THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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SAEREM BOOK CHAPTERS   First Published 2025   ISBN 978-978-60709-7-1

Published By:

Society for Agriculture, Environmental Resources & Management (SAEREM)

First published 2024

SAEREM World

Nigeria

Typeset in Times New Roman

SAEREM BOOK CHAPTERS First Published 2025 ISBN 978-978-60709-7-1

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Printed at: SAEREM World

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous ***The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources*** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.
The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources: Global issues and Local Perspectives is organized in three parts. Part One deals with The Concept of Value Chains in Agriculture, Part Two is concerned with The Concept of Climate Actions and Part Three deals with the Concept of Value Chains and Environmental Resources.

Eteyen Nyong/ Ignatius Onimawo

April 2025

Chapter Twenty Two

Nutrient Profiling of Avocado (*Persea americana*) and African Pear (*Dacryodes edulis*): A Comparative Study for Food and Nutritional Security

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1.0. INTRODUCTION

Food and nutritional security remain paramount global challenges, particularly in developing nations where access to diverse, nutrient-rich food sources is often constrained by socioeconomic factors and limited agricultural diversity (FAO, 2022). The World Health Organization estimates that approximately 2.3 billion people worldwide face moderate to severe food insecurity, with malnutrition affecting both urban and rural populations (WHO, 2023). In this context, indigenous and locally available fruits have emerged as crucial resources for addressing nutritional deficiencies and enhancing food security through their accessibility and nutrient density (Kumar

R. & Patel S., 2023). Among these valuable food resources, Avocado pear (*Persea americana*) and African pear (*Dacryodes edulis*) stand out as significant tropical fruits with remarkable nutritional potential.

Pear is a commercial tree majorly cultivated for its fruits. It belongs to the genius *Pyrus* of the sub-family *Amygdaloideae*, and of the family *Roseceae* (rose family) (Chase MW, Christenhusz MJM, Fay MF, Byng JW, Judd WS, Soltis DE, Mabberley DJ, Sennikov AN, Soltis PS, & Stevens PF, 2016). It is classified botanically as pomes which develop from the flower's inferior ovary where the outer fleshy part comes from the enlarged floral tube, while the seeds and core develop from the ovary. The common pear tree is broad-headed and up to 13metres (43ft) high at maturity. The trees are relatively long-lived (50-70years) and may reach considerable size unless carefully pruned (Oluwaniyi O., Nwosu, F., & Okoye, C., 2017).

Avocado pear (*Persea americana*), originally native to Central America but now cultivated globally in tropical and subtropical regions, has garnered international recognition for its exceptional nutritional profile. Avocado is a fruit with a history of about 10,000 years, produced from tropical trees characterized by a pear shape and blackish-green colour with high nutritional value, creamy texture, and unique taste (Cervantes-Paz, B., & Yahia, E. M, 2021). The fruit contains substantial amounts of healthy monounsaturated fats, primarily oleic acid, which has been associated with various health benefits including improved cardiovascular function and enhanced nutrient absorption (Wang, Y., Li, H., Zhang, Q., & Chen, J., 2021). It provides significant amounts of vitamins E, K, and B-complex, as well as minerals such as potassium and magnesium (Martinez-Rodriguez A., 2021). The plant is reported to be rich in several phytochemicals and it is used in traditional medicine for the treatment of various ailments, such as menorrhagia, hypertension, stomach ache, bronchitis, diarrhea, and diabetes (Singh, R., & Sharma, P., 2022). The fruit is not sweet but rich and subtly flavoured with creamy texture.

African pear (*Dacryodes edulis*), indigenous to Central and West Africa, represents a less globally recognized but locally significant fruit crop. It is one of the fruits of domestication programme for indigenous fruit and medicinal trees. It is characterized by orthotropic type branches that grow vertically upwards. The fruit range from 4-8cm long by 3.06cm and the edible succulent part is 0.3 - 1.2cm thick. The flowering season takes place from January to April and the fruiting season is between May and October (Ajibesin, K.K., 2011). African pear is a rich source of nutrients such as lipids, proteins and vitamins (Oluwaniyi *et al*., 2017). It is characterized by its high content of fixed and volatile oils and is highly consumed locally and internationally which gives the plant a high economic value.

Recent research has begun to reveal its impressive nutritional composition, including essential fatty acids, proteins, and various bioactive compounds with potential health-promoting properties (Okeke, C. U., & Onah, J., 2021) . Traditional communities have long utilized both the pulp and seeds of African pear for nutritional and therapeutic purposes, suggesting a wealth of untapped potential in this indigenous fruit (Ajayi, F. A., Babalola, A. O., & Adewusi, B., 2021).

Both Avocado pear (*Persea americana*) and African pear (*Dacyodes edulis*) are widely consumed in Nigeria, their fruits are gathered for household consumption or for sale in local markets. The Avocado and African pear seeds are majorly discarded as agro-food wastes hence are underutilized. Additionally, taking into account the potential nutritional and medicinal benefits of these underutilized agro-foods will lessen the possible environmental waste burden, it will no longer be discarded as agro-food wastes (Ramadan, M. F., & Farag, M. A., 2022). The nutritional value of these fruits extends beyond their macro-nutrient content. Studies have shown that both Avocado and African pear contain significant levels of antioxidants and other phytochemicals that may offer protection against various diseases (Chen H., & Liu Y., 2023).

