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Comparative Analysis for Nutritional Composition of Selected Leafy Vegetable Spieces of the Family (Malvaceae) in Bali, Taraba State, Nigeria

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Abstract:- Vegetables are considered as one of the cheap sources of nutients (minerals) supplement to man. Their nutritional worth is the richness in minerals which is necessary in the up keep of human health. This study focused on determining and comparing the nutritional composition (macronutrient, micronutritent and vitamin C) of kenaf, roselle and Jew's mallowin Bali Local Government of Taraba State.The plant were identified using pertinent taxonomic literature by Garjila (2016). Also standard procedure by Anne (2019) was used to determine the concentration of vitamin C and X-ray Fluorescence, Model: Nitin TM XL3t Analyzer was used to analyse the macro and micronutrients concentration of Cu, P, Zn, Pb, Mg, Mn, Fe, Cr, Ca and S. The result of the study shows that kenaf contain calcium 2.957 %, potassium 3.252 %, iron 0.023 %, zinc 0.004 %, aluminum 0.097 %. The concentration of phosphorus, vitamin C and sulphur are 0.464 %, 0.460 g/L and 1.170 % respectively. Roselle comprise of calcium 4.315 %, potassium 1.898 %, iron 0.007 %, zinc 0.002 % and aluminum 0.073 %. The amount of phosphorus, vitamin C and sulphur are 0.111 %, 0.232 g/L and 0.250 % respectively. The amount of phosphorus, vitamin C and sulphur in Jew's Mallow are 0.250 %, 0.212 g/L and 0.337 % respectively. Jew's Mallow also cotains 1.875 % calcium, 4.338 % potassium, 0.005 % iron, 0.002 % zinc and 0.144 %aluminum.The three vegetables (kenaf, roselle and Jew's mallow) contain significant amount of minerals (Ca, P, Fe, K, S, Zn, and Cu), and a reasonable amount of vitamins C. Thus, the vegetables may be used as mineral supplements and also useful in the management of various diseases and illnesses in human.

Keywords:- *Comparative Analysis, Nutritional Composition, Leafy Vegetable, Spieces.*

I. INTRODUCTION

The world population is increasing daily so is the demand for food. Thus, food is one of the essential component of the increasing world population survival. Along with other food alternatives, vegetables are consider as one of the cheap sources of nutients (minerals) supplement to man. Vegetables are essential foods both from economic and nutritive view points. Their nutritional implication is the richness in minerals which is very vital in the maintenance of human health [1], they are essential constituent of healthy nutrition, if consumed daily in adequate amounts, could help to prevent major illnesses such as cardiovascular diseases and certain cancers [2]. Similary, these vegetables are typically low in calories, low in fat, high in protein per calories, high in dietary fibre, high in some mineral substances such as K, Ca, Mg, Na, Fe while others may be present in traces. They are very great in disease fighting phytochemicals such as vitamin C, carotenoids, flavonoids and saponin [3].

Vitamin C is chemically refers to as ascorbic acid, is a vital component of a healthy food. The history of Vitamin C revolves around the history of the human disease scurvy, probably the first human illness to be recognized as a deficiency disease. Its symptoms include exhaustion, massive hemorrhaging of flesh and gums, general weakness and diarrhoea. Scurvy is a disease unique to guinea pigs, various primates, and humans. All other animal species have an enzyme which catalyzes the oxidation of L- gluconactone to L-ascorbic acid, allowing them to synthesize Vitamin C in amounts adequate for metabolic needs [4].

This research work aimed to determine and compare the nutritional composition (macronutrient, micronutritent and vitamin C) of three selected vegetables of the family (Malvaceae) in Bali, Taraba State, Nigeria.

II. LITERATURE REVIEWS

Kenaf (*Hibiscus cannabinus* L.*)*

Figure 1. Picture of Kenaf (*Hibiscus cannabinus* L.*)* (Source: Fieldwork Ojeaga, 2020).

