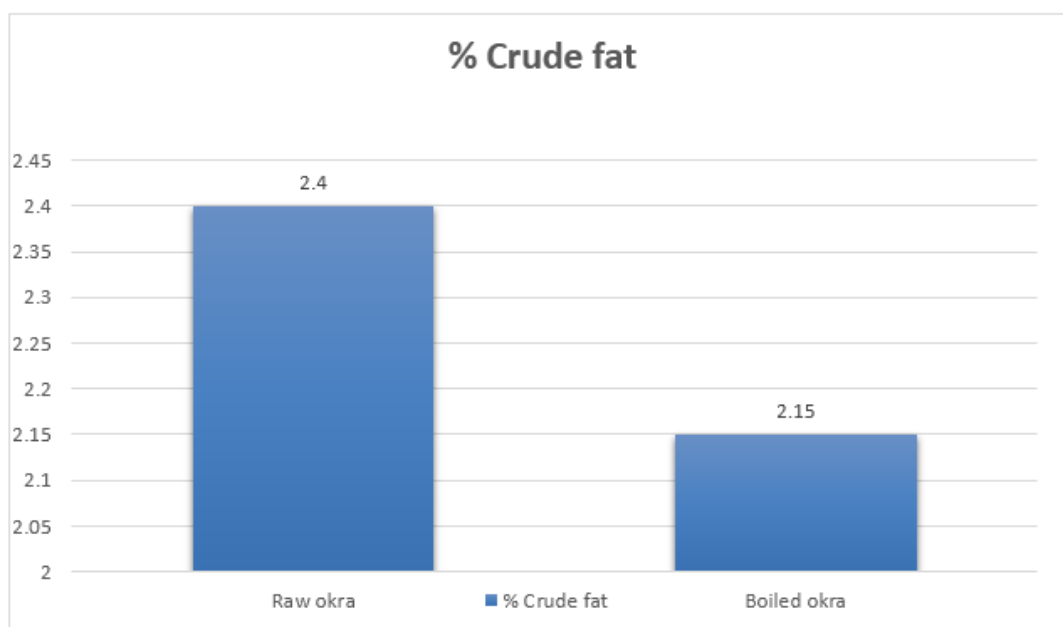


Figure 5: % crude fat content in raw and boiled okra

Calcium (Ca)

Calcium is the major component of bone and assists in teeth development. Calcium concentrations are also necessary for blood coagulation and for the integrity of intracellular cement substances (Okaka and Okaka 2001). Calcium content in raw and boiled okra is shown in Table 4.2. The concentration of Calcium in the sample is varied from 50.000 ppm in raw to 46.67 ppm in

boiled. The mean result is 48.33 ppm. Raw okra had the highest calcium content (50.00 ppm) which was significantly higher than the Calcium content in boiled okra (46.67 ppm). This result appeared to be far less than the Calcium contents of Okra variety reported by WHO (2011) which is 143.47 Mg/100g.

The difference between the calcium content of raw and boiled okra is shown in figure 6.

