Published by SET Publisher

Journal of Pharmacy and Nutrition Sciences

ISSN (online): 1927-5951

Nutritional Assessment of Pulps and Partial Characterization of Seed Oils from Varieties of Pear Fruits

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Article Info:

Keywords:

Amino acid score,
health benefit,
nutrients,
pear varieties,
fruit oil.

Timeline:
Received: November 22, 2022
Accepted: March 11, 2023
Published: April 28, 2023

Citation: Obasi NA, Aloke C, Obasi SE, Famurewa AC, Elom SO, Aja PM, Ajala LO. Nutritional assessment of pulps and partial characterization of seed oils from varieties of pear fruits. J Pharm Nutr Sci 2023; 13: 13-20.

DOI: https://doi.org/10.29169/1927-5951.2023.13.02

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Abstract:

The nutrients and chemical contents of *Persea americana*, *Dacryodes edulis*, and *Canarium scheinfurthi* fruits and partial characterization of their seed oils were carried out to ascertain their nutritional benefits. The fruit pulps were analyzed for chemical (proximate) composition, amino acids profile, vitamins, and phytochemical and anti-nutritional compositions. Oils were extracted from the fruit seeds and the physico-chemical properties of the seed oils were determined according to the standard protocols. The results showed that the fruit pulps contained an abundance of macro- and micro-nutrients which varied significantly ($p < 0.05$) among the varieties with low anti-nutrients. The essential amino acid contents were high and varied significantly ($p < 0.05$) among the varieties. Glutamic acid, followed by aspartic acid had the highest concentration of the amino acids, while the concentrations of methionine and cysteine were low in all the varieties. The results also revealed high essential amino acids score values, above 100% for isoleucine and total aromatic amino acids. The physicochemical properties of the fruit oils showed that the oils were edible (low acid value) and may have industrial potential due to their low peroxide, iodine, and saponification values. Overall, the results showed that the pears are nutritionally rich and could serve dietetic and industrial purposes.

INTRODUCTION

Plants and plant products are important sources of food worldwide supplying humans with unlimited nutrients and health-beneficial bioactive compounds [1,2]. Presently, most human health problems have been correlated with deficiency or excessive diets [3]. Fruits are important dietary sources that contain macro and micronutrients such as proteins, fiber, amino acids, vitamins, minerals, and other bioactive compounds necessary for a healthy life [4-6]. Apart from supplying the human body with essential nutrients needed for optimal metabolic processes, fruits supply bioactive compounds which possess anti-oxidant, anti-inflammatory, anti-carcinogenic, and anti-mutagenic potentials among others [2]. From the foregoing, it is clear why more studies have shown an increase in the pattern of consumption of fruits worldwide [7]. Pear fruits are consumed worldwide although the varieties differ among geographical spread. In most African countries such as Nigeria, *Persea americana* (avocado pear), *Dacryodes edulis* (African pear), and *Canarium scheinfurthi* (African elemi or canarium) are widely produced and consumed [8,9].

P. americana species belongs to the family *Lauraceae* and it is a nutritious and valuable fruit tree commonly found in the tropics. The fruit is a large fleshy berry with a single seed which has been reported to contain major and micro-nutrients [10]. A high intake of fruits has been reported to be highly beneficial to health including lowering serum cholesterol levels [11]. *D. edulis* species belongs to the family *Burseraceae* and it is a dioeciously shade-loving fruit tree of non-flooded forest indigenous in the humid lowlands and plateau regions of West Africa, Central African, and Gulf of Guinea countries. It bears a fleshy fruit with a squish purple. It can be eaten raw, roasted, or boiled in hot water [9]. Reports have shown that it could be an important source of vitamins, minerals, pulp oil, seed oil, and even whole fruit oil and flavor in snacks and non-alcoholic beverages [12]. *C. schweinfurthii* species belong to the family of *Burseraceae* and it is a fruit tree of tropical African origin. The fruits contain purplish green pulp with a single triangular-shaped seed with small projections at the three edges. The fruits which are usually oily can be eaten raw or softened in warm water to improve palatability. Although the fruit is not popular, reports have shown that the pulp oil contains about 71% palmitic acid and 18% oleic acid and the fruits can be good sources of nutrients and can be used as a flavor in snacks and non-alcoholic beverages [13].

