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Comparative Nutritional Assessment and Antioxidant Efficacy of Tamarindus indica L. Fruit Pulp and Seed

Monday Ogacheko Abubakar[1*], Ali Agaka Aremu[1], Joseph Isah Ruth[1], Saidu Adamu[1]

[1]*Federal university of technology, Owerri, Imo State, Nigeria.*

[*]*Corresponding author, ogacheko.monday@futo.edu.ng,*

https://orcid.org/0000-0003-0234-1063, https://orcid.org/0000-0002-4091-0469

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Abstract

Tamarindus indica L. is a tropical fruit with underexplored differences in bioactivity between its pulp and seed. This study compares the proximate composition, mineral content, amino acid profile, and antioxidant activity of T. indica pulp and seed extracts. Proximate analysis followed AOAC (2015) methods. Mineral content was quantified via flame photometry and atomic absorption spectroscopy. Amino acids were analyzed using Technicon Sequential Multi-Sample Analyzer (TSM). Antioxidant activity was assessed via DPPH assay. Results: Seeds exhibited higher carbohydrate (91.44% vs. 68.45%) and energy content (4030.10 vs. 2100.5 kJ/100g), while pulp was richer in crude fiber (5.00% vs. 0.62%) and vitamin C (43.90 vs. 39.70 mg/100g). Potassium (289.5 mg/100g) and magnesium (58.22 mg/100g) were predominant in seeds. Seventeen amino acids were identified, with seeds showing higher phenylalanine (4.95 g/100g) and leucine (5.01 g/100g). DPPH assays revealed concentration-dependent antioxidant activity, with pulp IC50 = 54.70 µg/mL and seed IC50 = 68.21 µg/mL. T. indica seeds are a superior energy source, while pulp offers higher fiber and antioxidants, supporting their dual use in functional foods.

Keywords: Tamarindus indica, proximate analysis, mineral content, amino acids, DPPH assay, nutraceuticals

1.0 Introduction

Wild plants play crucial roles in the diet of people in low income part of the world [1]. Its fruits are important to local diets and are a food source majorly in every part of the world that provide support to the global food basket [2]. Diet and lifestyle have a direct impact on the health of an individual and can aid to heal diseases mainly due to metabolic conditions. Frequent changes in diet and lifestyles that have occurred with, urbanization, Industrialization and economic development have increased over the past, which brought considerable alterations in general health of the masses [3]. The balance between energy consumption and energy expenditure has been brought under close monitoring and ever-evolving suggestions for good health. According to new American Heart Association diet and lifestyle recommendations, a healthy diet and lifestyle are key weapons in the fight to prevent heart related disease[4].

Tamarindus indica is a leguminous tree belonging to the family Fabaceae common to tropical Africa. It is well known for its delicious fruit. The edible portion of the fruit is, sticky, brown and sour in taste distinguished with a unique flavour that is used in a variety of dishes and drinks[5]. The usefulness of the tamarind tree does not end with its fruits. The tamarind tree is widely distributed or more appreciated as an ornamental plant in the tropics. It is sometimes compared to coconut as another "tree life", it is widely adaptable and easily managed. It produces many-valued foods, medicine, wood and construction products [6]. The tree is drought resistant, strong and performs well as windbreak. It also prevents soil erosion, protects people`s homes crops and animal in harsh environments and also plays crucial beautification role in thousands of parks[5]. Traditionally, the fruit's pulp is used as a flavoring agent, while its seeds often discarded as agro-waste made up 25–40% of the fruit's weight, this represent unused resource for sustainable food systems[7]. The shift from traditional plant-based diets to calorie-dense, processed foods has intensified undernourishment and oxidative stress-related diseases such as diabetes and cardiovascular disorders in developing nations[9]. *T. indica* are rich in polyphenols, vitamins, and minerals, offering a cost-effective way to manage micronutrient deficiencies[10]. Recent research point out their importance in modulating gut microbiota and reducing inflammation, conforming with the "food-as-medicine" paradigm[11].

Tamarind pulp's tartaric acid and laxative properties are well documented. The seed's nutritional profile remains underexplored. Comparative analyses of pulp and seed bioactivity are scarce, despite evidence that seed extracts exhibit higher antioxidant capacity. Furthermore, existing studies often overlook the amino acid composition, which is critical for assessing protein quality in plant-based diets[12].

This work validates traditional uses and guides industrial applications, such as seed flour fortification in baked goods or pulp extracts as natural preservatives.

This study addresses these gaps by:

- Comparative profiling: Proximate, mineral, and amino acid analyses of pulp and seeds.
- Antioxidant kinetics: DPPH assays to quantify scavenging activity.