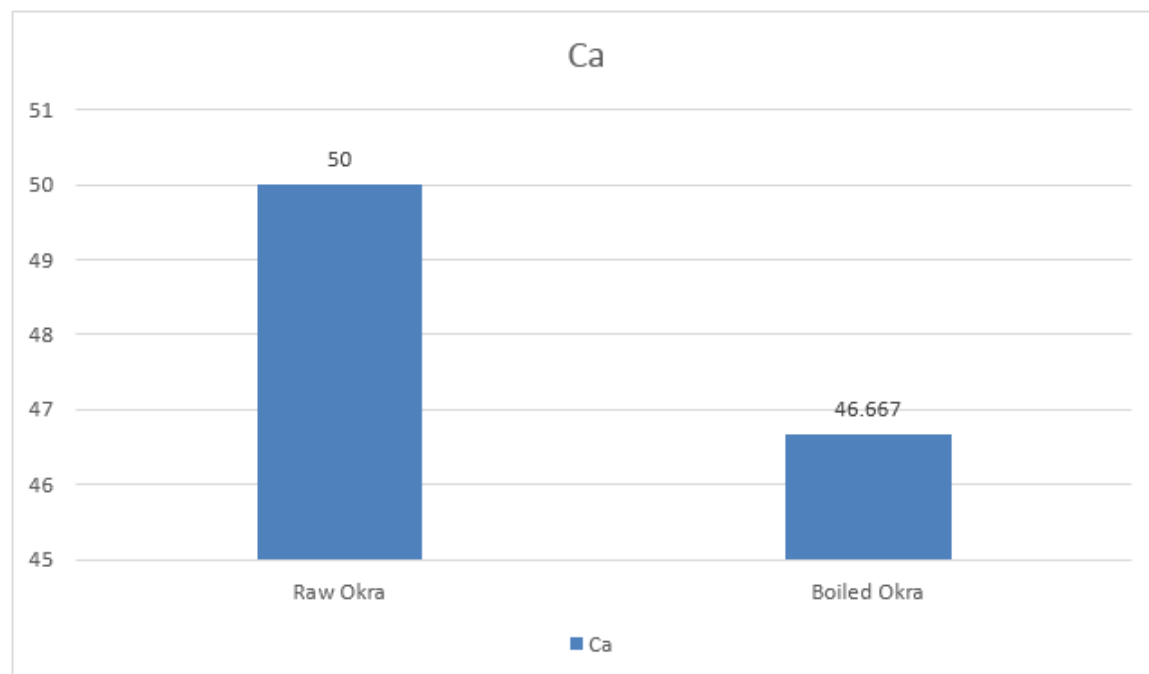


Figure.6: calcium (Ca) content in raw and boiled okra

Iron (Fe)

Iron is an essential trace element for hemoglobin formation, normal functioning of central nervous system and in the oxidation of carbohydrates, protein, and fats (Kermanshah *et al.*, 2014; Mlitan *et al.*, 2014). It also facilitates carbohydrates, protein, and fat to control body weight, which is very important factor in diabetes (Moses *et al.*, 2012). Iron is necessary for the formation of hemoglobin and also plays an important role in oxygen transfer in human body and low iron content causes gastrointestinal infection, nose bleeding myocardial

infection (Ullah *et al.*, 2012). Table 4.2 shows Iron content of raw and boiled Okra. The contents of Iron varied from 0.49 ppm to 0.23 ppm. The mean result is 0.38. The Iron content of raw okra had higher (0.49 ppm), but this did not differ significantly from boiled okra (0.23 ppm). The values obtained in this study were far less than the value reported by WHO. (2011) which is 5.50mg. This indicates that Okra pod is a rich source of Iron.

Figure .7: shows the difference between the Iron content of raw and boiled okra.

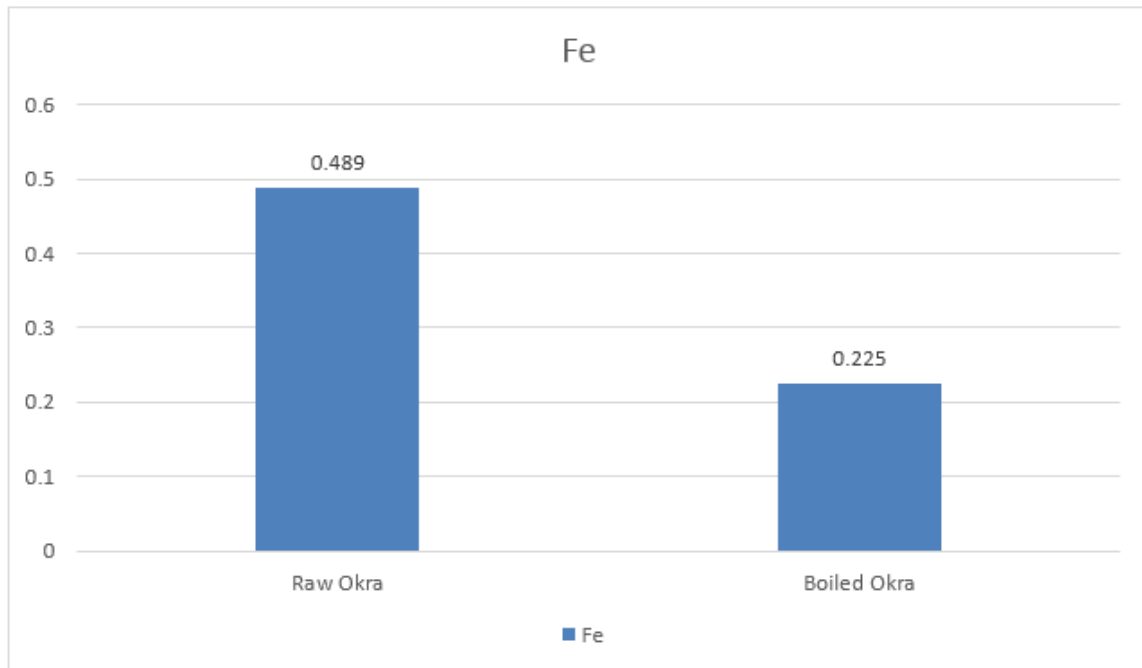


Figure 7: Iron (Fe) content in raw and boiled okra

Sodium (Na)

