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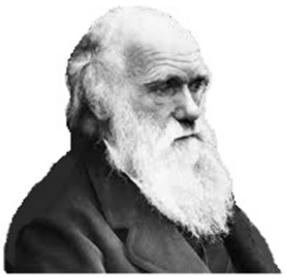

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Comparative Nutritional Composition of Selected Medicinal Fruit Seeds

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ABSTRACT

Fruits producing medicinal plants are particularly desirable, the seeds produced are considered as waste after the fruits are consumed. This study assessed the nutritional constituents of some fruits seeds by assessing the proximate, minerals and vitamins present in the seeds of *Citrullus lanatus* (Water melon), *Malus pumila* (Apple), *Annona muricata* (Sour sap), *Persea americana* (Avocado*), Terminalia catappa* (Almond fruit), and *Carica papaya* (Pawpaw*)*. The proximate analysis, mineral and vitamin composition of the selected medicinal fruit seeds were investigated using the standard method of analysis. On the proximate composition, protein content ranged from 15.21-34.70%, crude fat: 13.82-33.15%, crude fibre: 6.96-21.71%, ash content: 2.62-5.90%, moisture content: 7.81-20.72% and carbohydrate: 12.19-26.58%; for mineral content, Sodium ranged from 26.2-832 mg/kg, Potassium: 571-4862 mg/kg, Calcium: 194-2070 mg/kg, Magnesium: 28-862 mg/kg, Phosphorus: 104-1070 mg/kg, Iron: 2.53-60.00 mg/kg, Manganese: 2.73-240 mg/kg, Copper: 1.64-73.00 mg/kg and Zinc: 3.42-84.00 mg/kg, while for vitamins, vitamin C (Ascorbic acid) content ranged from 1.26-23.54 mg/100g, vitamin E content ranged from 0.70-1.57 mg/100g; vitamin A (β-carotene) content ranged from not detected-5.61 mg/100g, while vitamin B content ranged from 0.02 mg/100g-2.67 mg/100g. The fruits' seeds show a considerable amount of vital nutritional chemicals which makes them as good as the fruits and could serve as nutraceutical remedy.

***Keywords*:** *Malus pumila*, *Annona muricata, Terminalia catappa*, *Citrullus lanatus*, *Carica papaya*, *Persea americana*, Nutritional, Seeds, Fruits

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1. INTRODUCTION

Medicinal plants remain a vital component of health care in the developing countries, fruits producing medicinal plants are especially desired as the edible fruits produced from them are an essential part of diets as they provide much need nutrients which are vital for healthy living (1). However, seeds from some of these fruits are thought to be wastes after consumption or during the processing of the fruits and as a result, many are under-utilized though, data from the nutritional compositional analysis may provide potential means of utilizing these seeds in animal feed composition and also for medicinal purposes.

Over time, efforts to understand the food and nutritional benefits of diverse kinds of fruits seeds have been undertaken by several workers and consequently, information available on some of these seeds suggest that they may be as useful as the fruits for medicinal and nutritional uses, as some fruit seeds are edible and found to have a number of phytonutrients which can be exploited for medicinal uses (2). Some fruits and seeds of medicinal importance are readily available and are widely consumed in Nigeria, among these are *Carica papaya*, *Citrullus lanatus*, Avocado, *Annona muricata*, *Malus pumila* and *Terminalia catappa*.

Carica papaya L. (pawpaw) belongs to the family *Caricaceae*, the medicinal value of is various parts such as leaves, stems, and fruits have been reported (3-6). *Citrullus lanatus* (Thunb.) (watermelon) is an herbaceous plant in the family of Cucurbitaceae, the fleshy parts of the fruits are rich in nutrients with the juice reported to modulate oxidative damage induced by low dose X-ray in mice (7) also, the fruits and seeds have been shown to possess some phytochemicals and antioxidant activities (8-9).

Persea americana Mill. (Avocado), a member of the family Lauraceae, is an exotic fruit native to Mexico but now widely grown all over the world, an extensive review on the pharmacological importance of the leaves have been documented by (10, 53, 54). *Anonna muricata* L. (soursop) of the Annonaceae family, is a tropical plant species that is widely known for the medicinal benefits of its edible fruit, other parts of the plant had been noted for various pharmacological actions and a review on the pharmacological activities is presented by (11) and (12). *Malus pumila* Mill. (synonyms *Malus domestica* Borkh) commonly called apple is a member of the family Rosaceae, it is distributed widely in the temperate region.