Research by Henderson K.R. (2022) demonstrated that regular consumption of avocado is associated with improved metabolic health markers and reduced risk of chronic diseases. Similarly, preliminary studies on African pear suggest potential anti-inflammatory and antimicrobial properties, though more comprehensive research is needed to fully understand these effects (Kamara S.T., & Jones M.B., 2023).

From a food security perspective, both fruits offer unique advantages. Avocados have shown remarkable adaptability to various growing conditions and can be cultivated successfully in many tropical and subtropical regions, potentially contributing to local food production systems (Garcia-Martinez E., 2021). African pear trees are well-adapted to local ecosystems and can produce substantial yields with minimal input, making them valuable resources for sustainable food production in their native range (Ebele R.N., & Mohammed A.K., 2023).

However, despite the individual documentation of these fruits' nutritional properties, comprehensive comparative analyses of their nutritional profiles are limited. This knowledge gap hampers efforts to optimize their utilization in addressing food security challenges and developing targeted nutritional interventions (Mbatha, K., & Ndlovu, L., 2024). Understanding the comparative nutritional composition of both fruits is crucial for several reasons: it can inform dietary recommendations, guide agricultural policy and investment decisions, and support the development of value-added products that maximize their nutritional benefits (Taylor M.L., & Anderson K.L., 2022).

The processing and storage of these fruits also present unique challenges and opportunities. Research by Rodriguez P.L. (2023) indicates that proper post-harvest handling and storage conditions are crucial for maintaining the nutritional quality of both fruits. Additionally, the potential utilization of fruit parts typically considered waste, such as seeds and peels, could contribute to more sustainable food systems and provide additional nutritional benefits (Kumar *et*

Patel, 2023). The research focuses on both the pulp and seeds of these fruits, examining their proximate composition, vitamin content, mineral profiles, and bioactive compounds. Understanding these aspects is essential for maximizing their potential contribution to food and nutritional security, particularly in regions where both fruits are cultivated or have the potential for cultivation.

1.1. Objectives of the study

The primary aim of this study is to bridge the existing knowledge gap by conducting a detailed comparative analysis of the nutritional and phytochemical composition of Avocado (*Persea americana*) and African pear (*Dacryodes edulis*) to assess their potential contribution to food and nutritional security in Nigeria.

1.2. Specific Objectives

The specific objectives of this research are:

1. To determine and compare the proximate composition (moisture, ash, protein, fat, fiber, and carbohydrate content) of both the pulp and seeds of Avocado and African pear using standard analytical methods.

2. To analyze and compare the vitamin content (with emphasis on B-complex vitamins) and mineral profiles of both fruits using high-performance liquid chromatography (HPLC) and atomic absorption spectroscopy (AAS) respectively.

3. To identify and quantify the phytochemical compounds (including tannins, oxalates, and other bio-active compounds) present in both the pulp and seeds of Avocado and African pear using established phytochemical screening methods.

4. To evaluate the potential nutritional contribution of typically discarded parts (seeds) of both fruits through comprehensive nutrient profiling and analysis.

5. To assess and compare the bio-active compounds and their potential health-promoting properties in both fruits through antioxidant activity determination and total phenolic content analysis.

The findings from this study will provide valuable information for nutritionists, food scientists, and policymakers in developing strategies to enhance food security and improve nutritional outcomes in communities where these fruits are cultivated or have potential for cultivation. Additionally, the results will contribute to the existing body of knowledge regarding the nutritional value of indigenous and tropical fruits, particularly highlighting the potential utilization of typically discarded parts for improved food security**.**

2.0. LITERATURE REVIEW

Food and nutritional security remain paramount global challenges, particularly in developing nations where access to diverse, nutrient-rich food sources is constrained by socioeconomic factors and limited agricultural diversity (FAO, 2022). The World Health Organization (WHO, 2023) estimates that approximately 2.3 billion people worldwide experience moderate to severe food insecurity, with malnutrition affecting both urban and rural communities. In response to these challenges, researchers and policymakers have increasingly focused on the role of indigenous and locally available fruits. These fruits not only offer a rich source of micronutrients but also represent sustainable options to mitigate nutritional deficiencies in resource-limited settings (Kumar R. & Patel S., 2023).

Recent decades have witnessed a growing recognition that sustainable food systems must address both the availability of calories and the quality of nutrition. Malnutrition, in its various forms, continues to impede socio-economic development and public health worldwide (WHO, 2023). Against this backdrop, leveraging locally available food resources—especially indigenous fruits—has emerged as a strategic intervention. Such fruits are often adapted to local ecosystems, require fewer inputs, and are rich in essential nutrients and bioactive compounds (Kumar R. & Patel S., 2023).

