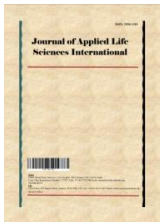

Journal of Applied Life Sciences International

23(7): 25-39, 2020; Article no.JALSI.59517
ISSN: 2394-1103

Estimation of Vitamins in *Aframomum melegueta* [Roscoe] K. Schum and Its Relevance as Natural Immune Booster

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Authors' contributions

This work was carried out in collaboration among all authors. Authors OTO, VOO, AOA, IOO and AO designed the materials and methods used for this research work. Author OTO performed the statistical analysis and wrote the first draft of the manuscript. Author VOO collected medicinal plants and helped to proof-read the first and final manuscript for constrictive criticism. Author AOA performed various researches on antimicrobial properties of medicinal plants and wrote the final draft of the manuscript. Author IOO helped to manage, interprets and analyzed the data collected from ultraviolet visible spectrophotometer. Author AO managed the estimation of vitamin protocol and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2020/v23i730173
Editor(s):
(1) Dr. Vasil Simeonov, University of Sofia "St. Kliment Okhridski", Bulgaria.
Reviewers:
(1) Dr. Sathya N. Dornala, Swami Vivekanand Ayurvedic Panchakarma Hospital, India.
(2) Dr. S. Porselvi, K. L. N. College of Engineering, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59517

Original Research Article

Received 28 May 2020
Accepted 05 August 2020
Published 13 August 2020

ABSTRACT

The importance of sourcing products of natural origin in boosting immunity against infectious diseases during therapeutic interventions especially in developing countries has been underscored. The need therefore arose to investigate candidate sources within locally available flora based on identified ethno-practices in the region. The potentiality of *Aframomum melegueta* as a source of vitamins which are recognized immune boosters was investigated. Plant samples were collected from the wild near Akungba-Akoko, Ondo state, Nigeria and separated into Stem, Leaf sheath, Fruit pulp (mesocarp) and Seed parts. The samples were oven-dried, pulverized and extracted with methanol and filtered with Whatman No 1 filtered paper. The filtrates were concentrated *in-vacuo* using vacuum rotary evaporator at 40°C and was later concentrated to dryness in a ventilated oven at 40°C. Analyses of vitamin content of the samples were conducted using standard analytical

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methods. The plant displayed a rich array of Vitamins with the seeds having the highest concentration compared to the Stem, Leaf sheath, Fruit pulp (mesocarp) and Seed extracts. Values obtained for seed and stem extracts respectively were Vitamin C (16.8 mg/g, 5.85 mg/g), Vitamin B (1.15 mg/g, 0.41 mg/g), Vitamin B_3 (0.98 mg/g, 0.30 mg/g), Vitamin E (0.75 mg/g, 0.11 mg/g), Vitamin B_6 (0.03 mg/g, 0.006 mg/g), Vitamin B_{12} (4.22 mg/g, 0.50 mg/g), Vitamin A (1024.1 mg/g, 189.9 mg/g), Vitamin E (0.75 mg/g, 0.11 mg/g), Vitamin D (0.68 mg/g, 0.03 mg/g) and Vitamin K (0.017 mg/g,0.007 mg/g). Standard daily recommended intakes for each vitamin are vitamin C -75 mg, $B_{2, 3, 6}$ and B_{12} ranges from 2 mg to 18 mg, A -600 µg, E -10 mg, D -5 µg, and vitamin K -80 µg. This study therefore elucidates the richness of *Aframomum melegueta* in essential vitamins and suggests its potential as an immune booster especially during the outbreaks of diseases. Direct consumption of the plant parts studied or as food supplement formula will be of benefit in the management of diseases.

Keywords: Aframomum melegueta; vitamin composition; natural immune booster; therapeutic interventions; infectious diseases.

1. INTRODUCTION

Aframomum melegueta has different names such as grains of paradise, Atare (in Yoruba), Chitta (Hausa), or Guinea pepper, is one seed with many healing power and its benefits to mankind seems endless. *Aframomum melegueta is* an herbaceous perennial plant native to swampy habitats along the West African coast of Nigeria. Its trumpet-shaped, purple flowers develop into 5 to 7 cm long pods containing numerous small, reddish-brown seeds. melegueta pepper and alligator pepper, *Aframomum melegueta* is among the species that belong in the ginger family Zingiberaceae. It is most abundantly in the countries of Ghana, Liberia, Ivory Coast, Togo, and Nigeria (Osuntokun 2020).

Aframomum melegueta is a medicinal plant that can be used traditionally for treating ailments. It belongs to the family Zingiberaceae [1,2,3]. Previous studies [4,5,6] shows that *Aframomum melegueta* seeds have been used as a spice for various food preparations including sauces, meats and soups. Similarly, this plant formula can also be traditionally mixed with other herbs for the treatment of common ailments such as sore throat, catarrh, body pains, rheumatism, diarrhoea and congestion in West Africa [4]. It is a perennial herbal plant found valuable for its antimicrobial, hepato-protective, anti-diabetic and anti-cancer effects [1,5,6].

A previous study in literature [7] reveals that, *Aframomum melegueta* contains an array of vitamins. For this research work, vitamins content of *Aframomum melegueta* will be determined to ascertain its value and usefulness as a recognized natural immune booster for therapeutic interventions.

Plate 1. *Aframomum melegueta*
(Source: Osuntokun, 2020) [47]

Summary of known Vitamin. Benefit and dietary sources

Vitamin Name	Benefits	Dietary Sources
Ascorbic Acid (Vitamin C)	Ascorbic acid is an antioxidant, and it is a portion of an enzyme that is required for protein metabolism. It also helps with iron absorption and is important for the health of the immune system.	Found in vegetables and fruits, especially: Kiwifruit, mangoes, papayas, lettuce, potatoes, tomatoes, peppers, strawberries, cantaloupe and so on.
Thiamine (Vitamin B_1)	Thiamine is a portion of an enzyme that is required for energy metabolism, and it is important for nerve function.	Found in moderate amounts in all nutritious foods: Nuts and seeds, legumes, whole grain/enriched cereals and breads, pork.
Riboflavin (Vitamin B_2)	Riboflavin is a portion of an enzyme that is required for energy metabolism. It is also important for skin health and normal vision.	Enriched, wholegrain cereals and breads, leafy green vegetables, milk products.
Niacin (Vitamin B_3)	Niacin is a portion of an enzyme that is required for energy metabolism. It is also important for skin health as well as the digestive and nervous systems	Peanut butter, vegetables (particularly leafy green vegetables, asparagus and mushrooms), enriched or wholegrain cereals and breads, fish, poultry and meat.
Pyridoxine (Vitamin B_6)	Pyridoxine is a portion of an enzyme that is required for protein metabolism. It also helps with the production of red blood cells	Fruits, vegetables, poultry, fish, meat.
Folic Acid/ (Vitamin B_9)	Folic acid is a portion of an enzyme that is required for creating new cells and DNA.	Liver, orange juice, seeds, legumes, leafy green vege tables. It is now added to many refined grains.
Cobalamin (Vitamin B_{12})	Cobalamin is a portion of an enzyme required for the production of new cells, and it is important to the function of nerves	Milk, milk products, eggs, seafood, fish, poultry, meat. It is not present in plant foods.

