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Assessment of variation in mineral content of ripe and unripe African eggplant fruit (*Solanum aethiopicum* L.) Exocarps

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Abstract
This study investigated variation in mineral content of ripe and unripe *Solanum aethiopicum* fruit exocarp. Thirteen minerals; Ca, Mg, K, Na, Mn, Fe, Cu, Zn, Cd, Pb Co, Cr and Ni were assayed with Atomic Absorption Spectrophotometer while P was assayed by using UV-Visible Spectrophotometer. Results of this study showed variation in concentration of essential minerals (Ca, Mg, K, Na, P, Mn, Fe, Cu and Zn) while toxic minerals (Cd, Pb Co, Cr and Ni) were not detected in both exocarps. Concentrations of K were highest in both ripe and unripe exocarps in comparison with other minerals. Concentration of Mn (0.005mg/g) was lowest and equal in both exocarps. Only Mg was higher in the unripe (0.625mg/g) than the ripe (0.595mg/g) exocarp. Since the concentrations of all the essential minerals except Mg were higher in the ripe exocarp, this study suggested that consumption of ripe *Solanum aethiopicum* fruits seems more beneficial especially in terms of the amount of minerals obtainable from them.

Keywords: *Solanum aethiopicum*, minerals, exocarp, ripe, unripe

1. Introduction
Entrenched in nature are substances capable of tackling the myriad ailments of ancient occurrence and those of current emergence. Extensive studies of some indigenous food plants have established their potentials as natural remedies for old and emerging health challenges. The bombardment of the human body with synthetic drugs for the chemotherapeutic control of disease coupled with its long term harmful effects could be what triggered the search and use of therapeutic agents with less toxic effects wherever possible [1]. The outcome of this development is the association of plant food and medicine with specific therapies.
In the developed nations, the new trend of applying phyto-therapy has led to an upsurge in the consumption of medicinal plants. This demand for medicinal plants is steadily increasing not only in developing countries but also in the industrialized nations [2]. The status of phyto-therapy in developing countries as stated by the World Health Organization (WHO) is that approximately 80% of the developing world's population meets their primary health care needs through traditional medicines. About 25 % of prescription drugs dispensed in the United States of America contain at least one active ingredient derived from plant material. With plant extracts however, efficacy, risk factors such as toxicity and side effects are low and reasonable safety measures are often established [3].
African eggplant also called garden eggs (Hausa: Dauta; Igbo: afufa or añara; Yoruba: igba) is a plant genus of the family *Solanaceae*. Of the over 1000 species that exist worldwide and over 100 species that are indigenous to Africa, *Solanum aethiopicm L* is one of the most widely cultivated in Nigeria. It is an important part of the Nigerian foods and indigenous medicines and it is commonly consumed by both rural and urban dwellers. In different parts of Africa, the roots and fruits are used as sedative, and to treat colic and high blood pressure while the juice obtained by macerating the leaves is used to treat uterine complaints [4]. Also, the extract of the leaves is reportedly used as sedative and anti-emetic and to treat tetanus associated with miscarriages [5]. In the sub-Saharan Africa culture, the fruit is believed to represent blessings and fruitfulness and are offered as a token of goodwill during visits, marriages and other social events [5]. They are eaten raw and also boiled or fried as ingredient of stews, soups and vegetable sauces. In traditional medicine, its uses range from weight reduction to treatment of several ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease, swollen joint pains, gastro-esophageal reflux disease,

constipation and dyspepsia [6]. The pharmacological properties of *Solanum aethiopicum L.* have been attributed to the presence of certain chemical compounds in the plants, such as fiber, ascorbic acid, phenols, anthocyanin, glycoalkaloids and a-chaconine [7, 8].

Mineral elements are very vital parts of human diets. Their importance to the proper and normal functioning of the body systems cannot be overemphasized. Human body mass is composed of 4 % of minerals and they perform essential functions which include but not limited to providing structure for the formation of bones and teeth, maintenance of heart rhythm, muscle contractility, acid-base balance, enzymatic reactions and regulation of cellular metabolism [9]. Minerals that are essential for the body are categorized into two; macro-minerals and micro-minerals or trace minerals. These two groups of minerals are equally important, but the micro minerals are needed in smaller amounts than macro minerals. Although they are required in minute amount, trace minerals are very essential and critical for health and immunity [10]. They serve as cofactors of enzymes like superoxide dismutase [11, 12], glutathione reductase, glutathione peroxide, thioredoxin reductase [13], ceruloplasmin [14] and catalase [15]. They play vital role in growth, production and reproduction [16, 17].