1.1 Antioxidants

Antioxidants are molecules that can neutralize free radicals by accepting or donating electron(s) to eliminate the unpaired conditions of the radical. The antioxidant molecules can directly react with the reactive radicals and destroy them, while they become new free radicals which are less active, longer lived and less dangerous than those radicals they have neutralized. They may be neutralized by other antioxidants or other mechanisms to terminate their radical status[13].

Oxidation is the transfer of electrons from one atom to another and represents an essential part of aerobic life. Oxygen is the ultimate electro acceptor in the electron flow system that produces energy in the form of Adenosine triphosphate. However, problems may arise when the electron flow becomes uncoupled (transfer of unpaired single electrons), generating free radicals [14].

Free radicals are a biological response to environmental toxins, such as cigarette smoke, chemical, sunlight, cosmic and man-made radiation, and even a key feature of pharmaceutical drugs. Free radicals are also produced when you have inflammation in your body and when you exercise [15].

Antioxidant mechanisms of action include:

Preventive: being the first line of defense, preventing reactions of free radicals and their derivatives with biological substances in the body.

Repairing: Involving interruption into a radical oxidation reaction.

Inactivating: the products of free radical reaction and their derivatives, by repairing or eliminating structural damage[16].

Antioxidants can be categorized based on their sources. Endogenous antioxidants are products of the body's metabolism. Dietary antioxidants are present in significant amounts in commonly consumed fruits, vegetables, beverages, nuts and cereal products, they are known as the exogenous antioxidants[17]. Dietary antioxidants can delay the process of aging and may also mitigate complications of diabetes and cardiovascular diseases e.g. polyphenols[18].

1.1.1 Enzymatic and non-enzymatic antioxidants

1.1.1.1 Enzymatic antioxidants

The important parts of the enzymatic antioxidant defense system include superoxide dismutase (SOD), an enzyme that scavenges superoxide ions and converts them to molecular oxygen and hydrogen peroxide; catalase (CAT), this breakdown hydrogen peroxide; glutathione peroxidase (GPx), which decomposes hydrogen peroxide to water and oxygen; glutathione reductase (GR), which is primarily responsible for maintaining adequate levels of reduced glutathione and thioredoxin reductase (TrxR, TR), an enzyme that carryout similar actions to glutathione reductase[19]. Superoxide dismutase (SOD) catalyzes the dismutation of $O_2^{\cdot-}$ to O_2 with remarkably high reaction rates by successive oxidation and reduction of the transition metal ion and to the less reactive species H_2O_2 [20].

Catalase is an enzyme present in the cells of plants, animals and aerobic bacteria. Catalase is in a cell organelle called peroxisome. The enzyme very efficiently promotes the conversion of hydrogen peroxide to water and molecular oxygen [20]

1.1.2 Non-enzymatic

Non-enzymatic antioxidants are the second line of defense against ROS. They are represented by molecules characterized by the ability to rapidly inactivate radicals and oxidants. They work by interrupting free radical chain reactions. Few examples of the non-enzymatic antioxidants are vitamins, plant polyphenol, carotenoids and glutathione [13].

Vitamin E: (α-tocopherol), is an efficient lipid soluble antioxidant and functions as a 'chain breaker' during lipid peroxidation in cell membranes and various lipid particles including low density lipoprotein (LDL). It functions to intercept lipid peroxyl radicals ($LOO^{\cdot}$) and to terminate the lipid peroxidation chain reactions. The resultant tocopheroxyl radical is relatively stable and in normal circumstances, insufficiently reactive to initiate lipid peroxidation itself, which is an essential criterion of a good antioxidant. It should be noted that, vitamin E exerts antioxidant effects by scavenging lipid peroxyl radicals in vivo as well as in vitro systems. However, vitamin E is not an efficient scavenger of OH and alkoxy radicals in vivo [21].

Vitamin C (ascorbic acid) is a water-soluble free radical scavenger. Moreover, it regenerates vitamin E in cell membranes in combination with glutathione or compounds capable of donating reducing equivalents. Vitamin C changes to the absorbate radical by donating an electron to the lipid radicals to terminate the lipid peroxidation chain reaction. The pairs of ascorbate radicals react rapidly to produce one molecule of ascorbate and one molecule of dehydroascorbate. The dehydroascorbate does not have any antioxidant capacity. Hence, dehydroascorbate is converted back into the ascorbate by the addition of two electrons. The last stage of the addition of two electrons to the dehydroascorbate has been proposed to be carried out by oxidoreductase [21].