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Description of Kenaf (*Hibiscus cannabinus* L.*)*

Kenaf (*Hibiscus cannabinus*), also called Deccan hemp and Java jute, is a plant in the family Malvaceae. *Hibiscus cannabinus* is in the genus Hibiscus and is inborn to Southern Asia, though its exact origin is unknown. The designation also relates to the fibre acquired from this plant [5, 6]. Kenaf is one of the allied fibres of jute and shows comparable characteristics. It is an annual or biennial herbaceous plant (rarely a shosrt-lived perennial) growing to 1.5-3.5 m tall with a woody base [5].

Taxonomy/Classification of Kenaf (*Hibiscus cannabinus* L.*)*

Kingdom: Plantae
Family: Malvaceae
Genus: Hibiscus
Species: cannabinus
Botanical name: *Hibiscus cannabinus* L. [5].
Vernacular name: Rama (Hausa)

Nutritional Valueand Uses of Kenaf (*Hibiscus cannabinus*L.*)*

100g edible kenaf leaves have the following chemical and biochemical composition: Water 79.0g, sugar 280kj (67Kcal), protein 5.5g, fat 1.2g, starch 12.2g, fibre 2.3g, calcium 484mg, phosphorus 18mg, iron 12.1mg, ascorbic acid 75mg. Kenaf seeds contain up to 22-26 percent fat, with palmitic acid accounting for 14-20 percent, stearic acid accounting for 3-7 percent, oleic acid accounting for 28-51%, and lanolin acid accounting for 23-46%. The oil is phytotoxic as well as antifungal. The moisture content of the press cake is 9%, the crude protein content is 32%, the oil content is 8%, and the crude fibre content is 8% [6].

Buds, flowers, young leaves, and fruits are used to make vegetables. The stem is a rich source of fibre that is often used to produce twine yarn, coarse textiles for sacking, packaging cloth, and raw material for the pulp and paper industries. Similarly, the seeds of the fibre crop are used to make fat, while the rest is used as feed. The oil is used in lubrication and lighting, as well as the manufacture of soap, linoleum, paints, and varnishes. Powdered leaves are used to treat sores and boils, and a leaf infusion is used to treat coughs. It is thought that the seeds have stomachic and aphrodisiac effects. Despite the fact that young plants make outstanding cattle fodder, [6].

Roselle (*Hibiscus Sabdariffa)*

Figure 2.Picture of Roselle (*Hibiscus sabdariffa)* (Source: Fieldwork Ojeaga, 2020).

Description of Roselle (*Hibiscus sabdariffa)*

Hibiscus sabdariffa, a member of the Malvaceae genus, is a well-known medicinal plant with a global reputation [7]. Hibiscus is a genus of over three hundred species found in tropical and subtropical regions of the world and is widely used as an ornamental plant. Certain varieties of Hibiscus, including *Hibiscus sabdariffa,* have been found to have therapeutic properties [8]. The popular name for *Hibiscus sabdariffa* is "red sorrel" or "Roselle." Though permeable soil is preferable, Roselle can thrive in a variety of soil types in a colder, more humid climate [9, 10].

Taxonomy/Classification of Roselle (*Hibiscus sabdariffa)*

Kingdom: Plantae
Family: Malvaceae
Genus: Hibiscus
Species: *sabdariffa*
Botanical name: *Hibiscus sabdariffa* [7].
Vernacular name: Yakuwa (Hausa)

Nutritional Compositionand Uses of Roselle (*Hibiscus sabdariffa)*

Nutritional value per 100 g : Energy 205 kJ (49 kcal), Carbohydrates 11.31 g, Fat 0.64 g, Protein 0.96 g, Vitamins: Vitamin A equiv.(2%) 14 µg, Thiamine (B1) (1%) 0.011 mg, Riboflavin (B2) (2%) 0.028 mg, Niacin (B3) (2%) 0.31 mg, Vitamin C (14%) 12 mg, trace metals: Calcium (22%) 215 mg, Iron (11%) 1.48 mg, Magnesium (14%) 51 mg, Phosphorus (5%) 37 mg, Potassium (4%) 20 mg, Sodium (0%) 6 mg [11].

More specifically, Roselle tea is used to treat hypertension, and its leaves are used in pharmacy and cosmetics as a source of mucilage. Additionally, roselle leaves have been used as a poultice to cure sores and ulcers, in addition to being used as an antiscorbutic for the prevention of scurvy, a refrigerant to alleviate fevers, an emollient, a diuretic, and a sedative [12]. Additionally, Roselle is grown for the baste fibre extracted from the roots, which is used in a variety of applications, including weaving jute sacks, cords, handbags, and door mats [13].