Consumption of apple has been reported to elicit many pharmacological activities as documented in the review by Lobo *et al.*, (13) while the leaves have also been reported for various activities (14). *Terminalia catappa* L. (almond) is a member of the Combretaceae family is known for its medicinal benefits and its nutritional fruits, parts of the plants such as the leaves, root, bark and fruits have been reported to have diverse pharmacological activities (15-16).

Seeds from some of these fruits are known to be edible and have been included in the diets for nutritional and medicinal purposes, for instance, almond seeds are edible, it is extracted from the leftover of the fleshy fruit after its consumption and widely consumed in Nigeria (17).

Consumption of grind papaya seeds mixed with hot water and taken twice daily is reportedly used in the management of obesity and diabetes (5). During its fruiting season, almond fruits are observed to drop from the tree in large number thus, constituting waste to the environment, while seeds from pawpaw, watermelon, apple, soursop and avocado are usually discarded after consumption.

Thus, the objective of this study is to assess the nutritional chemical composition of the seeds obtained from the fruits of almond, soursop, pawpaw, apple, watermelon and avocado.

2. MATERIALS AND METHODS

2. 1. The Seed Sample Collection and Preparation

Fresh and matured fruits of *Citrullus lanatus* (Watermelon), *Malus pumila* (Apple), *Annona muricata* (Sour sap), *Persea Americana* (Avocado), *Terminalia catappa* (Almond fruit), and *Carica papaya* (Pawpaw), were purchased at Bodija market, Ibadan, Oyo State. Identification of the Fruits was done at the taxonomy unit of the Forestry Research Institute of Nigeria. The seeds/nut were extracted from the fruits after consuming the fleshy/pulp part, cleaned and oven-dried at 60 ºC for up to 12h depending on seed type, the dried seeds were milled using a milling machine (Arthur H. Thomas Co. Phila, P.A. S.A) and then, stored in airtight jar for further analysis.

2. 2. Proximate analyses

Proximate parameters (carbohydrate, fats, protein, fibre, ash and moisture) of the fruit seeds were determined using the Association of Official Analytical Chemists method (18).

Moisture content was done on wet basis by oven drying 2g of the samples to constant weight at 105 ºC; ash content was determined by the ignition of organic materials present in the seed samples in a muffle furnace at 550 ºC for 5h; crude fats was determined by soxhlet extraction of the fat content using petroleum ether; the crude fibre content was determined by defatting 1g of the powdered seeds samples followed by successive treatment with boiling solutions of H_2SO_4 and KOH, then, the residue was filtered, washed, dried and weighed after which it was ashed in a muffle furnace at 550 ºC where the loss in weight after ashing is the crude fibre content; the protein content of the samples was determined by the micro-Kjeldhal method where nitrogen was first determined by digesting 1g of seed samples with concentrated H_2SO_4 in the presence of copper tablets as catalyst, the mixture was heated on a heating mantle to 400 ºC for 2h, this was followed by the distillation of ammonia obtained which was then collected in HCl, after which the excess unreacted HCl was titrated with standard sodium hydroxide solution to get the % nitrogen.

Crude protein was then estimated by multiplying the % nitrogen with a factor of 6.25. Carbohydrate content was estimated by difference.

2. 3. Mineral analyses

Mineral contents of the fruit seeds were determined according to the standard method previously used by Oshodi (19) with slight modification. The ash residues of each fruit seeds obtained from the ash content determination was digested with 10ml of 3M HNO_3 and then made up to 50 ml with deionized water, the salts of various metals to be analysed were used to prepare standard solutions of each metal and analysis of calcium, magnesium, phosphorus, iron, zinc, copper, and manganese was done using the Atomic Absorption Spectrophotometer (Buck Scientific 210VGP), while sodium and potassium were analysed using the flame photometer (Jenway).

2. 4. Vitamin Composition

Vitamin C (Ascorbic acid) was determined spectrophotometrically according to the AOAC (20) methods where 1g of the powdered seed samples were soaked in 0.4% oxalic acid

(20 ml) for about 10 minutes followed by centrifugation for 5 minutes, then, 1 ml of the supernatant was mixed with 9 ml of 2,6-dichlorophenolindophenol with thorough agitation.