Vitamins are vital organic nutrients in our meal that are valuable for various metabolic activities, improvement of immune system efficacy as well as disease prevention. Vitamin deficiency can impair immune response in human system. Thereby increases the morbidity, malnutrition, and mortality in our society due to specific ailments. Vitamins A, C, and E plays major role in enhancing the skin epithelium barrier function. With the exception of vitamin C, all vitamins are essential for antibody production [7]. Vitamins are also important for developing innate immunity and adaptive immunity in the body, thereby promoting health [8]. Complementary to this, the intake of some essential vitamins especially from *Aframomum melegueta* herbal remedy can help to support the cognitive power of the body to enhance health safety [9].

Vitamin A is essential for maintaining and recovery of epithelial structures at the skin, urinary tract and lungs epithelium. Similarly, it improves intestinal integrity among children suffering from severe infections or malnutrition. According to Villamor and Fawzi [10], vitamin A supplements can correct deficiency in malnourished HIV-infected individuals. In HIV-infected children, the administration of vitamin A supplements help to reduce some associated symptoms, such as cough, diarrhoea, pneumonia and other factors that leads to mortality [11].

Vitamin D compounds are another valuable source of vitamins that can be catabolized via 24-hydroxylation by CYP24, whose expression is strongly inducible by 1,25D, which constitutes a negative feedback loop [12]. Renal 1-hydroxylation is tightly controlled by calcium homeostatic signals, particularly circulating parathyroid hormone (PTH). Although initially characterized as a calcium homeostatic agent, vitamin D is now known to have pleiotropic actions, including its key role in immune system regulation [13].

Vitamin B_6 is prominent among the B complex vitamins. It actually acts as co-factor for certain enzymes for cellular activities [14]. Vitamin B_6contains 3 pyridine derivatives and helps control levels of homocysteine in the blood. Homocysteine is a common amino acid [15]. Higher level of homocysteine (hyper-homo-systeinaemia) is associated with heart diseases like Acute Coronary Syndrome (ACS) and cardiovascular death, collectively called athero-thrombosis [16]. The body needs Vitamin B_6 in order to absorb vitamin B_{12} and to make red blood cells and cells of the immune system. Study of Kunisawa and Kiyono [17] shows that vitamin B_6 helps to improve immune response to the increase in production of antibodies and also helps in communicative interactions between cytokines and chemokines.

Vitamin B_9 or Folic acid (folate) also plays a role in immunity enhancement. This is intensified in the study of Stover [18] which shows its role in the biosynthesis of nucleic acids, proteins, blood cells and nervous tissues. Food that served as rich sources of folic acid include, medicinal plants like *Aframomum melegueta*, dark leafy vegetables, whole grains, beans, orange juice, citrus fruits, cantaloupes, asparagus, milk, salmon and tuna etc. Folic acid is very important for proper brain function as well as mental and emotional health. Its deficiency in central nervous tissue may lead to depression, insomnia, fatigue, anxiety and related symptoms [19].

Vitamin E molecules produced in plants like *Aframomum melegueta* are valuable for human healthy living. There are approximately eight (8) different kinds of molecules that are obtained from plant sources which are vital for human body activities [20]. This includes the concentrate containing antioxidant molecules referred to as the 'inhibitols' because it resembled inhibitols obtained from different plant sources like *Aframomum melegueta* as described by Niki and Traber [20]. This study therefore elucidates the richness of *Aframomum melegueta* and its medicinal value for use as potential immune booster especially during the outbreaks of diseases including viral infections responsible for outbreak of pandemic diseases worldwide.

2. MATERIALS AND METHODS

2.1 Preparation of *Aframomum melegueta* Plant Extracts (Ultraviolet Visible Spectrophotometer)

Different parts of *Aframomum melegueta,* including dried and pulverized stem, leaf sheath, Fruit pulp (mesocarp) and seed (200 g each) were extracted by cold maceration method for 48 hours at room temperature in a Winchester bottle. The *Aframomum melegueta* extract was filtered with Whitman No. 1 filter paper. The filtrate was concentrated *in–vacuo* using vacuum rotary evaporator at 40°C and was later concentrated to dryness in a hot-air oven at 40°C. The extract was stored in a refrigerator at 4°C throughout the duration of this study.

2.2 Determination of Vitamin A from Plant Sample

A weighed quantity of sample that contain 1 g fat was mixed with at least 240 unit of vitamin A. 30ml absolute alcohol and 3 ml of 5% potassium hydroxide was added and boil gently under reflux for 30min in a stream of oxygen free nitrogen. It was cooled rapidly and 30 ml water added. This was transferred to separator, washed with 3x50 ml ether. The vitamin A was extracted by shaking for 1 min. After complete separation, the lower layer was discarded. The extract was washed with 4x50 ml water by mixing and cautiously during the first two washes to avoid emulsion formation. The washed extract was evaporated down to about 5ml and remaining ether was removed in a stream of nitrogen at room temperature. The residue was then dissolved in sufficient isopropyl alcohol to give a solution containing 9-15 units per ml and measure the extinctions at 300 nm, 310 nm, 325 nm and 334 nm as well as wavelength of maximum absorption [21,22].

2.3 Determination of Vitamin E from Plant Sample

1.0 g of the test sample was weighed in 100 ml flask fitted with a reflux condenser and then 10

ml of absolute alcohol and 20 ml of 1M alcoholic sulphuric acid was added. It was refluxed for 45 mins and cooled. 50 ml water was added; transferred to a separating funnel of low actinic glass with the addition of a further 50 ml of water. The unsaponifiable matter was extracted with 5x30 ml diethyl ether. Combined ether extract was washed free from acid and dried over anhydrous sodium sulphate. The extracts evaporated at low temperature. It was protected from sunlight and the residue dissolved in 10 ml absolute alcohol. Then both the standard and the sample was transferred to a 20 ml volumetric flask and 5 ml of absolute alcohol was added followed by 1 ml conc. nitric acid. The flask was placed on a water bath at 90°C for 3 min. cooled under running water and made up the volume to 20 ml with absolute alcohol. The absorbance was measured at 470 nm against blank containing absolute alcohol [21,22].

