International Journal of Chemical and Biomedical Science
2015; 1(3): 83-88
Published online July 30, 2015 (http://www.aascit.org/journal/ijcbs)

American Association for Science and Technology

International Journal of Chemical and Biomedical Science

Nutritional and Heavy Metal Analysis on Four Local Fruits in Awka South Eastern Nigeria

Ogbuagu A. S.*, Onyema A. O., Ekpunobi U. E., Onyema C. T.

Pure and Industrial Chemistry Department, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Email address

as.ogbuagu@unizik.edu.ng (Ogbuagu A. S.)

Citation

Ogbuagu A. S., Onyema A. O., Ekpunobi U. E., Onyema C.T.. Nutritional and Heavy Metal Analysis on Four Local Fruits in Awka South Eastern Nigeria. *International Journal of Chemical and Biomedical Science.* Vol. 1, No. 3, 2015, pp. 83-88.

Keywords

Fruits,
Nutrition,
Heavy Metals,
Analysis

Received: June 28, 2015
Revised: July 14, 2015
Accepted: July 15, 2015

Abstract

The aim of this study was to assess and evaluate the nutritional and metal analysis on four local fruits. Proximate analysis was carried out to determine the levels of crude protein, crude fiber, total ash, mineral content, lipids and carbohydrates on the four local fruits (Chrysophyllum albidum, Solanum macrocarpon, Aabelmoschus esculentus and Dalium indium. The presence of Lycopene was also determined. Results of the proximate analyses of the fruits indicated that crude protein content ranged from (3.40±0.12% - 5.07±0.14)g/100g with Solanum macrocarpon having the highest, ash content was in the ranges of (0.50±0.00- 5.00±0.00)g/100g, crude fiber gave values in the range (3.31±0.31-54.17±0.16)g/100g, moisture content was in the range of (15.00±0.04- 68.35±1.73)g/100g, it recorded the highest value in Solanum macrocarpon and the least in Abelmoschus esculentus and total carbohydrates was (11.15±0.14- 32.73±2.30)g/100g with Chrysophyllum albidum having the highest and Dalium indium, the least. Result on lycopene concentration gave Dalium indium with 0.0962mg/g as the highest, others showed appreciable values of 0.0202mg/g, 0.0285mg/g and 0.0147mg/g for S. macrocarpon, C. albidum and A. esculentus respectively. The mineral composition contained in the fruits were calcium which had the highest values in the four fruits (49.622, 65.153, 27.016 and 30.425) ppm, magnesium gave (20.811, 21.291, 11.105 and 11.304) ppm, copper gave (0.075, 0.113, 0.116 and 0.158) ppm, zinc (6.594, 6.452, 3.743 and 5.239) ppm, manganese (1.476, 4.840, 4.050,0.696) ppm, iron (3.486, 5.456, 4.858 and 4.539) ppm, cobalt (0.148, 0.126, 0.064 and 0.123) ppm, lead (1.410, 0.170, 0.070, 0.030) ppm, nickel (0.077, 0.042, 0.065 and 0.040)ppm, cadmium (0.00, 0.096, 0.039, 0.018)ppm, chromium (0.250, 0.142, 0.00, 0.073) ppm and the least values in aluminium (0.00- 0.130) ppm for C. albidum, A. esculentus, D. indium and S. macrocarpon respectively. The collection of nutritional information may serve as a basis for increased consumption and utilization.