Jew's Mallon (*Corchorus olitorius* L.)

Figure 3. Picture of Jew's Mallon (*Corchorus olitorius* L.) (Source: Fieldwork Ojeaga, 2020).

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Description of Jew's Mallon (*Corchorus olitorius* L.)

Jew's mallow (*Corchorus olitorius*) also known as Jute mallow or nalta jute, other local names include "tossa jute", "bush okra", "krinkrin", "etinyung", "molokhia", and "West African sorrel", often invoking the most important traits [14, 15] is a Malvaceae family shrub that is the primary source of jute fibre [14]. *Corchorus olitorius* is an erect herbaceous plant that can reach a height of 1.5 metres. When grown exclusively for fibre production, it can reach heights of up to 4 m [14, 16, 17].

Taxonomy/Classification of Jew's Mallon (*Corchorus olitorius* L.)

Kingdom: Plantae
Family: Malvaceae
Genus: Corchorus
Species: olitorius
Binomial name: *Corchorus olitorius* L. [9].
Vernacular name: Laloh (Hausa)

Nutritional Valueand **Uses of Jew's Mallon (*Corchorus olitorius* L.)**

The composition of 100g fresh edible jew'smallon leaves is as follows: water 80.4g (74.2-91.1 percent), energy 243Kj (58Kcal), protein 4.5g, fat 0.3g, carbohydrate 12.4g, fibre 2.0g, calcium 360mg, potassium 122mg, riboflavin 0.53mg, niacin 1.2mg, and ascorbic acid 80mg [6]. It is also high in potassium, vitamin B6, iron, vitamin A, and vitamin C, which makes it especially essential in areas where people depend heavily on micronutrient-deficient staple crops to meet their energy needs [15].

The leaves of Jew's mallon are nutritious. Numerous textiles, including wool, twine, sacking, carpet backing fabric, and other mixed textiles, are made of jute. Additionally, it is used as a raw material in the manufacture of cords and strings. [14, 17].

Minerals

Minerals are elements that originate in the earth and cannot be made by living organisms [18]. Plants obtain minerals from the soil, and most of the minerals in human diets come directly from plants or indirectly from animal sources (in a human diet come from eating plants and animals or from drinking water) [18, 19]. Minerals may also be present in the water, but this varies with geographical location. Minerals from plant sources may also vary from place to place, because soil mineral content varies geographically [19].

Nutritionally, a mineral is a chemical element required as an essential nutrient by living things (organisms) to perform functions necessary for life [20, 21]. Likewise, minerals are one of the four (4) groups of essential nutrients; others are vitamins, essential fatty acids, and essential amino acids [14, 19]. There are five major minerals (elements) in the human body, they are calcium, phosphorus, potassium, sodium, and magnesium [21]. All of the remaining minerals in a human body are called "trace elements". The trace elements that have a specific biochemical function in the human body are iron, cobalt, copper, zinc, manganese, molybdenum, iodine, and selenium [19].

III. MATERIALS AND METHODS

Sample Collection, Identification and Preparation

The young leaves of the three plants (Kenaf, Roselle and Jew's Mallon) were bought at Daniya and behind rest house residence, Bali, Bali Local Government Area, Taraba State in the month of October, 2020. The plants were identified using pertinent taxonomic literature by [6].The leaves of the three plants were rinsed separately with clean flowing water from the laboratory tap to remove all the foreign materials that was attached to them. The leaves were detached from the stem by hand, the leaves were then dried on the laboratory table of Science Laboratory Technology Department, Federal Polytechnic Bali and each labelled according to the sample number. After drying at room temperature the leaves were milled using pestle and mortar and the powder obtained each were transferred into a clean sample container with same label and were ready for used for the analysis. The elemental analysis were carried out in the Resaerch center, Kaduna Polytechnic using X-ray Fluorescence (XRF) (Model: Nitin TM XL3t Analyzer) and vitamin C by titrimetic method at Science Laboratory Technology Department, Federal Polytechnic Bali.