Vitamin A was first described by Monaghan Schmitt, who reported that vitamin A can protect lipids against rancidity. Several reviews have appeared to outline the structural and metabolic characteristics of vitamin A and information about its potential as antioxidants in relation to the heart diseases. Vitamin A has a vital antioxidant contribution in protecting human LDL against copper-stimulated oxidation [21]. Glutathione is the most significant n on enzymatic oxidant defense mechanism. It exists in relatively large amounts and serves to detoxify peroxides and regenerate several important antioxidants (e.g. α-tocopherol and ascorbic acid). Reduced glutathione is regenerated from its oxidized form glutathione disulphide by the action of nicotinamide adenine dinucleotide phosphate (NADPH) dependent reductase [21]

1.1.3 Based on antioxidant solubility in the water or lipids:

The antioxidants can be categorized as water-soluble and lipid soluble. The water-soluble antioxidants, for example vitamin C, are present in cellular fluids such as the cytoplasmic matrix (cytosol). They react with oxidants in the cell cytoplasm and blood plasma. The lipid-soluble antioxidants are vitamin E, carotenoids and lipoic acid, they are more predominantly located in cell membranes [13].

1.1.4 Based on the size of the antioxidant:

The small-molecule antioxidants neutralize the reactive oxygen species in a process called radical scavenging and carry them away. Examples of antioxidants in this category are vitamin C, vitamin E, carotenoids, and glutathione (GSH).

The large-molecule antioxidants for example are superoxide dismutase, catalase, and glutathione peroxide are also enzymes, while the sacrificial proteins albumin absorb ROS and prevent them from attacking other essential proteins [13].

2.0 Materials and Methods

2.1 Sample Preparation

Fresh *T. indica* fruits were collected from various locations in Ofu Local government area of Kogi State and identified by the department of biological science, Federal University of Technology, Owerri, Nigeria. Pulp and seeds were separated, sun-dried, and ground to 40-mesh particles.

2.3 Proximate Analysis

Moisture, ash, crude fiber, protein, lipid, and carbohydrate content were determined using the method of

Association of Official Analytical Chemist (AOAC) [22].

2.3.1 Determination of Moisture Content

The freshly collected sample (2 g) was weighed into a pre-weighed crucible and placed in a hot air-drying oven at 105^0C for 24 hours, after which the samples were removed and cooled in a desiccator and then weighed again. This was done using the AOAC method [22].

The weight lost was obtained by subtracting the weight of dry sample from the original weight of the sample and the moisture content calculated using equation 2.

$$(\%)\ \text{Moisture content} = \frac{\text{Loss in weight}}{\text{Sample weight}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots 1$$

2.3.2 Determination of Ash Content

The ash content was determined using the AOAC method [22]. Dried sample (2g) was weighed into a pre weighed crucible and incinerated in a muffle furnace at 550^0C for six hours. The sample was cooled in a desiccator and weighed.

The ash content was calculated using equation below.

$$(\%)\ \text{Ash} = \frac{\text{Weight of ash}}{\text{Weight of dry sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots 2$$

2.3.4 Determination of Crude Fibre

Using AOAC method, [22] crude fibre was determined. Ground sample (2 g) was weighed into 500 cm^3 conical flask, 200cm^3 of 10% H_2SO_4 was added and boiled for thirty minutes and then filtered. The residue was boiled in 200 cm^3 of 10% NaOH for 30 minutes and filtered again. The residue was dried, weighed and ashed at 600^{0C} for ninety minutes in a furnace. This was finally cooled in a desiccator and weighed.

The percentage crude fibre was calculated using equation 4.

$$(\%)\ \text{Crude fibre} = \frac{\text{Loss of weigh on ignition}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ 3$$

2.3.5 Determination of Crude Protein

The crude protein was determined using AOAC[22] method. Two grams of the dried sample were weighed into Kjeldahl digestion flask and a catalyst mixture ($NaSO_4$, $CuSO_4$ and Selenium oxide in 10:5:1 ratio) was added, followed by 10cm^3 of concentrated tetraoxosulphate (vi) acid. The flask was heated at 106°C in the digestion

block till the water was removed and frothing ceased. The heating continued for four hours until the digest became clear. After heating, the flask was cooled and diluted to 50 cm^3 with distilled water, filtered into a 100 cm^3 volumetric flask and made up to the mark with distilled water. 10 cm^3 of the aliquot was taken into the digestion flask and 20cm^3 of 45% NaOH solution was added. The content was diluted to 200cm^3 with distilled water and distilled using Micro-kjeldahl distillation apparatus. The distillate was received into receiver flask containing 10cm^3 boric acid indicator. After the distillation, the distillate was titrated with 0.01M HCl until the colour changes at the end point from green to pink. The blank was also prepared in the same manner without sample added.

The crude protein was calculated using equations below.

$$\text{Crude protein (\%)} = \frac{TV \times C \times 0.0014 \times V1}{W \times V2} \times 100 \quad \text{.....4}$$

Where,

TV = Titre value of the acid C = Concentration of acid used.