Sodium content of raw and boiled Okra are shown in Table 4.2. In this study, the sodium contents varied from 11.83 ppm in raw to 10.12 ppm in boiled. Sodium content of raw Okra (11.83 ppm) was higher than the boiled okra

but this did not differ significantly (10.98 ppm) The values obtained in this study were far less than the value reported by WHO. (2011) which was 17.82.

Figure .8: shows the difference between the sodium (Na) content in raw and boiled okra.

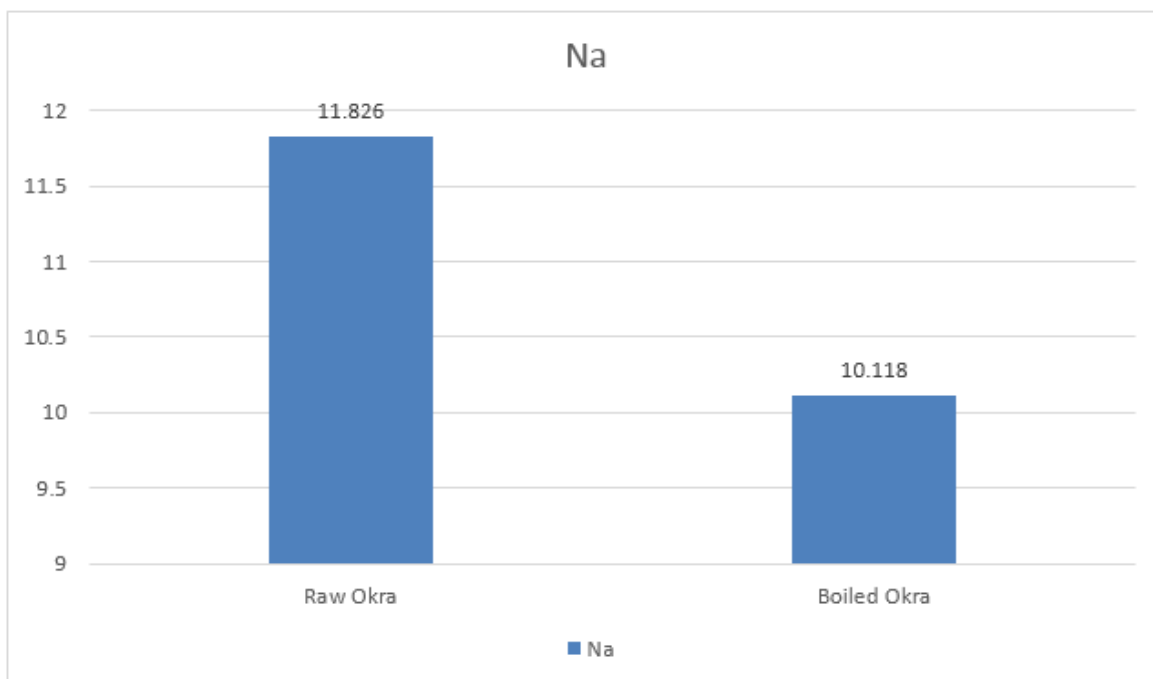


Figure 8: Sodium (Na) content in raw and boiled okra

Magnesium

Magnesium is an essential mineral required by the body for muscle and nerve function, maintaining heart rhythm, building strong bones and energy production. 7.45 ppm of raw sample and 6.93 ppm of boiled sample were presents in the okra pod. The mean value of the samples (i.e. raw and boiled) was obtained as 7.12 ppm. The value obtained from the samples was similar to the result reported by WHO (2011). The result of this present study

is completely below 11.00 mg/L reported by Ojokoh (2014) and 10.56 mg/L reported by Khuda (2014) in a similar work. This result shows that okra is a healthy consumption for Human and animals. Considering the raw sample (7.45 ppm), this sample was reduced after boiling to 6.93 ppm as it was determined using AAS {Atomic Absorption Spectrophotometer}.