In this study, variation in the concentration of minerals in ripe and unripe *Solanum aethiopicum* fruit exocarp was investigated.

2. Materials And Methods

2.1. Sample Collection and Preparation

Fresh and healthy unripe fruits of *Solanum aethiopicum* were purchased from Ijede market in Ikorodu Local Government Area, Lagos State, Nigeria, between September and October, 2016. A portion of the unripe fruit was kept under the shade for about one week in order for them to ripe. The fruits (ripe and unripe) were washed with copious amount of water to remove dirt and the exocarp was removed manually. The exocarp was oven-dried at 50 ^{o}C for 48 hours and thereafter pulverized with a laboratory blender (Lexus Model No. 25520). The pulverized samples were immediately analyzed for mineral analysis.

2.2. Mineral composition

Mineral content of the sample was assayed by modified AOAC method [18]. Two grams of the pulverized sample was transferred into a pre-weighed crucible and placed in a muffle furnace at 550 ^{0}C for about 6 hours by which time the sample had completely ashed. The resulting ash was dissolved in 20 mL HNO_3 (10 %) solution and the solution was boiled on a hotplate for 15 min, filtered and made up to mark with distilled water in a 100 mL volumetric flask. This ash solution was then used for mineral analysis. Reagent blank was prepared by boiling 20 mL HNO_3 (10 %) solution on a hotplate for 15 min, filtered and made up to mark with distilled water in a 100 ml volumetric flask. Thirteen minerals (Ca, Mg, K, Na, Mn, Fe, Co, Zn, Cu, Cr, Cd, Pb and Ni) were determined in the ash solution. The blank solution was also determined with an Atomic Absorption Spectrophotometer (Buck Scientific Model 2010 VGP). The equipment was calibrated with 100 mg/L of the standard solution of each element determined while P was determined with the use of a UV- visible Spectrophotometer (LabMed SPECTRO SC). Results are means of three replicates.

3. Results and Discussion

The results of the mineral composition of ripe and unripe exocarps of *S. aethiopicum* fruits are presented in Table 1. Variations were observed in the concentrations of these metals in the ripe and unripe *S. aethiopicum* fruits exocarps. Heavy metals (Cd, Pb, Co, Cr and Ni) were not detected in both ripe and unripe fruit exocarps. Only the concentration of Mg was higher in the unripe fruit exocarp than the ripe exocarp. This suggests that the Mg may have been consumed in the enzymatic biochemical reaction of ripening. Potassium was the most prominent mineral element found in the exocarps of both ripe (9.525 mg/g) and unripe (4.475 mg/g) fruit of *S. aethiopicum*. This suggests that garden egg could be a good source of potassium; making it an important food for people suffering from Hypokalaemia and other potassium deficiency related diseases. Its concentration was significantly increased (~112%) in the ripe fruit exocarp. Mn was the least occurring mineral in both exocarps. Both ripe and unripe exocarps contained the same concentration (0.005 mg/g) of Mn. Ca increased slightly (~16%) in the ripe fruit exocarp. Iron and Zinc were the most significantly increased of all the mineral elements in the ripe exocarp with ~4400 % and 3715 % increases respectively. The concentrations of Na, Cu, and P also increased between 14 - 16 %. These results suggest that ripening of *S. aethiopicum* fruit influenced the composition of mineral elements especially in the exocarp as captured in this study. Generally, many people especially in Nigeria prefer the green-colored unripe *S. aethiopicum* fruit to the orange-colored ripe *Solanum* one. Consequently, they would rather not buy or even discard the ripe *S. aethiopicum* fruit as no longer fitting for consumption. The results of this study however found otherwise. The results suggest that in order to obtain more minerals from S. *aethiopicum* fruits, more of the ripe one should be consumed. However, several studies have reported variations in the proximate, mineral and phytochemical compositions and by extension on nutritional and medicinal potentials of food crops due to ripening [22, 23, 24, 25, 26, 27, 28]. From the result of this present study, sodium was observed to be lower than potassium in both ripe and unripe *S. aethiopicum* fruit exocarps. The low sodium concentration is nutritionally ideal for hypertensive patients since a high level of sodium in-take is associated with high blood pressure [29]. Low sodium diet has also been reported to be beneficial in the prevention of high blood pressure while high intake of dietary potassium has been reported beneficial in relation to blood pressure control [30]. Consumption of diets rich in essential minerals is important in order to avoid illnesses associated with mineral deficiency [31]. On the other hand, consumption of foods contaminated with toxic metals such as mercury, lead, cadmium, arsenic and so on is found to be injurious to human health. Na, Mg, Ca and Zn have been described as the mostly required mineral elements for the proper functioning of the living cells and their deficiencies have been associated with disrupted enzymatic activities and poor electrolyte balance of blood fluids [29].