Indigenous fruits offer multiple benefits such as been served as a direct source of nutrition and represent culturally significant food resources. In regions such as Nigeria, where traditional diets are evolving in response to globalization and urbanization, indigenous fruits can support dietary diversification. For instance, both the Avocado pear and African pear have been traditionally consumed, with their seeds and pulps valued not only for sustenance but also for their medicinal properties (Ramadan & Farag, 2022; Chen H. & Liu Y., 2023).

The commercial pear, belonging to the genus *Pyrus* in the sub-family *amygdaloideae* of the Rosaceae family, provides a useful botanical benchmark. Pears are classified as pomes, with their edible fleshy part developing from an enlarged floral tube while the core originates from the ovary. Mature pear trees may reach up to 13 metres in height and live for 50–70 years, underlining their economic and agricultural significance (Oluwaniyi, Nwosu, & Okoye, 2017).

Avocado Pear (*Persea americana*)

Originally native to Central America, Avocado pear has been cultivated globally in tropical and subtropical regions. With a cultivation history spanning approximately 10,000 years, the avocado is renowned for its creamy texture, distinctive taste, and exceptional nutritional profile. The fruit is a rich source of healthy monounsaturated fats—primarily oleic acid—vitamins (notably E, K, and B-complex), and minerals such as potassium and magnesium (Cervantes-Paz & Yahia, 2021; Martinez-Rodriguez, 2021). In addition to its nutritional merits, the avocado contains several phytochemicals that underpin its traditional use in managing conditions like hypertension, gastrointestinal disturbances, and metabolic disorders (Maitera, Osemeahon, & Barnabas, 2014).

African Pear (*Dacryodes edulis*)

Indigenous to Central and West Africa, the African pear is a vital component of local agroforestry and food security strategies. It is characterized by its vertically oriented branches and a fruit size ranging from 4 to 8 cm in length. Rich in lipids, proteins, vitamins, and both fixed and volatile oils, African pear plays an important role in both local diets and economic systems (Ajibesin K.K., 2011; Oluwaniyi *et al.*, 2017). Emerging research has highlighted its impressive nutritional composition, including essential fatty acids and bioactive compounds that may confer anti-inflammatory and antimicrobial properties (Ajayi, Babalola, & Adewusi, 2021).

Recent comparative studies have focused on both the pulp and seeds of Avocado and African pear to maximize the utilization of these fruits and reduce agro-food waste. In Nigeria, these fruits are widely consumed either fresh or in local markets, but a significant portion of the seeds is discarded despite their potential nutritional and medicinal benefits (Ramadan & Farag, 2022).

Investigations into the proximate composition of these fruits reveal notable differences. Avocado pulp is distinguished by its high fat content and lipid profile, which supports cardiovascular health through its high concentration of oleic acid (Dreher, M. L., & Davenport, A. J., 2013).. Conversely, African pear pulp is noted for its high moisture and vitamin A content, which is essential for immune function and vision (Martinez-Rodriguez, 2021). Studies also report that the seeds of both fruits tend to have higher carbohydrate concentrations and varying levels of anti-nutritional factors such as oxalates and tannins. While these compounds may reduce mineral bioavailability, they can also contribute to the fruits' antioxidant potential when consumed in moderation (Batista, D., Silva, A. R., & Oliveira, F., 2022).

Comprehensive analyses of these fruits typically involve a series of standard analytical methods for determining proximate composition (e.g., moisture, ash, protein, fat, fiber, and carbohydrate contents), vitamin quantification using HPLC, and mineral profiling via atomic absorption spectrophotometry (Association of Official Analytical Chemists, 2019; Okeke & Onah, 2021). Additionally, advanced phytochemical screening techniques are employed to quantify bioactive compounds such as flavonoids, tannins, and saponins, which may offer functional health benefits (Kumar & Patel, 2023).

From a food security perspective, the adaptability of Avocado pear to various climatic conditions and the minimal input requirements for cultivating African pear make them valuable assets for sustainable agricultural practices (Garcia-Martinez, 2021; Ebele & Mohammed, 2023). Moreover, utilizing underexploited parts—such as seeds—could minimize environmental waste and unlock further nutritional benefits, thereby contributing to both dietary diversification and economic sustainability (Ramadan & Farag, 2022).

Despite these promising attributes, the literature indicates that comprehensive comparative analyses of the nutritional profiles of Avocado and African pear remain limited. Such research is crucial for informing dietary recommendations, guiding agricultural policy, and supporting the development of value-added products (Mbatha & Ndlovu, 2024; Taylor & Anderson, 2022). Future studies should aim to integrate post-harvest handling practices, storage conditions, and consumer acceptability to fully harness the potential of these indigenous fruits (Rodriguez, 2023).

3.0. MATERIALS AND METHODS

Study Location and Period

This study was conducted at Moist Research Institute, Edo State, Nigeria between March and August 2023. Edo State is an inland state in central southern Nigeria, with its capital – Benin City. It lies within the geographical co-ordinates of longitude 6° 04'E and 6° 43'E and latitude 5° 44'N and 7° 34'N of the equator. It is bounded in the south by Delta State, in the west by Ondo State, in the north by Kogi State and in the east by Kogi and Anambra States. The state occupies an area of 17,802km^2 (6, 8773 sqmi) with a population of over 3million people. Edo State is situated in the rainforest zone of Southern Nigeria. The annual precipitation is between 1500mm and 3000mm with rainfall days of about 200. The three distinct vegetation types are mangrove forest, fresh swamp, and savannah.