The advocacy for the increased consumption of plants and plant products has increased in recent years due reported health benefits of edible plants. In Nigeria as in most African countries, most plants and plant products are under-utilized due to a lack of full nutritional and health benefits. This has led to over-dependence on exotic plants and plant products which in most cases have been reported to be preserved with chemicals that are health threatening. Thus, the need to properly evaluate local products to generate baseline data on the nutritional potentials for enhanced utility. Therefore, this research is aimed at evaluating the nutrient and chemical contents of three locally available pear fruits and characterizing their fruit oils to determine their safety and wholesomeness in terms of human nutrition.

MATERIALS AND METHODS

Sample Collection and Preparation

The fresh fruits of three varieties of pear- *P. americana*, *D. edulis*, and *C. scheinfurthi* were purchased from a local market (Eke, Afikpo, Nigeria). They were identified by a taxonomist at the Plant, Ecology, and Biology Unit, Department of Science Laboratory Technology, Akanu Ibiam Federal Polytechnic, Unwana, Nigeria. The voucher specimens were tagged AIFPU/18/PEB/LT/074a, AIFPU/18/PEB/LT/074b, and AIFPU/18/PEB/LT/074c, respectively, and deposited in the herbarium of the department.

The fruits were opened manually, and the pulp, peel, and seed were separated and sun-dried (between 28 and 30℃) for six days. They were separately pulverized with pestle and mortar (Genix brand); thereafter, sieved with 0.2 mm mesh, packed in cleaned labeled bottles, and stored at laboratory temperature.

Proximate Analysis of the Pulps

Proximate analysis of the pulp was carried out in line with the methods outlined in AOAC [14]. The ash content was determined by incinerating in a furnace (Method No. 930.05). Fresh samples were used for moisture content determination using a hot-air oven. The nitrogen content was converted to crude protein using factor 6.2 (Method No. 978.04). The crude lipid was determined by the continuous extraction using the soxhlet reflux apparatus (Method No. 930.09) while the carbohydrate was calculated as the difference. The energy contents (kCal) of the samples were estimated

by multiplying the percentages of crude protein, crude lipids, and available carbohydrates (Method No. 930.15) with the recommended factors of 2.44, 8.37, and 3.57, respectively.

Mineral Analysis

The mineral elements were determined after wet digestion. One gram (1.0 g) of the processed dry powder samples was digested with a mixture of nitric, perchloric, and sulphuric acids in a ratio of (9:2:1), respectively. Calcium (Ca), magnesium (Mg), zinc (Zn), and selenium (Se) were determined using atomic absorption spectrophotometer (Varian spectra, AA 55B) (Method No. 975.03), sodium (Na) and potassium (K) were determined using flame photometer (Method No. 969.23) (Buck Scientific, 200-A) while phosphorus (P) was determined by vanado-molybdate methods AOAC (Method No. 984.27) [14]

Amino Acid Contents Determination

The amino acid contents of the pear varieties were determined using an ion-exchange chromatographic method with the sequential multi-sample amino acid analyzer, (Technicon, TSM, DNA 0209) as previously described by Akubugwo *et al*. [15]. The amino acid chemical score was calculated as in Equation 1

$$\text{Amino acid chemical score} = \frac{\text{Amino acid in sample}}{\text{reference standard value of the amino acid}} \times 100$$

Eqn. 1

Vitamins Analysis

Vitamin A was determined by the method of Davies [16], ascorbic acid (vitamin C) (Method No.967.21) and pyridoxine (vitamin B6) (Method No. 969.06) were determined by the titrimetric method, and thiamine (B1) (Method No. 977.03), riboflavin (B2) (Method No. 968.07), niacin (B3) (Method No. 970.05) and vitamin E (Method No. 992.03) were determined by the spectrophotometric method as described by AOAC [14].

Phytochemical Analysis

Alkaloids, flavonoids, and saponins were determined as outlined by Obadoni and Ochuko [17], and phenols were determined by the Folin-ciocalteu spectrophotometric method outlined by Opara *et al*. [9]. Tannins and hydrocyanic acid were determined by the method of Van-Burden and Robinson [18], while the method of Wheeler and Ferrel [19] was used to estimate the phytic acid content of the sample.

Oil Extraction and Analysis

The oil extraction from the pears and the physical-chemical properties of the extracted oils were determined by the standard method as outlined by Kyari [20].