Table 1: Mineral Composition of Ripe and Unripe Fruit Exocarp of *Solanum aethiopicum* (mg/g dry weight basis).

S/N	Metal	UNRPEC	RPEC	% Δ Conc	DV
1	Calcium	0.310±0.001	0.360±0.002	+16.13	1000-1200 mg[19]
2	Magnesium	0.625±0.002	0.595±0.002	-4.80	310-420 mg[19]
3	Potassium	4.475±0.01	9.525±0.001	+112.85	4.7 g[20]
4	Sodium	0.865±0.001	1.005±0.001	+16.20	1.3-1.5 g[20]
5	Manganese	0.005±0.001	0.005±0.001	0	1.8-2.3 mg[21]
6	Iron	0.025±0.001	1.125±0.001	+4400	8-18 mg[21]
7	Copper	0.007±0.001	0.008±0.001	+14.30	900 µg[21]
8	Zinc	0.077±0.001	2.938 ±0.001	+3715.60	8-11 mg[21]
9	Phosphorus	1.091±0.001	1.245±0.001	+14.12	700 mg[19]
10	Chromium	ND	ND	-	-
11	Cadmium	ND	ND	-	-
12	Lead	ND	ND	-	-
13	Nickel	ND	ND	-	-
14	Cobalt	ND	ND	-	-

ND: Not detected, +Δ = % Increase in Concentration, -Δ = % Decrease in Concentration, DV= Daily value or requirement 19 = Institute of Medicine, 1997, 20 = Institute of Medicine, 2004 21 = Institute of Medicine, 2001, UNRPEC= Unripe Exocarp, RPEC = Ripe Exocarp

The importance of each of these minerals has been stated in literature. For example, along with sodium, potassium regulates the water balance and the acid-base balance in the blood and tissues [32]. Magnesium is an important constituent of bones, teeth and enzyme cofactor; kinases [33]. Copper is the essential element in two enzymes that are important for immune competence; copper/zinc-superoxide dismutase and ceruloplasmin [14]. Copper has a selected biochemical function in hemoglobin synthesis, connective tissue metabolism, and bone development. Copper acts as ceruloplasmin aid in the transport of iron to cells [34]. Zinc is required for the proper functioning of the reproductive system [35] and it is also involved in the secretion and function of male hormone testosterone through the enzymes that control the arachidonic acid cascade [36]. Manganese is part of enzyme involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis [37]. Calcium serves as a major constituent of teeth and bones and is also involved in regulation of nerve and muscle functions. It is essential for membrane permeability, muscle contraction, transmission of nerve impulses and neuromuscular excitability [38]. Iron plays an important role in ovarian activity [39]. Iron is vital in the formation of Hemoglobin and myoglobin, which function in oxygen-transport. Its deficiency causes severe disorders and the most important among them is iron deficiency anemia [40]. Phosphorus is an essential constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It is vital for many body metabolic processes.

4. Conclusion

The findings of this study showed the presence of essential mineral elements and the absence of toxic metals in the exocarp of both ripe and unripe *S. aethiopicum* fruit. This implies that the exocarp of this fruit (either ripe or unripe) is not only good but also safe for consumption. Concentrations of all the mineral elements except magnesium were higher in the ripe fruit exocarp while manganese content remained the same in both fruit exocarps. Therefore, consumption of the ripe *S. aethiopicum* fruit would supply the body with more minerals. Also, the variation in the results of this study showed that ripening significantly influenced the mineral composition of *S. aethiopicum* fruit exocarp.

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