The absorbance of the resulting mixture was measured at 520 nm against the blank. Standard solutions of ascorbic acid were prepared similarly at varying concentration and the standard curve was plotted where the absorbance values of the samples were used to estimate the vitamin C contents of the samples.

Vitamin E was determined as described by AOAC (20), 1g of the powdered sample was soaked in petroleum ether (20 ml), allowed to stand for an hour with constant shaking, it was centrifuged for 5 minutes and the supernatant (1 ml) was mixed with 0.2% of ferric acid in ethanol and 0.5% α-dipyridine, the mixture was then made up to 5ml with distilled water and the absorbance measured at 520 nm, standard solutions of α-tocopherol were prepared similarly at various concentration and the standard curve prepared from which the absorbance of the samples was used to estimate the vitamin E concentration.

Vitamin A was determined according to the procedure described by Onyesife *et al*., (21). 1g of the plant samples was extracted with petroleum ether (20 ml), it was shaken on a mechanical shaker for 30 minutes, the solvent was decanted and then evaporated to dryness, then chloroform-acetic anhydride (1:1 v/v) (0.2 ml) was introduced into the residue then, 2 ml trichloroacetic acid-chloroform (1:1 v/v) also added and the absorbance of the mixture was taken at 620 nm. Vitamin A (β-carotene) standards were prepared similarly at various concentrations and a standard curve plotted from which the vitamin A contents of the samples were estimated from the absorbance reading of the samples.

Vitamin B_6 was determined according to AOAC (20) method, 1g of powdered sample was macerated in 500 ml of distilled water for an hour, the mixture was filtered, then 1ml of the filtrate was mixed thoroughly with 50% sodium acetate (0.4 ml), distilled water (2 ml), diazotized reagent (0.1 ml) and 5.5% sodium carbonate (0.2 ml). The absorbance of the mixture was then measured at 540 nm, standard solutions of pyridoxine were prepared similarly and the standard curve prepared from which the vitamin B_6 content of each sample was estimated from their respective absorbance readings.

2. 5. Statistical analysis

Results were presented as the mean and standard deviation of triplicate measurement; analysis of variance was used to detect a significant difference between the mean of measured parameters of the fruit seeds, while Duncan's post hoc test was used for mean separation. IBM SPSS version 20 was used for the analysis and $p<0.05$ was considered significant.

3. RESULTS

The result of the proximate composition of the seeds of the selected plants is presented in Figure 1. The protein content ranged from 15.21-34.70%, crude fat: 13.82-33.15%, crude fibre: 6.96-21.71%, ash content: 2.62-5.90%, moisture content: 7.81-20.72% and carbohydrate: 12.19-26.58%.

The result of the mineral analysis is indicated in Table 1; sodium ranged from 26.2-832 mg/kg, potassium: 571-4862 mg/kg, calcium: 194-2070 mg/kg, magnesium: 28-862 mg/kg, phosphorus: 104-1070 mg/kg, iron: 2.53-60.00 mg/kg, manganese: 2.73-240 mg/kg, copper: 1.64-73.00 mg/kg and zinc: 3.42-84.00 mg/kg.