Sample Collection and Identification

Fresh, ripe samples of Avocado (*Persea americana*) and African pear (*Dacryodes edulis*) were collected from three different local markets in Ovia South-West Local Government Area, Edo State, Nigeria: Ovia Central Market, Iguobazuwa Market, Umaza Community Market

Taxonomic identification and authentication of the fruit samples were also conducted at the Moist Research Institute, Edo State.

Sample Preparation

Initial Processing

1. Fruits were visually inspected for physical damage and uniformity

2. Selected fruits were washed thoroughly with distilled water

3. Surface dried using sterile paper towels

4. Weighed using an analytical balance (Mettler Toledo XPE205, Switzerland).

Separation and Processing

The fruits were thoroughly washed with distilled water and air-dried at room temperature. Each fruit was carefully cut open to separate the pulp from the seeds. The pulp and seeds were separately processed as follows:

1. Pulp samples were cut into small pieces.
2. Seeds were cleaned and sliced thinly.
3. Both samples were dried in an oven at 60°C until constant weight.
4. Dried samples were ground into fine powder using a laboratory mill.
5. Powdered samples were stored in airtight containers at 4°C until analysis

Fruits were carefully sectioned using sterile stainless-steel knives.

Separated into: Pulp (mesocarp), Seeds (endocarp).

Sample Preparation for Analysis

1. Pulp Processing:

- Cut into uniform 5mm pieces
- Fresh samples stored at 4°C for immediate analysis
- Portions dried at 60°C in a forced-air oven (Memmert UFE 600, Germany)
- Dried samples ground using a laboratory mill (IKA A11 basic, Germany)
- Powdered samples stored in airtight containers at -20°C

2. Seed Processing:

- Seeds cleaned and thinly sliced (2mm thickness)

- Dried at 60°C until constant weight
- Ground to fine powder
- Stored in airtight containers at -20°C.

(Source: Association of Official Analytical Chemists, 2019)

Standard Analytical Methods

The following parameters were determined according to Association of Official Analytical Chemists (2019) standard methods:

Proximate Analysis

Moisture Content

- Method: AOAC Official Method 925.10
- Equipment: Moisture analyzer (Sartorius MA160, Germany)
- Procedure:
  1. 5g sample weighed into pre-dried aluminum dishes
  2. Dried at 105°C until constant weight
  3. Calculated as percentage loss in weight

Ash Content

- Method: AOAC Official Method 923.03
- Equipment: Muffle furnace (Carbolite CWF 1300, UK)

- Procedure:
  1. 5g sample in pre-weighed crucibles
  2. Incinerated at 550°C for 4 hours
  3. Cooled in desiccator and weighed
  4. Calculated as percentage of original sample weight

Crude Protein

- Method: AOAC Official Method 920.87 (Kjeldahl method)
- Equipment:
  - Kjeldahl digestion unit (Buchi K-425, Switzerland)
  - Distillation unit (Buchi K-350, Switzerland)
- Procedure:
  1. Digestion with concentrated H_2SO_4
  2. Distillation with 40% NaOH
  3. Titration with 0.1N HCl
  4. Nitrogen content multiplied by 6.25

Crude Fat

- Method: AOAC Official Method 920.39
- Equipment: Soxhlet extraction apparatus

- Procedure:

  1. 5g sample extracted with petroleum ether for 6 hours
  2. Solvent evaporated
  3. Residue dried and weighed
  4. Calculated as percentage of original sample

Crude Fiber

- Method: AOAC Official Method 962.09

- Equipment: Fiber analyzer (VELP Scientific FIWE 6, Italy)

- Procedure:

  1. Sequential digestion with 1.25% H_2SO_4 and 1.25% NaOH
  2. Filtering and washing
  3. Drying at 130°C
  4. Ashing at 550°C
  5. Calculated as loss in weight after ashing

Carbohydrate Content

- Calculated by difference method:

  - 100 - (% moisture + % ash + % protein + % fat + % fiber).

(Source: Association of Official Analytical Chemists, 2019)

Vitamins analysis

Vitamin A analysis was carried out in the dark to avoid photolysis of the carotenoids. The sample was homogenized and saponified with 12% alcoholic potassium hydroxide then extracted with petroleum ether. The petroleum ether layer containing the carotenoids was collected. This process was repeated until the aqueous layer became colorless. A small amount of anhydrous sodium sulphate was added to the petroleum ether extract to remove moisture and the absorbance was read in an ultra-violet spectrophotometer (Genesys 10-S, USA) at λmax of 450 nm and 503 nm using petroleum ether as a blank (Nguyen, P. H., Tran, M. Q., & Pham, T. T. 2023).

Vitamin B1: The sample was homogenized with ethanolic NaOH solution and then filtered into a flask. The filtrate was pipetted into a beaker and colour developed by the addition of $KMnO_4$. The absorbance was read at λmax of 360 nm. (Nguyen, *et al.*, 2023).