Table 1. Identification of Plant Samples [6].

S/No	Common Name	Scientific Name	Family	Hausa Name
1	Kenaf	*Hibiscus cannabinus*	Malvaceae	Rama
2	Roselle	*Hibiscus sabdariffa*	Malvaceae	Yakuwa
3	Jew's Mallow	*Corchorustrilocularis*	Malvaceae	Laloh

Note: S/No = Sample Reference Number
New Family Name (Old Family Name)
Tiliaceae (Malvaceae)

XRF Determination of Elemental Components

The macro and micronutrients concentration of Cu, K, Mg, Zn, Pb, Al, Mn, Fe, Cr, Ca, P and S of the three selected vegetable species was done using X-ray Fluorescence, Model: Nitin TM XL3t Analyzer. The grinded sample was sieved into a suitable vessel to obtain a fine powder of less than 10 microns which is best to overcome grain size effects and to ensure rapid dissolution in the borate flux during fusion.The die was clean with acetone to remove any grease or oil, the die was assembled and loading cylinder was inserted into the die. A 6" X 6" weighing paper was placed inside the loading cylinder and another weighing

paper was placed on the balance. The balance was tared, the sample was weighedout and transferred to an agate mortar. One (1) drop of binder was added for each gram of sample (If only 1 gram of sample was used, skip the binder). The binder was mixed until the sample was uniformly wetted with the binder and it was placed onto a weighing paper and then loaded into the loading cylinder. The briquetting piston was slowly inserted so the air turbulence does not scatter the backing material and the sample was formed into a pancake using the loading piston. The piston was carefully lifted out and the sample pancake was inspected (The surface should be perfectly smooth with no cracks or gaps. If the pancake is imperfect, insert the piston and repeat the operation). When the pancake was perfect, the loading cylinder was removed carefully without disrupting the pancake.The pancake was analyzed for required elements in XRF machine (X-ray Fluorescence, Model: Nitin TM XL3t Analyzer Manual).

Procedure for Determining Vitamin C [23].

A redox titration is one method for determining the level of vitamin C in food. The redox reaction is preferable to an acid-base titration since juice contains additional acids, but just a handful of them interact with the iodine-induced oxidation of ascorbic acid.

Since iodine is reasonably insoluble, this property can be enhanced by complexing it with iodide to form triiodide:

IV. RESULTS AND DISCUSSIONS

Table 2: Mineral Composition (%) of Dry Kenaf, Roselle and Jew's Mallow Leave found in Bali, Taraba State.

Parameter	Kenaf	Roselle	Jew's Mallow
Calcium (%)	2.957	4.315	1.875
Potassium (%)	3.252	1.898	4.338
Magnesium (%)	LOD	LOD	LOD
Copper (%)	LOD	LOD	LOD
Iron (%)	0.023	0.007	0.005
Manganese (%)	LOD	LOD	LOD
Zinc (%)	0.004	0.002	0.002
Lead (%)	LOD	LOD	LOD
Chromium (%)	LOD	LOD	LOD
Aluminum (%)	0.097	0.073	0.144
Sulphur (%)	1.170	0.250	0.337
Phosphorus (%)	0.464	0.111	0.252
Vitamin C (g/L)	0.460 ± 0.01	0.232 ± 0.03	0.212 ± 0.01

Mean of triplicate determinations ± standard deviation (SD)

❖ DISCUSSION

The mineral content of the three vegetables is shown in Table 2. The mineral content of species differed greatly. Calcium was abundant in the seeds, accounting for 1.875 percent of Jew's Mallow, 2.957 percent of Kenaf, and 4.318 percent of Roselle. As a result, Jew's Mallow is the least expensive, while Roselle is the most valuable. The calcium content of the leaf is significant since cells need calcium, and approximately 99 percent of calcium in the body is used as a structural component of bones and teeth [24]. Calcium ions are also needed for proper blood clotting as well as nerve and muscle function. Since some of the leaves contain calcium, their consumption can help the body sustain a stable calcium level and assist in the blood clotting process. The amount of potassium in Kenaf, Roselle and Jew's Mallow are 3.252 %, 1.898 % and 4.338 % respectively.The high calcium content in some of the leaves suggests that their consumption can help play an important role in managing blood pressure and also balances the effects of sodium on blood pressure because the more potassium you eat, the more sodium you lose through urine [25].