1. Introduction

The awareness on the intake of fruits has increased exponentially in recent years due to the prevalence of diseases that have proved difficult to treat by synthesized drugs and herbs. Fruits are nature's gifts to humanity which are present in abundance. Africa and indeed most tropical and subtropical countries are blessed with numerous fruits that are produced at different climates and seasons. Fruits are packed full of goodness and often contain a number of essential vitamins and minerals that cannot be found in other types of food or they may contain higher levels of these nutrients. They are made up of water, which are essential for the body and their skin and seeds contain plenty of fiber, which our body needs to help cleanse and rid itself of waste and toxins. This fiber is very important as it is needed to keep bowel movements regular, lower cholesterol, prevent constipation, bowel cancer and other illness of the bowel and intestine such as diventiculosis, they also contain some amount of protein, lipid and carbohydrates depending on type of fruit, in different proportions which are also beneficial and important part of a healthy diet. Different colored fruits contain different minerals, nutrients and antioxidants and therefore it is recommended that we consume a wide variety of fruits in other to receive the benefits from the various types. Carotenoids (majorly Lycopene) which are present in fruits is what gives all fruits their distinctive colors, red, yellow and orange colors. "Appearance of a fruit can be a powerful motivator", no wonder the colors of fruits are important and may determine the fruit selected by an individual. (Godze et al, 2012). Fruits constitute important part of a balance diet as they are natural sources of food nutrients-proteins, carbohydrates, fats and oils, dietary fiber needed by man and animals. With the global focus on increased food production and emphasis on provision of nutritive food for the world's teeming populace, it is therefore very important to consider our locally available fruits. (Shalom et al, 2011). Choosing foods from variety of fruits, vegetables and other plant source is likely healthier than eating large amounts of one type of food. The American Cancer Society's most recent nutrition guidelines amongst all recommend eating a balanced diet with an emphasis on plant sources which include 5 or more servings of vegetables and fruit each day. Even though fruits contain essential nutrients, a number of serious health problems can develop as a result of excessive uptake of dietary heavy metals and contamination of foods/fruits by heavy metals has become an inevitable challenge these days. Air, soil, and water pollution are contributing to the presence of harmful elements, such as cadmium, lead, and mercury in foodstuff. The occurrences of heavy metal-enriched ecosystem components, firstly, arose from rapid industrial growth, advances in the use of chemicals agriculture or the urban activities of human beings. These agents have led to metal dispersion in the environment and, consequently, impaired health of the population by the ingestion of victuals contaminated by harmful elements. It is advocated that any flooding from heavy downpour may lead to horizontal leaching from dump sites causing metal uptake by root of crops; the rest may find their way into open water bodies and the entire aquatic ecosystem, the entry into food chain of these metals leads to increased susceptibility and exposure to metal poisoning of the local population (Zukowska and Biziuk, 2008). Furthermore, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho- social behaviors, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer. Research has brought about the health benefits on the consumption of fruits. Eating a diet rich in fruits as part of an overall healthy diet may reduce risks of many diseases-heart attack, stroke, certain type of cancer, reduce obesity, blood cholesterol, constipation, in fact their benefits cannot be overemphasized, therefore, you hedge your bets by eating as much fruit as possible. The aims of this work was study the proximate and mineral composition of some local fruits in South Eastern Nigeria as well as the lycopene content of the four local fruits for use as basis for the selection of fruits suitable for processing. The long-term goal was to promote and increase the utilization and consumption of local indigenous fruits. The local fruits selected for the present study were Chrysophyllum albidum, Dalium indium, Abelmoschus esculentus and Solanum macrocarpon.

2. Materials and Methods

2.1. Species

Four local fruits were studied: family Sapotaceae, local name udara or agbalumo), Dalium indium (D. indium) (family leguminosae, local name icheku, awin or tsamiyar), Abelmoschusesculentus (A. esculentus) (family of musaspp local name unere) and Solanummacrocarpon (S. macrocarpon) (family Solanaceae, local name garden egg, anara). All the collected fruit samples were sourced from Eke Awka market in Awka South local government area of Anambra state. Nigeria. For both nutritive and metal analysis, the edible parts of the fruits were used.

(a) Solanummacrocarpon. (b) Dalium indium

(c) Abelmoschusesculentus (d) Chrysophyllumalbidum

Fig. 1. (a-d). *The local fruits selected for the study.*

2.2. Sample Preparation

All the collected samples of the various fruits were washed with deionized water to remove airborne pollutants. The seeds were removed in those that had and the remaining parts were homogenized in a hand blender to obtain pulp of each fruit.

2.3. Analysis

To determine the moisture content, 2g samples were dried in an oven until a constant weight, AOAC method. The samples were weighed before and after drying and the moisture content were calculated. Crude protein was calculated as N×6.25 according to AOAC. The ash content was determined by combustion of 5g samples and placed in a muffle furnace at 600˚C for 3hours according to AOAC. Crude fiber was carried out using acid/alkali digestion method according to AOAC. Fat determination followed the solvent extraction method also according to AOAC. Total carbohydrate was calculated by subtracting the previous components from 100. All determinations were performed at least in triplicate; the data are expressed as means ± standard deviations.

2.3.1. Lycopene Content Analysis

Extraction of Lycopene Pigment.