2.4 Determination of Vitamin D from Plant Sample

Vitamin D content was determined by mixing the carr-price reagent (20% m/v of antimony trichloride in chloroform with 40% pure acetylchloride) freshly prepare and free from alcohol. 9 ml of the carr-price was added to 1 ml sample extracted with chloroform and the extinction was measured at 500 nm against reagent blank. The concentration was extrapolated from standard curve graph using vitamin D standard [22].

2.5 Determination of Vitamin B_3 (Niacin) from Plant Sample

5 g of the sample was treated with 50 ml 1N H_2SO_4 and shaken for 30 min. 3 drops of ammonia solution were added to the sample and filtered. The filtrate was pipetted into a 50 ml volumetric flask and 5 ml of potassium cyanide was added. This was acidified with 5 ml of 0.02 N H_2SO_4 and absorbance was measure using spectrophotometer at 470 nm [23].

2.6 Determination of vitamin B_1 (Thiamin) from Plant Sample

5 g of the sample was homogenized with 50 ml ethanoic sodium hydroxide. It was filtered into a 100 ml conical flask, 10 ml of the filtrate was pipetted and the colour was developed by addition of 10 ml of 1% potassium dichromate and the absorbance was read at 360 nm. A blank solution is also prepared [23].

2.7 Determination of Vitamin B_2 (Riboflavin) from Plant Sample

5 g of the sample was extracted with 100 ml of 50% ethanol and shaken for one hour. This was filtered into 100 ml flask 10 ml of the extract was pipette into 50 ml volumetric flask. 10 ml of 5% potassium permanganate and 10 ml of 30% H_2O_2 was added and allowed to stand over a hot water bath for 30 min. 2 ml of 40% sodium sulphate was added. This was made up to 50ml mark and the absorbance measured at 510 nm using spectrophotometer [23].

2.8 Determination of Vitamin B_6 (Pyridoxine Hydrochloride) from Plant Sample

0.5 ml of the sample was pipetted into test tube. Then 1.5 ml of diazotized p-nitroaniline (5 mM) reagent solution and 3 ml of CTAB were added. The mixture was shaken, then 3 ml of (0.1 N) sodium carbonate solution was added and the volumes were made up to the mark with 5 ml distilled water. The mixtures were shaken and the absorbance was measured at 480 nm against the corresponding reagent blank [24].

2.9 Determination of Folic Acid from Plant Sample

1.0 ml of the standard or sample solution of folic acid was mixed with 1.0 ml of 4 mol l-hydrochloric acid, 1.0 ml of 1% (w/v) sodium nitrite, 1.0 ml of 1% (w/v) sulfamic acid and 1.0 ml of 1% (w/v) *3*-aminophenol which was the resulting orange-yellow complex. The absorption of complex was measured at 460 nm using UV-Visible spectrophotometer. This methodology is in accordance to analysis of folic acid [24].

2.10 Determination of Vitamin B_{12} from Plant Sample

50 mg of the sample was weighed and 10 ml of the extraction buffer was added with vortex mixing. After standing for 30 min, the samples were autoclaved at 121°C for 25 min at 15 psi and then cooled to ambient temperature in a water bath. Extracts were transferred quantitatively to a 25 mL graduated test tube and diluted to volume with extraction buffer. 50 microliter of the reagent and immobilize solution was added to 200 microlitter of the extract. After 1 hr 100 microliter of HBS-EP buffer and Cbl-binding-protein, and regeneration solutions were

added and the absorbance was read at 480 nm [24].

3. RESULTS

This study shows the richness and the potentiality of *Aframomum melegueta* as a source of vitamins as immune boosters. Result in Table 1 shows the concentration of Vitamin in *Aframomum melegueta* [Roscoe], that is, Vitamin C, A, B, A, E, D and K. Fig. 1 to Fig. 11 shows the quantity of each Vitamin in *Aframomum melegueta* ranging from A to K.

The *Aframomum melegueta* displayed a rich array of Vitamins. The seeds had the highest concentration of Vitamins compared to the Fruit pulp (Mesocarp), Leaf sheath and Stem extracts (Table 1). Values obtained for Seed and Stem extracts respectively are, Vitamin C (16.8 mg/g, 5.85 mg/g), Vitamin B (1.15 mg/g, 0.41 mg/g), Vitamin B3 (0.98 mg/g, 0.30 mg/g), Vitamin E (0.75 mg/g, 0.11 mg/g), Vitamin B6 (0.03 mg/g, 0.006 mg/g), Vitamin B12 (4.22 mg/g, 0.50 mg/g), Vitamin A (1024.1 mg/g, 189.9 mg/g), Vitamin E (0.75 mg/g, 0.11 mg/g, Vitamin D (0.68 mg/g, 0.03 mg/g) and Vitamin K (0.017 mg/g, 0.007 mg/g).

In Fig. 1, the overall graphical representation of Vitamin content in *Aframomum melegueta* [Roscoe], was determined. Fig. 2 shows the quantity of Vitamin C present in *Aframomum melegueta.* It was observed that the seed extract has the highest quantity of 16.8 mg/g while Stem has the lowest quantity of 5.85 mg/g in *Aframomum melegueta*. Fruitpulp (mesocarp) (13.56 mg/g) and Leaf sheath (13.06 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem. (Seed < Fruit pulp (mesocarp)< Leaf sheath < Stem).

Fig. 3 shows the quantity of Vitamin B_1 present in *Aframomum melegueta,* it was observed that the Seed extract has the highest quantity of 1.15 mg/g while Stem has the lowest quantity of 0.41 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (0.93 mg/g) and Leaf sheath (0.41 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp <Leaf Sheath < Stem).

Fig. 4 shows the quantity of Vitamin B_3 present in *Aframomum melegueta,* it was observed that the seed extract has the highest quantity of 0.98 mg/g while Stem has the lowest quantity of 0.30 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (0.77 mg/g) and Leaf sheath (0.48 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp) <Leaf Sheath < Stem).