V1 = Volume of the distilled water used for diluting the digest

V2 = Volume of the aliquot used for titration

W = Weight of the sample used F = Protein multiplication factor = 0.0014

2.3.6 Determination of Crude Lipid

Ground sample (2 g) was weighed into a porous cellulose thimble whose mouth is covered with fat free absorbent cotton wool. Hexane (200 cm^3) was filled into a dried and pre-weighed 250 cm^3 round bottom flask and the covered porous thimble was placed into the extraction chamber and the soxhlet apparatus assembled. The assembled apparatus was placed on a heating mantle, fixed to a clamp on a retort stand and cooled. The extraction was carried out by heating at 60^0C for 6 hours after which the thimble was carefully removed. The receiver flask was transferred to a rotary evaporator where the hexane was removed at 40^0C. The receiver flask containing the crude lipid was oven dried at 105^0C for one hour, cooled in a desiccator and weighed. AOAC[22] method was used to determine the crude lipid.

The percentage crude lipid content was calculated using equation below.

$$\text{Percentage crude oil lipid} = \frac{\text{Weight of oil extracted}}{\text{Weight of sample}} \times 100 \quad \text{..... 5}$$

2.3.7 Determination of Carbohydrate (By Difference).

The method of [23] was used where the total amount of carbohydrate in the sample was obtained by calculation using percentage weight difference. This involved subtracting the percentage sum of the food nutrients; % crude protein, % crude lipid, % crude fibre, % moisture and % ash from 100% dry weight.

The percentage carbohydrate was calculated using equation below:
Carbohydrate (%) = 100 – (% crude protein + % crude lipid + % crude fibre + % moisture + % ash) …….. 6

2.4 Mineral Analysis

Na, K, Mg, Ca, Fe, Zn, and P were quantified via flame photometry (PFP7) and atomic absorption spectrophotometry (AAS).

Mineral content analysis was determined according to AOAC, [22]. Phosphorus was determined calorimetrically by vanadomolybdate procedure. Flame emission photometer was used to determine the concentration of sodium, magnesium, and potassium while calcium, iron, zinc, manganese, copper and lead were measured by atomic absorption spectrophotometer.

The samples (2 g) were digested with 5 cm^3 of perchloric acid ($HClO_4$) and 10 cm^3 of Nitric acid (HNO_3) in a water bath. The mixture was allowed to boil at 80^oC until it digested and became a clear solution. The mixture was cooled to room temperature, diluted with deionized distilled water and made up to the mark in a 250 cm^3 standard volumetric flask. The solution was kept in plastic container prior to Atomic Absorption spectrophotometer experiments.

Sodium and potassium were determined using standard Flame Emission Photometer Model PFP7. Standard solutions 1mg Na/100 cm^3 and 1mg K/100 cm^3 were aspirated into the instrument. The digital readout was then set to the known concentrations of the fluid being aspirated. Then the Flame Photometer was calibrated, the sample was then aspirated and the result indicating the concentration was read from the digital display.

2.5 Amino Acid Profiling

The amino acid profile was determined based on the method described by [24], using Technicon sequential multi sample amino acid analyzer (TSM). Defatted sample (2 g) was weighed into glass ampoule. 7 ml of 6 N HCl was added and oxygen expelled by passing nitrogen into the ampoule. The glass ampoule was sealed off with Bunsen burner flame and put in an oven at 105ºC ± 5ºC for 22 hours. The ampoule was cooled before being broken open at the tip and the content filtered to remove the humins. The filtrate was evaporated to dryness at 40ºC under vacuum in a rotary evaporator. The residue (hydrolysate) was dissolved with 5 ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles which were kept in the freezer. The hydrosylate was vacuum dried to remove buffer solution before loading into the TSM. Compressed nitrogen was passed into the TSM to serve as a segmented stream flow of the amino acid which helped the analyzer to detect any amino acid found without mixing up the amino acids. About 5-10 mL of the sample was dispensed into the analyzer cartridge. The TSM analyzer is designed in such a way as to separate and analyze free acid, neutral and basic amino acid of the hydrosylate. Diomax chromelon data analyzing system attached to the amino acid analyzer interpreted the data.

2.6 Antioxidant Activity

The DPPH (2,2-diphenyl-1-picrylhydrazylhydrate) assay was done according to [25]. The samples reacted with the stable DPPH radical in an ethanol solution. The reaction mixture consisted of adding 0.5 cm^3 of sample, 3 cm^3 of absolute ethanol and 0.3 cm^3 of DPPH radical solution 0.5 mM in ethanol. When DPPH reacts

with an antioxidant compound, which can donate hydrogen, it is reduced. The changes in color (from deep violet to light yellow) were read Absorbance (Abs) at 517 nm after 100 min of reaction using a UV-VIS spectrophotometer (DU 800; Beckman Coulter, Fullerton, CA, USA). The mixture of ethanol (3.3 cm^3) and (0.5 cm^3) serve as blank. The control solution was prepared by mixing ethanol (3.5 cm^3) and DPPH radical solution (0.3 cm^3).