Statistical Analysis

All analyses were performed in five replicates and data obtained were expressed as mean ± standard deviation. The significant differences between the pear varieties were assessed by one-way analysis of variance using SPSS 18.0 software (SPSS Inc., Chicago, USA). The differences in the mean values were separated using Duncan multiple range test and significant differences were considered at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate and Elemental Compositions of the Pears

The results of the proximate contents of the pear varieties are shown in Table **1**. The results showed significant differences in the proximate contents of the three varieties of pear at $p < 0.05$. The % moisture, ash, and crude fiber were higher in *P. ameriana* compared to others while the % crude fat and protein were higher in *C. shweinfurtii* compared to others. The energy value of *C. shweinfurtii* was significantly higher ($p < 0.05$) compared to *P. americana* and *D. edulis* with no significant difference ($p > 0.05$) in their energy values.

The high percentage of moisture contents of the pulps compared favorably with values reported in other fruits [5,21]. The high moisture contents of these pears may contribute to their high perishable attributes as high moisture is associated with an increase in microbial activities [22]. The ash content of the pears, an indication of minerals showed that the fruits would be good sources of minerals for humans. The crude fat, protein, and fiber contents (Table **1**) were comparable with major edible fruits and vegetables reported [1,15]. Fats are important sources of adequate energy while proteins provide amino acids that are nutritionally essential for metabolism [22]. Crude fiber contents of fruits have been reported to improve the health of humans by reducing the risk of excessive cholesterol levels and through other mechanisms that decrease cancer risks [21].

Table **1** also shows the results of the mineral element compositions of the three varieties of pear pulp - *P.*

Table 1: Proximate and Elemental Compositions of Three Varieties of Pear Pulps – *P. americana, D. edulis,* and *C. schweinfurthii* on Dry Weight Basis

Parameters	*P. americana*	*D. edulis*	*C. schweinfurthii*
Moisture (%)	$71.13^{c} \pm 0.10$	$69.78^{b} \pm 0.07$	$67.01^{a} \pm 0.03$
Ash (%)	$2.08^{c} \pm 0.08$	$1.46^{a} \pm 0.13$	$1.75^{b} \pm 0.22$
Crude fat (%)	$14.30^{b} \pm 0.15$	$12.79^{a} \pm 0.10$	$15.84^{c} \pm 0.14$
Crude protein (%)	$1.85^{b} \pm 0.11$	$1.30^{a} \pm 0.09$	$2.08^{c} \pm 0.05$
Crude fibre (%)	$6.78^{c} \pm 0.07$	$5.89^{b} \pm 0.10$	$4.29^{a} \pm 0.11$
Carbohydrate (%)	74.99 ± 0.13	78.56 ± 0.21	76.04 ± 0.12
Energy value (Kcal/100g)	391.92^{a}	390.68^{a}	409.12^{b}
Calcium (mg/100g)	$14.06^{b} \pm 0.97$	$13.02^{a} \pm 0.16$	$13.67^{b} \pm 1.12$
Potassium (mg/100g)	$506.4^{c} \pm 1.07$	$484.50^{a} \pm 2.12$	$498.13^{b} \pm 1.84$
Sodium (mg/100g)	$10.25^{c} \pm 0.15$	$8.44^{a} \pm 0.75$	$9.78^{b} \pm 0.82$
Iron (mg/100g)	$0.96^{c} \pm 0.07$	$0.57^{a} \pm 0.04$	$0.76^{b} \pm 0.05$
Zinc (mg/100g)	$0.87^{c} \pm 0.03$	$0.58^{a} \pm 0.07$	$0.66^{b} \pm 0.05$
Copper (mg/100g)	$0.24^{b} \pm 0.02$	$0.17^{a} \pm 0.02$	$0.19^{a} \pm 0.03$
Selenium (µg/100g)	$0.52^{b} \pm 0.03$	$0.44^{a} \pm 0.02$	$0.48^{b} \pm 0.07$
Magnesium (mg/100g)	$31.07^{c} \pm 0.11$	$29.65^{a} \pm 0.17$	$30.06^{a} \pm 0.14$
Phosphorus (mg/100g)	$58.11^{c} \pm 0.19$	$53.95^{a} \pm 1.06$	$55.04^{b} \pm 0.23$
Na/K	0.02	0.02	0.02
Ca/P	0.24	0.24	0.25

Means with the same superscripts within the same column are significantly ($p < 0.05$) not different from each other.