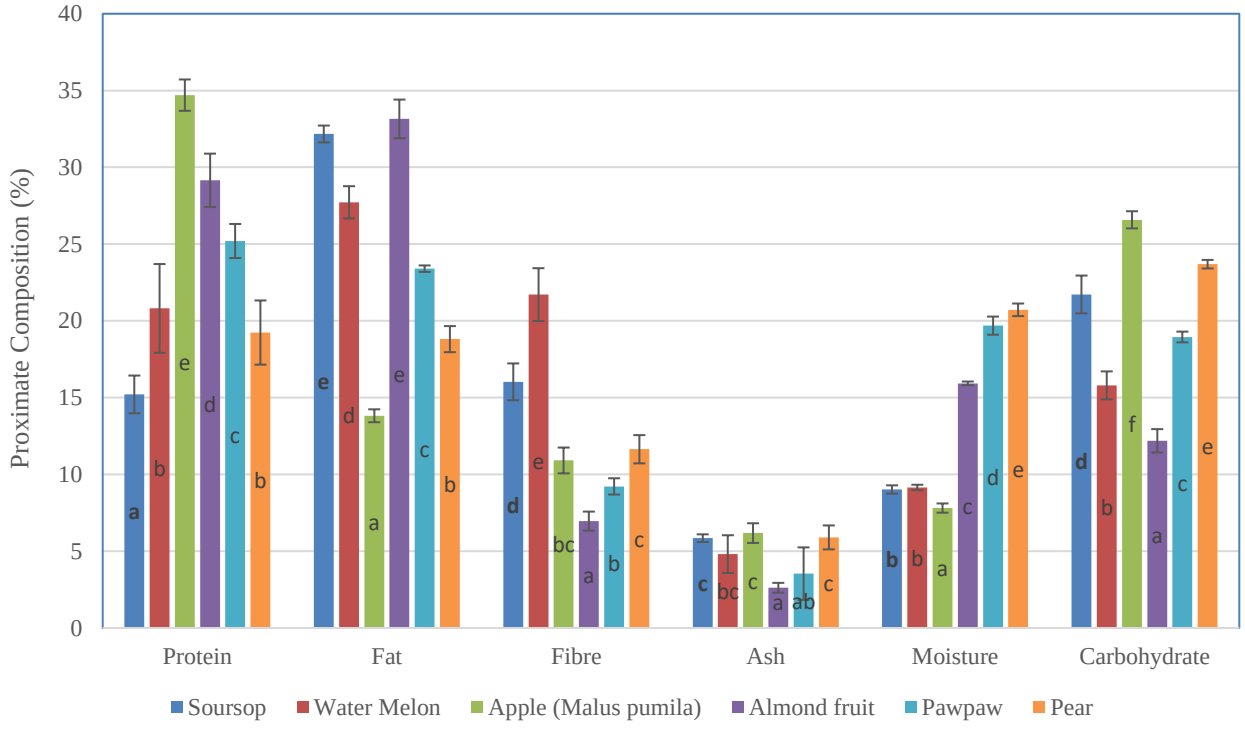

Figure 1. Proximate Composition of Selected Medicinal Fruit Seeds

Table 1. Mineral Analysis of some selected medicinal fruit seeds.

Minerals (mg/kg)	**Fruit Seeds**					
	Sour sop	**Water melon**	**Apple**	**Almond fruit**	**Pawpaw**	**Avocado**
Sodium (Na)	256±10**b**	832±121**d**	394±31**c**	26.2±2.21**a**	381±79**bc**	504±89**c**
Potassium (K)	3271±112**c**	4862±257**e**	776±113**a**	571±26**a**	4552±109**d**	1205±92**b**
Calcium (Ca)	2070±58**d**	571±21**c**	497±16**c**	380±72**b**	547±91**c**	194±32**a**
Magnesium (Mg)	171±23**bc**	862±43**e**	422±66**d**	203±30**c**	28±5**a**	108±14**b**
Phosphorus (P)	1020±133**d**	1070±112**d**	517±34**c**	104±15**a**	474±24**bc**	344±33**b**
Iron (Fe)	37.1±1.86**d**	23.7±2.48**c**	17.4±1.30**b**	60.00±4.05**e**	59±6.10**e**	2.53±0.91**a**
Manganese	9.1±0.83**a**	240±28.06**c**	2.73±0.77**a**	91±5.70**b**	13.23±2.03**a**	10.2±1.05**a**
Copper	1.72±0.27**a**	7.9±1.62**a**	1.64±0.74**a**	73±7.58**c**	16.0±1.89**b**	14.3±3.31**b**
Zinc	44.32±3.06**b**	12.4±2.18**a**	78±6.21**cd**	84±9.38**d**	71±4.24**c**	3.42±1.08**a**

Same alphabets in the same rows are not significantly different ($p<0.05$)

Table 2. presents the result for the vitamin composition of the selected medicinal fruit seeds where the vitamin C (Ascorbic acid) content ranged from 1.26 mg/100g in soursop seeds to 23.54 mg/100g in pawpaw seeds; vitamin E content ranged from 0.70 mg/100g in apple seeds to 1.57 mg/100g in pawpaw seeds; vitamin A (β-carotene) content ranged from not detected in apple seeds to 5.61 mg/100g in soursop seeds while vitamin B content ranged from 0.02 mg/100g in apple seeds to 2.67 mg/100g in soursop seeds. These levels are significantly different at $p<0.05$ demonstrating variability in the vitamin contents in the selected fruit seeds.