IC50 values were calculated using GraphPad Prism while the percentage of scavenging activity (X %) was calculated according to the equation below:

$$X\ \% = 100 - \frac{[(\text{Absorbance of sample} - \text{Absorbance of blank}) \times 100]}{\text{Absorbance of control}} \quad \ldots\ldots\ldots 7$$

2.7 Statistical Analysis

The raw data obtained from this research was analyzed with the T-test tool. A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related to certain features. Data was triplicated and analyzed via t-test ($p < 0.05$) using SPSS v26.

3.0 Results and Discussion

The results for the proximate analysis of *Tamarindus indica* are presented in table 1. Elemental contents of the fruits and pulp are presented in table 2. The amino acid profile of the fruits and pulp samples are presented in table 3. The in-vitro antioxidant potentials of the fruits and pulp are shown in figure 1 while figure 2 represents the IC_{50} of DPPH scavenging effects.

3.1 Proximate parameters of *Tamarindus indica* fruit (pulp and seeds)

The proximate analysis of fruits (pulp and seeds) *Tamarinduss indica* is shown in table 1. These analyses are important for determination of food quality, microbial stability and can be used for nutritional labeling [26]. The result revealed that the ash content (3.06 ± 0.06^a) in the pulp is higher when compared to the seed (1.98 ± 0.10^b) of the fruit. These values compare with apple, watermelon and orange in the range of (2.32-.5.42%) is higher than values obtained for *Tamarindus indica.*

Crude fibre (5.00 ± 0.30^a**)** content was higher in the pulp than the seed (0.62 ± 0.01^b) of *Tamarindus indica* fruit. The crude fibre content of fruits can be increased by the dehydration of fruits, as the consumption of fruits with high crude fibre content may contribute to a reduction in the incidence of diseases like colon cancer, coronary heart diseases, diabetes, high blood pressure, obesity and other digestive disorders. Increased crude fibre consumption also increases fecal bulk and rate of intestinal transit and have prebiotic effects [27]. The values for fibre obtained in this study are within the same range reported for legumes (5-6%), papaya, apple, watermelon, orange, apricot ranging between (3.43-8.32%) but lower than that of paprika, prickly pear and guava (33.83-64.67%) [28].

The crude lipid (1.51-2.99%) content in *Tamarindus indica* is low compared with those reported for lipids in guava, prickly pear, paprika, papaya, papaya, apple, watermelon, orange, apricot fruits (16.20-54.2%) [28]. Dietary lipids are essential for the structure and biological functions of cells, examples of lipids are phospholipids and sterols [26].

Crude protein (4.42-7.59%) contents obtained for the fruits of *Tamarindus indica* were lower than those of protein rich foods such as soyabean, cowpea, pigeon pea and pumpkin with protein content ranging between 23.1% and 33.0% and those reported for papaya, apple, watermelon, prickly pear, apricot and paprika in the range of 16.60 – 33.79, orange and guava are 3.06 and 7.90% respectively [28]. Proteins are essential component of diet needed for survival of animals and human beings whose basic function is to supply adequate amounts of required amino acids for nutrition. Protein deficiency causes growth retardation, muscle wasting, odema, abnormal swelling of the belly and collection of fluids in the body [29]. The protein content of the fruits is lower than the percentage recommended by Food and Agriculture [30] which is 12-15%).

The moisture content of the pulp (16.00 ± 0.55^{a}) is higher than in seed (2.00 ± 0.05^{b}) of the fruit. High moisture content is typical of fresh fruits at maturity, this account for rapid deterioration of fruits if left unprocessed for a long time after harvesting. The moisture in fruits also provides part of the medium for normal functioning of enzymes and general metabolic processes [31]. Moisture in fruits is largely dependent on humidity, temperature and harvest time of the species. The moisture in fruits make up part of the number of daily fluid intake in adult male (2.5L) and adult female (2.0L) [32].

The percentage carbohydrate (68.45-91.44%) obtained is higher than those reported for papaya, apple, watermelon, guava, orange, pear, apricot and paprika which were in the range of (8.54-34.74%).

3.2 Elemental constituent of *Tamarindus indica* Fruit (pulp and seeds)

The content of some elements present in fruit of *Tamarindus indica* are shown in Table 2. The results indicate that potassium (289.5^{b}-233.0^{a} %), Calcium (85.0^{b}-101.2^{a} %), Magnesium (26.21^{a}-58.22^{b} %), Sodium (19.91^{b}-26.95^{a} %) and Phosphorus (7.60^{b}-24.62^{a} %) were significantly ($p< 0.05$) higher while Iron (1.95^{b}-5.02^{a} %) and Zinc (0.45^{b}-0.75^{a} %) were low in both seeds and pulp respectively. Chromium was not found in *Tamarindus indica* fruit. The result obtained for the mineral composition as presented shows that potassium is the most predominant mineral in both pulp and seeds of *Tamarindus indica.* The Na^{+}/K^{+} ratio of both samples is less than one. Thus, both samples would be suitable for reducing high blood pressure [33].