americana, D. edulis, and *C. scheinfurthii.* The results showed significant differences ($P < 0.05$) in the elemental compositions with *P. americana* having the highest and *D. edulis* having the lowest in most cases. Minerals at appropriate quantities are essential for healthy development and their deficiencies manifest in clinical pathologies [1]. The results also showed that the ratios of sodium to potassium (Na/K) and calcium to phosphorus (Ca/P) were all less than unity (< 1) for all three pear varieties, indicating synergistic interaction in their metabolisms [23]. Na/K ratio correlates clinically to blood pressure and values less than one in dietary sources is recommended [24]. Similarly, the Ca/P ratio correlates clinically to healthy bones, and good intestinal absorption of minerals and values less than or equal to one are recommended [23,24]. The ratio observed in this study (Table **1**) may suggest that the pears are good sources of Ca and P needed for healthy bones. Overall, the mineral contents of these pear varieties showed that they are potent sources of Ca, K, Na, Fe, Zn, Cu, Mg, and P which could contribute to meeting up the recommended dietary allowances for children and adults [25].

Amino Acids Profile of the Pears

The amino acid compositions of the three varieties of pear pulps – *P. americana, D. edulis,* and *C. scheinfurthii* are shown in Table **2**. The results showed that leucine, followed by phenylalanine, was the highest essential amino acid present in all three varieties while methionine was the least. A non-essential amino acid component with the highest values was glutamic acid, followed by aspartic acid, while histidine was the least. The results also showed that the total essential amino acids in *P. americana* were significantly higher ($p < 0.05$) compared to that in *C. schweinfurthii,* which did not statistically differ ($p > 0.05$) from that of *D. edulis.* The amino acid contents of the pulp of the pear varieties (Table **2**) were comparable to other fruits and vegetables reported to provide adequate nutritive amino acid value [5,22,26,27].

Similarly, the chemical score of the nutritionally essential amino acids concerning the reference standard [2] (Table **2**) showed that the various pear

Table 2: Amino Acids Composition (mg/100 g) with FAO/WHO/UNU [28] Reference Values and Amino Acid Chemical Scores of Three Varieties of Pear Pulp – *P. americana, D. edulis,* and *C. schweinfurthii*

Amino acid	*P. Americana*		*D. edulis*		*C. schweinfurthii*		
	Composition	Score	Composition	Score	Composition	Score	Reference
Isoleucine	3.36	120	2.97	106	3.10	111	2.80
Leucine	6.73	102	6.33	96	5.47	83	6.60
Lysine	3.52	61	2.80	48	3.21	55	5.80
Methionine	1.24	Nd	0.75	Nd	0.98	Nd	Ns
Cysteine	1.02	Nd	1.00	Nd	1.06	Nd	Ns
Phenylalanine	4.16	Nd	4.05	Nd	4.34	Nd	Ns
Tyrosine	3.07	Nd	2.84	Nd	2.78	Nd	Ns
Threonine	2.83	83	2.11	62	2.32	68	3.40
Valine	3.99	114	3.35	96	3.27	93	3.50
Histidine	2.23	Nd	2.20	Nd	2.46	Nd	Ns
Alanine	4.08	Nd	3.68	Nd	3.88	Nd	Ns
Arginine	4.88	Nd	4.56	Nd	4.84	Nd	Ns
Aspartic acid	7.41	Nd	7.97	Nd	8.11	Nd	Ns
Glutamic acid	12.60	Nd	11.82	Nd	14.07	Nd	Ns
Glycine	3.80	Nd	3.55	Nd	3.53	Nd	Ns
Proline	3.14	Nd	3.22	Nd	2.89	Nd	Ns
Serine	3.47	Nd	3.08	Nd	3.05	Nd	Ns
TSAA	2.26	90	1.75	70	2.04	82	2.50
TArAA	7.23	115	6.89	109	7.12	113	6.30
TEAA	29.92	---	26.20	---	26.53	---	---
% TEAA	41.80	---	39.50	---	38.20	---	---
TNEAA	41.61	---	40.08	---	42.83	---	---
% TNEAA	58.20	---	60.50	---	61.80	---	---

TSAA = Total sulfur amino acids, TArAA = Total aromatic amino acids, TEAA = Total essential amino acids, TNEAA = Total non-essential amino acids, ns = not stated, nd = not determined because of lack of data.