5g of each fruit paste was weighed into a conical flask, then 10ml of acetone was added directly to the paste to extract the pulp, this was done until the residue became colorless. The acetone extracts was then transferred into a separating funnel containing 20ml petroleum ether and mixed gently. 20ml of 5% sodium sulphate solution was also added and the mixture swirled gently. After standing for a while, two layers were noticed. The two phases were separated and the lower, extracted with additional 20ml petroleum ether containing 10g anhydrous sodium sulphate and kept aside for 30mins or more. After the time elapsed, the extract was decanted into a 100ml volumetric flask through a funnel containing cotton wool. The sodium slurry was also washed with petroleum ether until it was colorless and then transferred intoa volumetric flask and the volume made up.

Measurement of the Concentration of Lycopene.

Procedure: The petroleum ether used for the extraction was used to standardize the photometer, after which 5ml each of the extracted solution of the fruits were pipette into the cuvette. The absorbance was read off at 503nm. The concentration of lycopene present in each fruit extract was calculated.

2.3.2. Metal Analysis

Atomic Absorption spectrophotometer was used for analyzing the metal content. The samples were thoroughly mixed by shaking and 100ml of it was transferred into a glass beaker of 250ml volume, to which 5ml of concentrated nitric acid was added and heated to boil till the volume reduces to about 15-20ml, by adding concentrated nitric acid in increments of 5ml till all the residue was completely dissolved. The mixture was cooled, transferred and made up to 100ml using metal free distilled water. The sample was then aspirated into the oxidizing air-acetylene flame. When the aqueous sample was aspirated, the sensitivity for 1% absorption is observed.

3. Results and Discussion

Table 1. *Proximate/Nutritional Composition of four local fruits in their average mean±SD(Standard Deviation).*

Fruits	%Carbohydrates	%Moisture	%Protein	%Fats &Oil	%Crude Fiber	%Ash
African Star Apple (Chrysophyllum albidium)	32.73±2.30	28.23±1.87	4.20±0.25	9.50±0.71	20.00±1.23	0.52±0.02
Velvet Tarmarind (Dalium indium)	11.15±0.14	28.48±1.80	3.40±0.12	20.50±0.70	30.98±4.47	0.50±0.00
SHORT BANANA (Abelmoschus esculentus)	13.42±0.12	15.00±0.04	3.50±0.04	7.22±0.24	54.17±0.61	4.60±0.31
GARDEN EGG (Solanum macrocarpon)	11.43±0.45	68.35±1.73	5.07±0.14	5.00±0.00	3.31±0.31	5.00±0.00

The proximate compositions of the fruits were given in Table 1 above. The moisture contents were in the range of (15.00±0.04) to (68.35±1.73)g/100g. The lowest value was recorded for lady finger banana and the highest for Solanum macrocarpon, while the rest of the values were in this range. The data are within the range of (36.5±0.00-55.84±0.00) g/100g for Solanum macrocarpon but lower than the other three fruits reported by Onuegbu and Ihediohamma(2008). The data recorded for Solanum macrocarpon was also lower than the value (78.35±0.17)g/100g reported by Shalom et al (2011). This variation on moisture content especially for Solanum macrocarpon recorded here and that of the literature could be as a result of difference in location and difference in analytical procedures used to carry out the analysis. The ash contents ranged between (0.50±0.00)g/100g dalium indium and (5.00±0.00)g/100g. In all the studied fruit samples, the total lipid contents were in the range of (5.00±0.00) to (20.50±0.70)g/100g. The highest value was found for Dalium indium and the lowest was for Solanum macrocarpon. These values were higher than the reported literature, Sadiq et al., (2012) on Aduwa fruit (0.52±0.07)g/100g, S. aethipicum and S. macrocarpon (0.52±0.04)g/100g and (0.17±0.01)g/100g respectively reported by Shalom et al. On the other hand, Onuegbu and Ihediohanma (2008), reported higher value of total lipid content on African pear as (18.81±0.00-38.36±0.00)g/100g. In the case of protein contents, Solanum macrocarpon showed the highest value (5.07±0.14)g/100g followed by chrysophyllumalbidum (4.20±0.25)g/100g, lady finger banana (3.50±0.04)g/100g and dalium indium (3.40±0.12)g/100g. The data presented here are higher than those reported by Sadiq et al, (2012) (2.04±0.05)g/100g on aduwa fruit and Shalom et al (2.24±0.03)g/100g on s. aeithipicum but the literature reported by Onuegbu and Ihediohanma (2008), (11.09±19.99%) on African pear were higher than the reported data. The crude fiber content of the fruits varied widely between (3.31±0.13) and (54.17±0.61)g/100g. The lady finger banana contained an exceptionally high content of fiber while the rest of the fruits showed considerable amount of fiber. These results showed that lady finger banana could be a good source of fiber. The carbohydrate content was found to be in the range from (11.15±0.14) to (32.73±0.23)g/100g. Chrysophyllumalbidum is seen to have more than twice the carbohydrate concentration of the rest of the fruits but according to the data reported by Oyebade et al gave C. albidum to be (11±0.00)g/100g showing a lower concentration. This variation could also be attributed to different location and different parameters used to carry out the analysis. The ascorbic acid contents (vitamin C) were found to range from (6.06± 0.25)g/100g lady finger banana to (19.67±0.85)g/100g chrysophyllumalbidum which was seen to be at par with Morus. alba (15.20±1.25)g/100g and Moruslaevigata (17.03±1.71)g/100g as reported by Mohammed et al., (2010)