3.3 Amino Acid Profile of *Tamarindus indica* Fruit

The amino acid profile of *Tamarindus indica* fruit is shown in Table 3. The result revealed 17 amino acids. 9 (Leucine (3.00 ± 0.01^{a}), Serine (2.80 ± 0.03^{a}), Aspartic acid (3.54 ± 0.21^{a}), Alanine (3.33 ± 0.01^{a}), Lysine (2.30 ± 0.03^{a}), Proline (2.13 ± 0.02^{a}), Glycine (2.00 ± 0.05^{a}), Threonine (2.01 ± 0.02^{a}), Phenylamine (2.20 ± 0.01^{a}) were found to be significantly ($p< 0.05$) higher in the pulp and 4 (Phenylamine (4.95 ± 0.01^{b}), Lysine (4.72 ± 0.26^{b}), Leucine (5.01 ± 0.06^{b}) and Tyrosine (5.11 ± 0.12^{b}) were found to be significantly ($p< 0.05$) higher in the seeds. Essential amino acids are not produced by the body and must be obtained from food. Essential amino acids such as Histidine, Isoleucine, leucine, phenylamine, threonine, lysine and valine were present. Foods that contain all nine essential amino acids are referred to as complete proteins. All nine essential amino acids perform varied roles in the body. They are involved in important processes such as tissue growth, energy production, immune function and nutrient absorption [34]. We have in total eleven nonessential amino acids.

Nonessential amino acids can easily be produced by the body and as such, they are readily available.

3.4 In-vitro Antioxidant Potential of *Tamarindus indica* Fruits (Pulp and Seeds)

The *in-vitro* antioxidant potential of *Tamarindus indica* fruits is captured in figure 1. DPPH is used as a stable free radical to determine the antioxidant activity of natural compounds, and the scavenging of stable radical (DPPH) is considered a valid and easy assay to evaluate scavenging activity of antioxidants. In this assay, purple color of DPPH is reduced to α-diphenyl-β-picrylhydrazine (yellow colored) when neutralized. The extent of the change in color is proportional to the concentration and strength of the antioxidants. The effect of antioxidants on DPPH could be due to their hydrogen donating ability [35]. The result revealed that percentage inhibitory effect of both samples (garlic acid standard, pulp and seeds of the fruits) increased with an increase in concentration. Hence, the inhibition potential is concentration dependent. However, the inhibitory effects of the pulp and seeds were relatively low compared to the standard. Although, the pulp showed a higher inhibition than the seeds. This indicates that the pulp may contribute to protection against diseases.

3.5 The IC_{50} DPPH Scavenging Effects of *Tamarindus indica* Fruits (Pulp and Seeds)

The IC_{50} values of the DPPH scavenging effects of the *Tamarindus indica* Fruits (Pulp and Seeds) are presented in Figure 2. A lower IC_{50} value indicates greater antioxidant activity. The result revealed that concentration of samples required to scavenge 50% free radicals were 7.08, 54.70, and 68.21 respectively for garlic acid standard, pulp and seeds of the fruits. These values are favorable when compared to reports on IC_{50} *M. calabura* fruits with value (90±0.04µg/cm^3). This confirms that the fruits have a lower DPPH scavenging effect.

4.0 Summary

The antioxidant potential of the samples indicated that the percentage inhibitory effect for both samples (garlic acid standard, pulp and seeds) increased with an increase in concentration an indication that the inhibition potential is concentration dependent. Mineral elements potassium (289.5^{b}-233.0^{a} %), Calcium (85.0^{b}-101.2^{a} %), Magnesium (26.21^{a}-58.22^{b} %), Sodium (19.91^{b}-26.95^{a} %) and Phosphorus (7.60^{b}-24.62^{a} %) were significantly ($p< 0.05$) higher while Iron (1.95^{b}-5.02^{a} %) and Zinc (0.45^{b}-0.75^{a} %) were low in both seeds and pulp respectively. Chromium was not found in *Tamarindus indica* fruit. The result revealed 17 amino acids. 9 (Leucine (3.00 ±0.01^{a}), Serine (2.80 ±0.03^{a}), Aspartic acid (3.54 ±0.21^{a}), Alanine (3.33 ±0.01^{a}), Lysine (2.30 ±0.03^{a}), Proline (2.13 ±0.02^{a}), Glycine (2.00 ±0.05^{a}), Threonine (2.01 ±0.02^{a}), Phenylamine (2.20**±**0.01^{a}) were found to be significantly ($p< 0.05$) higher in the pulp and 4 (Phenylamine (4.95**±**0.01^{b}), Lysine (4.72±0.26^{b}), Leucine (5.01±0.06^{b}) and Tyrosine (5.11±0.12^{b}) were found to be significantly ($p< 0.05$) higher in the seeds. The proximate values of carbohydrates, lipid, crude proteins, crude fibre, ash and moisture content are found to be 68.45%, 2.99%, 7.59%, 5.00%, 3.06%, 16.00% for the pulp and 91.44%, 1.51%, 4.42%, 0.62%, 1.98%, and 2.00% for the seeds respectively.