Fig. 5 shows the quantity of Vitamin B_1 present in *Aframomum melegueta,* it was observed that the Seed extract has the highest quantity of 0.75 mg/g while Stem has the lowest quantity of 0.11 mg/g in *Aframomum melegueta*. Fruitpulp (mesocarp) (0.28 mg/g) and Leaf sheath (0.21 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp)<Leaf sheath< Stem). While in Fig. 6 the quantity of Vitamin B_6 present in *Aframomum melegueta,* it was observed that the Seed extract has the highest quantity of 0.03 mg/g while Stem has the lowest quantity of 0.006 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (0.02 mg/g) and Leaf sheath (0.01 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp) <Leaf sheath < Stem).

Fig. 7 shows the quantity of Vitamin B_{12} present in *Aframomum melegueta*, it was observed that the Seed extract has the highest quantity of 4.22 mg/g while Stem has the lowest quantity of 0.50 mg/g in *Aframomum melegueta*. Fruit pulp (meso carp) (1.04 mg/g) and Leaf Sheath

Table 1. Concentration of vitamin in *Aframomum melegueta* [Roscoe]

***Aframomum melegueta* [Roscoe]**	**Vit.C mg/g**	**Vit.B_1 mg/g**	**Vit.B_2 mg/g**	**Vit.B_3 mg/g**	**Vit.B_6 mg/g**	**Vit.B_{12} mg/g**	**Vit.A mg/g**	**Vit. E mg/g**	**Vit. D mg/g**	**Vit.K mg/g**
Seed	16.83	0.87	1.15	0.98	0.03	4.22	1024.1	0.75	0.68	0.02
Fruit pulp (Mesocarp),	13.56	0.77	0.93	0.77	0.02	1.04	717.8	0.28	0.21	0.01
Leaf sheath	13.06	0.76	0.76	0.48	0.01	0.79	519.4	0.21	0.13	0.01
Stem	5.85	0.54	0.41	0.30	0.01	0.50	189.9	0.11	0.03	0.01

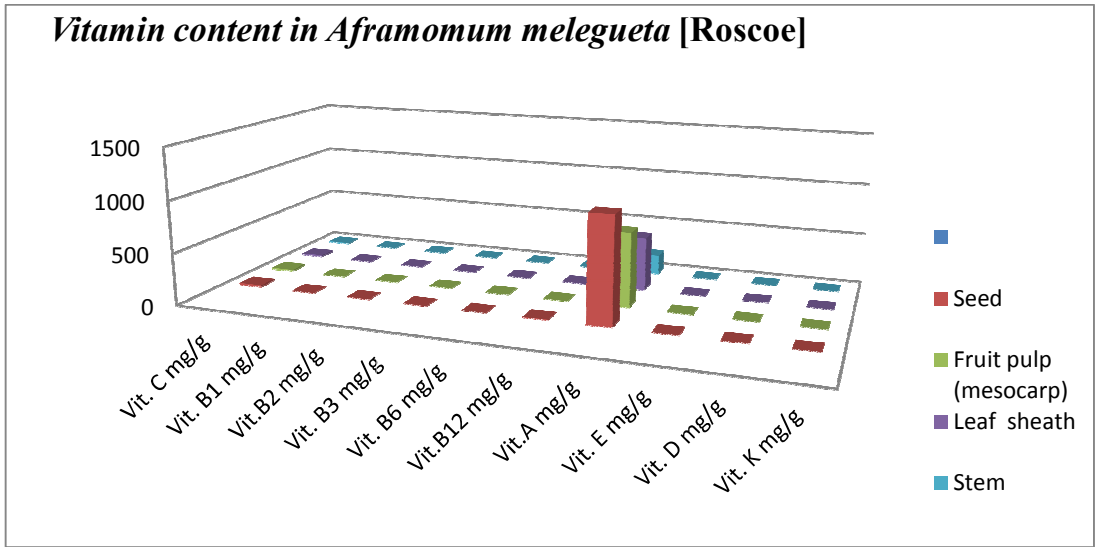

Fig. 1. Overall graphical representation of Vitamin content in *Aframomum melegueta* [Roscoe]

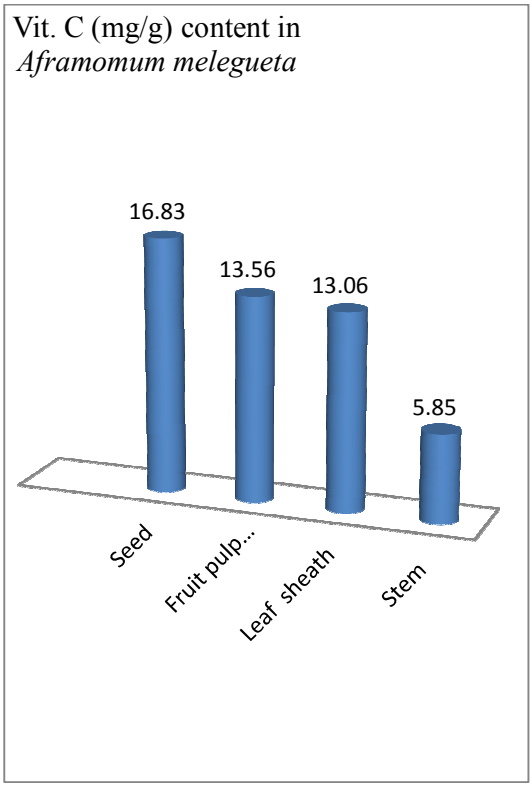

Fig. 2. Vitamin C content in *Aframomum meleguata*

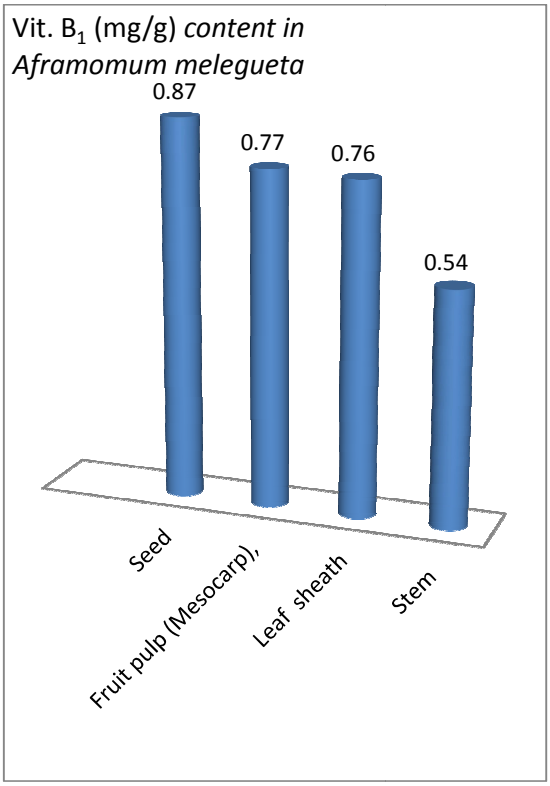

Fig. 3. Vitamin B_1 content in *Aframomum meleguata*

(0.79 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp)<Leaf sheath < Stem).