These levels of magnesium are however low detected for thethree vegetables which are below the National Agency for and Drug Administration and Control [26] recommended daily intake (RDI) of 375 mg/100g. The Recommended Daily Intake (RDI) of 2 mg/100g was recommended by NAFDAC for manganese but the levels of manganese in the samples were found to be below detection limit. In addition, the presence of copper in the dried samples was below detection limit and the RDI of 1 mg/100g was recommended by [26].

The concentration of available iron, zinc and aluminum (table 2.) in Kenaf, Roselle and Jew's Mallow were not significantly different from each other. Kenaf, Roselle and Jew's Mallow contain 0.023 %, 0.007 % and 0.005 % of iron respectively. Iron is an essential component of hemoglobin, an erythrocyte (red blood cell) protein that transfers oxygen from the lungs to the tissues. It also supports muscle metabolism and healthy connective tissue and as component of myoglobin, another protein that provides oxygen. According to the [27] the Recommended Dietary Allowances (RDAs) for iron, the adequate intake is between 15 mg/day - 7 mg/day. The vegetables have their content values within the recommended range.

Zinc is a nutritional supplement. It is needed for the catalytic activity of several enzymes as well as the proper functioning of the taste and smell organs. It also participates in a number of cellular processes such as metabolism, immune response, protein synthesis, wound healing, DNA synthesis, and cell division. Since the body requires a sophisticated zinc storage unit, zinc must be absorbed on a continuous basis to maintain a steady condition. According to [27], the recommended dietary allowances (RDAs) for zinc vary from 9 to 14 mg/day. The amount of zinc in Kenaf, Roselle and Jew's Mallow are 0.004 %, 0.002 % and 0.002 % respectively. Thus, thethree vegetables have values below 9 - 14 mg/day as recommended by the [27].

The Environmental Protection Agency (EPA) has recommended a Secondary Maximum Contaminant Level (SMCL) of 0.05–0.2 mg/L for aluminum in consumer products. The levels of aluminum in the samples were found to be below the recommended limit as reported by EPA. With Al values of 0.097 %, 0.073 % and 0.144 % for Kenaf, Roselle and Jew's Mallow respectively. Other elements like lead and chromium were below detection limit and the RDI of 2 - 6 mg/L and 5mg/L was recommended by [28] and [29] respectively.

Phosphorus can be obtainable as a dietary supplement. It is a component of bones, teeth, DNA, and RNA. It is also a component of cell membrane structure and of the body's key energy source. Phosphorus plays key roles in regulation of gene transcription, activation of enzymes, maintenance of normal pH in extracellular fluid, and intracellular energy storage [30]. The concentration of phosphorus in Kenaf, Roselle and Jew's Mallow are 0.464%, 0.111% and 0.252 %respectively. The values were below the report of [31, 32] that vegetables contribute about 5% of phosphorus.

Humans, unlike the majority of animals, lack the ability to synthesise ascorbic acid and therefore obtain it by food. Vitamin C is a coenzyme and cofactor in several enzymatic processes, including the biosynthesis of collagen, carnitine, and catecholamines, and it is also a potent antioxidant [33, 34, 35, 36]. Vitamin C deficiency impairs enzymatic processes and causes deficiencies in collagen, carnitine, and catecholamine synthesis. In the light of the above, the concentration of vitamin C available in Kenaf, Roselle and Jew's Mallow as indicated in Table 2. are 0.460 g/L, 0.232 g/L and 0.212 g/L respectively. The levels of vitamin C in the samples were found to be within the recommended average limit of 200 mg as reported by [37] that different vegetables vary in their vitamin C content, but should have an average of about 200 mg of vitamin C and recommended Nutrient Reference Values (NRV) limit of 100 mg as reported NAFDAC.