5.0 Conclusion

Proximate constituents, antioxidant potentials, mineral element contents, amino acid contents in the fruits of *Tamarindus indica* were analyzed. Looking at the composition, the fruits of *Tamarindus indica* have unique health benefits. The antioxidant activity of the studied fruits might be exploited in the food industry as nutrient supplement. Present research shows that fruits of *Tamarindus indica* has significant nutritional and antioxidant potential and can serve the malnutrition purpose across the African globe.

6.0 Recommendations

The results revealed in this research work will give way to:

Evaluating antioxidant potential with other methods apart from DPPH method.
Extraction of the essential amino acids in the fruits for supplements.
More studies on the antioxidant potential of the edible fruit in vivo.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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Table 1: Proximate composition of *Tamarindus indica*

Parameter g/100	Pulp	Seed
Ash content	3.06±0.06[a]	1.98±0.10[b]
Crude fiber	5.00±0.30[a]	0.62±0.01[b]
Crude protein	7.59±0.16[a]	4.42±0.13[b]
Crude lipid	2.99±0.07[a]	1.51±0.08[b]
Moisture content	16.00±0.55[a]	2.00±0.05[b]
Carbohydrate	68.45±0.16[a]	91.44±0.20[b]
Energy kj/100g	2100.5±18.60[a]	4030.10±28.00[b]
Vitamin C mg/100g	43.90±1.10[a]	39.70±0.99[b]

Values are presented as Mean ± standard deviation of three determinations. Means with different superscripts in the same row are significantly differed at P< 0.05.

Table 2: Some Elemental Constituents of *Tamarindus indica* Fruits

Element (mg/100g)	Pulp	Seed
Na	26.95±0.01	19.91±1.50
K	233.0±3.51	289.5±2.90
Mg	26.21±2.50	58.22±2.00
Ca	101.2±4.00	85.0±3.20
Fe	5.02±0.92	1.95±1.20
Zn	0.75±0.10	0.45±0.03
P	24.62±0.50	7.60±0.15

Values are presented as Mean ± standard deviation of three determinations. Means with different superscripts in the same row are significantly differed at P< 0.05.

Table 3: Amino Acids Profile Dry Weight of Pulp and Seed of *Tamarindus indica*

Amino Acid	Pulp	Seed
Phenylamine	2.20±0.01	4.95±0.01
Valine	1.81±0.03	1.10±0.01
Lysine	2.30 ±0.03	4.72±0.26
Leucine	3.00 ±0.01	5.01±0.06
Isoleucine	1.30 ±0.02	0.65±0.02
Threonine	2.01 ±0.02	1.12±0.02
Histidine	1.93 ±0.02	0.95±0.01
Glutamic acid	1.73±0.01	1.02±0.01
Serine	2.80 ±0.03	0.85±0.01
Tyrosine	1.60 ±0.02	5.11±0.12
Ammonia	0.39 ±0.01	0.37±0.01
Proline	2.13 ±0.02	0.12±0.01
Cysteine	0.58±0.02	0.28±0.04
Glycine	2.00 ±0.05	1.04±0.03
Aspartic acid	3.54 ±0.21	1.83±0.02
Arginine	1.40 ±0.01	0.71±0.04
Alanine	3.33 ±0.01	1.15±0.06
Total amino acid profile	34.05	30.98

Unit: g/100g Protein. Values are presented as mean ± standard deviation of three determinations. Means with different superscripts across the rows are significantly ($P< 0.05$) different.