Fig. 8 shows the quantity of Vitamin A present in *Aframomum melegueta*, it was observed that the Seed extract has the highest quantity of 1024.1 mg/g while Stem has the lowest quantity of

189.9 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (717.8 mg/g) and Leaf sheath (519.4 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (Mesocarp) <Leaf sheath < Stem).

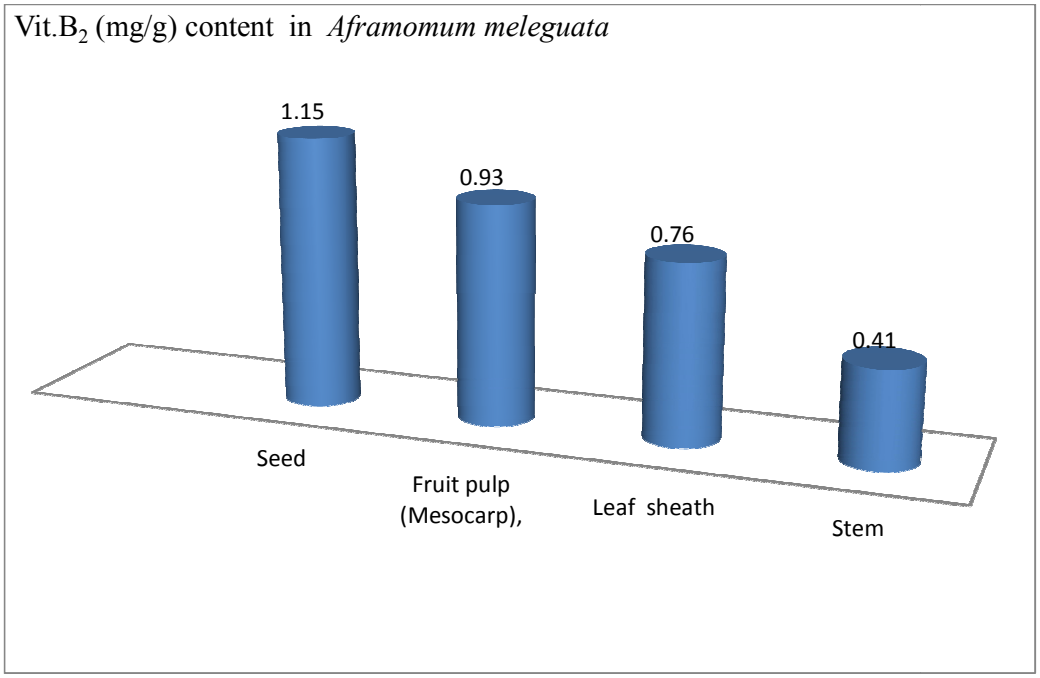

Fig. 4. Vitamin B_2 content in *Aframomum meleguata*

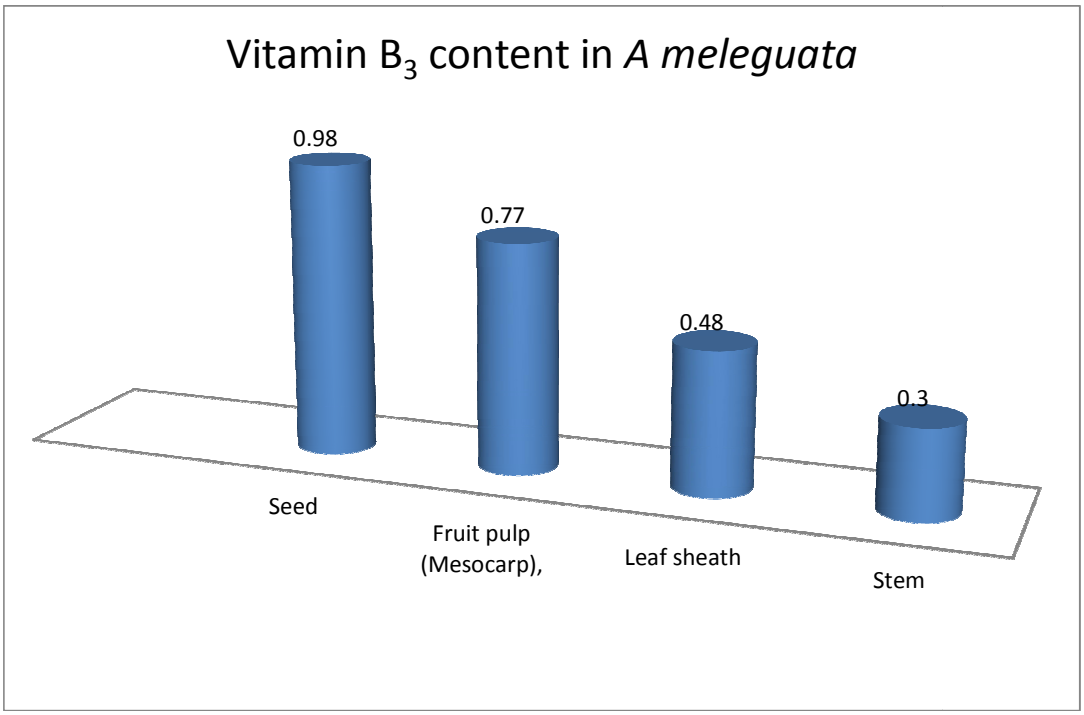

Fig. 5. Vitamin B_3 content in *Aframomum meleguata*

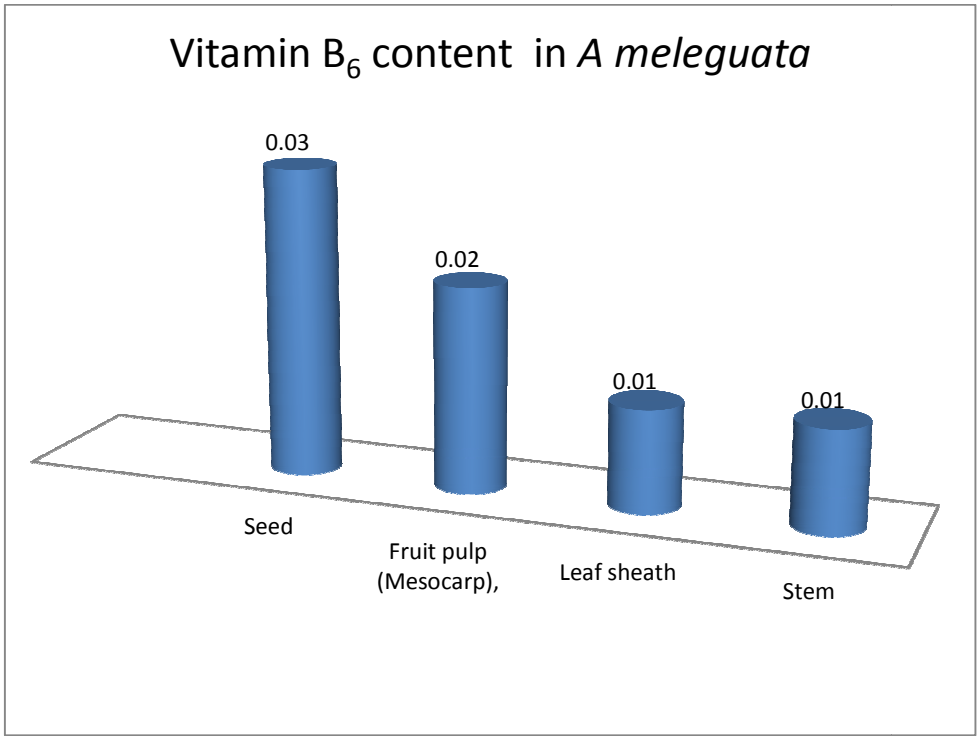

Fig. 6. Vitamin B_6 content in *Aframomum meleguata*

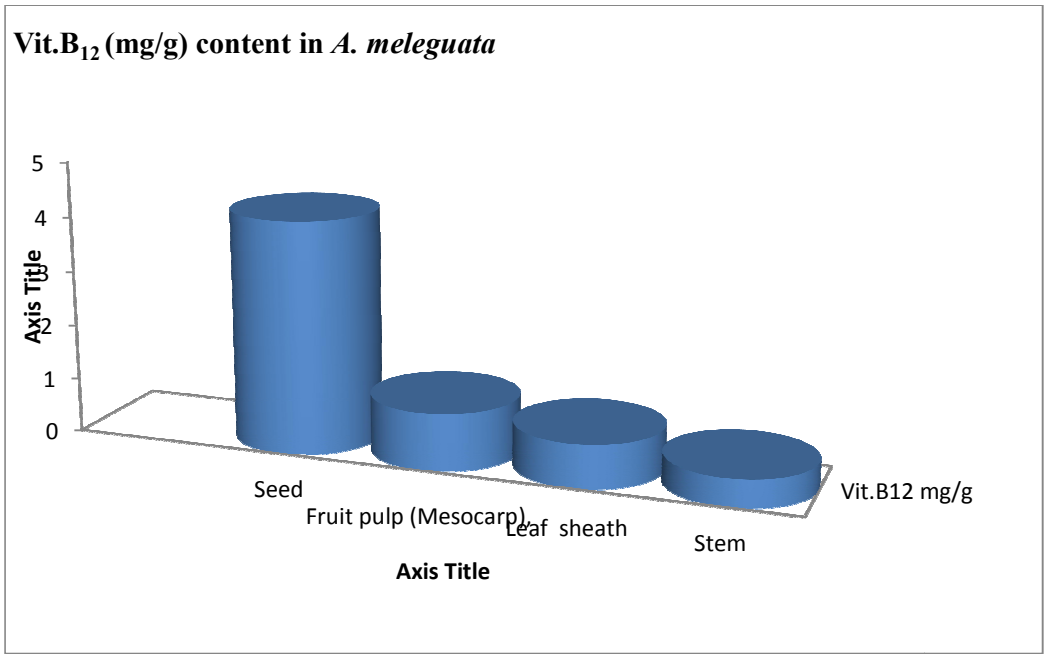

Fig. 7. Vitamin B_{12} content in *Aframomum meleguata*

Fig. 9 shows the quantity of Vitamin E present in *Aframomum melegueta*, it was observed that the seed extract has the highest quantity of 0.75 mg/g while Stem has the lowest quantity of 0.11 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (0.28 mg/g) and Leaf sheath (0.21

mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp) <Leaf sheath < Stem).

Fig. 10 shows the quantity of Vitamin D present in *Aframomum melegueta,* it was observed that the seed extract has the highest quantity of 0.68 mg/g while Stem has the lowest quantity of 0.03 mg/g in *Aframomum melegueta*. Seed (0.21 mg/g) and Leaf sheath (0.13 mg/g) respectively. All extracts part shows different concentration in decreasing order from seed to Stem (Seed < Fruit pulp (mesocarp)< Leaf sheath < Stem).

Fig. 11 shows the quantity of Vitamin K present in *Aframomum melegueta*, it was observed that the seed extract has the highest quantity of 0.017 mg/g while Stem has the lowest quantity of 0.007 mg/g in *Aframomum melegueta*. Fruit pulp (mesocarp) (0.01 mg/g) and Leaf sheath (0.009 mg/g) respectively. All extracts part shows different concentration in decreasing order from Seed to Stem (Seed < Fruit pulp (mesocarp <Leaf sheath < Stem).

4. DISCUSSION

This study shows richness and potential of *Aframomum melegueta* as an immune booster for health protection especially during the outbreaks of diseases including pandemics being experienced worldwide. The result in Table 1 shows the concentration of Vitamin from different parts of *Aframomum melegueta* extract. Vitamin A occurs naturally in *Aframomum melegueta* extracts.

This is consistent with the study of Tanumihardjo [25] who demonstrated the factors influencing the conversion of carotenoids to retinol. β-carotenes which functions as an antioxidant and retinol (a precursor of vitamin A) are the major precursors of vitamin A [25,26]. This vitamin is vital for some body functions, such as eye sight, reproduction, blood cells formation and it also improves body's immune response as well as growth [27].