The overall results showed that the fruits could be potential sources of lipids, proteins, carbohydrates, fiber and ascorbic acid; in general, these local fruits were highly nutritious. However, some variations were observed in the studied parameters; therefore, for food purposes, these fruits should be taken at advantage especially when they are in season. The results are in good agreement with the reported literature (Mohammed et al, 2010).

Lycopene Content Table 2 shows the concentration in mg/100g of Lycopene in the fruits. The method used for the analysis uses a much lower amount of organic solvents than conventional procedures. According to this method, absorbance at 503nm (A503) was selected in order to avoid interferences from other carotenoids present in the fruit.

Table 2. *Lycopene concentration of the Local fruits.*

Fruits	Absorbance	Concentration (mg/100g)
Dalium indium	1.54	0.10
Solanum macrocarpon	0.32	0.02
Chrysophyllum albidum	0.46	0.03
Abelmoschus esculentus	0.24	0.01

From the table, dalium indium ranks the highest with 0.0962mg/100g of Lycopene while the least was abelmoschusesculentus with 0.0147mg/100g. When compared with the literature values of other main fruit of high Lycopene contents (tomato, pawpaw, watermelon), the concentration in the four local fruits were appreciable recommendable. This observation therefore suggests the presence of Lycopene in almost all colored fruits.

The Lycopene content determined in this fruits are almost similar to those indicated in the literature for domestic fruits (watermelons and tomatoes) for example, Lycopenecontent in the works of Fish et al, 2002 and Perkins-Veazie et al. 2001. Concerning the analysis of Lycopene, it has been stated in the literature, Elizabeth and Diane (2006) that Lycopene varies widely among cultivators and with production seasons. The evidence of the presence of Lycopene in tomato and tomato product, watermelon, pawpaw have been established, the presence of Lycopene in the local fruits studied here is known but yet to be established

Table 3. *Minerals concentration in the fruits.*

PARAMETER	C. albidum	A. esculentus	D. indium	S. marcrocarpon
Copper(ppm)	0.075	0.113	0.166	0.158
Manganese(ppm)	1.476	4.840	4.050	0.696
Zinc(ppm)	6.594	6.542	3.743	5.239
Magnesium (ppm)	20.811	21.291	11.105	11.304
Iron(ppm)	3.486	5.456	4.858	4.539
Cobalt(ppm)	0.148	0.126	0.064	0.123
Chromium(ppm)	0.250	0.142	0.000	0.073
Aluminium(ppm)	0.000	0.000	0.130	0.000
Calcium(ppm)	49.622	65.153	27.016	30.425
Lead(ppm,)	1.410	0.170	0.070	0.030
Cadmium(ppm)	0.000	0.096	0.039	0.018
Nickel(ppm)	0.077	0.042	0.065	0.040