Sulfur is needed by the body for a number of critical functions, including protein synthesis, gene regulation, DNA synthesis and repair, and food metabolization [38]. The sulphur-containing amino acids (SAAs) methionine and cysteine present in plant materials are the main sources of S for humans. Furthermore, farm goods owe this to animals, as livestock obtain S from the two amino acids contained in grasses, fodder, and feeds. This is because organic compounds are only synthesised by plants and bacteria [39]. Plant ingredients, in addition to SAAs, include S, which includes the vitamins thiamin and biotin [40].The sulpur content in the dry Kenaf, Roselle and Jew's Mallow plant samples are 1.170 %, 0.250 % and 0.337 % respectively.

V. CONCLUSION

Vegetables are foods from plant leaves with different uses and are good source of minerals and nutrients (micro and macro-nutrients) content. This study revealed that kenaf, roselle and Jew's mallow vegetables contain significant amount of mineral and nutrient (micro and macro-nutrients) contents. The complex chemical content includes a significant content of minerals (Ca, P, Fe, K, S, Zn, and Cu), and a reasonable amount of vitamins C. They maybe essential sources of supplementary diets of several bioproducts such as of minerals (Ca, P, Fe, K, S, Zn, and Cu), and a reasonable amount of vitamins C vital for the biochemical functions in human. Thus, the vegetables may be use as mineral supplements and also useful in the management of various diseases and illnesses in human.

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REFERENCES

[1]. Arogba S. S. (2008). Phenolics: A class of nature's chemical weapons of self preservation inaugural lecture. K.S.U. Anyigba; 2008.
[2]. Bolaji P. T, Komolafe G. O, Allie (2008). Drying characteristics of selected local vegetables. *Nigerian Food Journal*. **2(1):**138-143.
[3]. Ghias, U. and R. Abdur, (2012). Phytochemical screening, antimicrobial and antioxidant activities of aerial parts of Quercusrobur L. *Middle-East Journal of Medicinal Plants Research,***1 (1):** 01- 04.
[4]. Online Chemistry Lab Manual at Santa Monica College, (nd).
[5]. The Plant List (2015). A Working List of All Plant Species". Retrieved 20 May.
[6]. Garjia, Y.A. (2016). A hand book of common vegetables in Taraba State for Schools and colleges. 1stedn. Taraba, Nigeria.
[7]. Abbas M, Shirin M, Patricia K, *et al*. (2011). The effect of *Hibiscus sabdariffa*on lipid profile, creatinine and serum electrolytes: a randomized clinical trial. International scholarly research network. *ISRN gastroenterology*. 1–4.
[8]. Yadong Qi, Kit L Chin, FatemahMalekian, *et al*. (2005). *Biological Characteristics, Nutritional and Medicinal Value of Roselle, Hibiscus sabdariffa*. Southern University and A & M College System; **225**:771–2262.