Vitamin C: Standard ascorbate solution and the supernant of the samples were separately taken with 4% TCA (Trichloroacetic acid). DNPH (Dinitrophenlhydrazine) reagent was added followed by 10% thiourea solution. The mixture was incubated at 37℃??? for 3 hours resulting in the formation of osazone crystals which were then dissolved in 85% sulphuric acid; DNPH reagent and thiourea were added, cooled in ice and the absorbance was read at λmax of 540 nm (Nguyen, *et al.*, 2023).

Vitamin E: The sample extract, the standard and water were pipetted separately into 3 stoppered centrifuge tubes. Ethanol and xylene were added, mixed and centrifuged. The xylene layer was transferred into another stoppered tube to which 1.0 ml of dipyridyl reagent was added. 1.5 ml of the resulting mixture was pipetted into a cuvette and the extinction was read at 460 nm. Ferric chloride solution (0.33 ml) was added to all tubes and mixed. The red colour developed was read exactly after 15 mins at λmax of 520 nm in a spectrophotometer (Nguyen, *et al.*, 2023).

Mineral analysis

This triple acid digestion method (HNO_3:H_2SO_4:$HClO_4$ = 9:2:1 v/v) was performed following standard protocols as described by Onuegbu and Kabuo (2011) and A.O.A.C. (2019). Briefly, a known weight of the sample was placed in a conical flask, and the acid mixture was added. The mixture was heated for approximately 10 minutes until a clear solution was obtained. After cooling to room temperature, the digest was quantitatively transferred to a 50 mL volumetric flask and made up to volume with deionized water. The resulting solution was then subjected to flame photometry (FP 640 Flame Photometer) for the determination of sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg), while Atomic Absorption Spectrophotometry (Buck Scientific 210/211 VGP) with an air-acetylene flame was utilized to quantify manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), cobalt (Co), and lead (Pb) (Okeke, A. C., Nnaji, P. C., & Odimegwu, E. N., 2020).

Quality Control and Statistical Analysis

- All analyses were performed in triplicate
- Quality control measures included: Use of analytical grade reagents, regular calibration of instruments, analysis of certified reference materials, blank determinations.
- Statistical analysis was performed using SPSS version 25.0
- Results were expressed as mean ± standard deviation
- Significant differences between means were determined using one-way ANOVA followed by Duncan's multiple range test at $p < 0.05$

Equipment Used

- Analytical balance (Mettler Toledo, Switzerland)

- Muffle furnace (Carbolite, UK)
- HPLC system (Shimadzu LC-20AT, Japan)
- Atomic Absorption Spectrophotometer (PerkinElmer AAnalyst 400)
- UV-Visible spectrophotometer (Shimadzu UV-1800)
- Laboratory oven (Memmert, Germany)
- Soxhlet apparatus
- Kjeldahl digestion and distillation units.

Chemical Reagents: All chemicals and solvents used were of analytical grade and obtained from reputable suppliers (Sigma-Aldrich, Merck). Standard solutions were prepared using deionized water.

RESULTS AND DISCUSSION

The results of the proximate composition of the pulp and seed of both the avocado pear and African pear on wet basis was represented in Table 1. Moisture content in the fruit is the water within the same fruit. It is noticeable that the pulp and seed of both pears contains a high level of moisture content, with the African pear pulp having a higher moisture content (46.20%) while the avocado seed has a lower moisture content (35.55%). Generally, fruit pulps tend to contain more water than seeds, which is consistent with the higher moisture in both avocado and African pear pulps (Adeyemi, O.S., & Onilude, M.A., 2021). Lower moisture in seeds (e.g., avocado pear seed at $35.55 \pm 0.55\%$) reflects their more concentrated nutrient storage and reduced water content.

Both seeds (avocado pear seed at $56.13 \pm 0.05\%$ and African pear seed at $49.63 \pm 0.05\%$) had significantly higher carbohydrate levels compared to their respective pulps. Seeds commonly store starch and other polysaccharides, which explains the higher carbohydrate content relative to pulp (Okeke, A. C., Nnaji, P. C., & Odimegwu, E. N., 2019).

Protein levels remained relatively low (< 3%) across all samples. African pear pulp showed the highest value (2.33 ± 0.10%). These values imply that neither avocado nor African pear pulp or seed is a major protein source. Environmental and species-specific factors can influence plant protein content (Martínez, A., López, S., & García, M., 2021).

Avocado pear pulp had the highest fat content (29.00 ± 0.10%), aligning with the well-known lipid richness of avocados, which are noted for their monounsaturated fatty acids (USDA, 2019). African pear pulp also contained a notable amount of fat (23.50 ± 0.50%), though less than avocado pulp. Both seeds were significantly lower in fat, suggesting that lipid reserves are predominantly stored in the pulp for these fruits (Sánchez-Mata, M. C., Vargas, A., & García, J., 2021).

Avocado pear seed (4.50 ± 0.58%) exhibited the highest ash content, indicative of a higher overall mineral presence. Mineral composition often varies due to soil conditions and genetic factors, particularly in seeds that may sequester essential minerals for embryonic development (Nwaokonkwo, C.U., & Ede, T., 2020).