Minerals/ Heavy Metal Concentrations

The minerals composition of the fruits was shown in Table 3 above. All the selected elements (Cu, Zn, Mg, Mn, Ca, Pb, Cd, Ni, Al, Cr, Fe, Co) were detected in the four fruits samples. As can be seen from Table 3, Calcium (Ca) is the predominant mineral; however their concentrations were found to be varied among the fruits. Among the macro-minerals (Ca and Mg), the concentration of Ca was varied from (27.016)ppm dalium indium to (65.153) ppm lady finger banana while chrysophyllumalbidum contained (49.662) ppm and solanummacrocarponwith (30.425)ppm, the high level of Ca might be of nutritional importance, especially in rural areas where sickly bones and teeth deficiencyrampant, that of Mg ranged from (11.105) to (21.291) ppm for dalium indium and lady finger banana respectively, C.albidum had (20.811)ppm and S. macrocarponwas with (11.304)ppm. Among the essential micro-minerals, Fe was present in considerable amount in lady finger banana (5.456) ppm followed by dalium indium (4.858) ppm, (4.539) ppm in S. macrocarpon and (3.486) ppm in C.albidum. Similarly, Zn was found in the range of (3.743) ppm dalium indium to (6.594) ppm C.albidum while a narrow range ofCu contents was recorded ranging from (0.075) ppm C.albidum to (0.166) ppm dalium indium. Mn recorded highest values of (4.840) ppm followed by (4.050), then (1.476) and (0.696) ppm for L.banana, D.indium, C.albidum and S. macrocarpon. Values for Cr gave (0.250, 0.142, and 0.073) for C.albidum, L.bananaand S.macrocarpon, no valuewas recorded for D. indium. Pb values ranged from (0.03) ppm S. macrocarpon to (1.170) ppm L.banana. For Ni, values were in the range of (0.040) ppm S.macrocarpon to (0.077) ppm C.albidum. The least concentration of minerals was recorded in Al which reported values only in dalium indium (0.130) ppm the rest were nil. The overall decreasing orderof mineral element in the studied fruits was Ca>Mg>Zn>Fe>Mn>Cu>Co>Cr>Pb>Ni>Cd>Al.

Permissible limit set by WHO, EU and EPA for the most toxic metals gave that Aluminum be 1.0ppm, Copper is 10ppm, lead be 0.2ppm, for chromium the guideline value is 0.05 ppm. The recommended value for Manganese is 0.1 ppm and that of cadmium was given as 0.5mg/kg. No permissible limit was recorded for Ca. My estimated values of the heavy metals in each of the fruits were less than permissible limit set by WHO/FAO for all of the fruits but that of lead as recorded in chrysophyllumalbidum was above the limit, thus, a cause for public concern. The exposure of consumers and the related health risk are usually expressed in terms of the provisional tolerable intake (PDTI) in mg/kg or ppm. The FAO/WHO have set a limit for the heavy metal intake based on body weight for an average adult (60kg). The average diet per person per day of fruits is 78µg. if the mean levels of Cu, Mn, Fe, Co, Cr, Al, Ca, Pb, Cd and Ni found in the fruits studied are consumed daily, the contents of heavy metal intake for an average human being from the fruit diet is as can be seen in Table 4 below following the calculation by (Cui et al, 2004) given as: Daily intakes of heavy metals × Daily fruit consumption. Those reported by the FAO/WHO which have set a PTDI limit for the heavy metal intake based on body weight for an average adult (60kg) is given as Pb-214µg, Cd-60µg, Cu-30µg, Zn-600µg, Cr-25µg, Mn-2500µg, Ni-5µg. It can be concluded that our estimated daily intakes for heavy metals studied here, given in the table above are all below the permissible PTDI Limit, therefore, the fruits studied here are highly recommendable.

Table 4. *Mineral intake per µg per day for an average person on the fruits studied (Cui et al, 2004).*

Foodstuff/g/person/day	78.000
Cu intake/µg/day	9.984
Mn intake/µg/day	215.709
Fe intake/µg/day	357.611
Co intake/µg/day	8.970
Cr intake/µg/day	4.189
Al intake/µg/day	2.535
Ca intake/µg/day	3358.212
Pb intake/µg/day	32.760
Cd intake/µg/day	2.987
Ni intake/µg/day	4.368

4. Conclusion

The thrust of this study was to determine the nutritional and heavy metal analysis on these local fruits. The result reported here highlighted significance of local fruits species as a cheap source of nutrient for especially the rural dwellers. The food value of the fruits compared very well with domesticated populated fruits (mango, pawpaw, apples, bananas etc.) in terms of protein carbohydrate, lipids and minerals (Akpuaka et al., 2015).

Also, Lycopene is certainly a true phenomenal material and one that is available for a price affordable to even the rural dwellers. Regular consumption of fruits and vegetables is recommended as part of healthy eating. 1-2 servings of Lycopene – rich fruits everyday should be taken against the effects of oxidative stress. Its content which was notably present in tomatoes and watermelon is now known in these fruits although yet to be established, it is therefore pertinent to note that Lycopene analysis is only a preliminary study and more work is necessary to ensure the significance of quantitative data.

Fruits are very important components of a healthy diet, if we consume them daily in sufficient amounts they could help prevent cardiovascular diseases and certain types of cancer as said earlier. The world health organization recommends eating a minimum of 400g of fruits a day to prevent chronic diseases such as cancer, diabetes and obesity. To reach that number, we can combine the different colors of fruits, and even vegetables, obtaining all the benefits they bring to our health.