[9]. Duke J. A. (1983). *Hibiscus sabdariffa* [cited 2009 August 29]; Available from: http://www.hort.purdue.edu/newcrop/duke_energy/Gliricidia_sepium.html.
[10]. Robert S. M. (2005). Roselle production: Botanical description.
[11]. United States Department of Agriculture (2007-2010). Plant. Retrieved 2011-09-26.
[12]. Duke, James (2009). Medicinal plants of the world.
[13]. Food and Agriculture Organization. (2007). Industrial uses of Roselle.Gallaher RN, Gallaher K, Marshall AJ, Marshall AC. Mineral analysis of ten types of commercially ava.
[14]. Grubben, G. J. H. (2004). Vegetables. PROTA. ISBN 9789057821479.
[15]. Duke, James (1980). Medicinal plants of the world.
[16]. Handoussa, Heba; Hanafi, Rasha; Eddiasty, Islam; El-Gendy, Mohamed; Khatib, Ahmed El; Linscheid, Micheal; Mahran, Laila; Ayoub, Nahla. (2013). "Anti-inflammatory and cytotoxic activities of dietary phenolics isolated from *C. olitorius* and *Vitisvinifera*". *Journal of Functional Foods*. **5(3)**: 1204–1216.
[17]. Ya Tang; Michael G. Gilbert; Dorr, Laurence J. (2007), "*Corchorusolitorius*Linnaeus", Flora of China online, 12.
[18]. Linus Pauling Institute (2016). "Minerals". Micronutrient Information Center. Oregon State University, Corvallis. Retrieved 19 December 2016.
[19]. Berdanier, Carolyn D.; Dwyer, Johanna T.; Heber, David (2016*). Handbook of nutrition and food*, Third Edition. CRC Press. pp. 211–224.
[20]. US National Institutes of Health (2016). "Minerals". MedlinePlus, National Library of Medicine. Retrieved 24 December 2016.
[21]. Berdanier, Carolyn D.; Dwyer, Johanna T.; Heber, David (2013). *Handbook of nutrition and food*. (3rd ed.). CRC Press. p. 199. ISBN 978-1-4665-0572-8. Retrieved 3 July 2016.
[22]. X-ray Fluorescence, Model: Nitin TM XL3t Analyzer Manual.
[23]. Anne Marie Helmenstine, (2019). Vitamin C Determination by Iodine Titration. Biomedical Sciences, University of Tennessee at Knoxville.
[24]. Grosvernor, M. B. and Smolin, L. A. (2002). Nutrition: From Science to Life. Harcourt College Publishers, New York, USA, pp. 288-371.
[25]. Institute of Medicine (2004). Dietary reference intakes: water, potassium, sodium, chloride, and sulfate. www.iom.edu/Reports/2004/Diet...d-Sulfate.aspx. Updated February 11, 2004. Accessed September 22, 2017.
[26]. NAFDAC (National Agency for Food and Drug Administration and Control). (2010). Nutrition, Health and other Claims on Food Regulations.
[27]. Institute of Medicine, Food and Nutrition Board (2001). Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press.
[28]. Broyer T. C, Johnson C. N, Paull R. E (1972). Some aspects of lead in plantnutrition. Plant Soil 36: p. 301.
[29]. Macnicol RD, Beckett PHT (1985). Critical tissue concentrations ofpotentially toxic elements. Plant Soil, 85: p. 107.
[30]. Heaney R. P. (2012). Phosphorus. In: Erdman J.W, Macdonald I.A, Zeisel S.H, eds. Present knowledge in nutrition. 10th ed. Washington, DC: Wiley-Blackwell; 447-58.
[31]. McClure S.T, Chang A.R, Selvin E, *et al*. (2017). Dietary sources of phosphorus among adults in the United States: Results from NHANES 2001-2014. *Nutrients*. 2017; 9.
[32]. Moshfegh A.J, Kovalchik A.F, Clemens J.C. (2016). Phosphorus intake of Americans: what we eat in American, NHANES 2011-2012. Food Surveys Research Group Dietary Data Brief No. 15.
[33]. Combs, J. R. and Gerald F. (2012). The Vitamins fundamental aspects in nutrition and health. 4thed.
[34]. Erdman K. A, Fung T. S, Reimer R. A. (2006). Influence of performance level ondietary supplementation in elite Canadian athletes.*MedSci Sport* Exerc.38:349–356.9. Bond-Brill.
[35]. Carr A., Frei B. (1999a). Does vitamin C act as a pro-oxidant under physiological conditions. *FASEB J*.13:1007–1024. [PubMed] [Google Scholar].
[36]. Carr A.C., Frei B. (1999b)Toward a new recommended dietary allowance for vitamin C based on antioxidant and health effects in humans. *Am. J. Clin. Nutr*; 69:1086–1107.
[37]. [37]. USDA (United State Department of Agriculture) (2009)-National Nutrient Database for Standard Reference Release 22. Nutrient data Laboratory. http://www.ars.usda.gov/ba/bhnrc/ndi Date accessed: 14th February 2014.
[38]. Joanne F. Doleman, KatrijnGrisar, Lena Van Liedekerke, ShikhaSaha, Mark Roe, Henri S. Tapp, Richard F. Mithena (2017). Food Chemistry - the contribution of alliaceous and cruciferous vegetables to dietary sulphur intake. Volume 234. Pp: 38 – 45.
[39]. Parcell Stephen (2002). Sulfur in human nutrition and applications in medicine.*Altern Med Rev*; **7(1):**22-44.
[40]. Prasad R. (2014). Major sulphur compounds in plants and their role in human nutrition and health–An Overview. Indian Agricultural Research Institute, *Proc Indian NatnSciAcad*: **80** No. 5; pp. 1045-1054.