African pear seed (45.67 ± 0.66%) and pulp (40.50 ± 1.10%) had notably higher crude fibre content than avocado pear samples. Increased fibre in seeds can be attributed to structural polysaccharides within seed coats and associated tissues (Zhou, M., Chen, Q., & Liu, J., 2021; Singh, R., Patel, V. K., & Sharma, R., 2022).

High dietary fibre is valuable in functional food development, supporting gastrointestinal health and potentially lowering serum cholesterol (Singh, R., Patel, V. K., & Sharma, R., 2022).

Overall, avocado pulp stands out for its high fat content, whereas African pear (particularly the seed) offers significant fibre. Seeds generally have higher carbohydrate and ash contents, while pulps can be richer in moisture and lipids. These findings align with the typical nutritional patterns of fruit pulp versus seed across various plant species.

Table 1: Proximate composition of pulps and seeds of African pear and avocado pear.

Samples (%)	Avocado Pear pulp	Avocado Pear seed	African Pear pulp	African Pear seed
Moisture Content	40.23±0.65^{d}	35.55 ±0.55^{b}	46.20±0.13^{e}	39.15±0.58^{c}
Carbohydrate Content	24.13±0.05^{c}	56.13 ± 0.05^{e}	26.47±0.05^{d}	49.63±0.05^{a}
Protein Content	2.00±0.10^{d}	1.73±0.04^{a}	2.33±0.10^{e}	1.97±0.02^{b}
Fat Content	29.00±0.10^{c}	7.01±0.12^{a}	23.50±0.50^{b}	6.50±0.60^{a}
Ash Content	2.78±1.50^{c}	4.50±0.58^{b}	2.61±1.20^{a}	1.99±0.60^{a}
Crude fibre Content	33.50±0.35^{c}	27.40±1.42^{a}	40.50±1.10^{d}	45.67±0.66^{e}

Values are means ± standard deviations of triplicate determinations. Values in the same row sharing the same letters are not significantly different ($p<0.05$ level).

Below is a scientific interpretation of the phytochemical composition (oxalates, tannins, flavonoids, phytates, saponins, and alkaloids) of avocado pear (pulp and seed) and African pear (pulp and seed). The discussion highlights comparisons across samples, nutritional/anti-nutritional implications, and relevant references. Values in the table (mg/100 g) are means ± standard deviations of triplicate determinations, with letter superscripts indicating statistical significance at $p < 0.05$.

The results presented in Table 2 revealed that Avocado Pear Pulp (0.37 ± 0.04 mg/100 g) has the lowest oxalate content, indicating a minimal risk of oxalate-related mineral binding (Eri, O. L., Okon, I. E., & Etefia, D. O., 2019). Avocado Pear Seed (5.00 ± 0.29 mg/100 g) had the highest oxalate levels, aligning with findings that seeds often store more anti-nutritional factors than pulp (Eri *et al*., 2019). African Pear Pulp (1.74 ± 0.03 mg/100 g) and African Pear Seed (1.93 ± 0.05 mg/100 g) contained moderate oxalate concentrations.

High oxalate levels can chelate calcium and magnesium, potentially reducing their bioavailability (Chen, L., Wang, Y., & Zhao, J., 2022)). Though the avocado seed's oxalate content is relatively high among the samples, it remains modest in an absolute sense compared to certain leafy vegetables.

African Pear Pulp (0.88 ± 0.11 mg/100 g) was slightly higher in tannins than the African pear seed (0.28 ± 0.05 mg/100 g), indicating some variability within the same fruit (Okeke *et* Onah, 2021).

Avocado Pear Seed (0.82 ± 0.20 mg/100 g) demonstrated higher tannin content than the pulp (0.28 ± 0.07 mg/100 g). This pattern is consistent with many seeds containing defense-related phenolics (Gonzalez, M., Hernandez, L., & Ramirez, A., 2022). Low to moderate tannin levels can contribute antioxidant properties; however, at high concentrations, tannins may reduce protein digestibility by forming complexes with proteins (Gonzalez *et al*., 2022).

Avocado Pear Pulp (20.97 ± 0.02 mg/100 g) exhibited the highest flavonoid content. Flavonoids are known for their antioxidant and anti-inflammatory properties (Cheng, C., Zhang, L., & Li, Y., 2020). Both Avocado Pear Seed (19.89 ± 0.01 mg/100 g) and the African pear samples (7.88 ± 0.02 mg/100 g pulp, 6.98 ± 0.00 mg/100 g seed) also contained measurable levels of flavonoids, but significantly lower than avocado pulp. High flavonoid content in avocado pulp aligns with the known antioxidant potential of avocados (Dreher *et al*., 2013).

Avocado Pear Seed (0.52 ± 0.01 mg/100 g) was marginally higher in phytates than the pulp (0.38 ± 0.05 mg/100 g). African Pear samples (0.39 ± 0.03 mg/100 g pulp, 0.40 ± 0.05 mg/100 g seed) showed relatively similar phytate levels. Phytates can bind to dietary minerals (e.g., iron, zinc), potentially reducing their absorption (Reddy, N.R., 2022). However, low to moderate phytate intake can also have beneficial anti-cancer properties (Reddy, N.R., 2022).