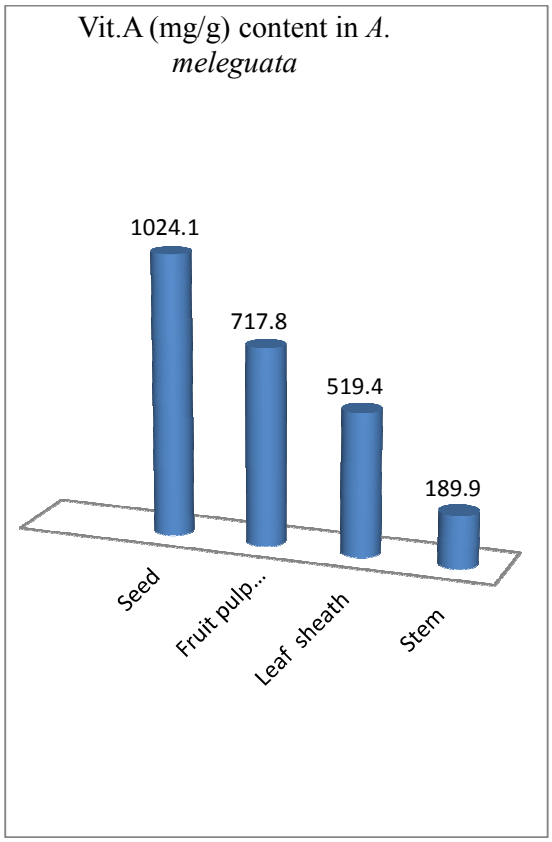

Fig. 8. Vitamin A content in *Aframomum meleguata*

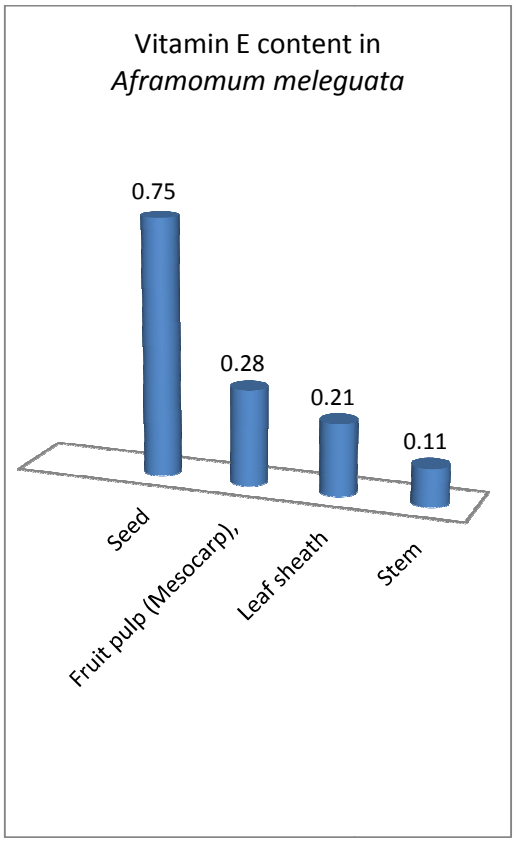

Fig. 9. Vitamin E content in *Aframomum meleguata*

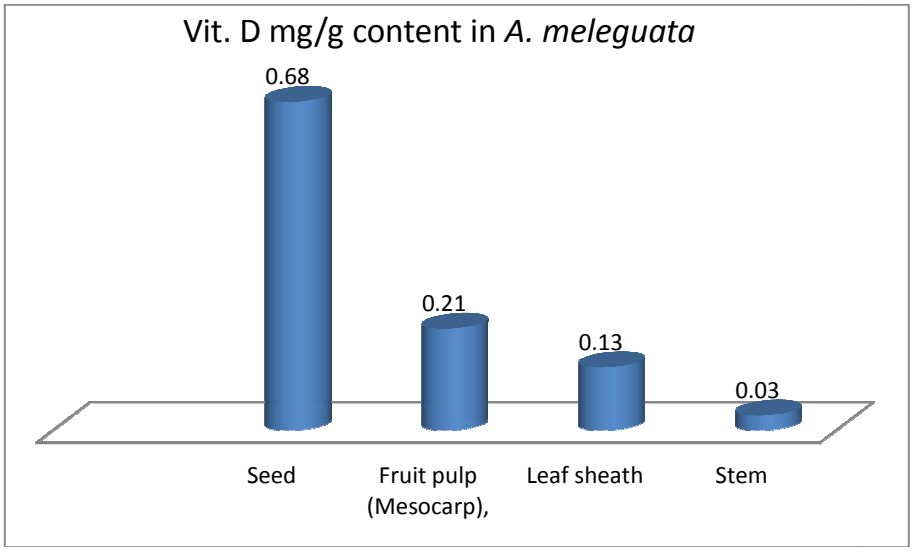

Fig. 10. Vitamin D content in *Aframomum meleguata*

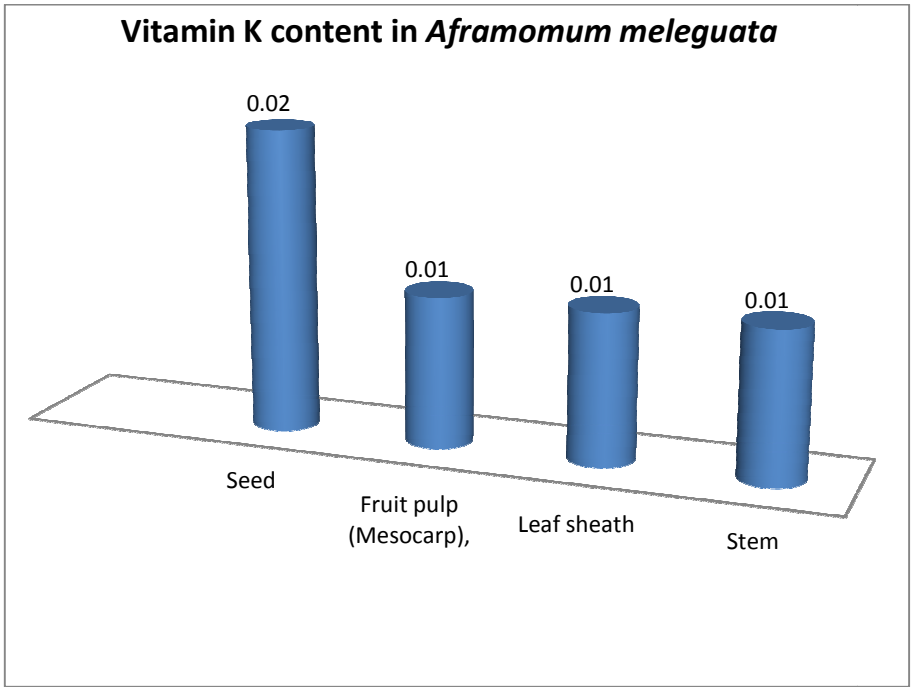

Fig. 11. Vitamin K content in *Aframomum meleguata*

It has also been known that vitamin A derivative called retinoic acid also plays an important role of allowing the proper migration of T-cells to the site of inflammation or infection in the gut [8].