Table 2. Vitamin composition of some selected medicinal fruit seeds

Vitamin (mg/100g)	**Fruit Seeds**					
	Soursop	**Water melon**	**Apple**	**Almond fruit**	**Pawpaw**	**Avocado**
Vitamin C	1.26±0.18**a**	4.21±0.**69ab**	7.52±1.**63bc**	11.23±1.05**c**	23.54±3.92**e**	16.47±2.89**d**
Vitamin E	1.07±0.06**ab**	0.81±0.05**a**	0.70±0.22**a**	1.51±0.13**bc**	1.57±0.54**c**	0.83±0.10**a**
Vitamin A	5.61±2.17**b**	0.26±0.04**a**	ND	4.54±1.06**b**	0.42±0.16**a**	0.74 ±0.25**a**
Vitamin B	2.67±0.62**c**	0.12±0.02**a**	0.02±0.01**a**	0.34±0.07**a**	1.45±0.68**b**	0.65±0.27**a**

Same alphabets in the same rows are not significantly different ($p<0.05$)

4. DISCUSSION

The result shows a high level of protein which varied across all the fruit seeds examined, Apple (*Malus pumila*) had the highest value, while Soursop (*Annona muricata*) had the lowest value, there was a significant difference ($p<0.05$) between all the fruit seeds. The importance of protein in diets cannot be overemphasized, apart from the fundamental functions of supplying much-needed amino acids, proteins are also known to repair or replace worn-out tissues thus, helping form body structures during the growth process, therefore its availability in any diet or nutraceutical materials is highly welcomed.

In this study, the higher protein content recorded in the seeds of apple, pawpaw and watermelon are within the range of 27.11-34.00% previously reported for protein in watermelon, apple, almond, and pawpaw seeds (17, 22-24), however, Okogeri and Onu (25) and Abiola (26) reported a lower protein level in the seeds of soursop and Alagbaoso (27) in avocado and the range of 14.5-23.4% reported in the almond seeds (28) while comparable levels were obtained in watermelon seeds as previously reported by Tabiri *et al*., (9).

These results suggest that the selected seeds are a very good source of protein and can be incorporated into animal feed diet. Fats are a good source of energy and therefore a vital component of food, the fat contents of the selected seeds show a high level across the seeds with the almond seed and soursop seeds having comparatively higher levels ($p<0.05$) of fats in them. The fat concentration range observed in this study compares favourably with those reported by Fasakin *et al*., (29) and Okogeri and Onu, (25) for *A. muricata* seeds, Akpakpan and Akpabio, (17) for *T. catappa* seeds, Alagbaoso, (27) for *P. americana*, Makanjuola and

Makanjuola, (24) and Adesuyi and Ipinmoroti, (30) for pawpaw seeds, Tabiri *et al.*, (9) for watermelon seeds, and Alagbaoso *et al*., (27) for avocado; conversely, the fat level in the apple seeds is lower when compared with that reported by Yu *et al*., (22), higher fat level was also reported in *T. catappa* seeds (31) and watermelon seeds (23) contrary to what is reported in this study. Some of the seeds have been reported for the production of seed oil, this may justify the high fat content in some of the seeds.

The carbohydrate content in the seeds of apple was found to be significantly higher ($p<0.05$) than the other seeds, the range of values (12.19-26.58%) observed for all the seeds in this study aligns with that generally reported for the seeds in other similar studies, higher carbohydrate content was however, reported by Alagbaoso *et al*., (27) in ripe avocado pear seeds and Abiola (26) in soursop seeds. These results suggested that all the seeds examined possess a moderate level of carbohydrates. Fibres are believed to cleanse the bowel, purifies the system and reduce the level of bad cholesterol in human blood and consequently reduce the threats of different cardiovascular diseases and certain cancers (32-33). The fibre content varied across the studied seeds, watermelon produced the significantly ($p<0.05$) highest fibre content (21.71%), other seeds present comparable levels of fibres with previous studies. The ash content indicated in the fruit seeds shows the estimates of the inorganic mineral elements present in the seeds. High mineral nutrients in foods promote growth and development and also perform the role of catalyst in metabolic processes in the human body.