Figure 9: shows the difference between the magnesium content in raw and boiled okra.

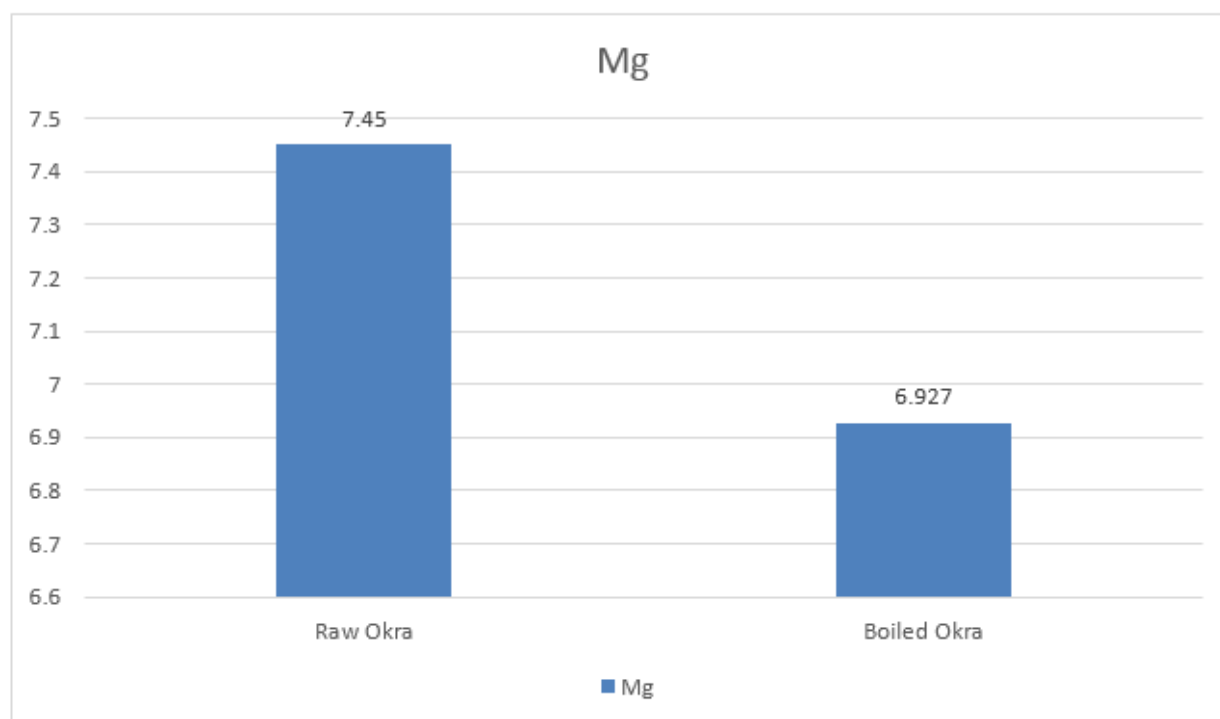


Figure 9: magnesium (Mg) content in raw and boiled okra

Zinc (Zn)

Zinc is an essential trace element and plays an important role in various cell processes including normal growth, brain development, behavioral response, bone formation, and wound healing (Mlitan *et al.*, 2014). Zinc also plays a very important role in protein and carbohydrate metabolism and also help in mobilizing vitamin A from its storage site in the liver and facilitates the synthesis of DNA and RNA necessary for cell production (Jabeen *et al.*, 2010). Zinc deficiency is common in people suffering from Chrohn's disease, hypothyroidism, and gum disease, and probably plays a part in susceptibility to viral infections and diabetes mellitus. It can be beneficial in the treatment of viral infections, including those of AIDS, prostate gland enlargement, rheumatoid arthritis, healing of wounds,

acne, eczema, and stress (Kermanshah *et al.*, 2014). Zinc content in the raw and boiled okra are shown in Table 2. The content of Zinc varied between 0.09 ppm in raw okra and 0.035 ppm in boiled okra. Zinc content of pod accession raw okra had higher content (0.09 ppm). This differ significantly ($P > 0.05$) from boiled okra (0.04 ppm). The values obtained in this study are less than the values reported by WHO (2011) (1.28).

This study revealed that mineral element of raw and boiled okra were below WHO standard. The mean shown in table 4.2 were lower compare to the WHO standard (2011) with calcium (Ca) having the Highest value of 48.33 ppm and Zinc (Zn) having the lowest value of 0.06 ppm.