Avocado Pear Pulp (1.00 ± 0.02 mg/100 g) was higher in saponins compared to avocado pear seed (0.85 ± 0.37 mg/100 g). African Pear Pulp (0.97 ± 0.35 mg/100 g) vs. African Pear Seed (0.61 ± 0.02 mg/100 g) showed a reversed trend, with the pulp containing more saponins than the seed. Saponins can exhibit cholesterol-lowering effects and contribute to foaming properties in foods, although excessive levels can impart bitterness or reduce nutrient uptake (Zhang, Y., & Chen, L., 2021).

Table 2: Phytochemicals and Antinutrients composition (mg / 100g)

Sample (mg/100g)	Oxalates	Tannins	Flavonoids	Phytates	Saponins	Alkaloids
Avocado Pear pulp	0.37 ± 0.04^{b}	0.28 ± 0.07^{a}	20.97 ± 0.02^{d}	0.38 ± 0.05^{b}	1.00 ± 0.02^{e}	6.10 ± 0.02^{c}
Avocado Pear seed	5.00 ± 0.29^{e}	0.82 ± 0.20^{d}	19.89 ± 0.01^{e}	0.52 ± 0.01^{b}	0.85 ± 0.37^{a}	4.90 ± 0.01^{b}
African Pear pulp	1.74 ± 0.03^{c}	0.88 ± 0.11^{c}	7.88 ± 0.02^{b}	0.39 ± 0.03^{a}	0.97 ± 0.35^{d}	3.77 ± 0.30^{a}
African Pear seed	1.93 ± 0.05^{c}	0.28 ± 0.05^{a}	6.98 ± 0.00^{c}	0.40 ± 0.05^{d}	0.61 ± 0.02^{c}	16.01 ± 0.00^{e}

Values are means ± standard deviations of triplicate determinations. Values in the same row sharing the same letters are not significantly different ($p<0.05$ level).

Table 3 presents the vitamin contents of the avocado and African pear pulps and seeds. It can be observed that vitamin A is found to be more abundant when compared with other vitamins, ranging from 97.00 mg/g in avocado pear seed to 615 mg/g in African pear pulp. The least abundant vitamin was vitamin B1 ranging from 9.50 µg/100g in African pear pulp to 19.98 µg/100g in African pear seed.

Table 3: Vitamin contents of Avocado pear (pulp and seed) and African pear (pulp and seed).

Samples	Vit A (mg/g) at 450 nm	Vit B1 (µg/100g) at 360 nm	Vit C mg/100g) at 420 nm	Vit E (µg/100g) at 520 nm
Avocado Pear pulp	239.57	9.01	52.44	51.03
Avocado Pear seed	97.00	6.13	7.24	33.67
African Pear pulp	615.00	9.50	44.29	54.25
African Pear seed	190.00	19.98	11.87	52.06

Percentage of standard error < 5%

African Pear Pulp (615.00 mg/g) exhibited the highest Vitamin A content among all samples. Such high values may relate to its pigmented tissues, given that carotenoids (precursors of Vitamin A) are known to accumulate in certain fruit pulps (Osei, F. A., Mensah, P. A., & Boateng, R., 2022).

Avocado Pear Pulp (239.57 mg/g) also contained a substantial amount of Vitamin A, while both seeds (97.00 mg/g avocado; 190.00 mg/g African) had lower levels than their pulps. Vitamin A supports vision, immune function, and epithelial integrity (Hernandez, P., & Kumar, V., 2022). Fruits with rich carotenoid profiles can help alleviate Vitamin A deficiency when consumed regularly (Osei *et al.*, 2022).

African Pear Seed (19.98 µg/100 g) stood out with the highest thiamine value, nearly double that of the other samples. Avocado Pear Pulp (9.01 µg/100 g) and African Pear Pulp (9.50 µg/100 g) were moderately similar, whereas Avocado Pear Seed was slightly lower (6.13 µg/100 g). Thiamine is crucial for energy metabolism (carbohydrate breakdown) and nervous system function (Whitney, E., & Rolfes, S.R., 2018). Seeds often store B vitamins for the developing embryo, which can explain higher seed concentrations in some species (Nwaokonkwo *et* Ede, 2020).

Avocado Pear Pulp (52.44 mg/100 g) had the highest Vitamin C content, followed closely by African Pear Pulp (44.29 mg/100 g). Both seeds had lower Vitamin C (7.24 mg/100 g in Avocado seed; 11.87 mg/100 g in African pear seed), aligning with the common finding that pulps generally concentrate ascorbic acid to support fruit development (Okoronkwo, C.L., & Eke, U.O., 2019). Vitamin C is a water-soluble antioxidant vital for collagen synthesis, immune health, and iron absorption (Jones, D., & Smith, A., 2022) . Regular consumption of Vitamin C-rich fruit pulp may help meet dietary recommendations.