Low sodium level relative to the potassium concentration was observed in all the seeds which are a good pointer that the seeds will be effective in the treatment of high blood pressure. The highest level of sodium was observed in the seeds of watermelon while the lowest levels were found in the almond seeds. The presence of high levels of sodium in the diet is connected with renal and cardiovascular disorders (34). Similarly, it is recommended that hypertensive patients or those that are prone to the disease are discouraged from diets with high sodium content. The potassium concentration in all the seeds are generally high, the highest concentration observed in watermelon seeds while apple and almond seeds had comparatively lower levels. This level varies in comparison with previous similar studies on the seeds of the studied plants. Higher levels of potassium were reported in pawpaw seeds (24), almond seeds (17, 31), watermelon seeds (9, 23, 55), apple seeds (23), soursop seeds (35) and avocado seeds (36) compared with the results of this study. Similarly, lower concentration was reported in apple seeds flour (22), soursop seeds (26, 29), pawpaw seeds (23), avocado seed flour (37) compared with this study.

The presence of potassium in the body at high concentration was reported to improve the utilization of iron (38), this is particularly helpful to patients using diuretics for the control of hypertension and therefore, struggle with excessive loss of potassium through the body fluid (39). Magnesium is present in all the fruit seeds; the lowest concentration was found in the pawpaw seeds while watermelon seeds present the highest concentration. Comparable levels have been reported in almond seeds (17) soursop seeds (35) and apple seeds (22) while other researchers reported higher levels in watermelon seeds (9) and almond seeds (31), with lower levels reported in soursop (26). Magnesium is helpful in the control of blood pressure, it assists in the prevention of cardiac arrest and stroke. Magnesium is also a vital part of the bone and plays an active role in the structural development just in a similar fashion like calcium, however, magnesium relaxes the muscle against the stimulation action of calcium (40). The deficiency of magnesium causes uncontrolled twisting of muscles and consequently, convulsion, and ultimately, death (41); it is also rampant among people with chronic alcoholism (42), thus, the

fruit seeds provide an abundant supply of this mineral. Calcium concentration in this study is generally high, the lowest levels were obtained in avocado seeds while the highest concentration was found in soursop seeds. This implies that all the fruit seeds especially soursop seeds are a good source of calcium.

Variable levels of calcium have been previously reported in different seeds samples, Akpakpan and Akpabio, (17) reported a comparable calcium concentration in the seeds of almond, however, higher concentration was reported in almond seeds (31), apple and watermelon seeds (9, 23); lower concentration was obtained in soursop seeds (26, 35), pawpaw seeds (24), and apple seeds (22). Other mineral elements investigated shows variable range when compared with published results which may reflect the difference in the method of analysis and sample preparation. It is noteworthy that the elemental composition in the studied fruit seed samples compares favourably with the levels previously reported for the various fruit pulps such as avocado pulp, pawpaw pulp, watermelon pulp (36), pawpaw pulp (43) soursop pulp (44) and other Nigerian fruits as reported by Ekpete and Edori, (45). This suggests that the seeds of the studied fruits could, in essence, serve as a functional food and can be compounded as animal feeds.

The range of values observed for vitamin C content compares favourably with those reported for common medicinal plants such as *Ficus exasperata* and *Anthocleista djalonensis* (46). Quite a number of studies have documented variable range of some vitamin content in some of the studied fruit seeds, comparable vitamins C, E and A concentration was reported in avocado seeds (9), while a range of 2.35-5.28 mg/100g vitamin C was reported in the dry and fresh watermelon seeds with a comparable vitamin A content (47).

The presence of vitamin B_6 in considerable amount in all the fruit seeds enables them to act as co-factor for certain enzymes that help in carrying out their respective functions (48). Vitamins are very useful as essential component of certain enzymes and coenzymes taking part in metabolic actions and other dedicated actions (49), and apart from their dietary benefits, some of them are known to possess antioxidant activity when consumed (50) while the presence of certain vitamins such as vitamin E gives significant action against certain infections (51). Hence, the results suggest that the seeds are a potentially good source of antioxidants that scavenge the free radicals present in the body and neutralize reactive oxygen species (ROS) formed in immune cells, which can destroy the cells (52).

5. CONCLUSION

The study has shown that the fruits' seeds investigated showed a considerable amount of vital nutritional chemicals which makes them as good as the fruits and could thus, be included in herbal medications and also components of animal feeds. The high-fat content in some of the seeds possibly justifies why they are harnessed for seed oil production.

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