Figure 10: shows the difference between the Zinc (Zn) content in raw and boiled okra pod.

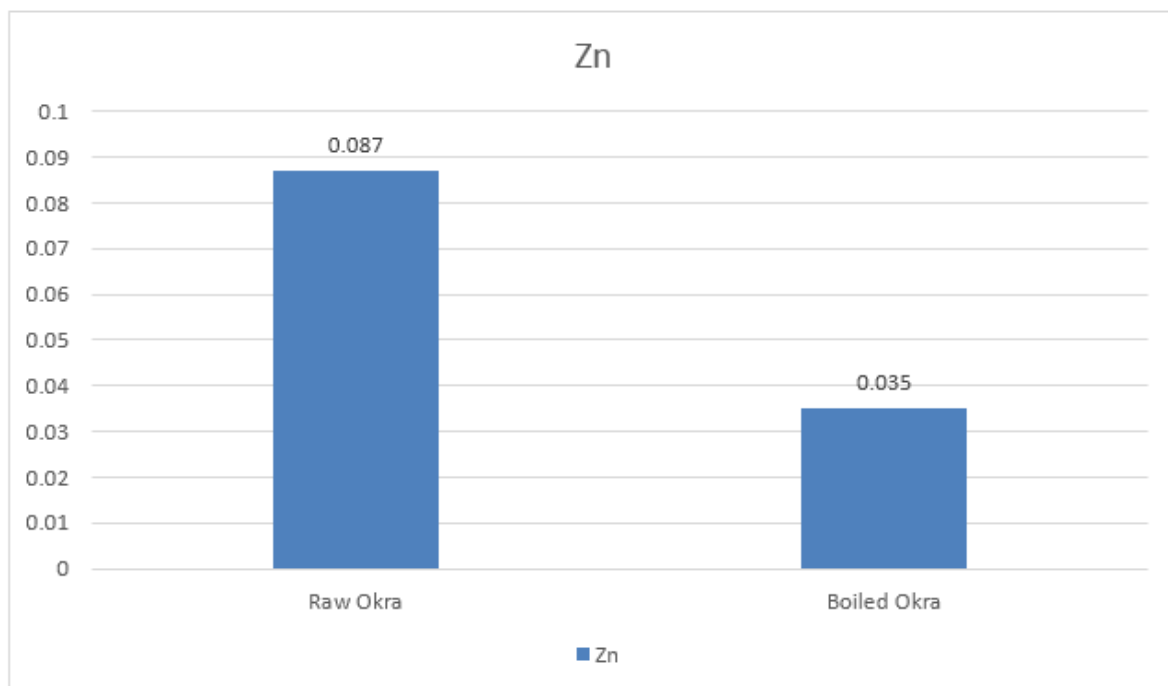


Figure 10: Zinc (Zn) content in raw and boiled okra

CONCLUSIONS

This study was carried out on proximate and mineral analysis of okra in Benue State Nigeria. Okra pod were purchased in Wurukun market Makurdi, Benue State.

The samples were washed with distilled water to remove sandy particles, the samples were sliced using a stainless-steel knife. The moisture content of each Okra was determined immediately after sliced. It was then oven dried and ponded to powder form and were analyzed for proximate and mineral content. The digested samples were aspirated into (AAS 969 model, Japan) equipped with mono-elemental hollow cathode lamps and digital display read the metal concentration in ppm from the metal concentration standard calibration curve while sodium magnesium and calcium were determined using flame photometer. Spectroscopic analysis was done for each element and values were recorded.

The result for proximate analysis revealed the presence for moisture content ranging from 12.20 – 12.82%, ash content (8.45 – 7.80%), crude fibre (17.65 – 15.58%), crude protein (16.44– 14.89%) and crude fat (2.40 – 2.15%).

The study revealed that there is a significant difference in the proximate and mineral compositions of raw and boiled Okra. The most remarkable finding of this study is that raw and boiled Okra were found to be a good source of vital nutrients like crude protein, crude fiber, crude ash, calcium, and iron. Specifically, raw Okra contained significantly higher amounts of crude fibre, while boiled okra contained higher ash content, crude fat, calcium, iron, and zinc and can be recommended as a remedy to alleviate malnutrition in the country. Therefore,

its cultivation and consumption is encouraged as additional source of minerals to the diet of the indigenous people. Therefore, Okra pods could be employed in fortification, formulation and supplementation of other food materials.

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