varieties are potent with high biological value in terms of meeting the amino acid needs of children and adults. Thus, the fruits may contribute significantly to the amino acids and hence protein needs of the malnourished and prevent diseases such as kwashiorkor and marasmus [3]. The results further showed that isoleucine and total aromatic amino acids (phenylalanine + tyrosine) had above 100% chemical scores in all three pear varieties. also, leucine and valine further scored above 100% in *P. americana.* Essential amino acids are regarded as obligatory amino acids which cannot be produced in the body at the needed level but must be supplied through food [22, 28]. Research has revealed that leucine and isoleucine are responsible for the synthesis of substrates for glucogenesis while phenylalanine is needed to produce a pigment called melanin that contributes to eye, hair, and skin color [21,22,27,28] The total sulfur amino acids (methionine + cysteine), lysine and threonine scored below 100% in all the three pear varieties with leucine and valine further scored below 100% in *D. edulis* and *C. schweifurthii.* Threonine helps in the proper functioning of the central nervous, boosts the immune system, assists in building strong bones, and tooth enamel, and healing wounds [22]. Tryptophan is the precursor for the synthesis of serotonin; aspartate and glutamate serve as ammonia transporters to the liver and kidney for urea synthesis [28].

Vitamin and Phytochemical Compositions of the Pears

The results of the vitamin compositions of the three pear varieties – *P. americana, and D. schweinfurthii* are

Table 3: Vitamin and Phytochemical Compositions of Three Varieties of Pear Pulp – *P. americana, D. edulis*, and *C. schweinfurthii* on Dry Weight Basis

Parameters	*P. americana*	*D. edulis*	*C. schweinfurthii*
Vitamin A (ug/100g)	$7.60^{b} \pm 0.11$	$5.18^{a} \pm 0.07$	$5.84^{a} \pm 0.16$
Vitamin B_1 (mg/100g)	$0.10^{a} \pm 0.03$	$0.08^{a} \pm 0.02$	$0.11^{a} \pm 0.04$
Vitamin B_2 (mg/100g)	$0.18^{a} \pm 0.02$	$0.14^{a} \pm 0.02$	$0.15^{a} \pm 0.02$
Vitamin B_3 (mg/100g)	$2.34^{c} \pm 0.02$	$1.96^{a} \pm 0.10$	$2.11^{b} \pm 0.05$
Vitamin B_6 (mg/100g)	$0.37^{b} \pm 0.06$	$0.27^{a} \pm 0.02$	$0.31^{a} \pm 0.03$
Vitamin C (mg/100g)	$9.40^{c} \pm 0.13$	$8.92^{a} \pm 0.05$	$8.55^{a} \pm 0.12$
Vitamin E (mg/100g)	$2.26^{c} \pm 0.09$	$1.83^{a} \pm 0.03$	$1.96^{b} \pm 0.05$
Flavonoid (%)	$8.57^{c} \pm 0.15$	$3.93^{a} \pm 0.07$	$4.89^{b} \pm 0.05$
Alkaloid (%)	$1.84^{a} \pm 0.20$	$2.76^{c} \pm 0.26$	$2.16^{b} \pm 0.13$
Saponin (%)	$2.58^{b} \pm 0.07$	$2.78^{c} \pm 0.05$	$2.34^{a} \pm 0.04$
Tannin (%)	$0.41^{a} \pm 0.06$	$1.94^{c} \pm 0.04$	$1.53^{b} \pm 0.07$
Phenols (GAE/100)	$117.76^{c} \pm 1.05$	$88.79^{a} \pm 2.04$	$93.98^{b} \pm 1.17$
Hydrocyanic acid (%)	$1.08^{a} \pm 0.02$	$1.23^{b} \pm 0.07$	$1.02^{a} \pm 0.08$
Phytic acid (%)	$1.16^{a} \pm 0.05$	$1.73^{c} \pm 0.06$	$1.44^{b} \pm 0.05$

Means with the same superscripts within the same column are significantly ($p < 0.05$) not different from each other.

shown in Table **3**. The results showed that the vitamin content of the pears varied from one variety to another with *P. americana* significantly ($p < 0.05$) higher than *C. schweinfurthii,* which vitamin contents were not significantly ($p > 0.05$) higher than those in *D. edulis* except for vitamin B_3 and vitamin E.

Vitamins are micro-nutrients essential for the maintenance of health via their physiological roles as coenzymes and precursors of numerous metabolic reactions [24]. The vitamin contents of these pear varieties (Table **3**) are promising in meeting up with the recommended dietary allowances [6] and the values compared with others reported for fruits and vegetables [12,15]. The high level of vitamin C and E in these pears implies that they may serve as important antioxidants and aid in increasing the fertile potency of humans [29].