Vitamin A is a fat soluble vitamin and essential nutrient that exists in several forms both in animal foods (as retinol, retinal or retinoic acid) and plant like *Aframomum melegueta* extracts (as carotenoids) [28,29] that was determined in this study. The body's first line of defence against infection is provided by the skin and mucosa, the integrity of which is maintained by vitamin A which are abundant in *Aframomum melegueta* extracts [30]. This also stresses the importance of micronutrient supplements for improving immune function in order to prevent viral disease progression.

Vitamin D was abundantly detected in *Aframomum melegueta* extracts. This is vital for many biological processes as reported in previous studies [31-35]. Vitamin D_2 and D_3, can be derived from irradiation of the steroid ergosterol in yeast. Biologically active vitamin D can also be generated via largely hepatic 25-hydroxylation catalyzed by CYP2R1, CYP27A1, and possibly other enzymes to produce 25-hydroxvitamin D (25D) [33-36], which has a long half-life and is the major circulating vitamin D metabolite. 25D is modified by -hydroxylation catalyzed by CYP27B1, which produces hormonal 1,25-dihydroxyvitamin D (1,25D) [34,35].

Vitamin B_6 and Vitamin E also recovered in substantive amount from the plant source studied helps the body to make several neuro transmitters like serotonin, chemicals that carry signals from one nerve cell to another as well as antioxidant respectively. The term “vitamin E” describes eight different compounds. Alpha-tocopherol is the most active one in humans [34]. Serotonin is only synthesized by the tryptophan and this conversion of tryptophan to serotonin occurs in the presence of pyridoxal phosphate which is a vitamin B6 derivative [36].

Vitamin B_6helps the body to function normally. It is also needed for normal brain development and function and aid the body to make nor-epinephrine, which influences the mood, and melatonin, that helps in regulating the body clock. Deficiency of vitamin B6 can lead to muscle weakness, nervousness, depression, irritability, difficulty concentrating and sometimes short-term memory loss. Based on this and other advantages, native hunters make good use *Aframomum melegueta* during hunting expedition. It aids them to be attentive and focused.

Folic acid which is also known as cobalamins because they contain cobalt [19] is another vital nutrient component determined in this study. Normally, 2.4-2.6 mcg for pregnant women and 2.8 mcg/day intake of vitamin B_{12} for lactating women is recommended. It aids in the metabolism of every cell of the human body, especially DNA synthesis, fatty acid, and amino acid metabolism. It is also involved in B-cell synthesis and T-cell multiplication [36]. According to Vellema [37], animal models devoid of vitamin B_{12} in their diets, as a result, deficiency of B_{12} experience immune response reduction during viral and bacterial infections. This experimentation shows the importance of vitamin B_{12} in boosting body’s immunity. Vitamin B_{12} cannot be synthesized naturally in humans and plants. Only bacteria have the enzymes needed for B_{12} synthesis. Food sources of vitamin B_{12} are animal products that include *Aframomum melegueta* meat, fish, poultry and dairy products.

Substantive amount of Vitamin C detected in *Aframomum melegueta* is significant health-wise. Vitamin C concentrates acts as antioxidant and helps to boost the immune system for diseases control [38]. Deficiency of ascorbic acid in the body leads to suppressed immune response, susceptibility to infections, weak collagen formation and in case of an injury wound healing process gets delayed [39]. *Aframomum melegueta* may be a good antimicrobial source for therapeutic intervention of diseases epidemics and even pandemic if properly managed [10,40].

Vitamin C boosts up human immunity towards infections and cold illnesses by increasing phagocytosis, lymphocyte proliferation and neutrophil chemotaxis against exogenous pathogens. It neutralizes reactive oxygen species (ROS) formed in immune cells. Without vitamin C, reactive oxygen species couldn’t have been removed from immune cells which would lead to the destruction of immune cells, these reactive oxygen species are necessary to kill foreign invaders but they may also damage the cell itself if not taken care of at the meantime. This essential role is played by antioxidants like vitamin C [7].

Vitamin D is another good component of *Aframomum meleguata*. It strengthens bone and is also best known for its activity in the expression of those genes that produce proteins which are toxic to a number of foreign microbes. According to Mora [41], vitamin D receptors (VDRs) are present in the monocytes, macrophages and thymus tissues which indicate their role in immunoregulation. They can regulate the immune response as well and can also modulate the innate and adaptive immunity of the human body [42]. The body defensive mechanism switch into action when there is conversion of vitamin D, synthesized in the skin cells by the absorption of ultraviolet rays from sunlight, to vitamin D_2 (25- hydroxyvitamin). This takes place inside the liver cells as a result of the action of certain enzymes, such as, CYP27A1 in mitochondria and another is the microsomal enzyme CYP2R1 [43]. The vitamin also enhances the regulation of T-lymphocytes lipo-

polysaccharide surface receptors and also down regulates expression of immunoglobulin E (IgE) initiated by vitamin A [44,45]. Standard daily recommended intakes for each vitamin are Vitamin C -75mg, $B_{2, 3, 6}$ and B_{12} ranges from 2mg to 18mg, A -600 µg, E -10mg, D -5 µg, and K -80 µg [46,47].

5. CONCLUSION

The study shows the richness of *Aframomum melegueta* and suggests its medicinal value as a recognized immune booster especially during the outbreaks of diseases such as COVID-19, Ebola, Lassa fever and other infectious diseases, when the seeds are consumed directly as part of the regular diet and as herbal infusions obtained from the leaves and stems. Its uniqueness and versatility as a medicinal plant should be encouraged for herbal use as well as synthetic drug intervention for the treatment of infectious diseases. *Aframomum melegueta* extracts is indeed a very rich medicinal plant that can be used to boost the immune system as intensified in this study. No wonder our fore fathers used it as a remedy cure of infectious diseases. Direct consumption of the seeds or as part of regular diet, possibly in powdered form and herbal infusions obtained from the leaves and stems will be of benefit in the management of diseases. In this regard, the plant extract source can also be used as supplement for some pharmaceutical products for therapeutic purposes.

FUNDING

This work was supported by TETFUND Institution Based Research, Nigeria.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to TETFUND Institution Based Research, Nigeria for sponsoring this research work and all the technical staff of the laboratory unit of the Department of Microbiology, Faculty of Science, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria, Obafemi Awolowo University, Ile Ife, Osun State, Nigeria and Federal University of technology Akure (FUTA), Ondo State Nigeria, for their technical support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59517