Fruits are also a major component of the human diet and a source of essential nutrients, antioxidants and metabolites. However, intake of toxic metal-contaminated fruits may pose a risk to human health. Agricultural activities (irrigation water, farm soil, and pesticides), pollution (transboundary) have been identified as contributors to increasing toxic metal contamination through the application of various types of pesticides and fertilizers. Results from present and previous studies demonstrate that the foods grown on contaminated soils are more contaminated with heavy metals, which pose a major health concern. (Anita et al, 2010; Liu et al, 2005; Khairiah et al, 2009).

Finally, Man's quest for a balanced diet demand for local food materials that could be genetically mass produced to meet up with human nutritional needs. The present study is also a step towards the standardization of these fruits as potential healthy foods, which may also be used aside food, in pharmaceutical industries.

References

[1] Akpuaka M.U., Ezem S. N., Ogbuagu A.S., and Ekpunobi U.E. (2015) The Chemical Constituents of some medicinal plants used in health management in South East Nigeria: A Review. International Journal of Chemical and Biomedical Science. Vol. 1(2): 17 – 24.

[2] Anita S., Rajesh K., Madhoolika A., Fiona M. (2010). "Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India". Food Chemical Toxicology48:611-619

[3] AOAC, (1984).Official method of Analysis International, Association of Official Analytical Chemistry. Washington D.C. USA.

[4] Cui M, Fay D.S and Han M (2004) Lin-35/Rb cooperates with the SWI/SNF complex to control Caenorhabditis elegans larval development. Genetics. 167 (3); 1177-85.

[5] Elizabeth, G., Diane, M. (2006). "Assessing lycopene content in California processing tomatoes". Journal of Food Processing and Presenting. 30: 58-63.

[6] Godze, O., Whitehead, H., Ian, D., David, I. (2012). American journal of public health, 102(2): 207.

[7] Joint FAO/WHO Expert Committee on Food Additives Toxicological Evaluation of Certain Food Additives (1999). ILSI Press International Life Sciences Institute: Washington. USA: DC

[8] Khairiah, J., Ding-Woei, Y., Habibah, J., Ahmed-Mahir, R., Aminah, A., Ismail, S. (2009).“Concentration of heavy metals in guava plant parts and soil in the Sungai Wangi Plantation, Perak, Malaysia”. International Journal Agriculture Research4:310-316.

[9] Liu, W., Zhao, J., Ouyang, Z., Soderlund, L., Liu, G. (2005). “Impacts of sewage irrigation on heavy metals distribution and contamination. Environ International, 31: 805-812.

[10] Mohammed, I., Hamayun, K., Mohibullah, S., Rasool, K., Faridullah, K. (2010). “Chemical Composition and Antioxidant activity in Morus species” Journal of Zhejiang University , SCIENCE B, 11(12): 973-980

[11] Onuegbu, N.C and Ihediohanma, N.C. (2008).“Proximate analysis on Africa pear (dacryodesedutu)”.Journal of Applied Science Environs Manage, 12(1): 83-85.

[12] Oyebade, B.A., Ekeke, B.A., Adeyemo, F.C. (2011). “Fruits categorization and diagnostic analyses of chrysophyllum albidum in Nigeria”. Advances in Applied Science Research, 2(1): 7-10.

[13] Perkins-Veazie, P., Collins, K., Pair, S., Roberts, W. (2001). Lycopene content differs among red-fleshed watermelon cultivars. Journal of Food Science and Agriculture, 81: 983-987.

[14] Raganna, S. (1986). Handbook of analysis and quality control for fruit and vegetable products, 2nd Edition. Tata McGraw-hill education press, pp 497.

[15] Sadiq, I.S., Dangogo, S.M., Hassan, L.G., Manga, S.B., Thompson, I and Itodo, A.U. (2012). “Nutritional components of Aduwa fruit from semi-arid region, north-western Nigeria”. International Journal of Food and Nutritional Science, 1(2): 23-27.

[16] Shalom, N.C., Abayomi, C.O., Okwuchukwu, K.E., Opeyemi, C.E., Olajumoke, K. (2011). “Proximate and phytochemical analyses of solanum aeithiopicum L. and solanum macrocarpon L. fruits”. Research Journal of Chemical Sciences, 1(3): 35-39.

[17] Zukowska J, Biziuk M. (2008).“Methodological Evaluation of Method for Dietary Heavy Metal Intake”. J Food Science, 73(2):R21-R29.