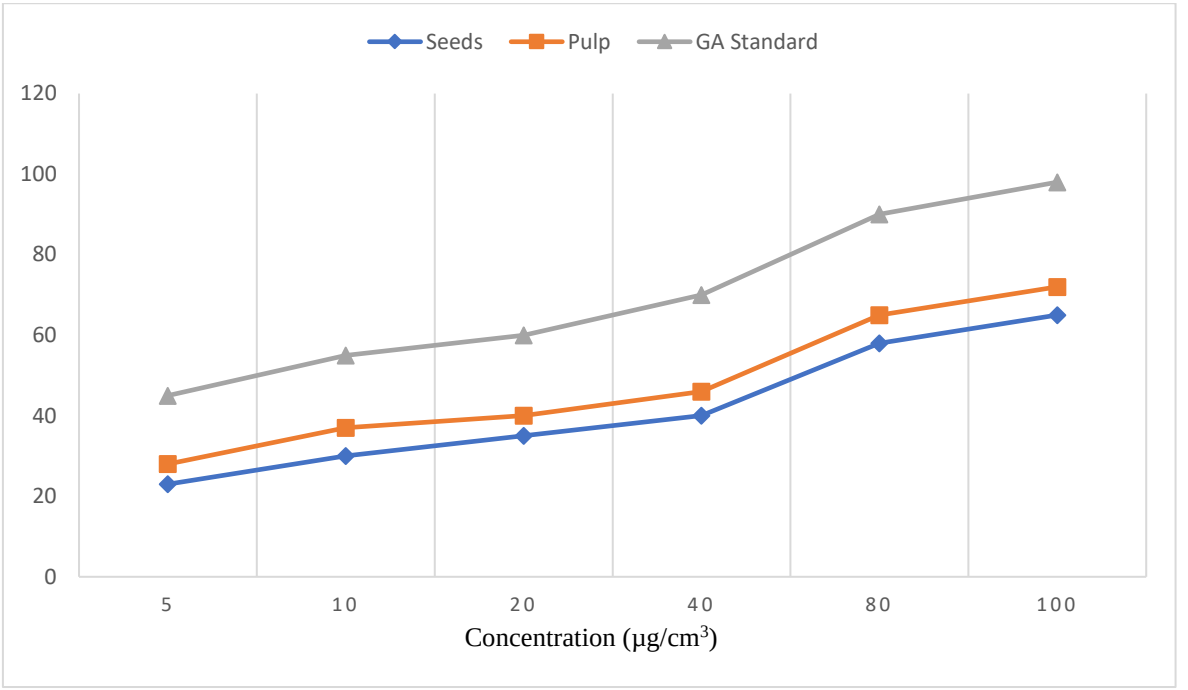

Figure 1: *In-vitro* Antioxidant Potential of Pulp and Seeds

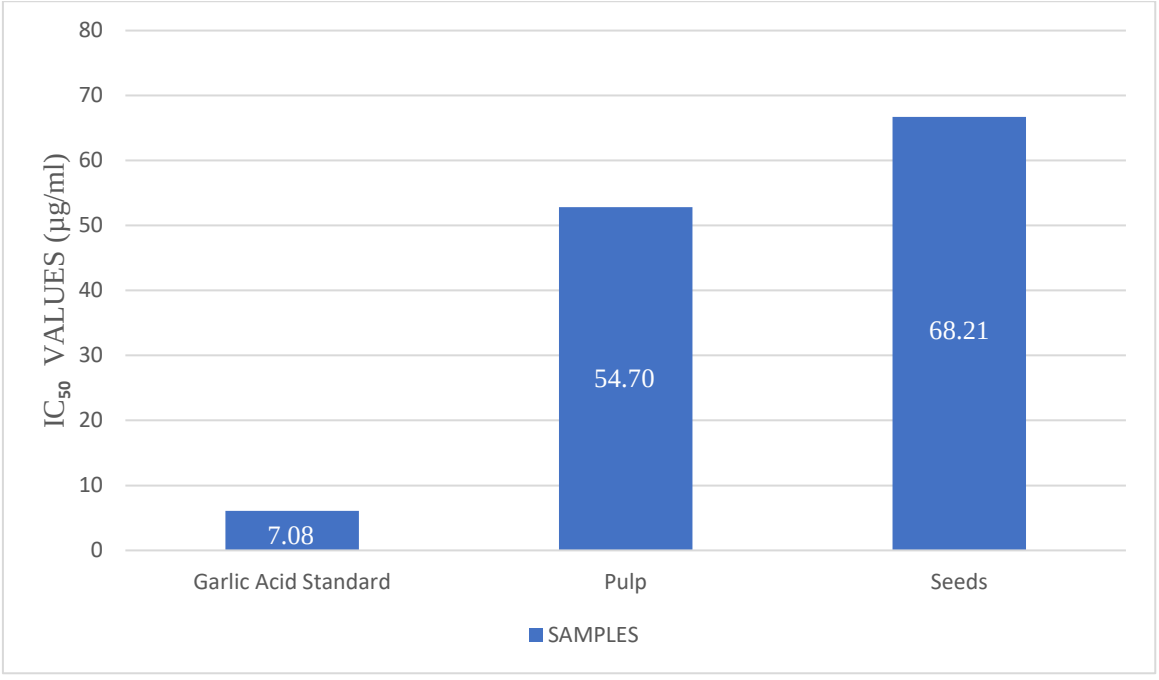

Figure 2: the IC_{50} of DPPH Scavenging Effects of Pulp and Seeds