African Pear Pulp (54.25 µg/100 g) showed slightly higher Vitamin E levels than African pear seed (52.06 µg/100 g) and avocado pear pulp (51.03 µg/100 g). Avocado Pear Seed was the lowest (33.67 µg/100 g). Vitamin E functions as a lipid-soluble antioxidant, protecting cell membranes from oxidative damage (Dreher *et al.*, 2013). High Vitamin E in fruit pulp may correlate with the presence of unsaturated lipids, as tocopherols stabilize oils within plant tissues (United States Department of Agriculture, 2019).

The Table 4 below shows the mineral compositions of the two species of pear and their seeds. While the exact units are not explicitly stated in the table, they are commonly reported as mg/100 g or mg/kg for fruit samples.

Table 4: Mineral composition of pulps and seeds of three species of pears (mg/g)

Samples	Mg	Ca	K	Fe	Cu	Na	Mn	Zn	Pb	Co
Avocado Pear pulp	1.43	0.17	16.25	0.15	0.01	0.17	0.01	0.03	0.00	0.00
Avocado Pear seed	1.19	0.43	14.50	0.55	0.01	0.18	0.01	0.05	0.00	0.00
African Pear pulp	1.55	3.71	7.53	0.15	0.01	0.17	0.04	0.02	0.00	0.00
African Pear seed	0.99	0.43	7.25	0.15	0.01	0.20	0.03	0.02	0.00	0.00

Percentage of standard error < 5%

African Pear Pulp (1.55) contains the highest Magnesium among the four samples, followed by Avocado Pear Pulp (1.43). Seeds (0.99–1.19) generally have slightly lower Magnesium content than pulp. Magnesium is crucial for enzyme activation, muscle function, and bone health (Walker, A. F., Marakis, G., Christie, S., & Tudur-Smith, C., 2022). Fruits usually provide moderate Mg levels, and these data suggest that pear pulps may be a modest source of dietary magnesium.

African Pear Pulp (3.71) stands out with substantially higher Calcium compared to all other samples (0.17–0.43). This indicates that African pear pulp may be a notable plant source of calcium, important for bone formation and neuromuscular function (Singh, *et al.*, 2022). Differences in cultivar, soil mineral availability, and fruit maturity can influence calcium distribution in fruit tissues (Nwaokonkwo *et* Ede, 2020).

Avocado Pear Pulp (16.25) showed the highest potassium content. Seeds for both avocado (14.50) and African pear (7.25) had lower values, with African pear pulp at 7.53. Potassium helps regulate blood pressure, fluid balance, and nerve impulses (Whitney *et* Rolfes, 2018). Avocado's known reputation for high K content is reaffirmed here (USDA, 2019).

All samples report 0.00 for Lead and Cobalt, suggesting no detectable levels of these potentially harmful or toxic metals. Zero lead content implies compliance with safety standards, especially critical for fruits consumed fresh (FAO/WHO, 2011). The absence of cobalt is also notable, as cobalt can be beneficial in trace amounts but toxic at higher levels (Brown, A., & Wilson, G., 2022).

CONCLUSION

This comparative nutrient profiling of Avocado (*Persea americana*) and African Pear (*Dacryodes edulis*) underscores the distinct nutritional advantages offered by each fruit. Proximate analyses revealed higher moisture and fiber content in African pear pulp, alongside comparatively elevated carbohydrate reserves in the seeds of both fruits. Avocado pulp excelled in lipid content and flavonoid concentration, suggesting notable antioxidant capacity. Despite modest protein levels, both pulp and seed samples contained valuable vitamins—including vitamins A, C, E, and thiamine—and essential minerals such as calcium and potassium. Crucially, no lead or cobalt was detected, indicating minimal safety concerns. Collectively, these findings point to the potential of each fruit's pulp and seed to enhance dietary diversification, reinforce food security, and deliver critical health benefits—particularly through their unique micronutrient and phytochemical profiles.

Overall, both avocado and African pear—across pulp and seeds—hold nutritional merits but differ notably in proximate, vitamin, mineral, and phytochemical compositions. They can be strategic functional foods or food ingredients if appropriately processed and incorporated into diets.

RECOMMENDATION

Avocado pulp and African pear pulp can be promoted as part of a balanced diet, capitalizing on their vitamin (A, C, E) and mineral (K, Ca) content. While seeds contain beneficial nutrients (iron, zinc, B1), they also carry higher anti-nutrients. Processing methods (e.g., fermentation, soaking, boiling) may reduce these compounds and improve nutrient bio-availability.

In food processing, exploring the use of avocado seed flour in baked goods or nutraceutical formulations, ensuring oxalate and alkaloid levels can be mitigated through thermal or enzymatic treatments.

African pear pulp's high Vitamin A and Ca content could be harnessed in weaning foods or functional beverages, especially in regions prone to deficiencies.

Further research by investigating the bio-availability of phytochemicals and vitamins after domestic processing (e.g., frying, roasting) to validate actual intake. Clinical trials should be conducted to ascertain potential health benefits (lipid-lowering, antioxidant effects) of regular African pear and avocado seed consumption.

Public Health and Safety Consumers should be encourage and educated on seed consumption limits due to anti-nutritional and potentially toxic constituents (especially high alkaloids in African pear seed).

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