Table **3** also shows the phytochemical contents of the three pears. The values of the phytochemical contents vary significantly ($p < 0.05$) from one variety to another. The highest level of flavonoid and phenols were observed in *P. americana* followed by *C. schweinfurthii* and *D. edulis* while the highest level of alkaloid, saponin, tannin, hydrocyanic acid, and phytic acid was observed in *D. edulis* followed by *C. schweinfurthii*, then in *P. americana*.

The presence of high levels of health-beneficial phytochemicals and low levels of anti-nutritional phytochemicals showed the safety and wholesomeness of the pears in human nutrition and health [8,29]. Phytochemicals in these fruits may contribute to numerous health benefits - anti-microbial, anti-oxidants, anti-carcinogenic, antimutagenic to immunological protections among others [30]. Phytic acid reduces the bioavailability of minerals in humans while hydrocyanic acid is a potent toxicological inhibitor of cytochrome oxidase in the electron transport chain [31]. The levels of these anti-nutrients were low and non-limiting in these pear varieties (Table **3**) and as such, could not drastically affect their nutritional contributions and health benefits [8].

Physico-Chemical Properties of the Pears' Oils

The physico-chemical properties of the oils extracted from the three varieties of pear seeds – *P. americana, D. edulis*, and *C. schweinfurthii* are shown in Table **4**. The oil's physico-chemical properties are compared favorably with oils reported for some plant seeds, fruits, and vegetables [10,32]. The results showed that *C. schweinfurthii* had the highest percentage oil yield followed by *P. Americana,* then, *D. edulis.* The oil extracts from the three varieties were all slightly acidic and liquid at laboratory temperature (30 ℃) with greenish-brown to reddish brown. The refractive index and specific gravity ranged from 1.40 and 0.894 in *P. americana* to 1.51 and 0.921 in *D. edulis*, respectively.

The results showed that the chemical properties of the oils varied significantly ($p < 0.05$) from one variety to

Table 4: Physico-Chemical Properties of Oil Extracts of Three Varieties of Pear Seeds – *P. americana, D. edulis,* and *C. schweinfurthii*

Parameter	*P. americana*	*D. edulis*	*C. schweinfurthii*
% oil yield	$14.30^{b} \pm 0.15$	$12.79^{a} \pm 0.10$	$15.84^{c} \pm 0.14$
State at 30 ℃	Liquid	Liquid	Liquid
Color	Greenish brown	Brownish	Reddish brown
Refractive index	1.40	1.51	1.45
Specific gravity	0.894	0.921	0.915
pH	5.8	5.7	5.8
Acid value ($mgNaOHg^{-1}$)	$0.84^{a} \pm 0.03$	$1.22^{c} \pm 0.12$	$1.06^{b} \pm 0.05$
Saponification value ($mgKOHg^{-1}$)	$135.17^{a} \pm 2.09$	$156.25^{b} \pm 1.03$	$167.42^{c} \pm 0.64$
Iodine value (mg of 1 g^{-1} of oil)	$78.43^{b} \pm 0.33$	$82.78^{c} \pm 0.45$	$74.19^{a} \pm 1.02$
Peroxide value (meq O_2 kg^{-1})	$0.18^{a} \pm 0.07$	$0.43^{b} \pm 0.02$	$0.65^{c} \pm 0.08$

Means with the same superscripts within the same column are significantly ($p < 0.05$) not different from each other.

another with *P. americana* having the lowest acid value, saponification value, and peroxide value, while *D. edulis* had the highest acid and iodine values among the varieties. The highest saponification value was observed in *C. schweinfurthii* followed by *D. edulis*. The lipid indices of the oils share similar properties with most conventional seed oils [33]. The oils are edible and may find use in edible products judging by their low acid values, but the low saponification values make the oils not applicable in soap industries. The oils are non-drying (low iodine value) and may not be suitable as alkyl resins for paint formulation but may be suitable for other industrial applications since the low peroxide values indicate a high level of anti-oxidative properties [33].

CONCLUSION

This study had shown that *P. americana*, *D. edulis*, and *C. scheinfurthi* fruits contained high levels of macro- and micro-nutrients as well valuable phytochemicals with low anti-nutrients. The study also revealed that the pears were rich in essential amino acids and high levels of anti-oxidative substances (flavonoids, phenols, and Zn). The fruit seed oils were discovered to have low acid, peroxide iodine, and saponification values. Overall, the results showed that fruits can contribute significantly to healthy human and animal nutrition as well as, serve as raw materials for industries.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING SOURCE

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The work was funded by all the authors who pooled funds together as a team.

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